

Efficacy of Sand Dams in Promoting Sustainable Rural Livelihoods in Semi-Arid Tropics: The Case of Garanyemba Community of Ward 23 in Gwanda District, Zimbabwe

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INTRODUCTION

This study explores the efficacy of sand dams in promoting sustainable rural livelihoods in Garanyemba community in Gwanda District, Zimbabwe. To begin with, Gwanda district, with its predominantly agrarian economy, emerges as a microcosm of vulnerability, experiencing prolonged periods of water scarcity and diminished agricultural output. The socio-economic ramifications are delineated, emphasizing the interconnectedness between climate change and the fabric of rural communities. Against this backdrop, the imperative to explore sustainable interventions becomes apparent, with sand dams emerging as a viable solution especially noting that accessibility of underground water is a challenge due to the domination of granite rock which does not give much water.

This study is rooted in the hurdles faced by rural communities, particularly in Gwanda district, Matabeleland South province, Zimbabwe, where climate change-induced drought has become an acute and recurrent challenge. According to Food and Agricultural Organization (2017), Zimbabwe has experienced a notable increase in the frequency and severity of drought events over the past decade, exacerbating the vulnerability of rural livelihoods. Reduced water availability due to erratic rainfall patterns have decreased crop yields, and decreased veld quality and quantity thus affecting livestock production, and posing significant threats to food security (Musengi, 2022). Moreover, as highlighted by Mugiyo et al. (2024), the interconnectedness between climate change and rural livelihoods is intricate, influencing not only agricultural productivity but also income generation, health, and overall community well-being.

The severity of these challenges has been witnessed in the context of Gwanda. With its predominantly agrarian economy, the district is highly susceptible to the impacts of climate change (Government of Zimbabwe, 2019). The region has witnessed a notable increase in the frequency and duration of droughts, and high temperatures that promote evaporation from surface water sources, resulting in prolonged periods of water scarcity and diminished agricultural output (Mupepi and Matsa, 2022). This adverse environment has led to strained rural livelihoods, characterized by diminished income opportunities and heightened vulnerability (Eisma and Merwade, 2020). The consequences are far-reaching, affecting not only the economic aspects of daily life but also the social fabric of these communities.

In light of this, Gwanda communities in partnership with the rural district council and Dabane Trust invested in the construction of over 13 sand dams across the district as a way of harnessing water for community livelihoods. However, no study has been done to assess the efficacy of these sand dams in promoting both livelihoods and agroecological development in the study area. This study, therefore, aims to fill this gap by seeking: to ascertain how community members in Garanyemba perceive the role of sand dams in enhancing their livelihoods and overall well-being; to examine the influence of community participation in influencing access to and control over sand dam water resources; and to explore the challenges experienced by local institutions in maintaining and sustaining sand dam infrastructure in the study area.

LITERATURE REVIEW

This section provides literature review on the efficacy of sand dams in promoting sustainable livelihoods. The literature is presented using a funnelling approach where a global context is first explored, followed by the regional context and lastly the national-local context. This approach helps to paint a clear picture on the importance of sand dams in sustaining rural livelihoods from different perspectives in different parts of the world.

Efficacy of Dams: Global Perspectives

The global perspective on the efficacy of sand dams for sustainable rural livelihoods in semi-arid tropics is of paramount importance in comprehending the intricate dynamics of water management on a worldwide scale. In the face of escalating challenges posed by climate change-induced water scarcity, the adoption of innovative solutions becomes imperative. Grey's (2023) insights underscore the gravity of the global water crisis, emphasizing the vulnerability of semi-arid regions and the need for transformative approaches. As a response to this, sand dams have garnered attention as a promising strategy to enhance water resilience and support sustainable livelihoods. Acknowledging that the effectiveness of sand dams is not confined to specific regions, global studies, such as that conducted by Ritchie, Eisma and Parker (2021), showcase diverse success stories, revealing the adaptability and potential impact of this technology across continents. This global discourse not only highlights the urgency of addressing water scarcity but also sets the stage for a comprehensive exploration of the varied applications, challenges, and innovations surrounding sand dams as a solution to sustainable water management in semi-arid tropics.

Across diverse geographical contexts globally, sand dams have emerged as successful and sustainable water management solutions, positively impacting rural livelihoods. Xie et al. (2021) present a comprehensive study examining the impact of sand dams on different continents, showcasing success stories that attest to the versatility and efficacy of this technology. These success stories underscore the potential of sand dams to transform communities by providing a reliable and climate-resilient water source. Beyond their immediate impact, sand dams contribute to ecological restoration and groundwater recharge, showcasing their potential for long-term sustainability on a global scale (Patel et al., 2019).

Regional Perspectives

The regional perspectives on the efficacy of sand dams for sustainable rural livelihoods in semi-arid tropics constitute a crucial facet of the broader discourse on water management. As communities grapple with the escalating challenges of climate change-induced water scarcity, the effectiveness of interventions such as sand dams is inherently tied to the regional context. Studies in East Africa, in countries like Ethiopia and Kenya have showcased the successes of sand dams in enhancing water availability and their contribution to agricultural productivity see, Ryan and Elsner (2016); Ndekezi et al (2023). The work of Oguge and Oremo (2017) demonstrates the positive outcomes of sand dam projects in Kenya, revealing their substantial contributions to enhancing water availability for agricultural purposes. The study emphasizes how this, in turn, fosters increased crop yields, improving food security and income for communities in the region. Complementing this, Mulugetta et al. (2016) explore the Ethiopian context, providing valuable insights into the regional adaptability and effectiveness of sand dams. Their findings reveal that sand dams in Ethiopia contribute not only to improved water access but also play a crucial role in safeguarding against climate-induced water variability, making them integral to sustainable rural development in East Africa. These East African case studies collectively highlight the regional success and potential of sand dams as a resilient and sustainable solution to water scarcity, addressing the specific challenges faced by communities in this part of the continent (Mbilinyi et al., 2018; Mulugetta et al., 2016).

Meanwhile, West Africa, exemplified by Nigeria and Burkina Faso, adds to the regional narrative, illustrating how sand dams can be instrumental in enhancing water resilience for agricultural development (Adamou, 2024). The sand dams in this region have emerged as promising solutions to water scarcity, with substantial contributions to sustainable rural livelihoods. The study conducted by Olaleye et al. (2019) in Nigeria provides valuable insights into the regional effectiveness of sand dams. The research emphasizes how sand dams

significantly enhance water availability for agricultural purposes, addressing the specific challenges posed by erratic rainfall patterns in West Africa. The work of Olaleye et al. (2019) in Burkina Faso showcases how these interventions positively impact water resilience, supporting agricultural development and improving overall community well-being. These West African case studies collectively underscore the adaptability and regional applicability of sand dams, offering insights into their potential as sustainable solutions for mitigating water scarcity and fostering rural livelihoods in West Africa (Olaleye et al., 2019).

In Southern Africa, particularly in Zimbabwe and Zambia, where water scarcity poses significant challenges to rural communities, sand dams have emerged as viable solutions to enhance water resilience and support sustainable livelihoods. Nhapi et al. (2015) conducted a study in Zimbabwe, revealing the positive impact of sand dams on water availability. Their research emphasizes the role of sand dams in capturing and storing rainwater, contributing to improved agricultural productivity and increased water access for both domestic and irrigation purposes. Furthermore, Mwendera et al. (2017) delve into the regional context of water management in Zambia, highlighting the effectiveness of sand dams in addressing the specific challenges faced by communities. The study demonstrates how sand dams contribute to sustainable water harvesting, mitigating the impact of climate change on water availability and supporting livelihoods in Southern Africa. These Southern African case studies collectively underscore the potential of sand dams as context-specific and effective tools for enhancing water resilience and promoting sustainable rural livelihoods in the region (Nhapi et al., 2015; Mwendera et al., 2017). While these regional success stories highlight the transformative potential of sand dams, the literature review also recognizes the need for nuanced approaches that consider environmental, cultural, and socio-economic factors.

National and Local Perspectives

Gwanda, located in a semi-arid region of Zimbabwe, faces persistent water challenges exacerbated by climate change-induced droughts. The adoption of sand dams in this context reflects a response to the pressing need for reliable water sources. The decision to embrace this technology is likely influenced by the potential benefits it brings to the community, such as enhanced water availability, improved agricultural productivity, and increased resilience to climate variability.

Local adoption of sand dams in Gwanda may also be linked to the community's active involvement in the decision-making process. Participatory approaches, as highlighted by Chikozho et al. (2018), emphasize the importance of engaging community members in the planning and implementation of water management projects. The participatory model ensures that the adoption of sand dams aligns with the specific needs and preferences of the local population, fostering a sense of ownership and commitment. The work of Chikozho et al. (2018) underscores the significance of adopting participatory approaches in the planning and execution of sand dam projects. This involves consultation and active collaboration with community members, integrating their traditional knowledge and practices into the design and implementation processes.

Similarly, Nyamahono et al (2025) underscored that community participation in rural development initiatives has been associated with several benefits linked to strengthening of community resilience, promotion of social cohesion and fostering a sense empowerment, ownership and responsibility among marginalised communities. The authors however, argued that community participation faces various challenges linked to limited education, capacity building, resources and information. In the same vein, Mambiravana, Nyamahono and Budzi (2024) noted that divergent world views and conflicting interests among stakeholders jeopardize decision-making process and impede collaborative efforts. In addition, exclusionary practices and power imbalances also marginalises vulnerable groups as Akpan, van Tol, Malambile & Mqalo (2017) pointed out that participation processes in some instances are mostly devoid of equity and justice as some individuals obtain concrete benefits from the participation process by manipulating other stakeholders. In marginalised communities like Garanyemba community, participation plays a significant role in the long-term sustainability of sand dams and empowerment, as community members become stewards of their water management structures.

Governmental Policies and Initiatives

Examining the efficacy of sand dams for sustainable rural livelihoods requires a comprehensive analysis of governmental policies and initiatives at the national level. Government involvement plays a pivotal role in shaping the trajectory and success of water management projects, with policies providing the regulatory framework necessary for their implementation. In Zimbabwe, the Ministry of Environment, Climate, Tourism, and Hospitality Industry (METI, 2020) has been at the forefront of developing and implementing initiatives to address water scarcity and enhance climate resilience.

Governmental policies serve as a guiding force, delineating the strategic direction for water resource management. METI's (2020) initiatives are emblematic of a commitment to addressing environmental challenges, including water scarcity, through multifaceted policies. These initiatives encompass not only water resource management but also broader climate and environmental considerations, reflecting a holistic approach to sustainable development.

Government-led initiatives contribute to the funding, coordination, and oversight of sand dam projects. Policies that promote and support the implementation of water conservation and management projects are crucial for creating an enabling environment. METI's (2020) initiatives, for instance, may involve financial incentives, technical support, and capacity-building programs, all of which play a role in enhancing the effectiveness of sand dams in mitigating water scarcity and supporting rural livelihoods.

Understanding the national perspective on governmental policies provides insights into the regulatory landscape, resource allocation, and the alignment of water management projects with broader national development goals. As we delve into these national perspectives, we gain a comprehensive understanding of how governmental policies shape the efficacy of sand dams and contribute to sustainable rural livelihoods in the semi-arid tropics.

Theoretical Framework

Sustainable Livelihoods in the Context of Sand Dams

The Sustainable Livelihoods Approach (SLA) is a comprehensive framework that has gained prominence in understanding and addressing the multidimensional nature of rural livelihoods. The SLA, as conceptualized by Chambers and Conway (1991), emphasizes a holistic understanding of livelihoods by incorporating various forms of capital, including economic, human, social, natural, and physical capital. This approach underscores the interconnectedness of these diverse assets and recognizes that vulnerability and resilience are influenced by the dynamic interactions among them. Furthermore, the SLA prioritizes the agency of individuals and communities, acknowledging their capacity to navigate and adapt to changing circumstances.

In the context of this study, the SLA provides a robust theoretical foundation for examining the impact of sand dams on rural livelihoods in semi-arid tropics. By considering the different forms of capital within the sustainable livelihoods framework, the study aims to assess how the introduction of sand dams influences economic activities, social networks, human skills, and access to natural resources. The SLA also facilitates the identification of potential trade-offs and synergies among these diverse livelihood components, offering a nuanced understanding of the complex dynamics at play.

Furthermore, Serrat (2008) enhances the SLA by emphasizing the role of knowledge and learning as crucial components of sustainable livelihoods. This perspective aligns with the broader goals of the study, as the exploration of sand dams as an intervention necessitates understanding not only the immediate economic and environmental impacts but also the knowledge-sharing processes and adaptive capacities within the community. In summary, the Sustainable Livelihoods Approach, enriched by insights from Serrat, provides a comprehensive lens through which to analyze the intricate web of factors influencing rural livelihoods and their interactions with sand dam interventions in the semi-arid tropics.

The Sustainable Livelihood Approach (SLA) offers a pertinent framework for understanding and enhancing the well-being of communities, particularly in the context of sand dams as a sustainable water management strategy in semi-arid tropics. As we explore the adoption and impact of sand dams, the SLA becomes instrumental in assessing the broader factors that contribute to sustainable rural livelihoods. The components of the SLA—social, human, natural, financial, and physical capital—provide a lens through which we can analyse the multifaceted dimensions of how sand dams influence the livelihoods of communities facing water scarcity challenges.

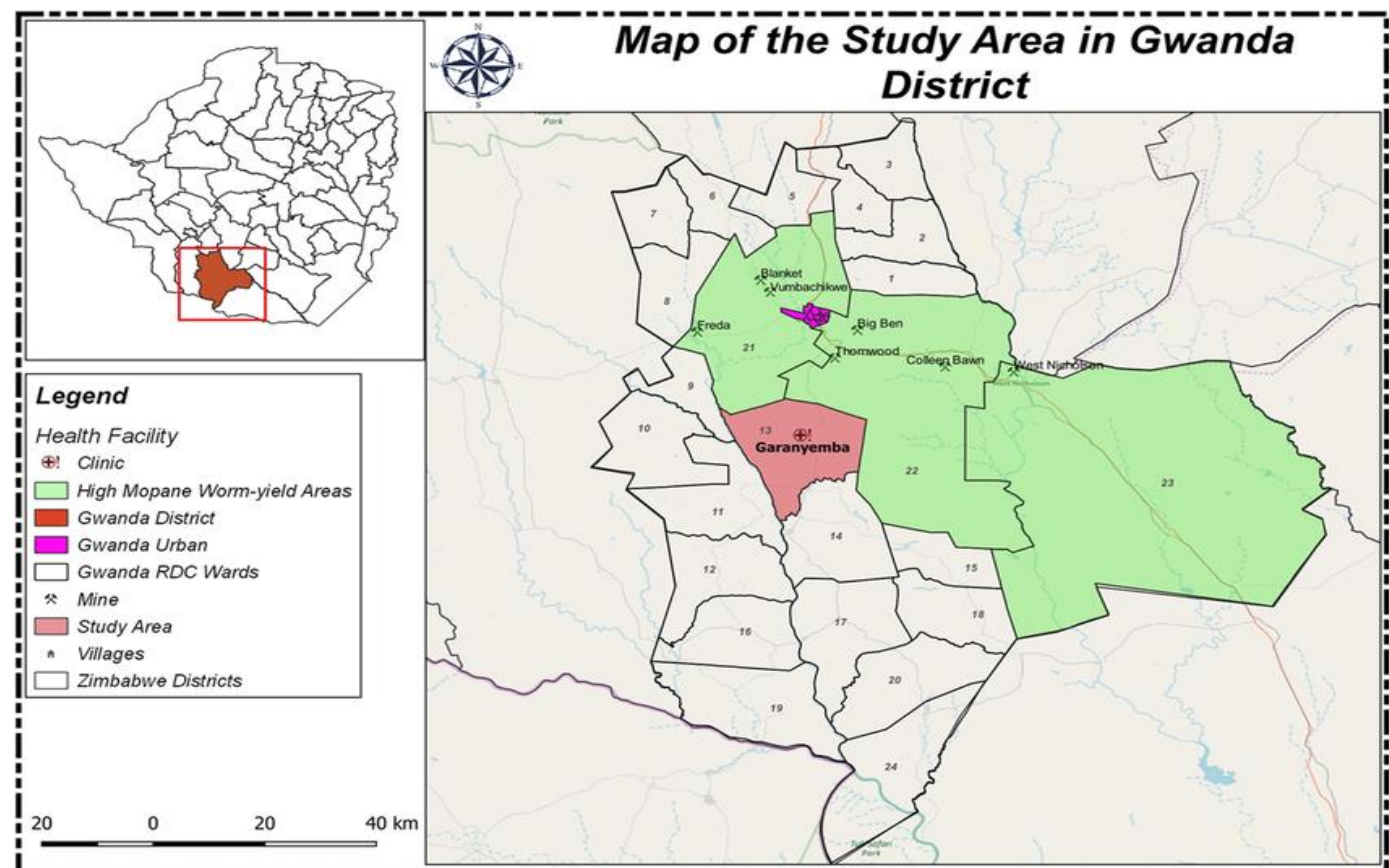
Application of SLA in the Study of Sand Dams

Applying the SLA to the study of sand dams enables a comprehensive analysis of the interconnected factors influencing sustainable livelihoods. Understanding how social, human, natural, financial, and physical capitals are impacted by the adoption of sand dams provides nuanced insights into the broader implications for community well-being (Scoones, 2009).

In essence, the Sustainable Livelihood Approach serves as a robust analytical tool, linking the adoption and impact of sand dams to the broader goal of sustainable rural livelihoods in semi-arid tropics. Through the lens of the SLA, we gain a comprehensive understanding of how sand dams contribute to the various dimensions of community well-being, offering not just water security but a holistic approach to sustainable development.

In Gwanda district, the water table is continually decreasing due to reduced rainfall amounts but this has been addressed by the sand dam technology as alluded to by Musengi (2022). The author indicated that the sand dam concept has improved the yield of riverbed wells due increase in retained water. Therefore, sand dams are intended to help communities adapt to climate by ensuring water availability throughout the year and promote some income-generating projects like gardens and orchards as well as brick moulding in addition to livestock keeping and backyard irrigation (Ndlovu 2020).

Study Site



Source: Google Maps

Gwanda rural district lies in ecological regions 4 and 5 in the south-western part of Zimbabwe. It is located in the hottest and driest region of the country and is characterized by low and erratic rainfall patterns and a series of droughts (Dube et al, 2018). Ward 23 in Gwanda district, Matabeleland South province, Zimbabwe, serves as the focal point of this study. Located within the semi-arid tropics, this region has faced escalating challenges stemming from climate change-induced drought (Manyakaidze, 2023). The site was purposely selected as it has three sand dams in a series along the same river. The soil in Gwanda is generally poor, infertile, and sandy with high seepage. Geologically the study area is dominated by granite rock which is associated with low underground water yield. The predominantly agrarian economy of Ward 23 makes it particularly susceptible to the impacts of erratic rainfall patterns and prolonged water scarcity, thereby significantly influencing rural livelihoods (Government of Zimbabwe, 2015). The socioeconomic dynamics and vulnerability of this specific ward contribute to the significance of the study, as it represents a microcosm of the broader issues faced by rural communities in similar semi-arid regions. By concentrating on Ward 23, the research aims to provide context-specific insights into the efficacy of sand dams as a sustainable water harvesting solution, acknowledging the unique challenges and opportunities inherent to this specific

MATERIALS AND METHODS

This study adopted a qualitative research approach, emphasizing an in-depth exploration of perceptions and experiences related to sand dams in Garanyemba community in Gwanda district. Qualitative research, as delineated by Creswell (2014), is particularly apt for capturing the nuanced and contextual aspects of the impact of sand dams on rural livelihoods. By employing a qualitative research, in the form of a phenomenology design, the study aims to uncover the intricate socio-economic dynamics influenced by the implementation of sand dams. This approach enables the collection of rich, narrative data through methods such as in-depth interviews and focus group discussions, allowing for a deeper understanding of the complexities involved (Creswell, 2014). The sample of the study was inclusive of 20 participants which were purposively selected in Garanyemba community in Ward 23 of Gwanda. These included 7 local farmers, 5 agricultural extension officers, 5 local community members and 3 representatives of Dabane Trust in Gwanda.

FINDINGS AND DISCUSSIONS

The key findings of this study are organized around the following research objectives:

1. To ascertain how community members in Garanyemba perceive the role of sand dams in enhancing their livelihoods and overall well-being
2. To examine the influence of community participation in influencing access to and control over sand dam water resources and
3. To explore the challenges experienced by local institutions in maintaining and sustaining sand dam infrastructure in the study area.

Informed by these objectives, the following discussion is structured around several key themes. It begins by assessing the impact of sand dams on agriculture, including crop and livestock production, and the resulting ecosystem transformations. The analysis then considers the socio-economic dimensions, focusing on farmers' perspectives and opportunities for economic diversification, such as market-farming and brick-making. Finally, the study addresses the governance challenges, particularly those related to ensuring equitable water distribution and facilitating collaborative efforts in the siting of new dams. These issues are thematically discussed in the sections below.

Agriculture (crop and livestock production) and ecosystem transformation

In the pre-sand dam intervention scenario, the agricultural landscape in Gwanda district was characterized by significant challenges related to water access, adversely impacting the livelihoods of the community. Limited water availability posed a substantial barrier to sustainable agricultural practices see, (Mishra, 2016). The semi-arid tropics, prone to erratic rainfall patterns, resulted in prolonged dry periods, restricting the cultivation of crops and creating vulnerability in the agricultural sector (Dube & Phiri, 2023). The authors added that this constraint on water access directly influenced the cropping calendar and restricted the cultivation of water-

dependent crops, exacerbating the community's reliance on rain-fed farming systems. While commenting on the transformation of agriculture due to the implementation of sand dams, a local farmer vividly described this difficult reality during an interview:

Prior to the introduction of the sand dam, farming in Gwanda was a significant challenge. We depended entirely on rainfall, and when it was insufficient, our crops would fail. The dry periods were prolonged, and the limited water available was barely adequate for drinking, let alone for irrigation. Most of us could only cultivate drought-tolerant crops like sorghum and millet, but these often failed to provide enough food or income for our families... The community attempted to dig wells, but they would quickly dry up, especially during the hot months. Livestock also suffered due to the lack of water, resulting in losses.

An Agricultural Extension Officer reinforced this sentiment, explaining the pre-intervention conditions from a technical perspective:

Before the implementation of the sand dam, the agricultural conditions in Gwanda were highly unstable... Smallholder farmers faced challenges in maintaining their crops due to their complete reliance on the unpredictable seasonal rains. This dependency hindered the community's ability to diversify their crops, causing them to rely heavily on a limited number of drought-resistant staples that failed to offer adequate nutritional or economic benefits. Consequently, many households experienced food insecurity, and income generation was erratic because of frequent crop failures.

These accounts underscore a significant shift following the implementation of sand dams. The newfound water security, as reported by participants, has become a cornerstone for diversifying agriculture. The narratives highlight how enhanced water access has been pivotal in enabling the cultivation of a wider range of crops, breaking the cycle of dependency on rain-fed, arid-condition farming.

Farmer's Perspective on the Impact of Sand Dam Interventions

The increased water availability, as articulated by participants not only ensured food security but also opened avenues for generating income through the cultivation of high-value crops. According to the local Agriculture extension officer, the farmers are now able to produce enough vegetables for consumption and marketing. Their main market is the local communities and Gwanda town. One community member enthusiastically noted the economic shift:

We are now able to send vegetables to Gwanda town and the roads are now busy with trucks coming from Gwanda to get vegetables like Kale and tomatoes. This has seen this area becoming an agricultural economic hub. A real transformation brought by the sand dam technology.

Another farmer detailed the personal and practical changes:

The sand dam completely changed how we farm here... Now, with reliable water access, we can farm throughout the year. We have started growing vegetables, tomatoes, and even maize, which was impossible before. I no longer worry about whether my family will have enough food. In fact, I now sell some of my produce at the local market, something I never imagined I would be able to do. This has given us a new sense of confidence in farming. Many farmers in our village have also expanded their fields and are trying new crops because we know the water will be there when we need it. This has given us a new sense of confidence in farming.

The responses of the participants above illuminate the transformative impact of sand dam technology on agricultural practices and livelihoods in Gwanda. Increased water availability has not only secured food for households but also enabled the cultivation of diverse, high-value crops such as kale, tomatoes, and maize. The transition from subsistence to market-oriented farming is evident, empowering local farmers to improve their livelihoods and build economic resilience with farmers now supplying produce to local markets and the nearby Gwanda town.

Economic Diversification: Market-Farming and Brick-making

The enhanced water access has catalysed a broader economic transformation beyond crop sales. Community members reported exploring new and more lucrative crops, leveraging the enhanced and reliable water access to participate in local markets. The economic resilience of households was strengthened, marking a departure from the income vulnerabilities associated with previous agricultural limitations. One Agricultural Extension Officer commented on this diversification and its social benefits:

*"Many are now growing high-value crops such as leafy vegetables, onions, and tomatoes... The ability to irrigate their fields has reduced the risks associated with climate variability, and as a result, we see more farmers treating agriculture as a business rather than just a survival strategy. **Women, in particular, have benefited** because they are now able to engage in small-scale agribusinesses, selling fresh produce and earning their own income."*

Furthermore, sand dams have revived a non-agricultural economic activity: **brick-making**. The availability of water along the stream has led to a mushrooming of brick-making businesses, creating local employment and stimulating the local economy. This according to participants has brought about some economic activity in the area. One community leader alluded that as a result of these economic activities, there is now cash circulation within the ward. People can buy basic food supplied despite poor harvests from the open field.

A community leader explained:

One of the unexpected benefits of the sand dam has been the revival of brick-making... This has created jobs for many, especially the youth, who used to leave the village to look for work elsewhere. Now, they can stay and earn a living here. As a result, there is more money circulating in our ward, and people are able to buy food and other basic supplies even if their harvests were not good.

The participant's view above illuminates how sand dams have improved local economic activities in terms of facilitating brick-making in the study area. This finding shows that the benefits of sand dams extend beyond their primary purpose for agriculture and domestic use, they are fostering diverse income-generating activities that strengthen the community's overall economic health. However, challenges related to equitable distribution were identified

Challenges in Equitable Water Distribution

While acknowledging the transformative impact of sand dams on water access, community members in Gwanda district candidly addressed challenges related to equitable water distribution. Respondents highlighted instances where competition for water resources or uneven access created friction. One participant explained:

The sand dam intervention has been a great deal to our community, but not everyone benefits equally. Some people live closer to the water points and can access water whenever they need it, while others, especially those farther away, struggle to get enough for their farms. Sometimes, those with more resources build better storage facilities, allowing them to take more water, while others have to wait their turn. This has created some tension, especially during the dry season when demand is high. We need a fair system to ensure that everyone, no matter where they live, gets their fair share of water. If we can manage this properly, the sand dam will continue to improve our lives without causing disputes

This narrative reveals that despite the overall positive outcomes, fair access to water remains a critical concern. As noted by Castelli et al. (2020), managing a shared resource within a community is complex and requires a nuanced approach that considers social dynamics. These reflections emphasize the importance of robust community-led governance in the sustainable management of water resources to prevent disparities and conflict.

Collaborative Efforts in the Identification of Suitable Locations for Sand Dams

Collaborative efforts in the identification of suitable locations for sand dams were highlighted as instrumental in the success of the interventions in the Gwanda district. A key informant from Dabane Trust, a partner organization, explained their community-led approach:

We first of all, train the community on how to identify suitable sites for sand dams, then we ask them to identify at least four sites before our engineers come for a technical survey. By this, we are trying to instill a sense of **ownership** of these projects, which goes a long way in ensuring the sustainability of these initiatives.

This participatory process was a stark contrast to previous top-down development projects. A farmer described the difference:

Before, decisions about water projects were made without much input from us... But with the sand dam project, things were different. We were trained... This made us feel like we were part of the project, not just recipients of aid... Now, we feel a sense of ownership over these sand dams, and we make sure they are well maintained because we were involved from the start.

A local community member commented how the sand dam project promoted social cohesion through public participation. Another community member explained how community members increasingly experience social solidarity and the sense of place while doing trainings and consultations for the sand dam projects. The member expressed that:

In the past, many water projects failed because they were imposed on us without considering the real needs of the community. This time, we were part of the decision-making process. We worked closely with Dabane Trust and the engineers to select the best locations. The training we received helped us understand what makes a good site, and we could contribute meaningfully together as a community. We are united as a community to take responsibility for maintaining the project. When we face any challenges, we come together as a community to solve them. The sense of ownership in this project has ensured us a sense of place and we assume our water problems are permanently solved.

These accounts demonstrate that involving the community from the outset is crucial. This consultative process ensures projects are technically sound, socially accepted, and sustainably managed long-term. The interlocutors shared insights into a collective and consultative process that involved community members, local experts, and project implementers. The narratives emphasized that, before the introduction of sand dams, there was limited community involvement in identifying suitable locations for water harvesting structures. The collaborative approach not only increased the likelihood of project success but also fostered a sense of shared responsibility among community members. Participants shared insights into a consultative process that involved discussions, workshops, and shared decision-making regarding how water resources should be utilized and distributed within the community. The narratives depicted a shift from pre-existing situations where water usage guidelines were often imposed externally, without considering the nuanced needs and preferences of the community.

While this study confirms that sand dams enhance local water security, assessing their broader effects on community resilience and adaptive capacity proved challenging. Participant responses regarding impacts on flood risk and downstream areas were often inconclusive, highlighting a limitation in the current research. These practical difficulties in assessment are compounded by known operational challenges documented in wider literature. For instance, existing research, Lasage & Verburg (2015); Lopez-Ray (2019); Neufeld et al. (2021) identifies recurring issues that can undermine sand dam performance, such as improper siting and siltation. A critical challenge for long-term sustainability, as these studies note, is the gap between the need for regular community-led maintenance and the frequent lack of local resources and technical expertise required to manage structural repairs.

CONCLUSION AND RECOMMENDATIONS

This study confirms that sand dams have significantly enhanced agricultural productivity and rural livelihoods in the Garanyemba community. By improving water accessibility, these interventions have enabled a transition from subsistence farming to more resilient, market-oriented agriculture and have spurred other economic activities like bricklaying. The symbiotic relationship between reliable water resources and agriculture has demonstrably built a more sustainable local economy.

The unequitable distribution of water resources within the community emerges as a critical concern, hinting at potential disparities that could compromise the intended benefits of sand dams. Governance structures, though instrumental in ensuring the success of such interventions, demand refinement to address existing gaps and guarantee their long-term efficacy. Thus, the conclusion draws attention not only to the triumphs of sand dam interventions but also to the complexities that necessitate a strategic and collaborative approach for sustainable impact.

The insights gleaned from this exploration serve as a compass for policymakers, community leaders, and development practitioners navigating the complex terrain of sustainable rural development in semi-arid regions. The recommendations present a roadmap for enhancing the effectiveness and longevity of sand dam interventions, emphasizing the need for community engagement, equitable resource distribution, and robust governance structures. However, the efficacy of this technology is not without its complexities. The emergence of challenges related to the inequitable distribution of water highlights potential disparities that could undermine the project's long-term benefits. This finding underscores that the success of physical infrastructure is inseparable from the social and governance structures that manage it. Therefore, while sand dams are a triumph of appropriate technology, their sustainable impact hinges on strategic, collaborative, and equitable management.

RECOMMENDATIONS

The insights from this study provide a roadmap for policymakers and development practitioners. To enhance the effectiveness and longevity of sand dam interventions in Gwanda District, the following actions are recommended:

1. **Strengthen Community Engagement:** Move beyond simple participation to empower community members as active partners in the planning, implementation, and management of projects. This ensures interventions are contextually relevant and fosters a crucial sense of local **ownership**.
2. **Establish Equitable Water Management Systems:** Develop and implement clear, community-agreed guidelines for water distribution. This is essential for preventing conflict and ensuring that the benefits of the sand dams are shared fairly among all community members, regardless of their social standing or proximity to the water source.
3. **Enhance Local Governance Structures:** Invest in building the capacity of local water committees or other governance bodies. These structures need to be robust, transparent, and empowered to manage resources, resolve disputes, and ensure the long-term maintenance and sustainability of the sand dams in Gwanda District.
4. **Establish a Regional Monitoring and Maintenance Framework:** To ensure the long-term effectiveness of sand dams, it is crucial for water authorities and local municipalities to collaboratively develop a standardized monitoring and maintenance framework. This framework should establish clear protocols for tracking key performance indicators, including siltation rates, water storage levels, and structural integrity. A vital component of this strategy is the allocation of dedicated budgets for routine maintenance and the creation of capacity-building programs. These programs would empower local communities with the technical skills required for ongoing upkeep and minor repairs, fostering a sense of ownership and ensuring the dams' longevity. This would also require effective budget allocations for routine maintenance.

5. **Integrate Sand Dams into Climate-Resilient Water Strategies:** Regional and national water policies must formally recognize sand dams as a critical tool for climate adaptation in semi-arid regions like Gwanda. Rather than being treated as isolated interventions, sand dams should be integrated into comprehensive, climate-resilient water security strategies. This holistic approach involves linking them with complementary initiatives such as rainwater harvesting, conservation agriculture, and broader watershed management programs. By creating a diversified portfolio of water solutions, authorities can build a more robust and sustainable water future for vulnerable communities.

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