SAND DAMS: A CATCHMENT GROUND WATER STORAGE APPROACH IN ARID AND SEMI ARID LANDS.

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Introduction

Water is a mobile resource governed by the hydrological cycle. In the Arid and Semi-arid lands (ASALs) characterized by short to very short wet periods followed by long dry periods, water storage and conservation is a priority concern. Capturing and storing water during the wet season for use throughout the dry season minimizes the impact of droughts on the ASAL inhabitants. The stored water drives development, which cannot happen without water.

Constructed, in a series, in a drainage channel, sand dams create multiple water storage sites in a catchment. These sites facilitate infiltration and ground water recharge in both deep and shallow aquifers. The sand dams have the potential to store sufficient water for domestic use, livestock and minor irrigation. Trees and increased vegetation flourish in areas, which previously had been sparsely vegetated.

This paper describes an approach of capturing production water and its retention in a catchment through construction of sand dams. Kitui sand dam communities, using collective self-help principles, have instituted the approach over the past ten years. Most of the dams have matured.

Initiating Sand Dams

SASOL (Sahelian Solutions Foundation) started as a usual intermediation Kenyan NGO dealing with drought and capacity building in 1990. Initially, school water supplies were addressed through shallow well and roof catchment tank construction, to supply clean water for drinking and feeding at schools. Though the surrounding community could utilize the school shallow well for drinking water, it was evident that greater supplies were required by the community to satisfy their production needs. The community vocalized this. SASOL then developed the concept of production water using the sand dam technology.

When SASOL launched the Kitui sand dam programme, it was a leap of faith for it did not understand two key variables: community ability to invest in production water and the positive dramatic environmental and socio-economic changes, since the technology is so simple that nobody else had implemented it on large scale. Most of the ideas existing about sand dams in 1996, when SASOL did the pilot project on serial dams, were patchy and unconvincing at the technological and social levels. Further in a world reeling with technological advances of the 80's and 90's decades, simple structures had no place in the scheme of things.

The strength of the programme is firstly the belief that, though simple, underneath the simplicity is enormous underlying potential for social organization, which could be tackled on a dam-to-dam basis. Secondly, scarcity of water is usually associated with lack of drinking water, but the programme focused on green water and blue water in the longer term. Thirdly, the community was to be involved totally in the development in the sand dams as a platform asset on which the developmental processes can be built. The implication of this was that sand dam construction was an experiment in social engineering. This is based on several conceptual ideas found in tradition but tempered by the emergent social systems as well as choosing a project technology and a development strategy, which does not enrich poverty. The overall vision is to enable the Kitui poor to generate life and assets. This was to be achieved by relying on collective self-help, enhancing individual and collective accumulation thereby assuring growth through community control and distribution of access to development assets.

The ASALs

Arid and semi arid lands (ASALs) account for 80% of the land in Kenya (Thomas, et. al. 1997; 105, Republic of Kenya 2002. Other countries in Africa have similar proportions. Arid areas receive less than 400 mm rainfall annually whereas semi arid lands receive 400-1000 mm.

The ASALs are characterized by low rainfall coupled with high temperatures and high evapo-transpiration rates. In addition, the distribution of the rainfall, over time, is short to very short. Typically one to two month-wet periods are followed by long dry hot periods, ranging from three to six months. To compound this situation, the rain falls as high intensity storms usually. For example, the bulk of the rain might occur in only a few days. This results in excessive runoff and little infiltration into subsurface water storage. Both factors lead to massive water losses from recipient catchments.

In the ASALs, the bulk of the rivers flow for only a few hours to a few days after storm. Usually there is no flow as the wet season tails off. With the attendant high evapo-transpiration rates, typically in excess of 2000 mm annually, these are really harsh lands for survival. People and animals obtain water from deep scoop holes made in the sands of seasonal rivers.

The water situation in the ASALs can be improved markedly by use of water retention technologies facilitating aquifer recharge. Extension of the time rainwater is held, at a catchment where it falls, allows it to infiltrate into the soil, which has a large storage capacity. The stored water can be recovered for domestic use, through wells. Plants can also use it thereby increasing land productivity. One such water retention technology is the sand dams.

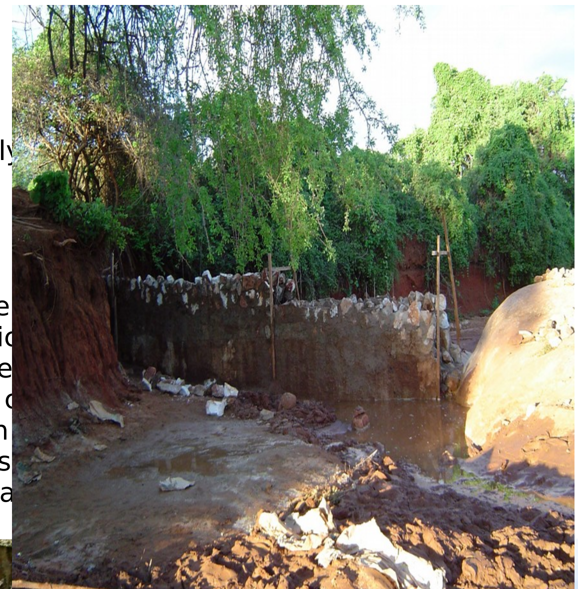
Sand Dams

A sand dam is an impervious barrier across an ephemeral river, which stores water and sand upstream.

This is an old technology, which has been used over millennia, since the Babylonian times. Unfortunately, it has not received the scientific study to legitimise its potential and to allow its extension. This has been to the detriment of the ASAL inhabitants whose water sources of last resort have over the years been natural sand dams. These are made of subterranean rock bars or clay formations across the seasonal rivers, which form the impervious barriers. Water collects in the subterranean reservoirs made by these barriers. By scooping out the sand in these areas the inhabitants of the ASALs have used water from the reservoirs as their water points of last resort for domestic and animal use.

These reservoirs are deep lying are few and far apart in Kitui geological areas formed out of basement rocks. They are////////////in volcanic and //////////in sea uplift areas. In the basement rock systems, this means that, to reach the scattered underground water sources, a great deal of time and energy is spent to collect only a few litres of water. Humans and animals have to trek many miles to water sources. Humans use much energy and time. This leads to less energy for other development activities over and above leading to poor health. Equally significant, animals loose body weight and get many diseases as they congregate on few sources. They get to water only two or three times a week and often it is inadequate.

Using the same principle of natural sand dams, man-made dams can bring the water level close to the surface of the riverbed and distribute sources to minimize trekking and the attendant energy losses. For dams to be effective, it is necessary that the foundation of the dam be on an impervious layer in a riverbed. Blocking base flow, through the overlaying sand, facilitates percolation into the riverbanks and the surrounding areas. The result is the uplift of the water table of the reservoir channel and surrounding areas, which form an extended reservoir.



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Dam Reservoir Filled with Water

Mature Dam at Kwa Kang’esa

Centrality of Cascades Of Dams

Sand dams, which were built in the 1950's e.g., Mukongwe (S 01° 26.8′ E 38° 3.4′) on the Mwiwe River and Uvati (S 01° 28.6′ E 38° 00°) on the Kiindu River, have served as sources of last resort for many inhabitants in their vicinities. This put ecological pressure on the areas adjacent to the dams.

Making a cascade of dams at distances between 500-3000m between dams, as determined by the gradient of the river, distributes the water points and decreases ecological pressure on adjacent lands. Instead of the water being held at one site, it is spread throughout the channel. In essence, a cascade of dams creates a continuous aquifer. This decreases distances to water for the inhabitants and increases enormously the amount of water in the channel. A study (Muinde et al, 2004) at Syonganga on the Kiindu river, covering seven dams from Uvati (S01° 28.6, E 38°.00); Nzemeini; Kwa Manya; Kwa Langwa; Kwa Ndunda; Kwa Kange'sa; to Syonganga (S01° 26.7' E 37° 59') a distance of 5km upstream affirms this. Since its construction in 1957, Uvati sand dam has been the principle supply of water in this area. The six other dams included in the study were constructed in 1997. In 1997 water could be abstracted only up to 500 meters upstream of Uvati dam site. Currently water can be extracted anywhere along this 5km stretch of the river. During the dry season, water is within 50 cm from the surface of the sand. Both distribution and increased availability have been achieved over and above the attendant environmental protection.

Criteria For Dam Site Selection

Based on the experiences garnered by SASOL in the process of construction of over 350 sand dams in Kitui, the following criteria for site selection have been developed.

1 (a) The site community must pick a site of choice which is appropriate and acceptable to all. This ensures participation in site development.
(b) The selected site can be shifted for technical reasons in consultation with the community.
2. The site must be easily accessible ideally close to an access road for ease of water abstraction for domestic use.
3. Adequate amount of local material stone and dam must be present within 1 km from the site. Water required for construction must be available within 5 km during the construction period. These have a major influence on dam construction cost and time.
4. The geology of the river must be suitable and soils must be firm enough to anchor the dam wings. An impervious base for laying the foundation is necessary. Bends are liable to be eroded creating bypasses.
5. There must be sufficient reservoir volume. A small gradient will create a large reservoir and more recharge increases the size of the reservoir.
6. At least 30 households should participate in a site development for provision of labour at the site.
7. The community must provide a store for cement and reinforcement material. Ideally, the distance should be not more than 1 km from the site to cut daily material transport costs from store to site.
8. Scoop holes are an indicator of a natural sub-terrain barrier on the downside. Scoop holes, which provide water during the dry season, indicate a good site for development to enhance the water supply.
9. Possible natural barriers downstream of scoop holes that yield water for long periods after the rains can be used far laying dam foundations.

Drought Mitigation

The major problem of the semi arid lands is not the absolute lack of precipitation. It is rather the nature of the precipitation, which results in the loss of the received precipitation from a catchment through runoff.

Instituting measures, which retain and conserve the received precipitation in a catchment is the only way to improve the situation. Water conservation is a water resources management tool used to ensure its availability at the area where it falls. Sand dams constructed in a catchment drainage channel provide a final line of defence to diminish water loss form a catchment. Their presence in a catchment ensures that part of the water loss is contained.

The size of the sand reservoir is not only that of the channel. It includes the zone of soakage into the surrounding soil. Established shallow wells and piezometers show this zone, which has the same water table as observed in the channel to be quite extensive (Frima et al 2002) in excess of 100m from the banks. Furthermore the water table is continuous both on the upper and lower sides of the dam.

When built in isolation a single dam is effective in capturing water in the reservoir formed. Constructed in a cascade there is a synergistic effect, hence large amounts of water are stored in the channel. The stress on an isolated site is reduced due to the hydrostatic head created in the adjacent sites in the cascade.

Stabilization of the water levels at the channel where the bulk of abstraction occurs is due to the large external reservoir. During the wet season, when the river flows, there is a sideways flow from the channel recharging the extension reservoir. As the dry spell sets on and abstraction from the channel continues, there is backflow from the banks towards the channel, hence maintenance of the high, levels observed in the channel throughout the dry periods.

Environmental Impact

The greatest environmental impact of sand dams is the permanent water availability. After construction of the sand dams, the water table has risen close to the surface of the riverbed in Kiindu and Kyuusi rivers (Musembi and Katumo, 2000). Perennial stoloniferous grasses have colonized the rivers and reeds protect the soil from erosion and minimize direct evaporation from the sun. Woody species along the river channels remain permanently green due to all year round availability of water. Tree nurseries, which supply seedlings for reforestation in catchments, have been recorded at many dam sites. Irrigation farming of vegetables, especially during the dry periods and thus extending land use, has increased. This illustrates a basic ecological function of water of sustaining biodiversity as well as creating new income streams.

Socio – Economic Impact

The primary impact of sand dams is the availability of water all year round at shortened distances from the households. Portable water from the dams is obtained from off take wells constructed at the side of the dam in the extended reservoir. The time saved on water chores is invested on more productive activities. Soon after the dams receives and retains water, there is transformation of community activities and time use. Those who are nearest to the dam start growing vegetables by bucket irrigation and indeed let out some of their land to other tenants. Other people start brick making for building, using the dam water. Yet others start tree nurseries to produce tree seedlings for out planting. In effect the dam acts as a base asset for the site community of which each member of the community should gain.

As the land around the dam site appreciates in value, due to the availability of water, the site community embarks on improving their individual lands in the catchment. By preventing runoff on the land and instituting water harvesting on their land holdings, crop productivity increases. Food security improves due to the enhanced productivity. Availability of seedlings facilitates planting of high value fruit crops and production of other tree products.

Incomes and health of sand dam site communities improve quite markedly as shown by (Isika, Muyanga 2001).

Conclusion

SASOL has been building dams in Kitui for mitigation of drought in Kitui communities during the past decade. In the programme areas there has been enhanced groundwater. The results so far show marked improvement on availability of water throughout the year for these communities, who no longer experience water stress. Studies carried out on the programme indicate that there are:

1. Positive environmental impacts which are bound to increase in the future as runoff control measures are instituted in the respective catchments.
2. There is increased productivity on the land, including livestock production.
3. Production of vegetables and fruit has impacted positively on the health of the community.
4. The standard of living for the dam communities has improved as a result of the new income streams.
5. The dams hold more water than originally anticipated.

Despite the progress made so far in this programme towards understanding the function and impacts of sand dams, much work remains to be done. When completed this initiative will enable many more people living in similar conditions avoid the frequent droughts and even prosper.

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