Tropentag 2023
September 20-22, 2023
Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the Leibniz Centre for Agricultural Landscape Research (ZALF), Germany in cooperation with Humboldt-Universität zu Berlin, Germany

Flood risk reduction nature-based solutions: potential forest restoration and agricultural land use in Búzi, Mozambique

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Abstract

The frequency and severity of flooding is increasing in different parts of the world, largely due to the effects of climate change, land-use intensification, and the degradation of natural ecosystems. Particularly in poor countries of the tropics and subtropics, floods are often associated with high numbers of casualties and long-lasting disruption of livelihoods due to the high vulnerability of the population. This is also the case in Mozambique, one of the poorest countries in the world, where the case study of this research is located. The application of nature-based solutions (NbS) presents an opportunity that can lead to the reduction of the risks of floods by utilising and harnessing elements, services and processes of ecosystems. The main focus of this study is to analyse the potential of restoring natural forests and creating floodplain and riparian forests, an intervention under the NbS approach, as a means to reduce the risk of flood disasters in the Búzi district of Mozambique. Furthermore, from the total area of the district, bare land and areas with sparse vegetation are presumed usable. These could contemplate transformation as part of interventions related to NbS, including revegetation and providing suitable agricultural land. The study involves the evaluation of the potential of risk reduction through the application of on-site semi-structured and expert interviews, the analysis of assessment criteria, the processing of satellite imagery and field observation undertaken in various district localities. Results of this study show that the restoration and creation of floodplain and riparian forests present a high potential to reduce the risk of flood disaster in the Búzi district through a number of ecosystem services for flood risk mitigation that also provide co-benefits. Moreover, an area dedicated to production would expand as an intervention entailed in the measure. Consequently, an increase in production poses economic opportunities in the region, contributing, among other factors, to overall resilience.

Keywords: *Agricultural land, flood risk mitigation, forests, nature-based solutions, resilience*

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Introduction

Climate change and the occurrence of weather extremes and natural hazards are progressing in frequency, intensity, duration and extension, as expressed by the Intergovernmental Panel on Climate Change (IPCC, 2021). Climate extremes increase the risk of hydro-meteorological hazards, such as floods and droughts, which can lead to disasters through exposure and vulnerability of the population. This is the case of Mozambique, a southern African country that due to geography and climate is highly prone to several natural hazards, registering over 99 events in the last 50 years, with an evident increasing trend in frequency and nearly doubling disasters in the previous decade (Moitinho de Almeida, 2018). In the last 20 years, the district of Búzi in central east Mozambique had a total of 26 disaster occurrences, one of the highest on a national level (EM-DAT/CRED, 2022). Particularly with fluvial and coastal floods, and cyclones, the resulting disaster have not been extensively profiled and a potential to reduce the risk is yet to be discovered. The district presents virtually no flood defences or any other physical constructions to reduce the risk of flooding. In contrast to the conventional grey solutions to combat the risk of flooding, the application of nature-based solutions (NbS) is increasingly being explored and appropriate interventions made on a national and regional level. Therefore, the present work is aimed at analysing the potential of the implementation of the restoration of natural forests and riparian woodland creation, a measure under the *umbrella* concept of NbS (Nehren et al., 2023), as a way to reduce flood risk in the district of Búzi, Mozambique.

Methodology

Semi-structured interviews to analyse the potential implementation of the measure were administered to two stakeholder groups: (A) 7 government officials and experts, and (B) 109 locals of six villages of the Búzi district, including farmers and fishers. Literature review and the focal groups' and experts' evaluations were assessed and used as direct inputs for the TOPHEE feasibility (technical, organisational, political, human, environmental, and economic criteria) and SWOT (strengths, weaknesses, opportunities, and threats) analyses. Moreover, the processing of satellite imagery of land cover was applied as a tool to unveil potential co-benefits of the implementation of the restoration of natural forests and riparian woodland creation (i.e., other benefits that arise from the application of the measure, in addition to reducing the vulnerability to flooding).

Results and Discussion

The evaluations obtained from both interviewed groups were examined through textual analysis and linked to the feasibility requirements, in addition to information from the literature. The restoration of natural forests and riparian woodland creation is a strategy of landscape restoration that presents opportunities that lead to the reduction of the risks of floods, as the main general benefit. The applicability of the intervention particularly depends on social organisation and participation, a "sense of ownership" of the locals, as displayed from success factors of previous projects in the area. Moreover, the application would be widely accepted, despite the specific place of deployment. The reason for this is that although some communities are "safer" than others are, all would benefit from the provision of protection and the lack of the subsequent need to flee to upstream areas.

The application of the restoration of natural forests and riparian woodland creation reduces the risk of flooding from the resulting benefits. Among the several co-benefits that result from ecosystem functions and services provided by the measure, those in Table 1 were identified by the stakeholder groups individually as positive socio-ecological impacts to their communities. Nevertheless, for

the implementation, several technical studies are needed, as well as the socialisation of the importance of the NbS, the selection and prioritisation of local species, and the need for ongoing community-led and managed monitoring and maintenance. Furthermore, under this measure, urban gardening in riparian areas as part of the creation of vegetation efforts is contemplated (e.g., as agroforestry systems), resulting in direct economic benefits to the communities.

Table 1. Co-benefits identified by stakeholders groups (A: government officials and experts, B: villagers)

Health and well-being		Spiritual land/religious		Cultural heritage		Recreation		Job opportunities	
A	B	A	B	A	B	A	B	A	B
Biodiversity		**Temperature regulation**		**Soil health**		**Air quality**		**Pollution control**	
A	B	A	B	A	B	A	B	A	B

Seen with the intensity of colour: the more intense, the most the co-benefit was mentioned by the stakeholder groups.

According to previous NbS-assessment projects in the country identifying areas for reforestation and urban gardening, land is presumed usable for intervention in areas such as bare/sparse vegetation and savannahs (e.g., CES Consulting Engineers Salzgitter GmbH and Inros Lackner SE, 2020). Their projects allocated up to 70% of the usable area for other solutions (e.g., reforestation), with 20% for the production of urban gardens. Nevertheless, in order to avoid major ecological impacts on biodiversity and the provision of services as illustrated by Fernandes et al. (2016), only a portion of the area could potentially be transformed for the application of the measure. Therefore, considering the value of 20% of the usable area for revegetation efforts, only 1.293,79 km^2 is envisioned for the restoration of natural forests and riparian woodland creation. From it, a higher value of 25% or 323.45 km^2 could be dedicated for agricultural land use purposes, resulting in a growth of 76.62% from the original cropland extension (422.13 km^2, see Table 2). The resulting increase in production results in economic opportunities in the localities and the region.

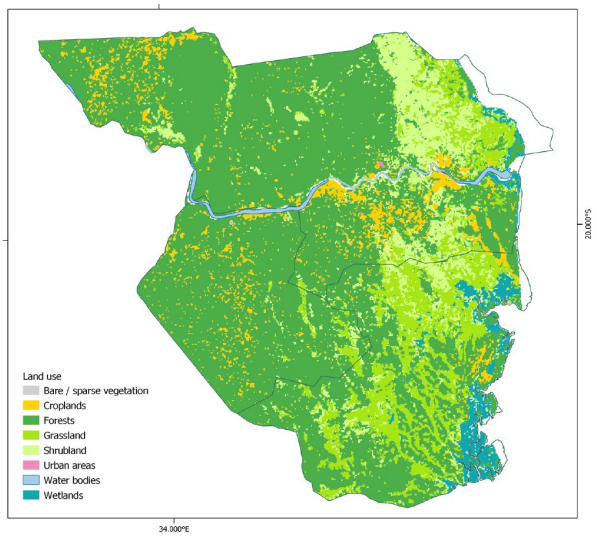

Table 2. Total land area allocated to types of land use

Type	Area km^2
Forests	4,853.93
Grasslands	1,010.93
Shrublands	747.24
Croplands	422.13
Wetlands	215.33
Urban areas	2.28
Bare/sparse vegetation	0.86
	7,479.22

Figure 1. Land cover in Búzi, 2019 (Generated from WaPOR - FAO, 2022, and used as the base for Table 2).

The costs of implementation include purchase, transaction, and monitoring costs. The benefits of implementation include environmental goods and services, such as carbon sequestration, potential for ecotourism, contribution to food security, and climate change adaptation. The costs have to be balanced against the benefits of implementation. Nonetheless, within the framework of the presented study, only those costs and benefits found in literature could be considered, therefore a full qualification of this balance was out of scope.

Conclusions and Outlook

The restoration of natural forests and riparian woodland creation has proven effects of reducing flood risk by providing regulating ecosystem services for flow regulation, runoff control, and water storage. This measure can be combined with other NbS to increase the potential of risk reduction and the provision of social-ecological benefits, as it is the case with floodplain management and retention areas, among others.

The time consuming and high investment nature of the measure, besides long-term commitment needed might reflect on major barriers for the expansive implementation as a NbS for disaster risk reduction. Nevertheless, it displays a great appeal because of the agricultural land expansion to up to 70% of the total usable land. In addition, in order to ensure the sustainability of the implementation of the measure, sustainable land use practices should be promoted and worked with and through the communities (e.g., agroforestry, avoiding uncontrolled burning). Finally, the evaluation of results of the research with stakeholders, particularly those in Group A (government officials and experts), is necessary to validate the process of evaluation.

With a reduced risk of flooding resulting from the application of the restoration of natural forests and riparian woodland creation, additional environmental and economic factors will further contribute to the overall resilience in the district of Búzi.

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