SAF-ADAPT

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Climate Adaptation
Research and Training
Partnership

RESEARCH BRIEF
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An Assessment of the Nature, Effectiveness, and Adaptability of Flood Control Mechanisms in the Vhembe District Area.

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RESEARCH BACKGROUND

The Vhembe district in South Africa is grappling with an alarming increase in flood occurrences, a trend amplified by the effects of climate change. This heightened vulnerability magnifies the destructive impact of floods, prompting a focused investigation into flood control mechanisms within three crucial study areas: Musina, Duthuni, and Sane. These regions were deliberately chosen due to their susceptibility to flooding, to evaluate the effectiveness and adaptability of existing flood control measures.

At the core of this research is the acknowledgment that flood damage can be mitigated and prevented through the strategic implementation of flood control mechanisms. The primary objective of this investigation is to understand the nature, functionality, and overall effectiveness of the existing flood control mechanisms deployed within the Vhembe district. Through a comprehensive analysis, the study seeks to evaluate the various strategies adopted in vulnerable areas to understand how they function and their capacity to reduce, alleviate, or prevent the impact of floods.

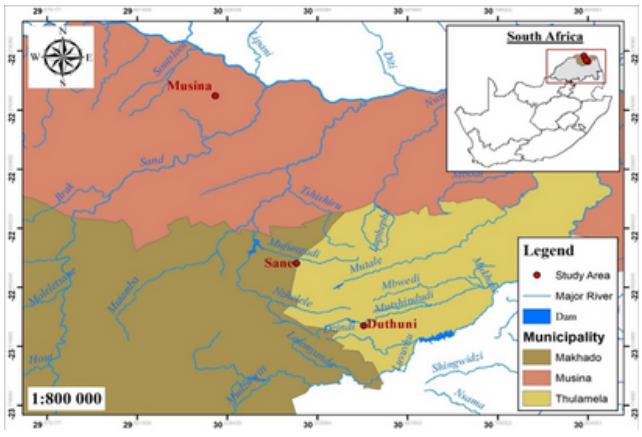

Figure 1. Map showing 3 study sites in the Vhembe District Municipality

PROJECT SUMMARY

This research evaluates flood control mechanisms in the Vhembe District Municipality to assess their resilience and adaptability to flooding highlighting regional variations in flood management approaches, influenced by local development levels, preferences, and historical practices.

KEY RESULTS

- Flood control methods **vary across regions based on development levels and local preferences**, encompassing both nature-based and engineered solutions.
- Concerns exist regarding the **long-term effectiveness and adaptability of flood control measures**, necessitating regular maintenance and monitoring.
- Many flood control strategies have ecological implications, **highlighting the need for sustainable and environmentally friendly approaches**.
- Effectiveness and acceptance of flood control measures are **influenced by community perceptions**, emphasising the importance of inclusive decision-making processes and integrating traditional and modern knowledge.

RESULTS AND DISCUSSION

TRENDS IN EXTREME RAINFALL AND THEIR RELATIONSHIP TO FLOOD OCCURENCES IN VHEMBE DISTRICT

Table 1 displays average seasonal precipitation data for Duthuni, Musina, and Sane from 1991 to 2020. The months of December, January, and February (DJF) consistently exhibit the highest average seasonal precipitation across all three areas, emphasising the vulnerability of these regions to flooding during this period. This seasonality is a pivotal aspect of the local climate and holds significant implications for various aspects of life in these areas. January was the most variable month, suggesting potential implications for flooding risk assessment and preparedness.

Table 1. Average seasonal precipitation for Duthuni, Musina, and Sane (1991-2020)

Location	DJF	MAM	JJA	SON
Duthuni	336.35	114.85	25.03	131.43
Musina	281.25	87.16	33.54	114.41
Sane	332.03	119.44	24.30	137.16

In Duthuni, annual flooding was a common occurrence, happening nearly every year except for 2002, 2008, and 2015. Conversely, Musina experienced flooding only in the years 2002, 2004, 2008, and 2015. Sane remained flood-free in 2001, 2002, and 2008.

The data also suggests a connection between daily rainfall amounts and flooding events, with most floods occurring when daily rainfall exceeded 20 mm per day (Figure 2). Critically, Duthuni had 170 days with precipitation levels surpassing the 95th percentile, signifying an exceptionally high frequency of intense rainfall. This knowledge not only helps us anticipate and respond to immediate flood risks but also informs our efforts to mitigate the impact of climate change, as extreme rainfall events are expected to become more frequent in the future.

PROBLEM STATEMENT

Climate change has resulted in an increased frequency and severity of floods in South Africa. Local communities in the Vhembe district are detrimentally impacted by flooding and, during the rainy season of December 2010 and January 2011, extensive damage to infrastructure and property occurred.

The Vhembe District Municipality lacked a clear understanding of the community's perceptions, experiences, and responses to the floods while the effectiveness and preferences around flood control mechanisms were also poorly understood. Flood control mechanisms are constructed in flood-prone areas to reduce the risk and impact of floods on the surrounding environment and communities, with different mechanisms being leveraged depending on the local context.

This research aims to evaluate flood control mechanisms in the Vhembe District Municipality to determine if they can withstand and adapt to flooding in the selected study areas. The ultimate goal is to recommend strategies that can reduce the negative effects of flooding in the Vhembe District Municipality.

METHODS

This study was conducted in the Vhembe district of northern Limpopo province, South Africa, focusing on Sane, Musina, and Duthuni villages. These sites were chosen for their susceptibility to floods and significant socioeconomic disparities. Vhembe's diverse topography includes low-lying floodplains, hills, and mountains, with major river catchments like the Limpopo and Luvuvhu rivers. Covering 2,771 square kilometres at an altitude of 400m, the district's soils primarily derive from basalt and sandstone. It receives around 500mm of annual rainfall, mostly between October and April, and has an average temperature of 24.6°C.

NATURE, EFFECTIVENESS, AND ADAPTABILITY OF FLOOD CONTROL MECHANISMS IN VHEMBE DISTRICT

In response to the frequent occurrence of floods in Duthuni, Musina, and Sane, various flood control mechanisms have been implemented. The analyses of flood control mechanisms were divided into two categories: community-level and household-level.

COMMUNITY AND HOUSEHOLD LEVEL FLOOD CONTROL MECHANISMS

Five types of flood control mechanisms were reported and observed across the three sites at the community and household level, as is depicted in Figure 3 and Figure 4 respectively.

EFFECTIVENESS OF COMMUNITY-LEVEL FLOOD CONTROL MECHANISMS IN DUTHINI, MUSINA, AND SANE.

Community-level flood control mechanisms demonstrated varying degrees of effectiveness. Furrows, primarily composed of loose soil, lacked structural integrity and were prone to erosion. Vegetation-based mechanisms relied on natural plant growth to stabilize soil but were sometimes weakened by high water flows and drought. Culverts and concrete channels, though generally robust, showed wear and erosion over time and needed regular maintenance. Storm drains, while structurally strong, faced issues with corrosion and habitat disruption. All these methods had varying environmental impacts, from sedimentation to habitat destruction and pollution.

With 1.2 million residents, 90% of whom live in rural areas relying on subsistence farming, the district faces heightened flood risk due to low-lying areas and inadequate drainage infrastructure. This vulnerability is exacerbated by economic disadvantages, leading to significant impacts on homes, crops, livelihoods, and the district's biodiversity and ecosystem health.

DATA COLLECTION AND ANALYSIS

The study employed a mixed-methods approach, incorporating both quantitative and qualitative methods to comprehensively understand flooding and flood control mechanisms. Using purposive sampling, 30 households from each of the three sites—Duthuni, Sane, and Musina—were selected based on their direct experiences with flood events, focusing on adult members from each household. Primary data was gathered through qualitative in-depth interviews and extensive field observations, while secondary data, such as rainfall information, was sourced from NASA's Power website. Rainfall data was analysed using various graphical representations to depict monthly and seasonal patterns. Questionnaire data was analysed using frequencies and percentages, which were presented in tables and graphs. Field observations were utilised to assess the composition, structural integrity, erosion and wear, maintenance and repairs, and environmental considerations of the sites.

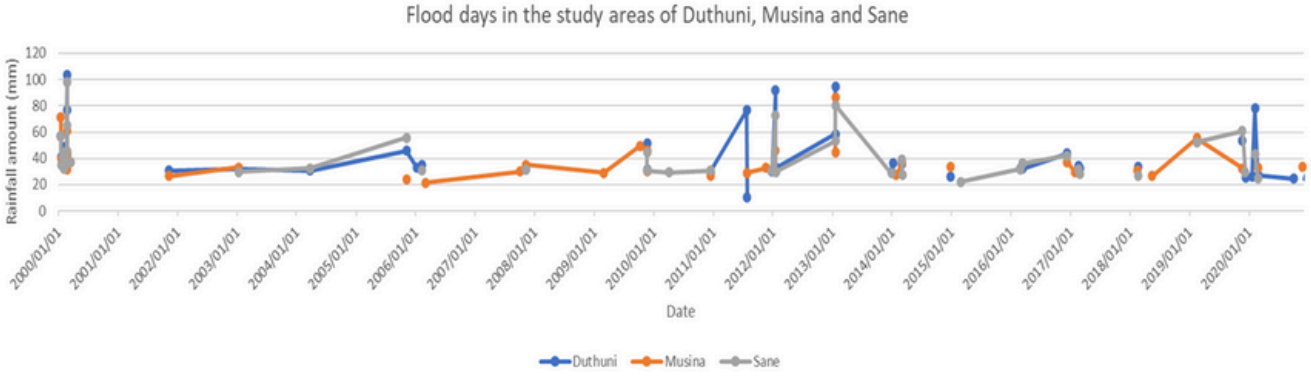

Figure 2. Variability in Annual Flood Days and Corrresponding Rainfall Amounts in Duthini, Musina, and Sane (2000-2020)

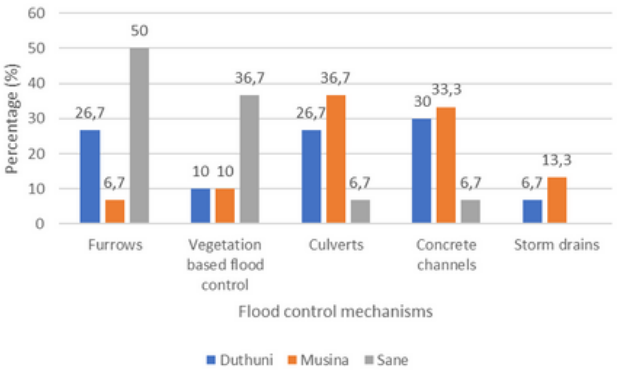

Figure 3. Flood control mechanisms at community level in Duthini, Musina, and Sane.

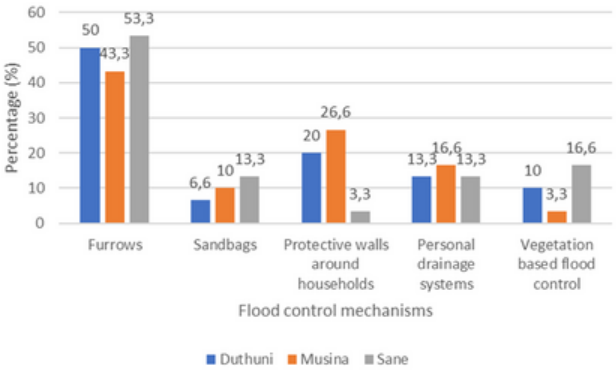

Figure 4. Flood control mechanisms at household level in Duthini, Musina, and Sane.

EFFECTIVENESS OF FLOOD CONTROL MECHANISMS AT THE HOUSEHOLD LEVEL

At the household level, furrows and sandbags lacked reinforcement and were highly susceptible to erosion and wear, requiring frequent maintenance. Protective walls, often made from reinforced concrete or bricks, needed proper drainage to prevent failure. Personal drainage systems, commonly made of concrete, were prone to clogging and corrosion, demanding regular upkeep. Vegetation-based methods offered ecological benefits and also need consistent maintenance to remain effective. Overall, both community and household flood control mechanisms required significant maintenance to ensure long-term functionality and stability.

PREFFERED FLOOD COPING MEASURES IN DUTHUNI, MUSINA, AND SANE

Sane, a rural village, demonstrated a preference for sustainable, nature-based, traditional solutions (Statistics South Africa, 2022) at the community and household level, preferring a holistic approach that emphasised the intrinsic connection between people and the environment (Sedddon *et al.,* 2021).

Musina, a more developed and urbanised township, favoured concrete channels and culverts at the community level. Household-level measures tended to adopt a combination of traditional and more modern, engineered methods.

Duthuni, a developed village, embraced a balanace of natural and engineered mechanisms at the community level and, at the household level, it favoured furrows, thereby indicating a strong preference for traditional methods. Therefore, the study reveals a complex interplay between community preferences, infrastructure development, and the effectiveness of various flood control measures. Each region's unique combination of natural, traditional, and engineered approaches highlights the need for tailored solutions that consider the local environment and resources.

Table 1: Table displaying the percentages of people who reported a preference for specific flood coping measures in the study areas

Preferred flood coping measures	Duthuni	Musina	Sane
Constructing more road drainage systems (Culverts and Concrete channels) with a maintenance plan.	26.6	26.6	23.7
Building protective walls around households(subsidized).	23.3	23.6	16.6
Temporary relocation to safer areas in times of floods.	20	13.3	10
Personal drainage systems (subsidized or with help from the government).	16.8	16.6	
Effective early warning systems.	10	3.3	13.3
Education on different flood control mechanisms that the residents can employ.	3.3		
Collecting and storing rainwater/floodwater and constructing retention ponds to help with farming water.		10	13.2
A raised porch.		6.6	
Disaster relief that includes constructing emergency flood control mechanisms.			10
Education on how to effectively protect oneself when floods hit.			6.6
Have municipal help on standby in times of floods.			3.3
Building houses with stone and cement to replace those built with mud.			3.3

CONCLUSION

This research underscores the urgent need for a comprehensive approach to address escalating flood challenges in South Africa's Vhembe district, with a focus on Musina, Duthuni, and Sane. Evaluating existing flood control mechanisms, the study reveals a diversity of strategies influenced by regional development levels, local preferences, and historical practices. While various measures—from nature-based solutions to engineered approaches—are in place, their effectiveness is significantly influenced by structural integrity, maintenance, environmental impacts, and community perceptions.

The study's recommendations aim to empower communities by harnessing nature-based solutions and promoting collaboration to tailor flood control strategies to regional needs. Emphasising sustainability and effectiveness, these recommendations are crucial for enhancing flood resilience and mitigating future risks.

Ultimately, this research contributes valuable insights to the broader discourse on flood management and provides a roadmap for strengthening flood resilience in the Vhembe district. Implementing these recommendations is essential to fortifying defenses against floods and fostering adaptive, sustainable flood control strategies.

RECOMMENDATIONS

- **Enhancing Community Participation**: Encouraging the active involvement of local communities in decision-making and implementation of flood control measures through education, community engagement platforms, and involvement in the planning and maintenance phases.

- **Resource Allocation, Infrastructure Development, and Management**: Stressing the need for adequate financial resources, infrastructure development, and maintenance specific to each region's requirements.

- **Integration of Natural Methods**: Emphasising the use of nature-based flood control methods, such as vegetation planting and wetland restoration, to create natural buffers against flooding.

- **Collaboration and Interdisciplinary Research**: Encouraging collaboration among diverse stakeholders, including researchers, policymakers, practitioners, and communities. Advocating for interdisciplinary research to develop comprehensive flood control mechanisms

- **Policy Formulation and Implementation**: Prioritising the seamless integration of robust flood control mechanisms into local, regional, and national policies. Stressing the importance of tailored approaches, continuous monitoring, and adaptation to evolving community needs.

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