Sand dams or silt traps?

It has been known from the African Land Development Project (ALDEV) since the late 1950s, that the spillways of sand dams must be raised in stages not exceeding a height of 50 cm in order for floods to deposit coarse sand from where most water can be extracted. If a spillway is not built in stages, then silt will be deposited instead of sand and very little water, if any, can be extracted from such a sand dam - or is it a silt trap?

It is therefore disappointing to see that an NGO built two new sand dams near my home and the Kimuu Sand Dam at Kibwezi last year. Kimuu Sand Dam and another 5 sand dams were built by the Ministry of Agriculture in 1978-9. Five of these 6 sand dams were destroyed by floods after a few rainy seasons. Only Kimuu Sand Dam still exists but it has never supplied any water because its reservoir is filled with silt due to not building the 2.4 metres high spillway in the recommended stages.

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The Kimuu Sand Dam from where no water has been extracted ever since it was built!

Sadly, several hundreds of dams have been built in the same manner as the Kimuu Sand Dam, and are therefore basically silt traps instead of sand dams. More sadly, some NGOs are still continuing building sand dams in this hopeless way.

For the purpose of informing builders of sand dams to design and construct useful structures, the Kimuu Sand Dam was investigated and the result is hereby presented.

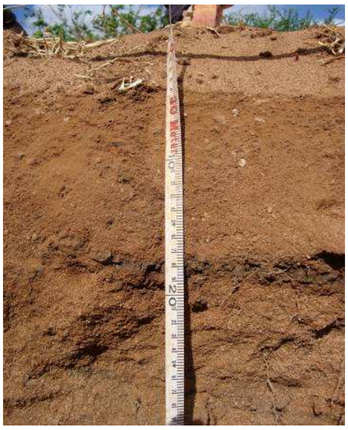
1) The dam wall is 36 metres long, and it has a 17 metres long spillway with a height of 2.4 metres. The height of the spillway is 0.6 metres below the height of the wing walls.

2) An 1.5 metres deep pit was excavated into the dam reservoir at a distance of 10 metres upstream from the dam wall.

3) 7 sand/soil samples were taken from different depths of the excavation.

4) Photos of the excavation in Kimuu Sand Dam

From the surface to 0.8 m down



Sand only in upper 0.2 m depth

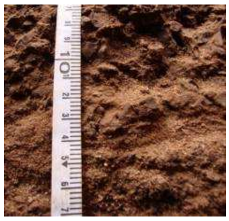
0.2 m depth

5)

0.8 m depth

From 0.8 m to 1.28 m down

Soil and silt below



Some sand in the soil below 1.5 m depth

Testing the samples

The 7 samples were analyzed by pouring 0.5 litres of a sample into a transparent plastic bottle and saturating each sample with 0.2 litres of water. After 6 hours of saturation, a hole was made in the bottom of each bottle and a glass placed underneath so that water could drain from the samples into the glasses. After 12 hours of drainage the volume of extracted water was measured as recorded below.

Extraction of water from the samples.

Summary of testing

Name of sample	Depth of excavation Metres	Type of sand/soil/silt	Volume of sample Litres	Volume of water extracted from the saturated soil samples after 12 hours Litres = Extractability
0	0	Coarse sand	0.5	0.08 = 16 %
20	0.2	Soil	0.5	0.01 = 2 %
40	0.4	Soil	0.5	0.01 = 2 %
60	0.6	Soil/fine sand	0.5	0.05 = 10 %
90	0.9	Silt/clay	0.5	0.00 = 0 %
120	1.2	Soil/fine sand	0.5	0.06 = 12 %
150	1.5	Soil/fine sand	0.5	0.06 = 12 %

Conclusions on Kimuu Sand Dam:

1) The 16% extractable water in the upper 0.2 metre deep layer evaporates in a few days.

2) The 12% extractable water below 1.2 metre depth cannot be extracted, and cannot be recharged, due to the compacted hard layers of soil/silt/clay above it.

Trial on a sand dam similar to Kimuu Sand Dam:

A trial was done on facilitating the infiltration of floodwater into a similar sand dam, rightly called '*Silanga ya tabu*' (Dam with problem), which had been built by MoA Kitui in the 1950s The trial involved the sinking of a wide-diameter well with infiltration holes and sand-filled trenches into the deepest part of the reservoir, but it failed to produce any noticeable recharge of the silted reservoir.

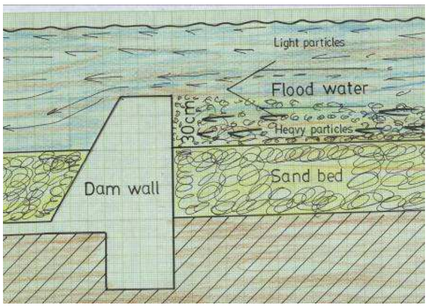
How the Kimuu Sand Dam should have been built

The purpose of sand dams is to store floodwater in the voids between the sand particles in dry riverbeds, seasonal watercourses, sand rivers, luggahs, wadis and ephemeral streambeds. Since the storage capacity of water in sand depends on the size of its voids, it is of utmost importance that the spillways of sand dams can harvest the coarsest sand from the floodwater passing over it. The table below illustrates the difference between silt and coarse sand:

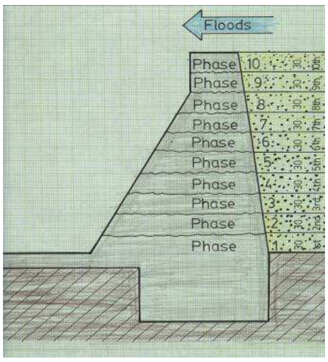
1) Extractability of water from sand

	Silt	**Fine sand**	**Medium sand**	**Coarse sand**
Size of particles mm	<0.5	0.5 to 1.0	1.0 to 1.5	1.5 to 5.0
Saturation by water	38%	40%	41%	45%
Extraction of water	5%	19%	25%	35%

Reference: '*Water from Dry Riverbeds*' by Erik Nissen-Petersen, 2006



When floodwater passes over a spillway, it will trap the heavier coarse sand, while the lighter silt will flow over the spillway on its way downstream in the riverbed.



The whole reservoir of a sand dam can be filled with coarse sand by raising the spillway in stages of between 20 and 50 cm height over each previous stage of level sand.

The height of the stages depends on the type of catchment area from where rains transport run-off material to a sand dam. A farmland catchment area will deposit quite fine soil and sand particles, and a spillway may then only be raised in stages of a maximum of 0.2 m in order to capture useful coarse sand.

Where a catchment area contains boulders, rocky hills or rock outcrops, which typically produce coarse sand, the spillway may be raised in stages of a maximum of 0.5 m.

2) Sand storage capacity

The volume of water that can be extracted from a correctly constructed sand dam depends on the coarseness and volume of sand that is contained in the dam. The maximum volume of extractable water is equivalent to 35% of the total volume of the sand. The volume of sand in a sand dam can be estimated using the following formula:

$$Q = \frac{L \times T \times D}{6}$$

where **Q** is the sand storage capacity, or volume, in cubic metres,
L is the length of the dam wall in metres at full sand level,
D is the maximum depth in metres, and
T is the throwback (maximum length of water surface) in metres.

Reference: *'Field Engineering for agricultural development'* by N.W. Hudson, 1975

The sand storage capacity of Kimuu Sand Dam can therefore be estimated as:

Sand storage capacity: $\frac{L\ 25\ m \times D\ 2.4\ m \times T\ 65\ m}{6} =$ 650 cubic metres

3) Extraction volume of water

The supply of water from Kimuu Sand Dam could have been:

35% water extraction capacity: $\frac{650 \text{ cubic metres} \times 35}{100}$ = **227 cubic metres** of water if the spillway had been built in 0.2 metre stages.

4) Conclusion on Kimuu Sand Dam

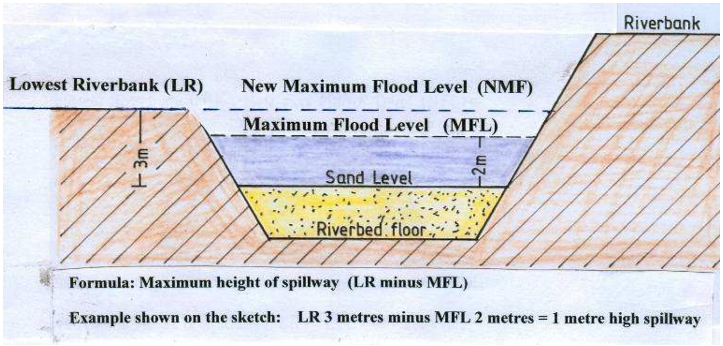
The failure of not raising the spillway in stages has resulted in Kimuu Sand Dam not having any water since it was built 32 years ago. It could have supplied 227 cubic metres of water after each flooding, and during the rainy seasons, in all those years.

Height and width of spillways in sand dams

The final height and width of spillways are critical for sand dams because:

If a spillway is too high and/or too narrow, the excess floodwater will pass around the lowest wing wall, remove the riverbank and create a new course, leaving the sand dam high, dry and useless.

This high spillway forced the floodwater to create a new course by removing the riverbank.



The recommended maximum height of a spillway can be calculated by deducting the Maximum Flood Level (MFL) from the height of the Lowest Riverbank (LR). The width of the spillway should be equal to the width of the surface of sand in a riverbed.

In this example the recommended maximum height of the spillway should be 1 metre because when the Maximum Flood Level (MFL) of 2 metres is deducted from the Lowest Riverbank (LR), which is 3 metres above the sand level, the result is 1 metre.

The Maximum Flood Level (MFL) can be found by interviewing long time residents of the area and/or by observing debris from floods hanging on branches.

The photo shows debris hanging on the fence from a flood that was double as high as the Maximum Flood Height. The sand was damaged by the exceptional high flood. This is one of many damages caused by higher density rainfalls due to climate change.

Nairobi 25 March 2011 Erik Nissen-Petersen