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Research paper

How local communities access, utilise and evaluate inland fisheries, and their influence on fishery conservation status in northern Zimbabwe

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The conservation status of inland fishery resources is vulnerable worldwide, and this threatens the livelihoods of fishing-dependent communities. This case study aimed to: (i) establish the use and perception of fisheries and ecosystem services by locals, (ii) undertake a monetary valuation of the fisheries, (iii) determine the potential threats to the fisheries, and (iv) examine the social drivers and barriers for citizen science involvement. Lastly, (v) we evaluated how the above factors affected the conservation of fisheries at Mushumbi Pools, Zimbabwe. A cross-sectional survey of 69 households was conducted. Results of the study showed that locals utilised 17 fish species for social, economic, cultural and religious purposes. Locals attach high intrinsic socio-economic value to the fisheries resources and wetland ecosystem services provided by the Mushumbi Pools. Despite the sustained income from fisheries, the local market in Mushumbi Pools is actually undervaluing fisheries resources, as the fish prices in the area are very low compared to standard market prices countrywide. A larger proportion of the respondents (65%) cited poor land-tilling practices, heavy application of agropesticides and use of unsustainable fish harvesting methods as the main threats to fish diversity in Mushumbi Pools. Relaxed fishing concessions for women and children in specific fishing zones were key drivers for community participation in fisheries conservation. However, strict enforcement of fishing bans in breeding and nursery zones and restricted access to some parts of the Mushumbi Pools were the main barriers for local involvement in the conservation of fisheries resources. Without the fishing community's participation there is no guaranteed sustainability of the fishery resources in the pools. Legitimising community access, ensuring fair valuation and utility rights is a key driver for successful management of inland fisheries resources in Sub-Saharan Africa.

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INTRODUCTION

Ecosystem services provision and human exploitation of Mushumbi Pools

Ecosystem service assessment is vital to determine the ecological, socio-cultural, economic and monetary trade-offs associated with human exploitation of common wetland resources (Wang et al. 2011; Chifamba, 2013). Mushumbi Pools are a network of interconnected low-lying deep and extensive flood pools in the Mbire Rural District of Zimbabwe (FAO, 2006; LGDA, 2009). Mushumbi Pools provide essential freshwater ecosystem services and serve as filtration and purification points for pollutants and nutrients and for recharging the Zambezi River (AWF, 2010). The pools provide habitats for fish, macroinvertebrates, cladocerans, crocodiles, hippopotamuses and macrophytes (Gratwicke and Marshall, 2001). Some endangered wetland birds, crabs, frogs and aquatic mammals such as otters are common in the pools (AWF, 2010).

Local people utilise the Mushumbi Pools for various purposes, e.g., recreation, religious, economic, cultural and tourism activities, besides deriving nutritious fish resources (which enhance food security), and some are entirely dependent on them for livelihood sustenance (Hove and Chapungu, 2013). However, their perceptions on the significance of, and threats to, the fishery resources and ecosystems services of the pools are currently understudied and poorly documented (AWF, 2010). It is important to explore and establish the perceptions of the local community towards fisheries resources in order to develop comprehensive pragmatic and effective conservation strategies (Wood et al., 2002; Hove and Chapungu, 2013).

Mushumbi Pools (Figs 1–2, Figs A1–A2, Appendix) are located on two rivers, Angwa and Manyame, which are highly polluted and modified in their upper sections (Gratwicke et al., 2003). Urbanisation and industrial development in the upper sections of Angwa and Manyame Rivers influence water quality, quantity, and aquatic biodiversity and recharge capacity, and threaten the aesthetic value and ecosystem services provision of the pools downstream (Marshall, 2011; Nhiwatiwa et al., 2011). Further, Mushumbi Pools are located in the hot (daily temperatures near 32°C) and dry (average annual rainfall amounts less than 450 mm) Region V, with a highly variable climate, which poses a threat to the health of the pools (Bosongo, 2011; Muhonda, 2011; Mugandani et al., 2012; Alvera, 2013). A combination of human exploitation and highly variable climatic factors threaten the conservation status of fisheries resources in Mushumbi Pools (Fritz et al., 2003; Marshall, 2011).

Addressing the sustainability of natural resources needs to incorporate several disciplines to be achieved; this includes limnology and social research (AWF, 2010). Establishment and examination of the target component systems, i.e., local communities and their perceptions of sustainable utilisation of freshwater resources such as Mushumbi Pools, helps to avoid the extremes of either dismissing local perceptions, practices, and knowledge as 'unscientific' and harmful, or idealising them (Verhoeven and Setter, 2010; Marambanyika et al., 2012). Therefore, for effective sustainable conservation of scarce freshwater resources, there is a need to explore, establish and examine local perceptions on the common resources. What is even more crucial is to document suggested indigenous conservation strategies as the local resource users have a critical input to the sustainability of the freshwater resources (Dube and Chitiga, 2011; Marambanyika et al., 2017; Utete et al., 2018, 2019; Mandishona and Knight, 2019). This active participatory approach integrates citizen science and scientific knowledge in crafting pragmatic natural resource utilisation policies.

Contextual challenges facing fisheries resources and their valuation in Mushumbi Pools

The main fisheries resources and ecosystem services of the Mushumbi Pools are derived from the Manyame and Angwa rivers (Gratwicke et al., 2003; Marshall, 2011). Marshall (2011) indicated a reduction in the abundance of fisheries resources in the Manyame River and sections of the Angwa River because of anthropogenic activities (e.g. damming, overfishing, mining, construction, and agriculture), water pollution and weed proliferation. Consequently, fish species which formerly occurred in high abundance in the lower Manyame Catchment, e.g. the, African mottled eel *Anguilla bengalensis labiate* (Peters, 1852), eastern bottlenose, *Mormyrus longirostris* (Peters, 1852), imberi, *Brycinus imberi* (Peters, 1852) and Manyame labeo, *Labeo altivelis* (Peters, 1852), are no longer abundant (Marshall, 2011).

Despite the intrinsic and extrinsic socio-economic values of fisheries and water resources, in Zimbabwe there has been lack of proper assessment and valuation of fisheries resources and ecosystem services provision from wetlands (Mahlatini et al., 2018). The task of properly evaluating wetland ecosystem service provision is onerous and complex, though this is not an excuse for lack of use and nonuse evaluation (Wang et al., 2020). It is important to note that ecosystem assessment and economic valuation should be spatio-temporally explicit at scales meaningful for policy formation or interventions (De Groot et al., 2010). The proper value of ecosystem goods and services is estimated using the total economic approach, which sums up the use and non-use values of a wetland resource (Barbier, 2007; Goldman, 2010; Mahlatini et al., 2018).

For this study, the focus was on direct use values of fisheries resources which are feasible to identify and quantify (De Groot et al., 2006; Tursi et al., 2015). The value of direct use goods, i.e., fish, was determined by the market price method (MPM), a method more commonly used in mining, agriculture and manufacturing industries, and rarely used in the fisheries and aquaculture sector (Mathoko, 2009; Satihgile et al., 2011; Dobson et al., 2016). Accurate calculation of direct monetary benefits derived from ecosystems such as Mushumbi Pools is used as a basis to solicit and elicit citizen perceptions and participation in the sustainable conservation of freshwater fisheries resources, an approach that is rarely used in Sub-Saharan Africa (Satihgile et al., 2011; Wasswa et al., 2013; Mahlatini et al., 2018).

Objectives

This case study aimed to: (i) establish the use and perception of fisheries and ecosystem services by locals, (ii) undertake a monetary valuation of the fisheries, (iii) determine the perceived threats to the fisheries, and (iv) examine the social drivers and barriers for citizen science involvement. Lastly, we (v) evaluated how these affected the conservation of fisheries at Mushumbi Pools in Zimbabwe.

METHODS

Study area

Mbire District (Fig. 1) covers 2 700km^2 at 350–500 m amsl in the Middle Zambezi Valley in the northern parts of Zimbabwe and is bordered by Mozambique to the north and Zambia to the north-west (Alvera, 2013). The climate of the Middle Zambezi Valley is hot dry tropical, with low and very variable annual rainfalls averaging 450 to 650 mm/yr and high temperatures exceeding 40°C in October and November (Fritz et al., 2003).

The district has 16 administrative wards (Fig. 1) and most of the community members in the wards are immigrants or seasonally migrate, criss-crossing neighbouring countries in times of dire economic crisis and severe droughts (ZimVAC, 2013). Most villagers using the Mushumbi Pools are located in Musumbi Ward 9 and were the main participants in this study. Villagers in Ward 9 alternate between agropastoral activities, fishing, wildlife poaching and trinket selling in the area; however, recurrent floods and droughts (signs of climate change) in the area have made communities' livelihoods vulnerable and villagers resort to poaching and overexploiting fisheries resources in Mushumbi Pools to survive (FAO, 2006; AWF, 2010; Bosongo, 2011; Alvera, 2013). Mushumbi Pools (Fig. 1) is a flat floodplain interspaced with slow-flowing pools formed in the river channels and some are off-channel pools with sandy sediments and submerged logs, with sparse macrophytes supporting different aquatic organisms, e.g., fish that are utilised by local communities for sustaining livelihoods.

Data collection

We used a cross-sectional descriptive survey to collect data using open- and closed-ended structured questionnaires from 69 fishing-dependent locals in Ward 9, who were purposively selected for the study. Three key informants in each village (i.e. the chief, headman and village head) were included. Along with this, 6 key informants were identified from Zimbabwe Parks and Wildlife Management Authority (ZimParks), Mbire District Council, political leaders and the CAMPFIRE programme. The key informants were selected based on their expert knowledge and history of interaction with the study area. Two focus group discussions (FGDs) comprising at least 12 people (aged >35) were also conducted in order to triangulate data and improve response reliability and validity (Mahlatini, 2018).

Additional fisheries data were collected from 13 individual fishers through observation and personal structured interviews. For validation and accurate monetary valuation, practical follow-ups to observe and measure fish catches (using an electronic scale) by villagers were conducted for 18 consecutive days – 2 days in each village. Secondary data on law enforcement, wildlife-related arrests and patrols were obtained from ZimParks.

Data analysis

Data collected were tabulated in Microsoft Excel 2007, coded and transferred to SPSS 25 for analysis. Descriptive analyses and multivariate inferential analyses (i.e Chi-square tests of independence p = 0.05) were done for documentation of the state of affairs and testing for statistically significant relationships between the variables. The market price method was used to determine the value of identified fish resources following Dobson et al. (2016). The MPM method was used as actual market prices exist for most of the fish, and give a realistic estimate value (Mathoko, 2009).

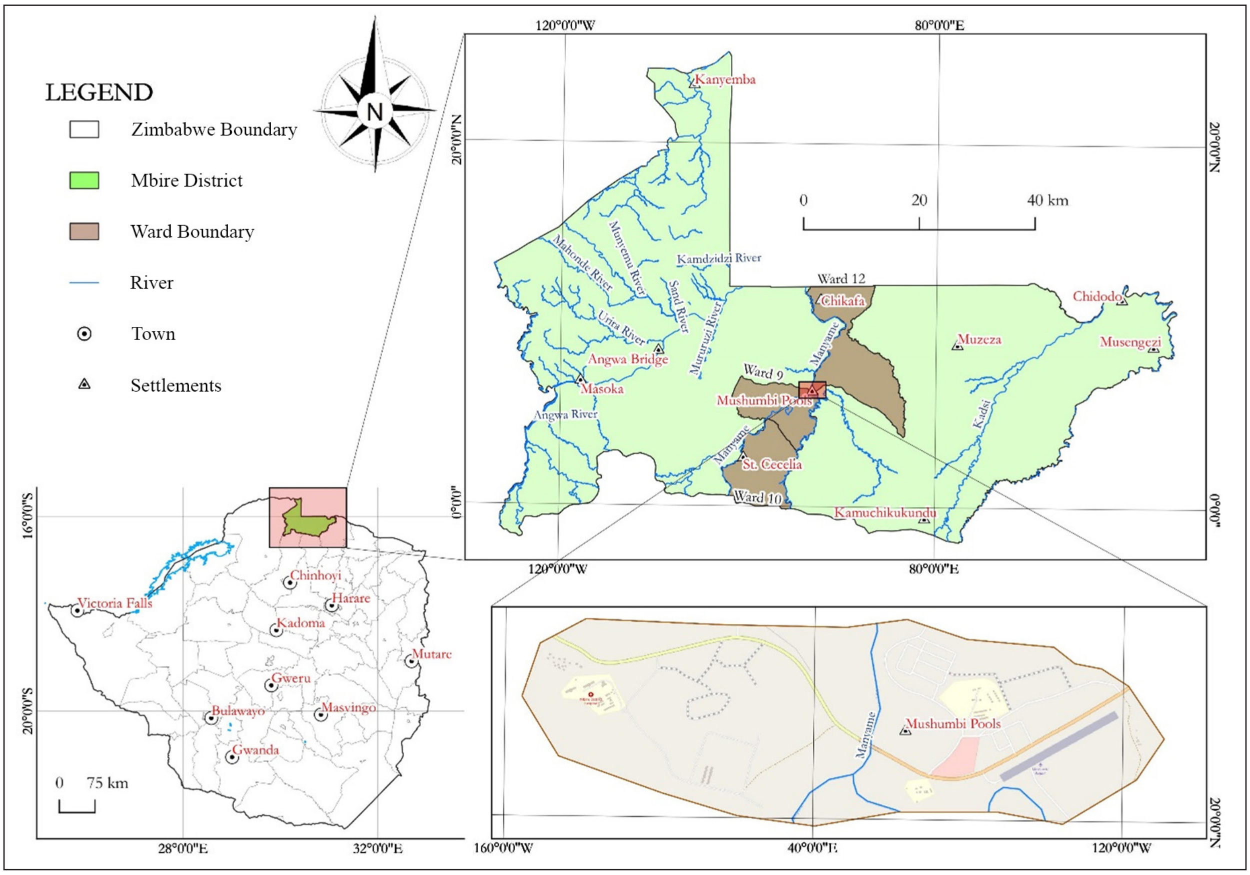

Figure 1. Map of Mbire District showing the Mushumbi Pools town, adjacent to the Mushumbi Pools

Figure 2. Aerial view of the Mushumbi Pools and surrounding Mushumbi Pools town

The actual prices of goods or services traded were used to value the goods identified. Two indicators, i.e., gross financial value (GFV) – economic worth of total quantity harvested, and fisheries resource income (FI) – economic worth of fish quantity sold, were used to express the monetary value of goods for each wetland provision, following Adekola (2007) and using the equation:

$$GFV = ¼\ TQH \times P \tag{1}$$

Where: TQH = the total quantity harvested; *P* = average price per unit of product at which a resource/commodity was sold at the market.

$$WI \text{ or } FI = ¼\ QSD \times P \tag{2}$$

Where: QSD = quantity sold, WI = wetland income, FI = fish income

Contribution of wetlands or fish resources to household income was determined by calculating the total household income (Satihgile et al., 2011). Data on sources of income for Mushumbi Pools wetland users were obtained from the questionnaire survey. The contribution of each activity (as a fraction of the total household income) was then calculated. Indicators of economic value were identified to provide estimates of total returns to income, subsistence value and returns to land. Focus was placed on the gross income, subsistence consumption value and gross value as indicators of economic value for selected goods and services.

Key economic indicator expressions

The WI or FI is different from GFV in that it is an indication of the total local market value of the quantity sold out of the total harvest.

Gross financial value = units harvested, used, produced, or sold x price per unit

Gross cash income = units sold x price per unit

Subsistence consumption value = gross value – gross cash income or units used at home x price per unit

Total net economic value = net economic value of wetland goods + net economic value of wetland services

RESULTS

Demographic and fish-related income profiles

A total of 69 people were interviewed; 36 (52.2%) males and 33 females (47.8%). A large proportion (34; 49.3%) of respondents were aged between 18 and 35 years. Some did schooling up to primary (14; 20.3%) and secondary level (34; 49.3%). At least 20.3% (14) of the respondents were farmers and occasional fishers who embark on fishing for sale and family consumption. About 49.3% (34) of the respondents were fishers who actually depend on fishing as their source of income and nutrition and have more than 20 years' experience of fishing. There were no significant differences (Chi-squared test, $p > 0.05$) in the gender proportions ($p = 0.064$) and sources of livelihood ($p = 0.073$) among the respondents. However, the education attained by the locals differed significantly ($p = 0.032$).

Economic profiling showed that 20.3% (14) of the fishers had income levels from 48 600–102 960 USD/a from fish sales. Around 18.8% (13) of the fishers had income levels up to 14 400 USD/a from fish sales. The standard market price of fish shows that income level ranges from 81 900–125 820 for full time fishers, and for part time fishers was 35 280 USD/a (FAO, 2018). Gross economic value was 801 USD/a, gross cash income value was 679 USD/a, subsistence consumption value was 122 USD/a and the total net economic value was 1 603 USD/a. Comparing standard prices offered by the national market board and the local market prices showed that locals in Mushumbi Pools may be undervaluing the fisheries resources. There was a significant difference (Chi squared test, $p < 0.05$) in fish-related income levels of the locals in Mushumbi Pools, which may relate either to the full- or part-time nature of fishers in the area.

Fisheries resources in Mushumbi Pools

Seventeen (n = 17) common fish species were identified by fishers during the study (Table 1). The most frequently recurring captured fish species, as identified by the locals, were silver labeo, *Labeo ruddi* and tigerfish, *Hydrocynus vittatus* (Castelnau 1861). Pollution-sensitive and herbivorous fish species such as tilapia, *Oreochromis* spp., were less frequently captured by the locals in the Mushumbi Pools. Most (n = 51; 14.2%) respondents felt that fish biodiversity and average body size has decreased drastically in the pools during the past 15–20 years (Table 1). Frequency of occurrence of fish species, determined from the interviewed fishers' based on what they observed in their catches, comprised in descending order: silver labeo; tigerfish; small-mouth bass; chubbyhead barb; red-breasted tilapia; eastern bottlenose; African sharptooth catfish; redeye labeo; African freshwater eel; snake catfish; chessa; Kariba tilapia; greenhead tilapia; Nile tilapia; Zambezi bream; black tilapia; large-mouth bass (Table 1).

Table 1. Fish species, frequency and contribution to catches as indicated by local fishers in Mushumbi Pools. IUCN (2016) conservation status is added for emphasis. FOB = frequency of observation, RF = relative frequency and % SIC = % significance of contribution

Local name	Southern African name	Latin name	FOB (n)	RF	% SIC	IUCN status
Labeo	Silver labeo	*Labeo ruddi*	51	1	14.2	Data deficient
Tiger fish	African tigerfish	*Hydrocynus vittatus*	49	2	13.7	Least concern
Brown bass	Small-mouth bass	*Micropterus dolomieu*	47	3	13.2	Least concern
Barbel fish	Chubbyhead barb	*Enteromius anoplus*	38	4	10.6	Least concern
Red-breasted bream	Red-breasted tilapia	*Coptodon rendalli*	35	5	9.8	Data deficient
Bottlefish	Eastern bottlenose	*Mormyrus longirostris*	34	6	9.5	Data deficient
Mud catfish	African sharptooth catfish	*Clarias gariepinus*	32	7	8.9	Least concern
Redeye fish	Redeye labeo	*Labeo cylindricus*	16	8	4.5	Least concern
Electric eel	African freshwater eel	*Anguilla. spp*	15	9	4.2	Data deficient
Snake catfish	Snake catfish	*Clarias theodorae*	12	10	3.4	Least concern
Chessa	Chessa	*Distichodus schengae*	7	11	2.0	Least concern
Kariba bream	Kariba tilapia	*Oreochromis mortimeri*	6	12	1.7	Least concern
Green headed bream	Greenhead tilapia	*Oreochromis macrochir*	5	13	1.4	Least concern
Nile tilapia	Nile tilapia	*Oreochromis niloticus*	3	14	0.8	Least concern
Zambezi bream	Zambezi bream	*Pharyngochromis acuticeps*	3	14	0.8	Least concern
Black bream	Black tilapia	*Oreochromis placidus*	2	15	0.5	Least concern
Black bass	Large-mouth bass	*Micropterus salmoides*	2	15	0.5	Data deficient

Local perceptions towards the socio-cultural and economic use of fisheries resources

Most respondents (n = 69; significance of use (SOU) = 27.9%) indicated commercial and subsistence utility as the major use of fisheries resources in the pools. In addition to fish as a food source, some respondents (n = 16; SOU = 6.5%) indicated that selected fish species (e.g. African sharptooth catfish) have traditional and socio-cultural uses, such as bewitching rival men who sleep with another man's wife. However, very few respondents (n = 3; SOU = 1.2%) mentioned that some fish species (e.g. African sharptooth catfish) are used for luck and as a love portion to enhance marriages. Few respondents (n = 14; SOU = 4.9%) indicated that some fish species (e.g. snake catfish) actually help conserve water in the pools (Table 2). Local perceptions towards the socio-cultural and economic use values of fisheries resources differed significantly (Chi test, p = 0.0021) in the area with a larger proportion of respondents considering fish as a food source, and sizeable portions citing their cultural, recreational, ornamental, educational and conservation significance (Table 2).

Valuation of fisheries resources in Mushumbi Pools

Economic valuation of fisheries resources showed that 49.3% (n = 34) of respondents depended on fishing as their main source of income throughout the year, with annual income ranges from 81 900–102 960 (Tables A1–A3, Appendix). Full-time fishers earn more money from fisheries resources relative to part-time fishers who have other sources of income (Tables A1–A3, Appendix). Indicators of economic value were identified to provide estimates of total returns to income, subsistence value and returns to land (Adekola, 2007). The economic indicators calculated showed that gross economic value was 801 USD, gross cash income value was 679 USD, subsistence consumption value was 122 USD and total net economic value was 1 603 USD.

Economic indicator expressions

Indicators of economic value were identified to provide estimates of total returns to income, subsistence value and returns to land (Adekola, 2007). The GFV = 801.50 USD, gross cash income = 679 USD, subsistence consumption value = 122.50 USD, total net economic value = 1 602.50 USD.

Perceived threats facing fisheries resources in Mushumbi Pools

Most (n = 45; 65.2%) respondents cited poor land-tilling practices and heavy application of pesticides, especially for cotton and tobacco farming, as key drivers for the decline in fish catches and diversity (Table 3). A sizeable portion (n = 43; 62.3%) of respondents cited use of unsustainable harvesting techniques, for example mosquito nets, as a threat to fish biodiversity. Respondents indicated that mosquito nets do not select, but simply trap all sizes of fish which decreases fish density and diversity in the pools. Few respondents (n = 5; 7.2%) indicated that implementing improper fish conservation science and practices was a driver of fish decline in Mushumbi Pools (Table 3).

Table 2. The perceptions of respondents towards fish as a resource in Mushumbi Pools. The FAO (2018) global rank of fish utility in communities is added for comparison.

Fish use	Frequency (n)	Rank of use	% Significance of use (SOU)	FAO ranking of fish utility
Food	69	1	27.9	1
Trade	69	1	27.9	2
Bewitching rival lovers	16	2	6.5	7
Aquatic biodiversity	14	3	5.7	3
Decoration purpose	12	4	4.9	5
Sports	11	5	4.5	4
Education/research	10	6	4.0	6
Love potion	7	7	2.8	7
Curing sick babies	6	8	2.4	7
Healing chest pains	3	9	1.2	7
Luck charm	3	9	1.2	9

Table 3. Locally perceived causes of fish decline in Mushumbi Pools

Cause of fish decline	Frequency of response	Rank	Significance of the factor (%)
Wrong land tilling and use of pesticides	45	1	23.1
Use of unsustainable harvesting techniques e.g. mosquito nets	43	2	22.0
Low levels of water in the channel	34	3	17.4
Drought resulting in drying of channels	24	4	12.3
Fish poisoning as a way of harvesting fish	23	5	11.8
Presence of crabs and water birds as fish predators	13	6	6.7
Water pollution	8	7	4.1
Implementing wrong fish conservation practices due to lack of knowledge	5	8	2.6

Conservation measures suggested for fisheries resources in Mushumbi Pools

About 65.2% (n = 45) of the respondents suggested that people should stop the use of poison as a harvesting method as it does not promote fish conservation (Table 4). At least 62.3% (n = 43) of the respondents suggested that banning streambank cultivation will promote fish conservation. At least 50.7% (n = 35) of the respondents suggested arresting individuals using fish poisoning as a harvesting method. Some 29% (n = 20) of the respondents suggested introduction of fish species which prey on crabs and crayfish to reduce their population in the pools.

Only 17.4% (n = 12) of respondents cited creation of fish nurseries and spawning zones to promote fish conservation. Some (n = 16; 23.2%) locals indicated the negative effects of swimming, dishwashing, laundry and bathing on fish populations in the pools, and suggested that such activities must be banned with offenders severely punished. Few (n = 10; 14.5%) respondents suggested introduction of fish sanctuaries and fish farms as a conservation strategy. Few (n = 5; 7.2%) locals suggested increasing fisheries resources awareness (for example by conducting more fish conservation campaigns to promote fisheries resource conservation in the pools) (Table 4).

Drivers and barriers for community access and citizen science in Mushumbi Pools

Mushumbi Pools community cited drivers and barriers for their effective participation in conservation of fisheries resources, which are summarised and categorised in relation to modern fisheries management practices in freshwater protected areas in Table 5. The key drivers were cited as: relaxed fishing concessions for women and children in some wetland zones, involvement of locals in the environmental monitoring committees, and strict adherence to cultural norms which prohibited the fishing of some species, enabling citizens to monitor each other and in the process conserving some vital fisheries resources in Mushumbi Pools. Restricted access to some parts of the pools, cordoning off fish-breeding nurseries, and lack of efficient fishing gear, post-harvest technology and financial capital were cited as key barriers to local management of fisheries conservation in Mushumbi Pools (Table 5).

Table 4. Local residents' suggestions for Fish conservation measures in Mushumbi Pools

Conservation measures	Frequency of response	Rank	% Significance of the measure
Avoiding fish poisoning	45	1	19.3
Banning streambank cultivation	43	2	18.5
Arresting and suing culprits who poison fish	35	3	15.1
Introducing predators which prey on crabs/crayfish	20	4	8.6
Avoiding washing in the channel	16	5	6.95
Introducing new fish species which adapt to current conditions	14	6	6.0
Avoiding swimming in the channel	13	7	5.6
Creation of fish nurseries and spawning zones	12	8	5.2
Introducing fish sanctuaries	10	9	4.3
Introducing fish farms	9	10	3.9
Giving locals power to manage water resources	5	11	2.2
Increasing awareness of fish resource	5	11	2.2
Reducing erosion on the upper streams	5	11	2.2

Table 5. Drivers and barriers to local management of conservation strategies in Mushumbi Pools

Barriers	Description	Analogy in modern fisheries management techniques
Spatial areas	Areas closed to fishing	Freshwater protected areas, temporary fisheries closures
Temporal	Restricting fishing/harvesting activities during specific time periods	Closed seasons
Gear	Prohibiting/restricting certain harvesting technologies or techniques	Gear prohibitions
Effort	Limiting who can harvest certain species, use certain gears, fish certain areas, etc.	Permitting
Species	Prohibiting the consumption of certain species.	Species-specific bans
Catch	Restricting the quantity of a harvest	Total allowable catch
Institutional	Strict no-access to wetland zones	Closed seasons
Economic	Non-payment of incentives to committee member	Low income and wages for fish protection agencies
Institutional	Relaxed access to sensitive fishing zones for children and women	Seasonal open of marine/freshwater nursing sanctuaries for underprivileged groups
Institutional	Involvement of locals in environmental committees	Community fishing initiatives
Economic	Incentives for locals involved in environmental monitoring committees	Community participatory fisheries
Cultural	Prohibited fish and fishing seasons	Protected and endangered species and no access zones

DISCUSSION

Fisheries resources, and local peoples' perceptions

Seventeen locally identified fish species were documented during the study. Predator fish comprised tigerfish, small-mouth bass and African sharptooth catfish, whilst the common prey fish species were silver labeo, red-breasted tilapia, and chubbyhead barb (Marshall, 2011). Locals indicated that silver labeo dominated the catches in Mushumbi Pools. This is possible as silver labeo prefers deeper waters in the main river channels and off-channel pools, and is found over sand or mud bottoms, habitats which are rife in Mushumbi Pools (Skelton, 2001; Marshall, 2011; Marr et al., 2018). Respondents cited frequently capturing a prey fish, the red-breasted tilapia in Mushumbi Pools. The high frequency of red-breasted tilapia may be related to the predominantly flat plain, resulting in the undulating gradient of the pools which are a favourable environment for the proliferation of the herbivorous species, as these prefer slow-moving planktivorous rich zones in water (Marshall, 2011). Off-channel pools are normally used as breeding, nursery and spawning zones by red-breasted tilapia as they avoid predation of fingerlings and fry in the main river channel (Weyl and Hecht, 1998). The other fish frequently cited by respondents, e.g., chubbyhead barb, tends to favour a variety of habitats in cooler water within fragmented off-channel pools (Skelton, 2001). In addition, chubbyhead barb prefers murky waters for camouflage and is commonly found under fallen trees or old rotting logs (Marshall, 2011), habitats which are prevalent in Mushumbi Pools. The lowlying habitats in off-channel Mushumbi Pools favour fish species adapted to low gradients, high alluvial deposits, wide water level fluctuations and highly variable flow regimes (Marshall, 2011).

Availability of suitable prey and diet flexibility for some predators (e.g. African sharptooth catfish) infers a competitive feeding advantage over other predators in aquatic systems (Skelton, 2001; Zengeya and Marshall, 2010; Marshall, 2011). Competition also exists among herbivores like red-breasted tilapia, greenhead tilapia, black tilapia and Nile tilapia. Red-breasted tilapia and Nile tilapia outcompete black tilapia and greenhead tilapia, as the latter have relatively inefficient digestive, reproductive, recruitment and growth mechanisms and are less adapted to pollution (Zengeya and Marshall 2008; Marshall, 2011). The major implication of the available fisheries resources is that they have an ability to survive and reproduce only if sustainable fishing methods are used and the preferred habitats are maintained (Zengeya and Marshall, 2008). These factors are hardly controllable in the face of a changing climate, shifting landuse patterns (Musiwa and Mhlanga, 2020), water pollution, over-exploitation and habitat degradation (Marshall, 2011; Alvera, 2013; FAO, 2018) in the Mushumbi Pools.

Most respondents felt that availability, diversity and average body size of fish, and the quantities of commercial fish species (e.g. large-mouth bass, black tilapia), in Mushumbi Pools has decreased during the past 15–20 years (Skelton, 2001; Zengeya and Marshall, 2008; Marshall, 2011). Locals attributed this decline in fish population and body sizes to anthropogenic factors, for example, water pollution, overfishing, illegal fishing gear, and agriculture, which lowers water and food quantities in the pools. However, it is important to indicate that there is no supporting literature on a scientific fisheries stock assessment of Mushumbi Pools. This necessitates a future long-term fish stock assessment to verify local perceptions. Future studies on fish diversity in Mushumbi Pools need to integrate the effects of available feed, pollution, climate change, landuse patterns, fishing regulations, and use of sustainable fishing techniques (Skelton, 2001; Zengeya and Marshall, 2008; Ndebele-Murisa et al., 2012, 2013).

The fact that some species, for example, silver labeo, were cited as abundant and can be easily trapped with maizemeal baits by women and children, increases daily catches and enhances food security for households. However, the large-sized and commercially important species (for example; tigerfish, small-mouth bass and large-mouth bass) are located in deep waters and cannot be trapped by maizemeal dough and bait worms (Marshall, 2011; FAO, 2018). To actively target these species in Mushumbi Pools requires non-standardised fishing gear, such as fishing rods, tracers and spinners or artificial lures, and often draws in tourists targeting these species recreationally and who use boats (McCafferty et al., 2012; Magqina et al., 2020). More intensive fishing efforts and using non-selective netting (for example, mosquito nets) reduces overall catch and leads to overfishing and overexploitation threatening the recruitment, survival and growth of sensitive fish species simultaneously threatening the future of fishing livelihoods (FAO, 2018; Utete et al., 2018). Currently, most local people are using gillnets, mosquito and seine nets which are unsustainable methods as they are often non–species selective (FAO, 2018). Thus, it may require local people to use more species and even size-selective though not always efficient fishing methods, for example, basket nets and rod line angling, to preserve fish biodiversity in Mushumbi Pools.

Economic valuation of fisheries resources

Fish are a major source of income for indigenous people in Mushumbi Pools. However, most income generated from selling fish is used to purchase grains from nearby Guruve District where there is high production of maize, since Mushumbi area receives low rainfall which fails to sustain maize production (Zuze, 2013). Income generated from fisheries resources is also used to pay school fees for children and purchase basic commodities (ZIMVAC, 2013). Despite the sustained income from fisheries, the local market in Mushumbi Pools is undervaluing their fisheries resource because fish prices are very low compared to standard regional market prices. The reasons for the undervaluation of the fish products are not clear; however, locals cite low purchasing power of the local market (where a majority are impoverished), long distance to lucrative markets in Guruve and Harare (fish is highly perishable and transport costs prohibitive) and fish price uncertainty that exists in Zimbabwe (ZIMVAC, 2013; FAO, 2018).

These issues means that local people, especially full-time fishers, in Mushumbi Pools are forced to sell fish in desperation in order to meet their basic household needs. Consequently, they are obtaining poor income from fisheries resources and are undervaluing the contribution of the resource to their socio-economic well-being. In future it implies that local fishers will be forced to catch more fish to keep selling at low prices to survive, which threatens the productivity and conservation status of fisheries resources in Mushumbi Pools (Mahlatini et al., 2018). In light of the prevailing economic conditions in the country a plausible solution may be to diversify livelihoods or migrate into neighbouring countries to look for jobs for survival (Zuze, 2013; Marambanyika et al., 2017b).

Cultural and socio-economic uses of fisheries resources in Mushumbi Pools

In addition to trade and food, most locals in the Mushumbi Pools use fish for medicinal, spiritual and cultural purposes. Fish such as snake catfish and African sharptooth catfish are used to make love potions, lucky charms, and for bewitching rival men who sleep with another man's wife. In each society, there are cultural, culinary and social beliefs in which it is forbidden to catch and consume certain fish species (Fisher, 2004). Some fish species, especially the Clariidae and Anguillidae family, are used to make both healing and non-healing medicines, for witchcraft purposes, to enhance fighting, or as an aphrodisiac for males (Fisher, 2004; Marambanyika et al., 2012). Sentimental, cultural and economic values attached to different fish species by community members differ significantly, indicating deeper underlying differences in antecedent factors, for example, area of origin, education levels attained, and religious beliefs. This implies a need for a holistic contextualised conceptualisation of conservation policies for inland fisheries in Sub-Saharan Africa, encompassing cultural, spiritual, social, economic and ecologic aspects.

The fact that locals differed significantly in their socio-economic valuation of fisheries resources implies that there are mixed perceptions of the value of fisheries. As indicated in studies by Rebelo et al. (2010), Mbereko at al. (2015) and Marambanyika et al. (2017a), there are different perceptions on the socio-economic and cultural value of wetlands and fisheries resources even within the same communities. The more communities access and benefit from wetlands and fisheries resources the greater the economic and custodian value they attach to the resources which enhances conservation (Mbereko et al., 2007; Turyahabwe et al., 2013). However, the issue is far more complicated than just allowing people into the wetlands; rather there is a need to delicately balance, recalibrate and optimise conservation, protection, and sustainability of Mushumbi Pools (Marambanyika et al., 2017). There is a need to examine the effectiveness of the current management strategy of Mushumbi Pools where there is a complex combination of restricted access and co-management (inclusion of local human committees) of the fisheries resources (Mbereko et al., 2015).

Local perceptions of threats and plausible conservation measures

Locals indicated that destructive and nonspecies-selective fishing methods (e.g. small mesh-sized mosquito nets) threaten recruitment of smallsized fingerlings leading to declines in fish abundance and biodiversity. Further, locals indicated that an increased crab abundance or rather an invading crayfish population was preying on fish and contributing to fish declines in the pools. The generalist feeding behaviour of crayfish imply diet plasticity enabling wide food selection and, in the process, outcompeting other species (Marufu et al., 2018). Consequently, locals suggested introduction of a crayfish-specific predator in the pools; however, the suggestion though feasible, is a very dangerous biological solution as the introduced predator may also target other commercially valuable fishes (Marufu et al., 2018). Most respondents suggested avoiding fish poisoning as a harvesting method and banning of agricultural tilling on the banks of the pools. The respondents indicated that high chemical doses in fish poisons pollute the pools and kill even nontarget fish species, whereas agricultural activities degrade the habitat and cause erosion and siltation of the pools (Chifamba, 2013). Crafting strict policies and enforcement of heavy fines for violators of fishing regulations were suggested by respondents as solutions to fish poaching. However, strict enforcement of laws and regulations needs comprehensive and functional institutional arrangements that involve full cooperation of the local communities and effective antifish-poaching patrols by ZimParks (Marambanyika and Beckedahl, 2017). Respondents suggested development of sanctuaries to conserve fish as a feasible conservation strategy, i.e., to maintain a particular demarcated protected area in water bodies as a permanent shelter for the protection of fish for natural propagation, where targeted fish will not be disturbed or captured (Béné, 2003; Marshall, 2011). Establishing aquatic sanctuaries is an effective tool for conserving habitats, fish stock, preserving biodiversity and increasing fish production (Ramsar, 2010).

Locals suggested devolution of power and allocation of more roles to manage fisheries resources to the community, since the existing fisheries department in ZimParks has limited capacity and is resource constrained to fully monitor activities in Mushumbi Pools. Mbereko et al. (2007, 2015) reflects that when a community is given ownership of fisheries resources, they will voluntarily monitor the activities as custodians and stewards of the environment. However, it should be noted that there is no 'happy medium', i.e., a framework that fully allows locals to participate with assistance from authorities for a shared resource such as the fisheries resources in Mushumbi Pools. Most locals indicated a need for more fisheries resource awareness campaigns, meetings, and workshops to address challenges and threats to fisheries resources. This reflects that locals are aware of the threats to inland fisheries and most suggested plausible conservation measures which inform local indigenous knowledge systems. However, the significant differences in the importance and effectiveness of the locally proffered conservation strategies indicated inherent differences in community perceptions of the value of inland fisheries resources in Mushumbi Pools. Thus, future research needs to assess latent factors, for example, education and conservation awareness levels of a community, governance and institutional regulations for access to wetland resources, and how these affect the perceptions of locals (and conservation status) of riparian fisheries resources (Mbereko et al., 2007).

Drivers and barriers for citizen science involvement in the conservation of the pools

There is a local environmental committee which monitors conservation of natural resources, and an anti-poaching unit employed by the District Council and village scouts helped by ZimParks rangers (AWF, 2010). This includes and give incentives to locals in the monitoring of wetland resources and drives community science involvement in the conservation of the pools (Adekola 2007; Marambanyika et al., 2017). Modern conceptual suggestions for managing fisheries advocate getting locals involved and applying a knowledge framework for action in monitoring programmes by participating in telemetry research (Nguyen et al., 2017; Burnett et al., 2021). However, for the Mushumbi Pools, where an elementary fisheries stock assessment has not been done, this may be resource taxing (Nguyen et al., 2017).

ZimParks and local authorities do not limit fish harvests for individuals, most of whom do not own sophisticated modern fishing gear and technology and thus seldom fish in prohibited 'breeding streams'. Law enforcers do not strictly restrict certain harvesting methods (e.g mosquito nets) as long as they are used by women and children, so as to encourage large fish harvests as a poverty alleviation measure and food security boosting strategy in the area (Bosongo, 2011), though it must be noted that use of destructive and nonspecies-selective gear such as mosquito, gill and seine nets needs to be curtailed. Relaxing regulations is a driver for involving citizens in the conservation and sustainable utilisation of fisheries resources, and a prevalent poverty alleviation and food security enhancement strategy for vulnerable small-scale inland African fishers (Béné, 2003). Nonetheless, the same locals who want strict enforcement of fishing rules to reduce fish poaching are the ones who also need relaxed access in some sections of the pools. This therefore requires delicate balancing and astute fisheries management by ZimParks and the remnants of the local monitoring communities. Cultural and religious ties to certain fish species (for example; snake catfish) makes their fishing strictly prohibited in Mushumbi Pools (AWF, 2010). Strict adherence and self-monitoring among locals is a key driver encouraging citizen science in fisheries resource conservation.

ZimParks and Mbire District Council officials deploy rangers in the pools to monitor fishing activities and prohibit fishing during breeding seasons (i.e. from December–February) in areas called 'breeding streams'. Fishers are allowed to fish in deep pools, not in 'breeding streams' and nursery areas during fish-breeding periods. Using unsustainable harvesting methods (e.g gill, seine and mosquito nets) is strictly prohibited in breeding areas. Whilst these strategies work to some extent to encourage community/citizen science, locals perceive strict enforcement of the no-fishing zones as a barrier to their effective participation in fisheries resources conservation initiatives in the pools.

Another major barrier to fish conservation is that local people are against the idea of banning streambank cultivation because large portions of fertile and arable lands are close to water sources. Consequently, local citizens have adopted passive resistance (least-participation approach) by limiting (or not even) participating in conservation programmes, especially in rainy seasons when land is cultivated. Turyahabwe et al. (2013) indicated that wetland resources are an indispensable aspect of community livelihoods rather than a food-security safety net as suggested by Klaus (2005) and Rebelo et al. (2010). Thus, strict enforcement of prohibition of access to perceived lucrative wetland zones acts as a barrier to citizen science. Locals argued that wetlands do not necessarily get degraded if used for vital food-security purposes; rather, involving communities ensures conservation (Marambanyika and Beckedahl, 2016), although there must be effective institutional monitoring mechanisms (Mbereko et al., 2017).

Policy and managerial implications

Inadequate policy implementation by authorities is a key driver for the failure of most conservation strategies in Zimbabwe (Marambanyika et al., 2017). The locals are very clear on the need for a policy on devolution of government authority in the Mushumbi Pools. The CAMPFIRE concept devolves power to the community and not to individual households. As a result, there is mistrust and community conflict. A rather complicated management pattern is further worsened by adaptive co-management in some sections of the pools where CAMPFIRE, ZimParks and local community representatives enforce compliance in the open-access section, in terms of fishing gear and pollution, for example. This triangular co-management incorporating the local community does not always result in positive local perceptions, as suggested by some respondents who actually indicated that it leads them to place a low value on the fisheries and in fact results in poaching and overexploitation of the fisheries resources. From a managerial perspective there is a need for adaptive and interactive co-management of the fisheries resources across the whole Mushumbi Pools with high conservation awareness imparted to the local community, as opposed to the exclusion approach used by parks officials.

The limited extent of community authority to make decisions related to access and use rights implies a need for tailor-made policies legitimising community access, ensuring fair valuation and utility rights of fisheries resources in riparian wetlands. To this end we propose a local community resources access policy (LOCRA) which clearly spells out several components, namely: (i) the context of the community, for example, its location, demographics, challenges and needs; (ii) the specific wildlife resources targeted and their location; (iii) the responsible wildlife authorities, for example, their location, human capacity and challenges, their mandate and expectations (this starts at the national level but must address the local context); (iv) the legislation governing access rights; (v) terms of reference and operation for adaptive co-management for the specific area; (vi) conflict-resolution mechanisms for a specific area and a framework for sharing benefits from the wildlife resource in a transparent and accountable manner. This would at most address the challenges of access, utility, benefits, and value placed on fisheries resources by locals, in turn encouraging conservation.

CONCLUSION AND RECOMMENDATIONS

Local communities access and utilise fisheries resources in Mushumbi Pools and value their socio-economic and more importantly cultural importance, in sustaining their livelihoods and way of life. This study did not fully evaluate the state and status of the current fisheries based on current management. Therefore, in future there is a need for a nonbiased two-way approach, i.e. (i) scientific long-term fisheries stock assessment and review of current fisheries management systems, and (ii) evidence-based incorporation of local citizens in the management of the fisheries resources in Mushumbi Pools. However, the extent of community authority to make decisions related to access and use rights are limited by state bureaucratic interventions and strict enforcement, hampering adaptive co-management. This implies a need for tailor-made policies legitimising community access, ensuring fair valuation and utility rights for successful management of inland fisheries resources in wetlands such as Mushumbi Pools in Sub-Saharan Africa.

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APPENDIX

Table A1. Income obtained by full-time fishers in Mushumbi Pools

Economically important fish species	Mean perceived catch (kg/day)	Mean perceived price (USD/kg)	Mean income obtained (USD/day)	Mean consumption (kg/day)	Standard market price (USD)
Tigerfish	10	5.00	50.00 (10 kg x 5 USD/kg)	2	35.00 (10 kg x 3.5 USD/kg)
Bottlefish	12	5.00	60.00 (12 kg x 5 USD/kg)	2	42.00 (12 kg x 3.5 USD/kg)
Silver labeo	15	3.00	45.00 (15 kg x 3 USD/kg)	2	52.50 (15 kg x 3.5 USD/kg)
Chessa	5	3.00	15.00 (5 kg x 3 USD/kg)	2	17.50 (5 kg x 3.5 USD/kg)
Nile tilapia	10	3.00	30.00 (10 kg x 3 USD/kg)	2	35.00 (10 kg x 3.5 USD/kg)
Zambezi tilapia	5	2.00	10.00 (5 kg x 2 USD/kg)	2	17.50 (5 kg x 3.5 USD/kg)
Small-mouth bass	20	2.00	40.00 (20 kg x 2 USD/kg)	2	70.00 (20 kg x 3.5 USD/kg)
Barbel fish	8	2.00	16.00 (8 kg x 2 USD/kg)	2	28.00 (8 kg x 3.5 USD/kg)
Large-mouth bass	5	2.00	10.00 (5 kg x 2 USD/kg)	2	17.50 (5 kg x 3.5 USD/kg)
Redeye labeo	10	1.00	10.00 (10 kg x 1 USD/kg)	2	35.00 (10 kg x 3.5 USD/kg)
Income per day			**286.00**		**350.00**
Monthly income			**8 580.00**		**10 500.00**
Yearly income			**102 960.00**		**126 000.00**

Table A2. Income obtained by full-time and part time fishers in Mushumbi Pools

Economically important fish species	Mean perceived catch (kg/day)	Mean perceived price (USD/kg)	Mean income obtained (USD/day)	Mean consumption (kg/day)	Standard market price (USD)
Tigerfish	5	3	15	1	17.50
Bottlefish	5	3	15	1	17.50
Silver labeo	6	2	12	1	21.00
Chessa	8	2	16	1	28.00
Nile tilapia	5	2	10	1	17.50
Zambezi tilapia	6	2	12	1	21.00
Small-mouth bass	9	2	18	1	31.50
Barbel fish	7	3	21	1	24.50
Large-mouth bass	5	2	10	1	17.50
Redeye labeo	9	2	18	1	31.50
Income per day			**135.00**		**227.50**
Monthly income			**4 050.00**		**6 825.00**
Yearly income			**48 600.00**		**81 900.00**

Table A3. Income obtained by occasional or part-time fishers in Mushumbi Pools

Economically important fish species	Mean perceived catch (kg/day)	Mean perceived price (USD/kg)	Mean income obtained (USD/day)	Mean consumption (kg/day)	Standard market price (USD)
Tigerfish	3	2.50	7.50	0.5	10.50
Bottlefish	3	2.50	7.50	0.5	10.50
Silver labeo	2	2.00	4.00	0.5	7.00
Chessa	3	1.00	3.00	0.5	7.00
Nile tilapia	6	1.00	6.00	0.5	21.00
Zambezi tilapia	4	1.00	4.00	0.5	14.00
Small-mouth bass	2	1.00	2.00	0.5	7.00
Barbel fish	2	1.00	2.00	0.5	7.00
Large-mouth bass	2	1.00	2.00	0.5	7.00
Redeye labeo	2	1.00	2.00	0.5	7.00
Income per day			**40.00**		**98**
Monthly income			**1 200.00**		**2 940**
Yearly income			**14 400.00**		**35 280**

Figure A1. Aerial view of three interconnected pools which are part of the Mushumbi Pools

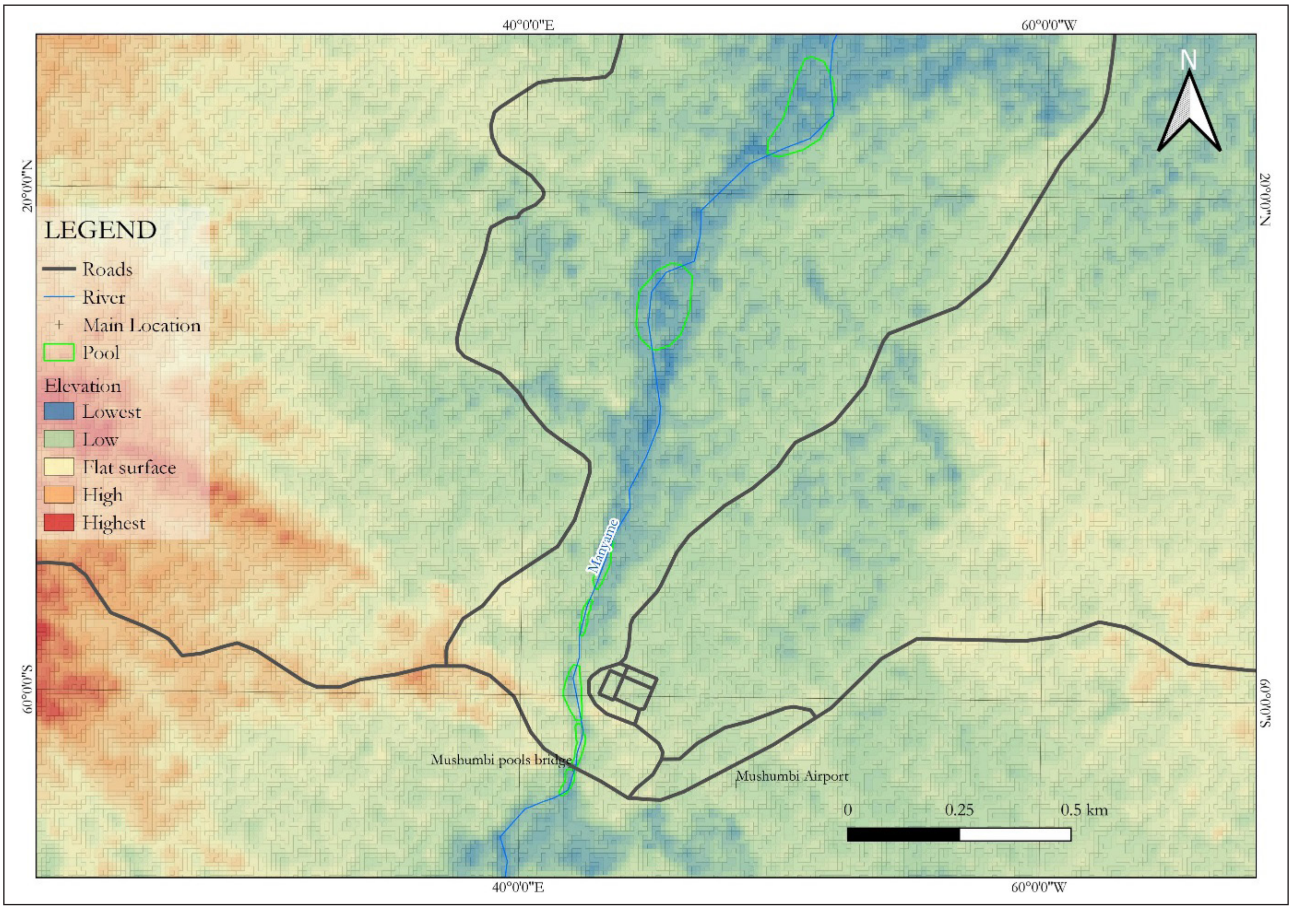

Figure A2. Scaled map showing the elevation and main features near Mushumbi Pools