Final Evaluation Report

Your Details	
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Project Title	Monitoring pollution to enhance human health and conservation of *Oreochromis karomo* along the Malagarasi River, Tanzania
Application ID	40411-1
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1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
To assesses the factors that have contributed to the decline of the critically endangered, *Oreochromis karomo* species			■	To find out what is causing the *Oreochromis karomo* to decline along the Malagarasi River, we used both questionnaires, focus group discussions and interviews. The investigation involved 100 respondents. The results suggest that the decline of *Oreochromis karomo* to the extent that IUCN has classified it as critically endangered, is caused by anthropogenic activities including keeping large numbers of livestock, use of illegal poor fishing gear (small mesh size) (figure 1), dynamite fishing and crop production along the river (figure 2) that involve the use of chemicals. As a result of anthropogenic activity, the fish habitats along the river have been impacted with heavy metals. The inhabitants of the area along the Malagarasi River have a strong preference for eating fish of the *Oreochromis* species. This has contributed to overfishing associated with use of poor fishing gear which aid for the decline of the *O. karomo* species. The results of this investigation demonstrate the necessity for improved conservation strategies to conserve the critically endangered *Oreochromis karomo* fish species as well as other threatened fish species.

To assess the impact of heavy metal pollution on the habitats and tissues ofhighly consumed *Oreochromis Karomo* fish species along the malagarasi river			[redacted]	An atomic absorption spectrophotometer from Thermo Fisher Scientific USA CE 3000 Series AA was used to analyse heavy metal levels in muscle tissues. The analysis included calculating the hazard index, estimated dietary intake, and total risks quotient. An evaluation was conducted on the possible health effects of heavy metal exposure on humans. The findings indicated that while the concentrations in fish tissues were under the FAO and WHO recommended threshold for humans, there was a substantial difference ($P<0.05$) in concentration between sample locations that had been impacted by human activities and relatively pristine sites. The fish tissues have a concentration of heavy metals in the following order: Zn>Cu>Cr>Fe>Ni>Hg. In the sediments sampled in Musoma, Ilagala, Mtego wa noti, Mliyabibi, and Kavumangabo, the contamiation factor and pollution load index were $1 < PLI < 2$, indicating the presence of elevated levels of pollutants. To protect the aquatic ecosystem and reduce human health risks associated with consuming contaminated fish along the Malagarasi River, it is imperative to monitor the levels of heavy metal pollutants caused by human activities. During the dissemination of findings, the study team raised awareness to the community around the

				Malagarasi River about sustainable measures that can help reduce the levels of heavy metal contamination. Furthermore, we succeeded in collecting samples of other consumable fish species present at each sampling location during the first and second trip sampling. To verify the trend seen in the current study, we intend to add data from the other collected species to the current findings on heavy metal pollution in Karomo tilapia.
To assess the effects of heavy metal pollutions on the genetic diversity, effective population size and extent of gene flow among the populations of the critically endangered, karomo tilapias along malagarasi River.				We collected 100 *Oreochromis karomo* samples from five various points along the Malagarasi River: Musoma, Ilagala, Mtego wa noti, Mliyabibi, and Kavumangabo. Microsatelite analysis was performed and the genetic information obtained showed that the relative pristine sites (Mtego wa noti, Mliyabibi, and Kavumangabo) had significantly higher genetic diversity and a larger scaled mutational effective population size compared to human-impacted sites (Musoma and Ilagala). Extensive gene flow among the sampling sites was revealed along the Malagarasi River suggesting genetic connectivity between the populations. The molecular analysis conducted yielded significant insights into their genetic diversity and population dynamics. Despite *O. karomo*'s critical endangered status, assessments of its effective population size and gene flow

				suggest that the species is still viable and has the capacity to exchange genetic material. At Ilagala and Musoma, decreased genetic diversity was an evident indicator of the effects of catchment area degradation, underscoring the importance of conservation efforts to conserve genetic diversity and protect this declining species from the threat of extinction. The findings highlight the need for targeted conservation strategies in general for conserving the genetic diversity and long-term sustainability of the karomo tilapia populations in the Malagarasi River. Additionally, some samples of *Oreochromis niloticus* present in the sampling sites were collected for potential future validation of the present research findings regarding the effects of heavy metal pollution on genetic diversity and effective population size, along the Malagarasi River.

2. Describe the three most important outcomes of your project.

- This project raised awareness on local communities on the factors that led to decline of fish populations to the extent that they are classified by IUCN as critically endangered species. Among the factors identified along the Malagarasi River were keeping large number of livestock, use of illegal poor fishing gear (figure 1) and crop production (figure 2) that involves the use of agrochemicals. The areas impacted by human activities along the river were found to have elevated concentration of heavy metal in sediments as well as in fish tissue. During the field campaign, the research team further identified that most members of community along the Malagarasi River are poor and therefore some cut the Bulrushes, (*Typha* sp.) *papyrus L.* and other vegetation that acts

as refugia and spawning areas for fish species for income generation. This lack of awareness has contributed to poor use of illegal fishing gears (Figure 1) and crop farming in the catchments that acts as spawning areas for fish species (Figure 2) and therefore nutrients and other agrochemicals are eroded in water bodies causing pollution on fish and other aquatic life.

- The project has significantly benefited local communities through awareness raising. They currently understand that their actions in or near fish habitats may be a factor in the extinction of different fish species. The differences in heavy metal concentration between the two types of sample locations highlighted the significance of continued monitoring and mitigation activities, even if the concentration of heavy metals in fish tissues were below international thresholds. Increased concentrations of Cu, Cr, Ni, and Hg in the sediments and muscle tissues of the impacted areas were used as indicators of future health issues if significant action was not taken to stop human activities that cause water pollution. The dissemination of these findings was crucial in informing consumers, policymakers, and artisanal fishermen about the environmental dangers posed by heavy metal contamination in the river. It is anticipated that members of the community will be more willing to take preventative action and abide by rules designed to stop additional pollution of the aquatic ecosystem because of this awareness.

- The genetic analysis conducted on *Oreochromis karomo* populations along the Malagarasi River represents a pivotal outcome with far-reaching implications for local communities, policymakers, and conservation efforts alike. By revealing higher genetic diversity and effective population sizes in relative pristine sites compared to human-impacted areas like Ilagala, the study underlines the critical importance of conservation strategies focused on habitat conservation and enhancing population connectivity along Malagarasi River. For the local community, this finding is crucial as it directly informs sustainable resource management practices and livelihood strategies. Understanding the genetic health of *Oreochromis karomo* populations helps community members appreciate the ecological value of maintaining healthy fish stocks. It empowers them to advocate for conservation measures that support long-term fishery sustainability, ensuring continued access to this vital food source. Policy makers benefit significantly from this genetic insight by gaining a scientific basis for formulating effective conservation policies and regulations. The

identification of genetic hotspots informs decisions on establishing protected areas, implementing habitat restoration initiatives, and enforcing sustainable fishing practices. By integrating genetic diversity considerations into policy frameworks, policymakers can enhance the resilience *of Oreochromis karomo* populations to environmental changes and anthropogenic pressures. This approach supports biodiversity conservation goals while promoting sustainable development practices that benefit both ecosystems and local economies.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

The first field campaign was limited by the remoteness of the location, making it impossible to study many catchments to determine the impact of catchments degradation. Additionally, the local populations around the catchment regions were afraid to speak with us because they believed that the information they provided would be utilised by policymakers to force them to leave the area or to impose other sanctions against them. When visiting the most remote areas and conducting interviews with locals, we made use of local leaders and research assistants. The integration of local leaders and researchers really aided us in overcoming the obstacles posed by remote areas and local reluctance to participate in interviews. Furthermore, the heavy rains in the Kigoma and most of Tanzania regions during the initial field campaign hindered our ability to collect sample of some catchment areas especially in remote areas, making it impossible to obtain enough tissues samples of *Oreochromis karomo*. Nonetheless, we succeeded in gathering all the samples required for our study during the second field campaign.

4. Describe the involvement of local communities and how they have benefitted from the project.

Twenty-five individuals from each landing site, including members of the local communities such as fishers, village leaders, and fish sellers, participated in this project. They were actively engaged in answering questionnaires and participating in interviews. To support the research team in the field and throughout the dissemination of findings, capacity-building training was also given to local leaders and the research assistant. Engagement of community members in fieldwork and findings dissemination created a feeling of project ownership. Consequently, it made it easier for the research team to finish the necessary tasks.

5. Are there any plans to continue this work?

Yes, we intend to carry out this work. During our field trips, we came across a considerable number of economically disadvantaged people who live along the Malagarasi River. Many of these people participate in commercially operated businesses that involve the harvesting of grasses like *Cyperus papyrus L*. and bulrushes, which they then sell to others in the nearby town for use in making fans, fences, shelters, boxes, ropes, and mats. These activities worsen the degradation of the local fish species' habitats. To investigate the scope of the issue, identify the *Cyperus papyrus L.* and bulrush species impacted in the area, and highlight the significance of protecting *Oreochromis karomo* habitat as well as the ecosystem as a whole, we intend to form a multidisciplinary team comprising representatives from the agricultural and forest sectors. It is anticipated that this team will identify alternate sources of income in the area and educate local populations about the value of *Cyperus papyrus L*. and bulrushes for fish diversity and productivity. While providing for the basic needs of the local community without compromising the ecosystem, alternative economic activities in the area will guarantee the protection of fish habitats along the Malagarasi River. Furthermore, we discovered during our sampling that some of the fishing gear used by local fishermen is not compliant with the Fisheries Act of 1994's Tanzania Fisheries Legislation Amendment Regulation 2021. We intend to conduct a comprehensive survey to identify all illegal fishing gears. As demonstrated in Figure 1, for example, we observed that local fishermen near the Malagarasi River were using small mesh sizes, which we intend to measure. We will advise them on optimal mesh sizes and fishing gear based on our findings.

6. How do you plan to share the results of your work with others?

In addition to the Rufford small grant webpages, the initial results of this work were presented at scientific conferences at the SUA memorials. We intend to publish one conference proceedings and at least two peer-reviewed journal articles. The findings of this project will be communicated to governmental officials including local community leaders, fisheries officers and forest resource management in the study area. The results of this study will be disseminated by local community leaders to fishermen and other stakeholders.

7. Looking ahead, what do you feel are the important next steps?

To ensure the feasibility of the initiative, the research team is looking for funding. The socio-economic challenges that residents who are economically poor face must be addressed. To provide alternative livelihood options that have no impact on the Karomo tilapia's habitat, focus should be given to projects that promote sustainable agriculture and diversify revenue streams.

The proposed project requires a multidisciplinary team with specialists in forestry and agriculture to help and advise community members in adopting sustainable practices while meeting their financial demands.

Conducting a comprehensive social survey is crucial to detect prohibited fishing gear within the project study area. This survey will provide empirical data on the extent of non-compliance with fisheries laws, particularly about small mesh sizes and other types of illegal gear. The outcomes will serve as the foundation for targeted interventions and enforcement measures designed to ensure sustainable fishing practices and conserve fish populations.

Coordinated action is needed to lessen the negative effects of human activity on the river environment. It is essential to develop cooperative measures with the local community to prevent habitat degradation from vegetation harvesting and reduce pollution from agrochemicals. Community stewardship and behavioral change will be greatly aided by education and communication initiatives that highlight the negative environmental effects of these practices

For the long-term preservation of *Oreochromis karomo* habitat and the general health of the Malagarasi River ecosystem, it is imperative to raise local community's awareness regarding issues related to conservation. Communities will be empowered to take an active role as partners in conservation efforts by becoming involved in workshops, educational campaigns, and participatory approaches. This holistic approach not only protects biodiversity but also promotes sustainable development that benefits both people and nature.

8. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

The Rufford Foundation logo was used during the presentations of the findings to local communities and during SUA scientific conferences as well as Sokoine memorials events. The logo has also included at the acknowledgement section of the manuscripts prepared. Not only the logo found at the PowerPoint but also the communities were informed about, who has been funded this whole journey of our research.

9. Provide a full list of all the members of your team and their role in the project.

- ✓ **Tlehema Gwandu Umbayda**- A tutorial assistant from Department of Biosciences, a principle investigator of this project. I involved in sample

collection, Molecular and Heavy metal analysis, report writeup, supervision of all project activities.

- ✓ **Dr. Alex Nahnson Nehemia:** He is a senior lecturer at the Sokoine University of Agriculture and expert in ecology and molecular population genetics and has published several articles focusing on genetic molecular analysis. He was responsible for molecular analysis and involved in sample collection.
- ✓ **Fisheries officer and research assistants.** We worked with two fisheries officers at Musoma, and Ilagala during field samples collection**.** We also worked with one research assistant at each sampling site.

Figure 1. Fishing gears with fish net having small mesh size

Figure 2. Tomato fruits grown along the Malagarasi River

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Figure 3. A Bulrushes, (*Typha sp*) havested at Ilagala

10. Any other comments?

We kindly dedicate all our achievements to The Rufford Foundation for providing funds that enables research teams and community to carried out the whole research activities. The residents along the Malagarasi River will benefits from the raised awareness concerning the conservation of fishes at the catchment's areas.