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Scaling sand dams in Southern Africa: Policy guidance for optimizing rollout within an integrated water storage framework

Key messages

- Sand dams **increase local water access** in semi-arid areas, particularly in the early dry season, supporting domestic and income-related water use.
- **When properly sited, designed, and managed,** sand dams can enhance community resilience to climate extremes.
- Sand dams only store modest volumes at the catchment scale, but they are **critical for water security and resillience at the community scale.**
- Sand dam **performance depends on site conditions;** therefore, careful siting and management of abstraction are crucial.
- Sand dams should be implemented within a **broader water storage framework** that considers sand dams along with other storage options.

This policy brief synthesizes new field evidence from Zimbabwe's portion of the Shashe catchment to assess the performance, benefits, and enabling conditions for sand dams as a strategic rural water intervention. It provides priority actions and practical guidance for a range of actors to support integration of sand dams into catchment, national and basin water security and climate adaptation strategies.

Introduction

Southern Africa's dryland ecosystems face mounting water insecurity that threatens livelihoods, food security, and public health (Oluwasanya et al. 2022). Climate change is intensifying these pressures, with the IPCC's Sixth Assessment Report projecting more frequent droughts, increasingly erratic rainfall, and delayed rainy seasons (IPCC 2023). Regional modeling suggests wet-season rainfall across much of the region could decrease by up to 30% in the coming decades (Serdeczny et al. 2017).

Sand dam in the Shashe catchment, Zimbabwe (*photo*: Girma Ebrahim).

Rural communities already struggle to meet year-round water needs for domestic use, irrigation, and livestock. Climate variability undermines poverty reduction efforts and widens rural inequalities. Limited water infrastructure, weak governance, and rising demand further exacerbate these challenges, reducing agricultural productivity and adding to the burden on women and girls in terms of water collection (IPCC 2023).

Water storage remains central to effective climate adaptation. Historically, dams and their associated surface reservoirs have dominated infrastructure planning, but these systems are centralized, costly, and often produce externalities that have come under increasing scrutiny (Yu et al. 2021). As climate change reduces the reliability of surface water, groundwater has become essential for domestic supply, agricultural production, and resilient livelihoods for much of Southern Africa's population.

Water storage interventions also carry gendered implications, as they often affect livelihoods and responsibilities, such as water collection, that are typically assigned to women. Increasing attention is therefore being directed toward smaller and more robust nature-based solutions such as managed aquifer recharge (MAR), rainwater harvesting, and sand dams that are more adaptable and socially inclusive (Ebrahim et al. 2020).

Sand dams capture seasonal flows in ephemeral rivers and store them within sand deposits, providing reliable, low-maintenance supplies well-suited to the drylands (Ritchie et al. 2021) (see Box 1). However, despite their potential, evidence of their performance and role in integrated water planning and management in Southern Africa remains limited.

Box 1. What are sand dams?

Sand dams are small, reinforced concrete or stone structures built across seasonal sandy riverbeds to store water within coarse sand deposits (Figure 1). As seasonal flows slow behind the dam, coarse sand gradually fills the area behind the structure. Water is stored between these sand grains and can be accessed for months after the rains through scoop holes or shallow wells.

Sand dams provide water for domestic use, livestock, and small-scale farming, while minimizing evaporation and protecting water quality. They help communities deal with droughts and erratic rainfall, safeguarding rural livelihoods under climate change.

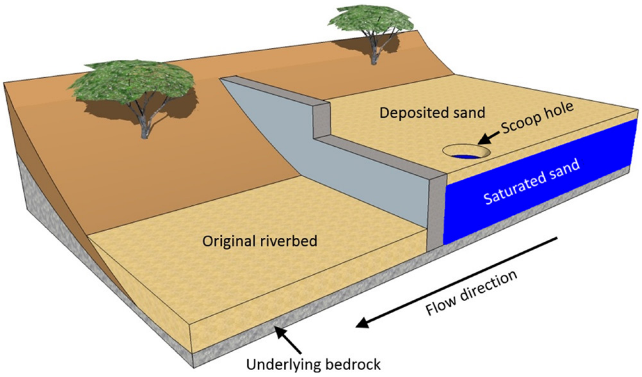

Figure 1. Cross-sectional view of an established sand dam.
Source: Viducich and Selker (2021)

Purpose and scope

This policy brief aims to inform policymakers, implementing agencies, development partners, and researchers about the role of sand dams in strengthening water security and climate resilience in semi-arid regions. This brief presents new field evidence and modeling insights from Zimbabwe's portion of the Shashe catchment (Figure 2) to guide evidence-based decision-making and provide practical recommendations for scaling and integrating sand dams into broader water security and climate adaptation strategies.

Three recent studies together form a complementary evidence base for assessing the role of sand dams in water storage and community resilience. Lazurko et al. (2024) use a resilience assessment and function evaluation framework, combining focus group discussions, site inspections, and interviews, to evaluate environmental and social changes before and after construction in **20 villages near sand dams**. Ebrahim et al. (2024) integrate hydrological modeling and remote sensing, drawing on reservoir time-series data, sediment analyses, and a SWAT-MODFLOW model[1] to estimate multiple water storage components **across the Shashe catchment**. Ebrahim et al. (Forthcoming) conducted detailed field monitoring, installing piezometers **in five sand-dam and two natural sand-bed sites**, analyzing sediment properties, and applying water balance methods to quantify storage dynamics and abstraction.

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[1] SWAT-MODFLOW is an integrated modeling system that combines the Soil and Water Assessment Tool (SWAT) and the Modular Groundwater Flow Model (MODFLOW) to simulate surface water and groundwater interactions effectively.

Figure 2. Locations of studied sand dams and natural sand-bed sites within the Shashe catchment.
Source: Adapted from Ebrahim et al. (Forthcoming).

Benefits and challenges of sand dams

Household and livelihood benefits

The assessment of 20 sand dams (Figure 3) revealed major improvements in dry-season water availability (Lazurko et al. 2024). The number of months with accessible water increased from fewer than seven before implementation to around eleven afterward, with benefits sustained even during drought years. The availability of nearby, more reliable water sources in the form of sand dams reduces the time women and children spend collecting water, freeing up time for them to engage in productive activities such as education and income generation. Communities also reported cleaner water, improved hygiene, increased income, and strengthened social cohesion. Similar interventions in Kenya have demonstrated comparable outcomes, including higher agricultural productivity and improved household incomes (Ritchie et al. 2021).

> *"Before the sand dam, women had to walk 4 kilometers carrying 20 liters of water—a time-consuming and exhausting task—before returning home to many more chores."*
> – Mr. Playmore Ndlovu, Sifanjani community, Gwanda District, Zimbabwe (Dabane Trust and Excellent Development)

Figure 3. Representatives from IWMI and the Dabane Trust conducting sand dam monitoring at the Gwanda site in Zimbabwe.

Source: Dabane Trust

Environmental benefits

Sand dams provide important environmental co-benefits. By storing seasonal runoff within sand deposits, they support groundwater recharge, reduce evaporation losses, improve water quality through natural filtration, and sustain water availability during dry periods. Storing water below the surface also protects it from pollution and waterborne diseases.

Sand dams improve soil moisture, encouraging the growth of native grasses and trees that stabilize riverbanks and reduce erosion. They can also raise the local water table, enhancing the supply in nearby wells (Eisma et al. 2021).

Challenges

While sand dams provide many benefits, they also present certain risks. Factors such as poor siting, design or construction; rapid siltation by fine sediments; weak community management; and inequitable and inadequate access can undermine their long-term viability. These challenges highlight the need for careful technical screening, strong community engagement, and sustained monitoring when planning and implementing sand dams.

Sand dam performance and role in integrated storage

Storage dynamics and site variability

To understand cross-site variability in sand dam performance and identify seasonal trends, five sand dam sites and two natural sand-bed sites were monitored in Zimbabwe's Shashe catchment. The results show that sand dams recharge mainly during periods of high river flow in December–January, followed by a steady decline through the dry season (Ebrahim et al. Forthcoming). In drought years, some dams did not reach full capacity (Mansell and Hussey 2005). Dry-season storage volumes varied widely, ranging from less than 800 m³ at Tshaheyi to more than 11,000 m³ at Nathi (Figure 4). Higher storage volumes were associated with larger catchments, thicker sediment deposits and greater upstream accumulation areas.

Usage patterns also influenced late-season availability: sites supporting irrigation depleted faster than those used mainly for domestic or livestock needs. Although the physical properties of the sands were broadly similar across sites (porosity ~0.40; specific yield ~0.34), patterns of human use explained most differences in dry-season depletion (Ebrahim et al. Forthcoming).

Compared with natural sand beds, sand dams held more water and maintained supply longer into the dry season. For example, the Mawane-Zhokwe natural site, with four times the surface area and more than ten times the catchment area of the Tadla sand dam, still depleted faster and had a lower saturated thickness. While boreholes generally provided more stable, year-round access, well-sited sand dams offered comparable reliability.

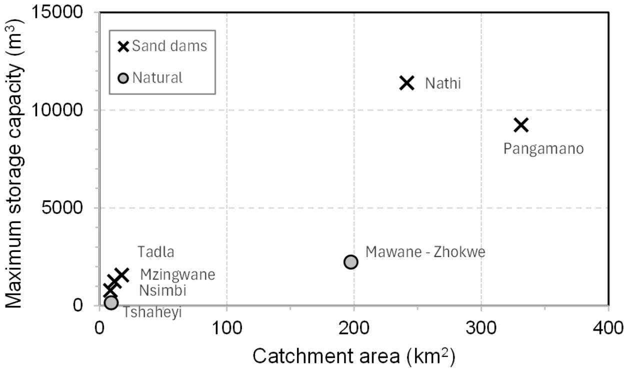

Figure 4. Relationship between catchment area and storage capacity of sand dams and natural sand-bed sites.

Comparative role in catchment storage

In the Shashe catchment, water storage is dominated by large and small dams (49%), followed by soil moisture (43%) and groundwater recharge (7%) (Figure 5). Total groundwater storage is overwhelmingly composed of an 'ambient' component, which buffers seasonal variability but cannot be safely extracted. Although sand dams represent less than 0.1% of total storage, they play an important role in bridging dry-season gaps.

Reliability of water stores could be improved if a seasonally adjusted conjunctive management approach were followed:

- *Wet season to early dry season:* Prioritize sand dams for domestic and livestock use to reduce pressure on groundwater.
- *Mid to late dry season:* Shift to boreholes as sand dam storage nears depletion, with borehole water allocated to

users requiring higher-volume supplies. If communities prefer the taste of sand dam water, borehole supplies can be used for irrigation or livestock, reserving the higher-quality sand dam water for drinking.

This seasonal complementarity positions sand dams as a niche but valuable intervention, particularly in upstream tributaries where larger dams are not feasible. Such integrated storage planning aligns with a broader trend toward combining multiple storage types to spread risk and enhance resilience (Figure 6). Notably, the timing of peak water availability also differs among sources: surface dams and sand dams respond quickly to rainfall, whereas boreholes depend on slower subsurface recharge, creating a seasonal lag.

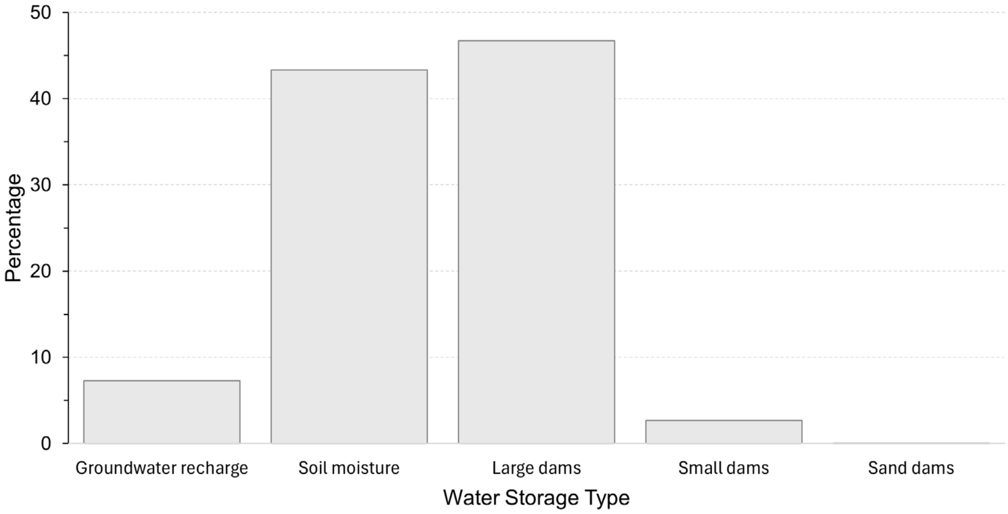

Figure 5. Distribution of annual water storage in the Shashe catchment.

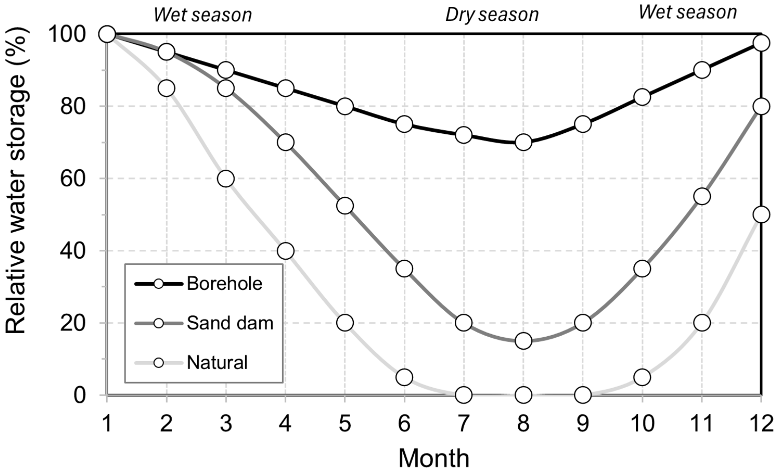

Figure 6. Indicative comparison of seasonal water availability across alternative water sources.

Policy-relevant insights for catchment planning

The evidence highlights that sand dams add most value when integrated into diversified storage strategies (Figure 7). Their distributed nature reduces the risk of system-wide failure, while their siting close to villages enhances accessibility and reduces water collection burdens.

Key insights for planners:

- *Appropriate siting:* Sand dams perform best in headwater tributaries with suitable sediment and bedrock conditions (Maddrell and Neal 2012).
- *Temporal complementarity:* Sand dams help meet early dry-season demand, complementing aquifers and reservoirs that sustain supply later in the year.
- *Water quality considerations:* The quality of water from different sources can guide their appropriate use. For example, if borehole water is saline, communities can rely on water from sand dams for drinking while using borehole water for other purposes, such as livestock.
- *Community management:* Local engagement in maintenance and abstraction control can optimize water abstraction and prolong viability of infrastructure.

- *Hydrological benefits:* By slowing flows and promoting recharge, sand dams contribute to baseflow.

While sand dams cannot replace other water sources, they can form part of a conjunctive storage system that strengthens resilience and bolsters rural water security under climate change.

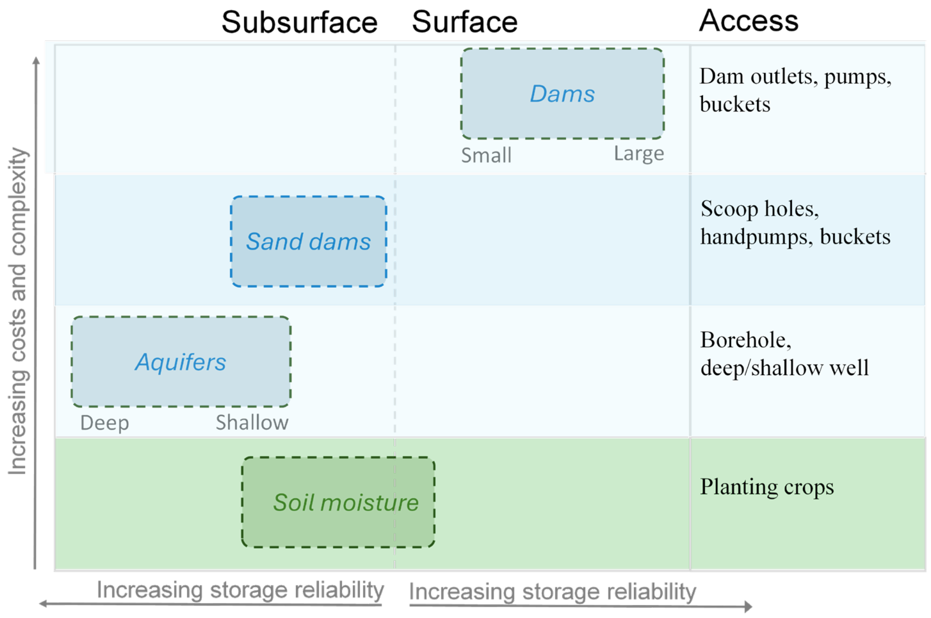

Figure 7. Water storage options in the Shashe catchment.
Source: Adapted from McCartney and Smakhtin (2010).

Key recommendations to optimize sand dam implementation

The benefits of sand dams can be maximized through careful attention to key variables such as catchment area, sediment supply, dam size, and community management arrangements. Catchments vary in size and sediment availability depending on particular geological and rainfall characteristics. Communities can also depend on multiple water sources. To move beyond site selection alone, it is essential to optimize design, integrate sand dams within broader water storage systems, and ensure effective management. From our work, five key recommendations have emerged to guide the optimization of sand dam performance and benefits:

1. Maximize water storage through catchment and channel choice
Select larger catchments with wide, gently sloping channels where coarse sand can accumulate deeply. These features enable greater storage, extending water supplies further into the dry season, and reducing the risk of siltation.

2. Prioritize coarse, well-sorted sediments for reliable storage
Coarse sands create well-connected pore spaces that act as a natural aquifer with low evaporation losses. In contrast, fine sediments such as silts and clays clog pores and drastically limit usable storage. Upstream geology and sediment supply must be assessed in sufficient detail to ensure suitable deposits.

3. Monitor performance to inform management and promote scaling
Monitoring water levels, sedimentation rates, and downstream impacts supports adaptive management at a local level. As water levels decrease, for example, communities can start to ration water and prioritize essential uses such as domestic needs over irrigation. While strict regulation of water abstraction may be difficult to enforce, sharing information on water levels can promote behavioral adaptation to some extent. Likewise, monitoring water levels and related parameters enables a robust assessment of sand dam impacts, providing the evidence base needed to inform decision-making and support scaling of the innovation.

4. Plan water allocation to balance multiple uses
As water storage is finite and variable, water should be allocated strategically among domestic, irrigation, and livestock uses. Designs should include controlled withdrawal points (e.g., handpumps or lined wells) to reduce the need to dig numerous scoop-holes. Similarly, in communities with access to multiple water sources, higher-quality sand dam water can be prioritized for drinking, while other sources can serve irrigation or livestock.

5. Integrate sand dams within diversified storage systems
Sand dams add greatest value when combined with other storage options, such as boreholes, rainwater harvesting, and managed aquifer recharge. Including them in basin- and national-level storage inventories improves water allocation, drought preparedness, and climate adaptation strategies.

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