

## Sustainability of sand dams in Kitui Central, Kenya

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### Abstract

Sand dams or *mingeeto* as are known in the local language are widely constructed in these Semi-arid areas to harness water during the dry spells of the year. In Machakos, Kitui and Makueni sand dams have been in use since 1980s. In Kitui County alone, Eastern Kenya, more than 500 sand-storage dams have been built from 1990s to 2015 by local Non-Governmental Organization (NGO) Sahelian Solutions (SASOL) and other community based organisation supported by these NGOs.

The County Government of Kitui have also increased the Nos. of constructed sand dams to supplement the existing ones.

The overall objective of the research was:

1) To establish the key factors affecting the sustainability of sand dams

The specific objectives of the research work were:

a) To establish the key factors causing failure or non-performance of sand dams.

b) To establish the key challenges to the sustainability of sand dams.

1.1.1.

As per the records available in the year 2015, an inventory of 102 sand dams was developed on streams/rivers within the study area. From this inventory 62, of the sand dams were operational and 40 not operational. Using the hypergeometric sampling procedure for small populations, the minimum sample required for research work was two Sand dams. The other factors considered in sample selection included distances to site and accessibility of the sand dams. A representative sample of 9 sand dams which included 4 Operational and 5 non-operational representing 8.82% of the sample that was adopted for detailed study.

The representative sample for the beneficiaries was computed based on binomial equations from a population of 2550 from which a representative sample of 96 persons was adopted for detailed study.

The methods used in data collection included the review of existing literature, use of guided structured questionnaires in collecting data from beneficiaries, direct interview of key experts and technical field assessment to evaluate performance and challenges.

Based on the research assessment criteria developed on sustainability specific for evaluating failures of sand dams, the following points of assessment were found to be relatively good, the level of participation of community in project initiation, planning, site investigations, implementation and management. Stakeholder participation and contribution during construction was by collecting construction materials (sand, water, crushed aggregates) and providing labour.

The high percentage level of community participation noted in the research was not a guarantee of good performance of sand dams.

**Key words: Sustainability, Community participation and land use**

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### I. Introduction

Sand dams have become part and parcel of sustained investment in soil and water conservation. It creates opportunity for smallholder farmers in the rural areas to invest in sustainable agriculture and address the critical threats facing their livelihoods. Dry lands are at the front line of climate change. They are prone to floods, droughts and extreme weather events. Plate 1.1 shows the construction process of small sand dams (Excellent Development, 2007).



**Plate 1.1:** Small dams collect sand, which acts as a resilient store of water even when seasonal rains not available

Sand dams construction in ASALs (Arid and Semi-Arid Lands) lands are being advocated as the sustainable way of providing water to Semi-Arid regions and also an effective climate change adaptation strategies for developing countries. The technology of harvesting and storing water below ground is deemed appropriate for the environments with erratic rainfall patterns that quickly disappears through runoff and with the high evaporation due to long spells of dry period.



**Plate 1.2:** shows construction of a level drift which acts as an access through the river and at the same time acts as sand dams at Katilini in Kitui South.



**Plate 1.3:** Sand dam inform of a level drift constructed along Ikoo River in Kitui Central on well protected catchments

### 1.1 Purpose of the Research

The objective of the Research was to investigate the factors causing failure or non- performance of sand dams and the overall sustainability of sand dams

### 1.2 Contribution of the paper

These paper makes several findings as the main causes of failure or non- performance for sand dams and this includes;

- 1) Inadequate site Investigations and improper site Locations
- 2) Changes in Land use and population;
- 3) Inappropriate Engineering Design and Constructions. Most sand dams constructed have beneath the foundation water leakages which can be due to foundation lying on the sand instead of firm ground.



*Plate 1.4: Enziu River at Kurura showing foundation of the wall not properly anchored to stable ground causing under foundation seepage of water. Improved Engineering correction to control seepage.*

The research paper has established the following findings

- a) Good engineering design and practise is needed in construction of good performance and sustainable sand dams. Correction works are expensive. This is well illustrated in Plate 1.4 above.
- b) Changes in land use due to increased population has contributed immensely in clogging the reservoirs of Sand dams by eroding of unwanted soils from *shambas* where trees and other vegetation covers have been cleared to allow for cultivation.

## II. Methodology

### 1.3 Study Methodology

The research paper aimed at collecting data through quantitative methods by the use of questionnaires, discussions with individuals within the community, discussions with the key informants and review of past works done through documents as previous literature review.

For the qualitative, it was done through engineering assessment, making an informed engineering opinion on the standards, quality of completed sand dams done in the field and through review of relevant documents on previous works for comparative assessment. The study conducted investigation of the selected sand dams in line with the objectives of the study.

The study looked in depth at the factors causing failure or non-performance of sand dams and the challenges to sustainability of sand dams. The contribution of community participation was evaluated to measure their contribution to sustainability of sand dams.

The primary and secondary data collection began in the year 2014 with a review of relevant literature related to sand dams, water resources management and adaptation strategies to climate change in Sub-Saharan and in particular in ASALs. This review was important to gain a more comprehensive understanding of the issues and research initiatives that has taken place or taking place in the study area.

## III. Procedure on data collection

### 1.4 Development of sand dam inventory

In collecting the required data, extensive consultation was done with NGOs, community based organizations (CBOs), Government bodies and departments, the Catholic Church and affiliated NGOs, Development partners and county government of Kitui in developing the data base as a basis of evaluation.

The data collected from this organizations was tabulated and geo-referenced, the data collected was categorized into two (operating and non-operating). The information is mapped in Figure 3.1 below

### 1.5 Sampling frame

After the sand dam inventory, sand dams from the following rivers namely Kiindu River, Ethi, Ethamba akaa and Kyuusi were sampled for detailed study. Two sand dams were randomly selected from each of the river for detailed evaluation.

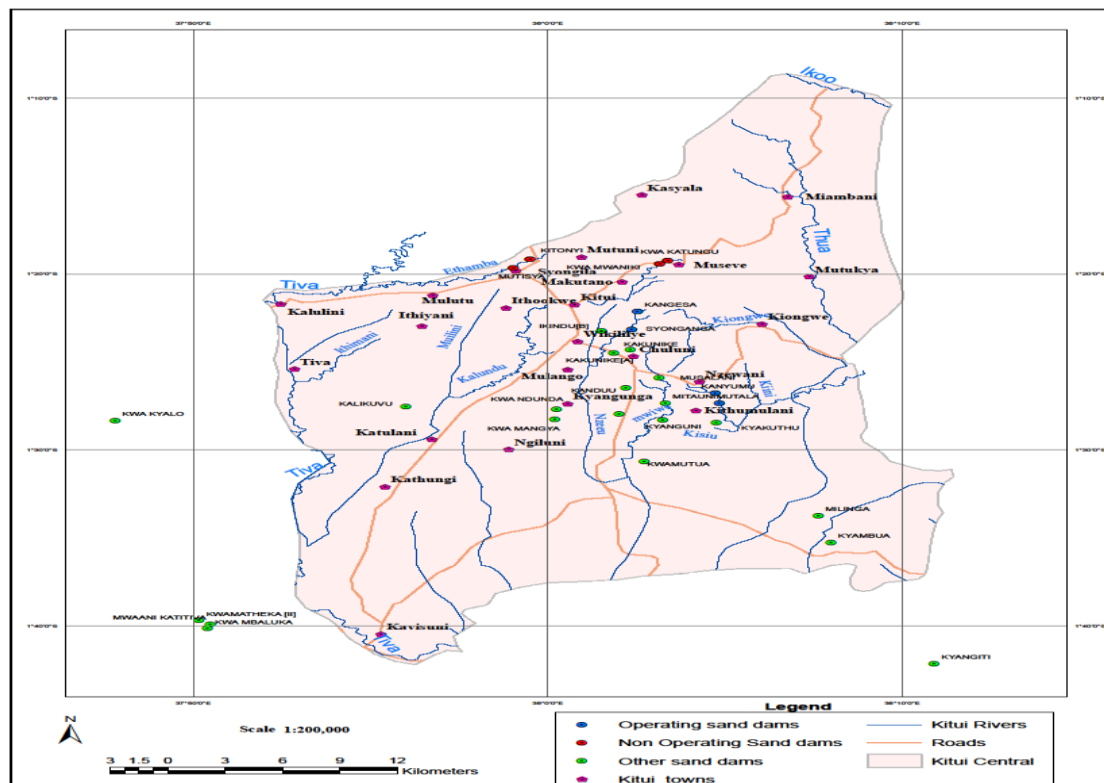


Figure 3.1: Data collected from Stakeholders involved sand dams' developments

## **1.6 Methods in data collection**

### **a) Desk Literature Review**

Under Desk Literature Review the details from relevant documents are obtained to obtain the baseline information. This documentary review provided understanding local micro (social and economic) conditions, data on demographic trends, land use sizes and practices, development strategies and plans (local and national). Intensive documentary review included the area maps.

### **b) Field Assessment and Observation**

Detailed field observation assessment were undertaken to enable determination of socio-economic activities within the study area. Among the broad focal areas for which observations were done included adherence to construction standards, performance of the sand dams, surrounding agricultural activities, land use practises, community involvement and ownership of the products by the community and usage and benefits of the water source.

### **c) Public and Stakeholders engagement**

This was done through the following ways;

- i. Community consultations through (*baraza*);
- ii. Personal interviews with key stakeholders, comprising of sand dam's experts and implementers, Local non-government organisations (NGOs), chiefs and Assistant chiefs residing within the areas of study, community opinion leaders and representatives from community based organisations (CBOs) to understand the processes involved to achieve the outputs so expected.

## **IV. Results And Discussion**

### **1.7 Results**

In this research study, it covered a population of 2550 Persons within the area and out of that a representative sample of 96 persons.

The research paper finds that community participation during project initiation, planning, Constructions process and post construction maintenance was very good as illustrated in Table 4.1 below.

From Table 4.2, the research finds that 55.6% of the sand dams had failed in performance due to the following;

- The people involved did not carry out detailed site investigations and eventually located the sand dams where it did not yield as expected.
- Changes in land use, catchment degradation associated with increase in population density Per Km<sup>2</sup> around the sand dam location has affected the performance due to increased soil erosion, reduction in vegetation cover.
- Lack of maintenance on part of the community where minor defects had been noted on the performance of the structure. This indicates that community project ownership was verbally expressed as excellent and not practically implemented.
- The research paper finds that 66.7% of the sampled sand dams has failed due poor Engineering design coupled with non-adherence to proper construction standards during implementation or construction.
- Except for Community Participation as illustrated in Table 4.1, Community contribution towards financing was very poor from research findings (Direct Financial Contribution). From the research study 86.4 % to 93.34% of the respondents participated in project implementations through indirect funding by provision of labour, water and collection of materials during construction.
- From field assessment and observations from the sampled sand dams 11.1% had failed due sand harvesting behind the wall. The retention capacity of sand was compromised due to exposure from agents of evaporations.
- 26.92% of the respondents from the community sampled indicted that most of sand dams that had failed in the area was due to lack of detailed site investigations and improper locations of sand dams coupled with not involving the community in preliminary data collections or total ignorance of the community.
- Through discussion with the sand dams experts consulted in this research paper, the most critical consideration in successful implementation, good performance and sustainable sand dams are involve the community from the onset, detailed site investigations and locations and good engineering design and constructions.

## 1.8 Community Participation

Table 4.1: Overall assessment of Community Participation

Name of sand dam	Status of sand dam	Stages of Project Development						Remarks
		Initiation	Planning	Implementation	Management	Post construction maintenance	Ownership	
Kwa Kangesa	Operational	Good	Very good	Very Poor	Excellent	Excellent	Excellent	Community involvement was very good
Kwa Syonganga	Operational	Very good	Very good	Poor	Very good	Excellent	Excellent	Community involvement was very good
Kwa Kanyumu	Operational	Very good	Very good	Very Poor	Excellent	Excellent	Excellent	Community involvement was very good
Kwa Mutala	Operational	Very good	Very good	Very Poor	Very good	Very good	Excellent	Community involvement was very good
Kwa Mwaniki	Non-operational	Good	Good	Very Poor	Good	Very good	Excellent	Community involvement was very good
Kwa Katungu	Non-operational	Good	Good	Very Poor	Good	Very good	Excellent	Community involvement was very good
Kwa Kasyala	Non-operational	Good	Good	Very Poor	Fair	Very good	Excellent	Community involvement was very good
Kwa Kitonyi	Non-operational	Good	Good	Very Poor	Good	Excellent	Excellent	Community involvement was very good
Kwa Mutisya	Non-operational	Very good	Very good	Very Poor	Very good	Very good	Excellent	Community involvement was very good

## 1.9 Causes of failure or non-Performance of sand dams

One of key factors causing non-performance of sand dams was the incorrect locations of sand dams which results in the collection of fine soils (alluvium soils, clay, silts and fine sand). These fine soils hinder the penetration of water to the lower coarse sand beds. Failure of sand dams was as a result various varied factors which included design and construction, Site investigations and locations of sand dams and catchment degradation as a function of land use. Table 4.2 shows the causes of failure associated with sampled sand dams.

Table 4.2: Causes of failure or Non-performance of sand dams

Item	Descriptions	Kwa Mwaniki	Kwa Katungu	Kwa Kangesa	Kwa Syonganga	Kwa Kasyala	Kwa Kitonyi	Kwa Mutisya	Kwa Kanyumu	Kwa Mutala	Total	Ranking
1	Engineering Design						✓	✓			2	5
2	Construction of sand dams						✓	✓			2	6
3	Site Investigations	✓	✓			✓	✓	✓			5	4
4	Locations of sand dams	✓	✓			✓	✓	✓			5	3
5	Land use and catchment degradation	✓	✓			✓	✓	✓			5	1
6	Maintenance	✓	✓			✓	✓	✓			5	2
	Total	3	4	0	0	4	6	6	1	0		

**V. Discussion**

The location of a sand dam was very important in the overall performance. Location influences the kind of soil deposited on the sand dams. With good locations the sand dam are likely to hold water for long periods but with bad locations the structure likely to have short and unproductive lifespan. From Figure 4.1, shows the influence of improper locations of sand dams, degraded catchments and their effects on the lifespan of sand dams, degraded catchments hastens soil erosion and eventual deposition in river beds.

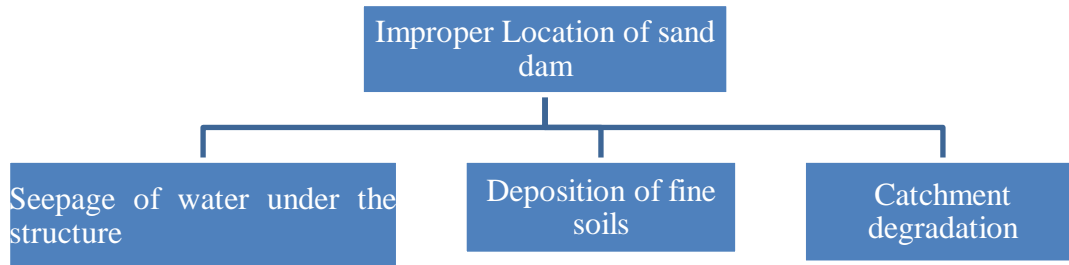


Figure 4.1: The inter-relationship and the consequence of improper locations of sand dams

Incorrect engineering design, quality control in the construction process of sand dams are some of the impediments in successful implementation of sand dams. Failure to construct structures which do not meet the required standards and specifications can lead to instances of concrete wall failure, leakage of water under the structures or through the concrete wall or under foundations due to not anchoring the foundations to the correct depth. Figure 4.2 shows the relationship with improper engineering design and construction can lead to leakage of the structure or structural failure of spillway concrete.

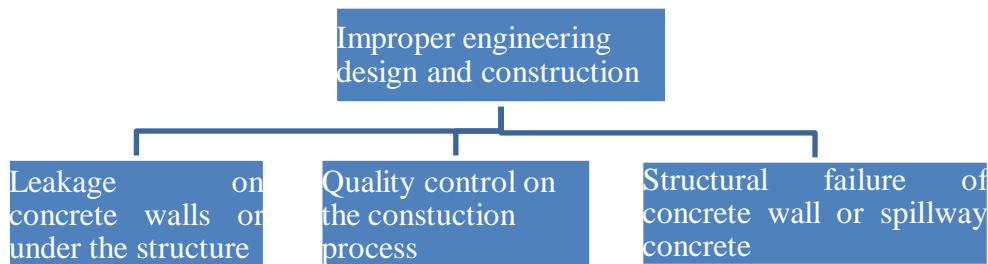


Figure 4.2: The inter-relationship between improper designs and the consequences

Incorrect site investigations or improper site investigations can have adverse and negative effects on performance of sand dams.

Figure 4.3 shows the interrelationship that exists due to improper site investigations, when sand dam are not properly sited especially in low coarse soil areas and in areas of unprotected catchments, there is high likely hood of accumulation of fine soils in river beds.

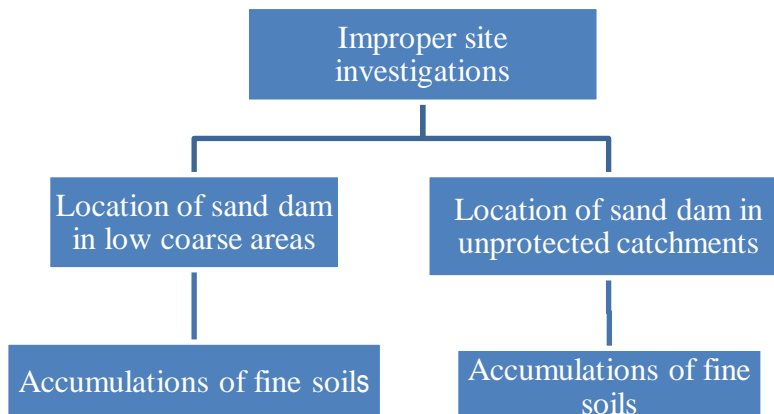


Figure 4.3: The siltation and its causes in sand dam locations

## VI. Conclusions

The challenges of performance and sustainability of sand dams is purely technical coupled with environmental factors which includes land use, catchment use and abuse and sand harvesting from these important river sources. In conclusion, performance of sand dams was not dependent only on community participation but there were other factors that contributed to failure or good performance of sand dams.

The overall challenges to sustainability for the sampled sand dams as established in the research study were:

- a) Land use coupled with Catchment degradations was observed in six out of nine sand dam's sampled;
- b) Site investigations Site locations, Operation and Maintenance; and
- c) Engineering Design and Constructions of sand dams.

In general site investigation, site location, Engineering Design, Constructions, Operation and Maintenance are essential and can be addressed adequately with the correct inputs at their various stages without being an obstacle to sustainability. The key challenge to sustainability of sand dams was land use coupled with catchment degradation Changes in land use, negative interference with the catchment leads to:

- Erosion and deposition of fine soils ( clay and silts) to constructed sand dams due to reduction in ground cover through cutting trees and other vegetation in the process of clearing for lands for cultivation;
- Unchecked Land sub-division with disregard to the effects.

In overall sustainability of sand dam can be achieved through community participation, site investigation and location, appropriate design and construction, operation and maintenance, environmental control through controlled sand harvestings, land use control and catchment protections. It is important to note in specifics that the key to sustainability is proper land use and catchment protection.

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