

Summary Sheet - An Assessment of Sand Dam Function

2017 Mennonite Central Committee Kenya, Utooni Development Organization, & Sahelian Solutions Foundation

Why was a study of sand dams undertaken?

Sand dams are commonly viewed as a successful and appropriate strategy for providing water to communities in semi-arid regions such as Ukambani. For instance, Lasage (2015) notes that sand dams are promoted as "...low-cost systems with easy maintenance that can be developed, constructed and operated with a high degree of community involvement, which improves their durability." Other studies have noted their limitations or have been outright critical of how they currently used. Thus, there is some lack of clarity on the degree to which sand dams are living up to their expectations.

This study was undertaken to address a number of aspects of sand dam which have not been fully addressed in other evaluations, but which are critical to the general question of the effectiveness of sand dams as a tool for improving livelihoods of communities in water-scarce regions. By some estimations, Ukambani has up to 5000 sand dams, likely making it the site of the largest concentration of sand dams in the world. This makes it a good site for making generalizable conclusions about sand dams.

What was studied?

97 sand dams were visited in Kitui, Machakos and Makueni counties. Data was collected to address the broad question of how well dams were functioning, both in terms of the actual structure, and in terms of how the dam is utilized. At each sand dam, we combined information collected through biophysical measurements and observations, with interview responses with local community members. The focus of the collected data was:

Biophysical: *How large is the dam? Is the dam silted? Is water present? Is there evidence of additional water adjacent to dams, or evidence of dam usage?*

Interview responses: *To what extent do community members report using the dam? What types of uses do members report, and how important is it to them?*

The current study adds to our knowledge of sand dams in a number of unique ways:

- Sand dams evaluated were based on a random selection design, and a large sample size was used - the results therefore avoid bias, and more representative of sand dams in general.
- Self-reported data were compared with observational data in an attempt to verify the reliability of these data collection methods. In other words, does what is seen at sand dams match with what locals tell us about them?
- We addressed the question of whether there is a consistent issue with siltation in the population of dams in Ukambani. In short, have these dams by and large silted up to the degree that it greatly hinders their successful usage?
- Newer techniques in satellite analysis of vegetation was used to analyze evidence of overall increased greening around sand dams.
- Water quality was assessed to address the assumption that water from sand dams is clean. Results of this aspect are reported in a separate report.

First, the big picture: How well are the dams working in general?

In an effort to rate dams on their functionality – essentially how successful they have been - we took measurements which indicated 1) how much water storage occurs in the dam, and 2) to what degree water is being used by the community. These various measurements were combined to give a single indication of overall functionality of the dam. Although choosing the measurements and combining them into a single value involves subjective judgments, it does give an overall picture of how successful the dams seem to have been.

We found that most dams would not be considered either “optimal” (ample water throughout the year and robust usage by the community) or “failures” (little capacity for water storage and/or largely unused). Most dams fall in the center of the rating, showing some clear evidence of use, but also showing some lack of water and/or lack of use by the community.

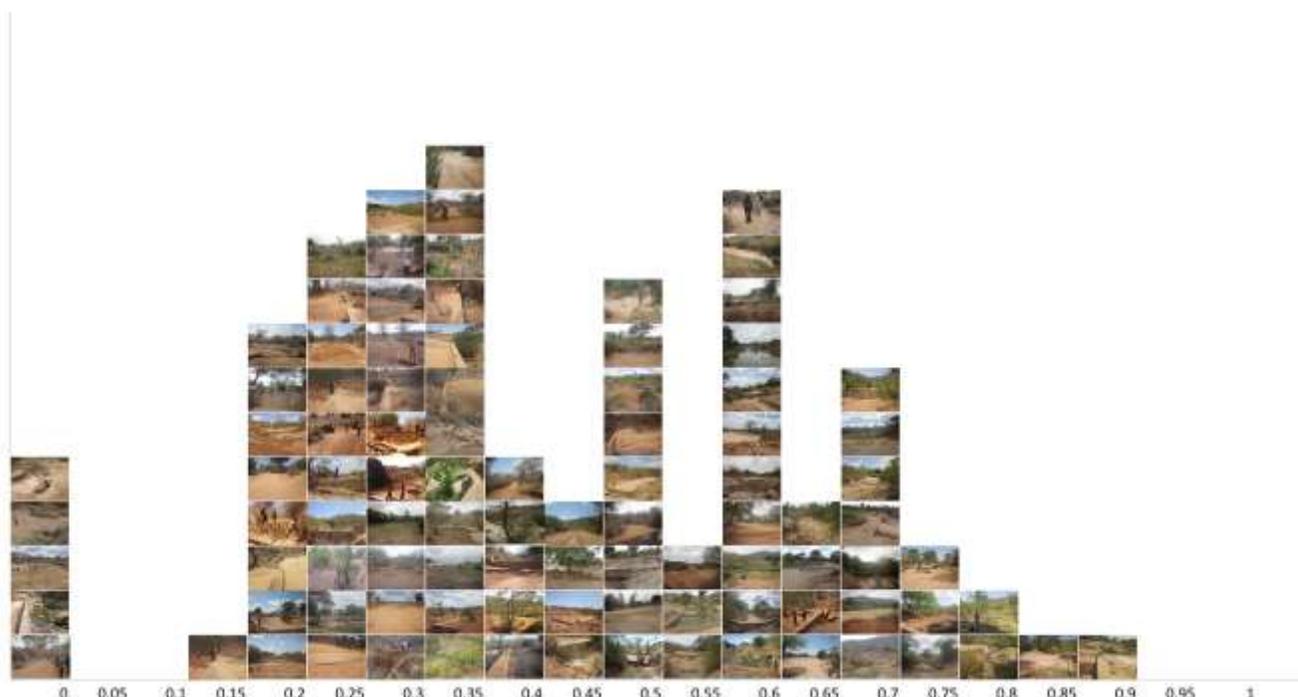


Figure 1. Pictures of the 97 surveyed dams, arranged based on their integrated rating of functionality. The five dams at "0" were completely broken and therefore nonfunctional. Dams closer to the "1" value were deemed the most functional. Note that most dams are distributed in the intermediate values.

In Summary: This study points toward sand dams as good solutions when focusing on water challenges, if they are carefully sited and constructed, and utilized to their potential. Water continues to be a major concern and determinant of the well-being of communities and individuals, and solutions are needed for water limitations in the region. However, it is critical that sand dams are viewed in the local context (see below), and that they are not seen as “silver bullets” – they have not definitively solved all livelihood challenges of communities they serve.

No factors analyzed in this evaluation were singly responsible for a large proportion of a dam’s success. Dams which are most successful probably have 1) a combination of individual factors (such as reduced siltation, high nearby population) that each contribute a small but important amount to the dam success and 2) a psychosocial context that encourages dam usage, such as strong motivation and planning on the group or individual level.

This gives us the big picture about how sand dams are functioning. What about individual aspects of sand dam function? Below we highlight a few specific findings.

Some key findings on what is generally working well at sand dams

1. Siltation is not a critical issue with most dams.

Questions about the degree of siltation at sand dams have been rightly raised in recent years, as practitioners seek to continually improve sand dam function. We found that while having some effect on reducing water volume, siltation did not severely limit the potential storage capacity in most dams. In broad terms, silt buildup is not the primary constraint to sand dam function.

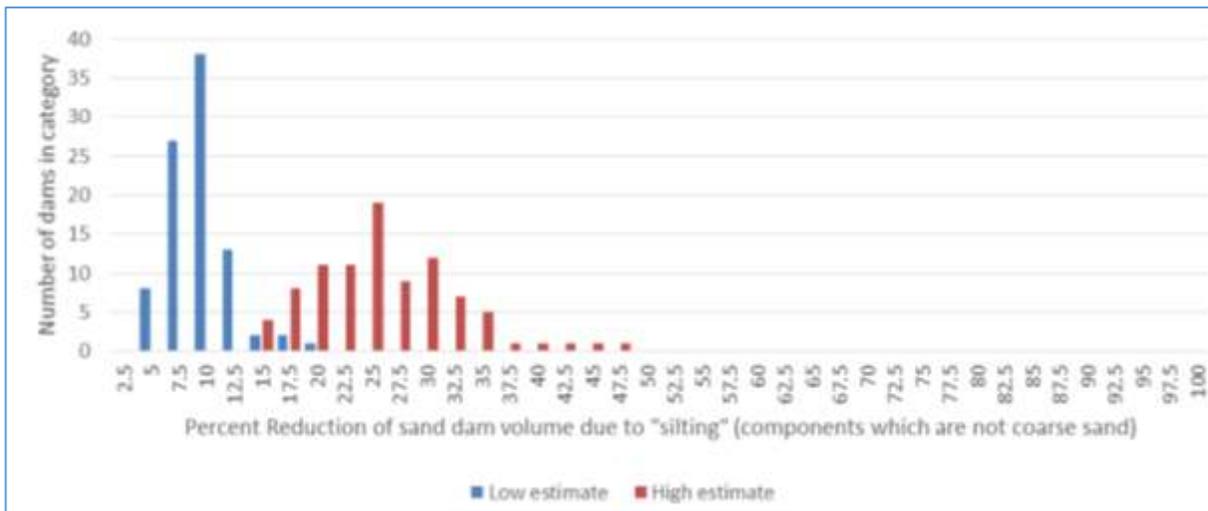


Figure 2. The effect of siltation on the volume of water held in sand dams was calculated, using two boundary estimates for how much water is held by sand, silt and clay. The average reduction of water volume due to siltation was 10 to 25% (depending on how it is estimated).

2. Most dams had water present in the dry season.

Most (78%) of dams had moisture in the sand from at least some samples, with most dams having moisture in more than half of their samples. The presence of moisture suggests most sand dams are holding water. Deep coring (on average, our cores were 0.7 m deep) would presumably increase the percentage showing water even more. Extractable water is likely present in most dams, although a smaller fraction of dams are actually being used for water harvesting.

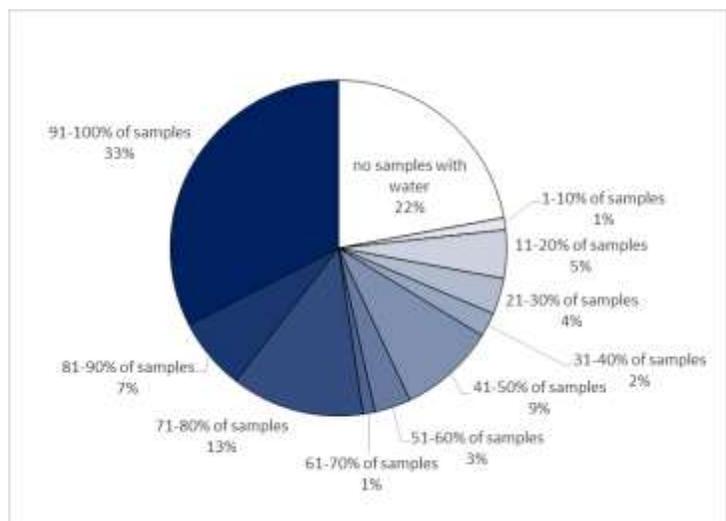


Figure 3. Percent of dams that have moisture in different proportions of samples taken at that dam. The darkest blue wedge, for instance, is the percent of all dams surveyed that had moisture in 91 to 100% of the sand samples taken from that dam.

3. Open-ended responses of sand dam impacts report a wide range of potential or realized benefits.

As a snapshot of how users view the impacts of sand dams, users were asked an open-ended question about positive or negative impacts. While not rigorous as quantitative indication of benefits or costs, responses did highlight a number of important points:

- Benefits are not restricted to traditional water harvesting solely for household or drinking. Other uses, such as water for livestock, brick-making and irrigation are all seen as important benefits by communities.
- Sand harvesting is seen as a major benefit by communities. Benefits are not solely contingent on the presence of water.
- Communities understand that there are indirect or more abstract benefits, such as a raised water table, or the facilitation of group activities and togetherness.

So...an understanding of benefits of sand dams is not the primary obstacle to its effective use.

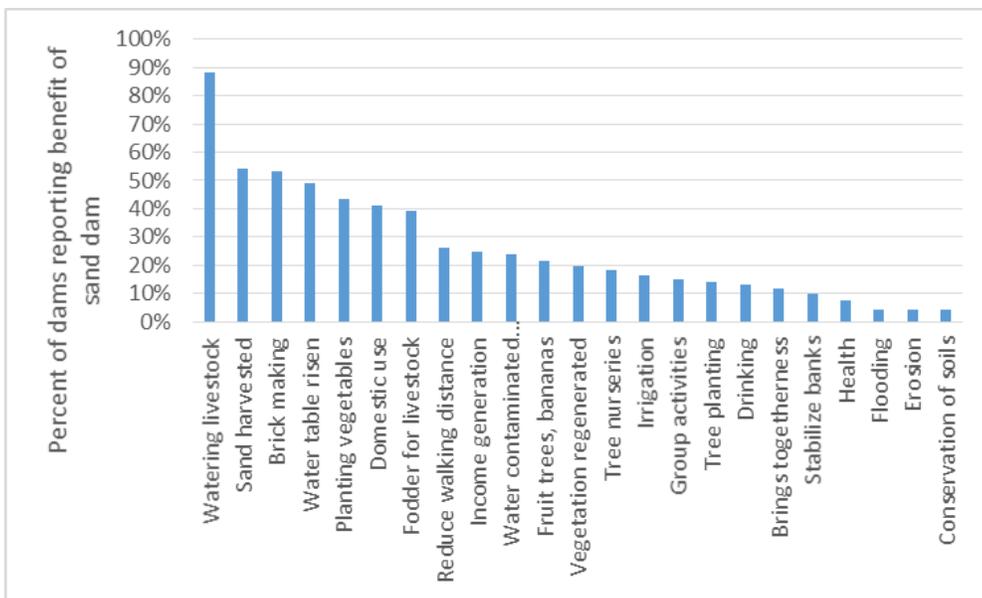


Figure 4. Reported benefits in open-ended question, categorized.

Some key findings on what could work better at sand dams

1. Most of the land adjacent to sand dams is not being actively utilized in a way that is linked to an increased water supply.

Land use was assessed in transects to an estimated 30 m laterally from the dams, at 15-50m intervals (depending on the size of the dam), as a means of quantifying agricultural uses of the land near dams. Most land adjacent to dams was bushland (including scrub trees,

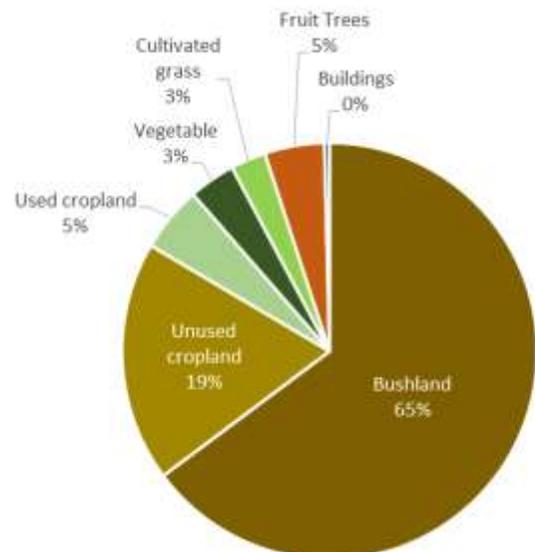


Figure 5. Land use adjacent to sand dams, expressed as average percent land used for various activities.

pastureland) and unused cropland (e.g. crops had obviously been grown in the past, but the land was currently unused) No active agricultural activities adjacent to dams were observed in 61% of dams surveyed, during the dry season when surveys occurred. In the 39% of dams with agricultural activities, most of these had multiple activities.

2. Many dams with evidence of water were not being actively used for water harvesting at the time of visit.

In 39% of all dams, there was no evidence of attempts to extract water. Of the remaining dams (where there was evidence of water harvesting), two-thirds were currently extracting water, and the remaining had stopped water usage as sources had dried. Of dams where there was no evidence of water harvesting, 81% had evidence of water in the sand cores.

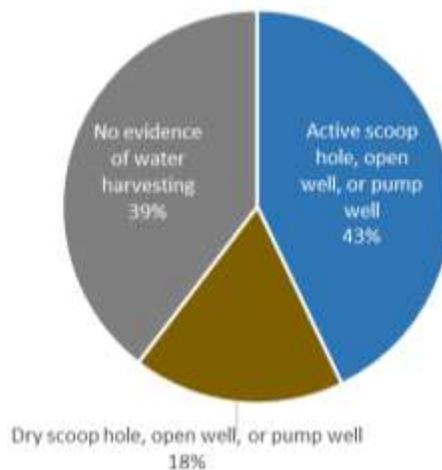


Figure 6 Percent of dams utilized for water harvesting.

In many cases, water is present in sand dams, but is not being used to its full extent.

Some key findings that raised questions for further studies on sand dams

1. Satellite vegetation analysis do not show that areas around sand dams are consistently greener than nearby areas without sand dams.

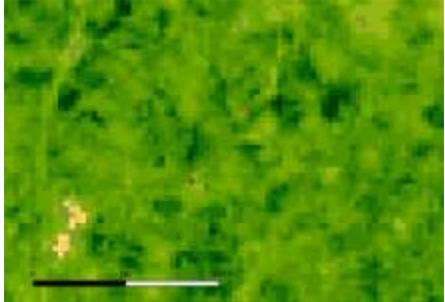
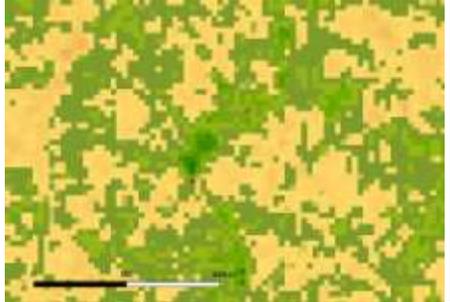
On average, there was no difference in vegetative greening of areas around sand dams compared to control areas (without sand dams), when analyzed using standard vegetative index methods.

Table 1. Vegetation index (NDVI) at sand dam compared with control (at least 200m away from dam, usually downstream, in absence of sand dam). Values vary roughly from 0 (bare ground) to 0.5 (full greening).

	NDVI at sand dam	NDVI at control site
Jan-Mar dry season	0.266 ± 0.051	0.269 ± 0.053
Aug-Oct dry season	0.176 ± 0.025	0.176 ± 0.028

This was surprising, as some dams have strikingly green areas around the dam. Those greened areas that are observed when visiting dam sites are possibly overestimated, precisely because of their striking nature – a relatively small area of green garners disproportionate attention relative to its size. This does not mean that some vegetative greening near dams is unimportant, greening of modest areas of fruit trees or vegetable can provide substantial benefits. At the scale analyzed (within 100m of dams), however, these benefits are not generalizable as a consistent effect greening all vegetation near the dam due to raised water tables.

Table 2 Some examples of vegetation analysis at dams

Satellite Image	NDVI, Jan-Mar dry season	NDVI, Aug-Oct dry season
<p>Makongwe, one of the more successful dams that was visited (red star is dam, orange star is drawback point). On the ground, there was obviously a great deal of vegetation around the dam.</p> 	<p>In both wet seasons, a notable green spot is obvious just upstream from the dam (red star) which corresponds with the vegetation seen on the ground.</p> 	<p>The increased greenery is especially obvious in the October image. Of all dams visited, this was the most obvious NDVI evidence of greenery associated with sand dams.</p> 
<p>Kyangiti, Kitui. Dam on a larger stream (which contains a good deal of sand throughout its channel).</p> 	<p>The 100m buffer zone is shown here, for which NDVI was quantitatively analyzed.</p> 	<p>A grove of trees upstream from the drawback shows higher greenery levels, but the sand dam area itself (bottom left buffer) is not obviously greener than other areas.</p> 

2. Women and men value sand dams for different reasons.

For women, the largest benefit was clearly in saving time as they walk shorter distances to get water. School attendance was cited most often for girls, but also to a lesser degree for boys. Possibly girls are more involved with gathering water, and thereby benefit more from the dams. Benefits related to education included not only staying in school or increased attendance, but also improved performance as children could do their homework and were not tired during the day. Improved health (*e.g.* through increased washing), and “Bringing togetherness and unity” was reported more often for women and girls, than for men and boys. For men, activities around brick-making, livestock, and other income generation projects were reported most often. Brick-making requires both the collection of sand and water, and appeared to be a common and valued activity for men.

Table 3. Reported benefits of sand dams, based on gender and age. The top five items are shown for each category.

Women		Girls		Men		Boys	
Saves time/shorter distance	96.7%	Improved school attendance and performance	75.0%	Brick making/constructi on	62.0%	Brick making/constructi on	46.7%
Improved health	42.4%	Improved health	51.1%	Livestock	51.1%	Income generation	37.0%
Income generation	13.0%	Brings unity/brings together	35.9%	Income generation	35.9%	Improved school attendance and performance	29.3%
Brings unity/brings together	5.4%	Saves time/shorter distance	32.6%	Irrigation	10.9%	Saves time/shorter distance	21.7%
Livestock	4.3%	Allows to sleep more	4.3%	Improved health	9.8%	Livestock	16.3%

What is the main conclusion from the study?

As a technology, sand dams are designed to hold water where water in a location would otherwise not be held for a long period. As an activity, sand dams rely on the organization of a group of motivated residents, and/or on individuals with access, resources and initiative. *As a technology, the dams largely succeed.* Evidence from this study suggests that siltation is not the primary barrier to the success of most sand dams. Water was present in the majority of dams visited. *As an activity, sand dams vary considerably in their success.* Signs of robust usage of water, either as direct evidence of harvesting or as indirect evidence in the utilization for a diversity of activities was less obvious than its presence. The case study below illustrates this main conclusion.

What are some recommendations based on these results?

- **Continue to optimize sand dam design and siting.** Using the most robust method possible to screen potential sand dam sites and groups could help ensure that locations are appropriate for sand dams, both from a biophysical and a social perspective.
- **Emphasize ongoing work with communities utilizing sand dams.** Link sand dam projects more closely with promoting associated activities, emphasize attention to management plans, and understand the social context of sand dams.
- **Work to better understand the social context of sand dams, and the psychosocial barriers to use.** Motivation and organization, either on the group or individual level, appears to be a challenge to achieve large benefits from sand dams. Lessons from other sectors that rely on both effective technology and behavioral change points towards the critical importance of two social components: 1) the local context and traditions, and 2) the broader nature of decision-making processes in humans.
- **Explore new options for how to improve or use dams.** Communities and organizations should be open to exploring new options for how sand dams are structured, and how users make the best use of them.

A CASE STUDY ILLUSTRATING SOME OF THE FINDINGS OF THIS STUDY.

MUNANDANI, MAKUENI

Two dams were built at Munandani, in Makueni County, on tributaries of the Thwake River. Dam #622 was built in 2010 at the request of a group, which rapidly made good use of the water for a variety of activities such as a thriving tree nursery. When visited on August 27, 2016 (late in the dry season), this was no longer the case. The group had ceased collaborative activities at the dam, and there was no evidence of water harvesting, or of activities adjacent to the dam that were supported by water from the sand dam.



Dam #622, Munandani; surface has sand, but no evidence of usage late in the dry season.

Why did use of the dam stop after a promising start? The structure was intact, albeit with notable erosion on the edges of the structure. The dam area was filled with medium and coarse sand – there was no indication that siltation was a problem. Water was found in half of cores from the dam, at depths of less than ½ meter. Satellite images show greening of vegetation along the waterway during the previous Jan-Feb dry season, albeit less than other nearby locations with sand dams. Thus in general, the dam itself seemed functional, and it seems likely that even in late dry season of Aug 27, 2016, that there would have been harvestable water deep in the sand.



Satellite analysis showing greening along waterways, especially at several dams. Dam #622 is located at the yellow star, lower center. Other dams are at red stars and yellow arrow. Thwake River runs through the center, at right scoop hole shows abundant water shallow in the sand.