THE SIGNIFICANCE OF SUB SURFACE WATER STORAGE IN KENYA

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BACKGROUND

Over 80% of Kenya is made up of ASALs (arid and semi-arid lands), (Thomas, et al, 1997:105; Republic of Kenya, 2002). According to the *1999 Human Population Report* an estimated 12 million people lived in the ASAL districts. This constitutes about 36% of the country's population in the same year, of these 20% live in the arid districts"(*National Policy For The Sustainable Development Of The Arid And Semi Arid Lands Of Kenya;* Republic of Kenya, OP, September 2003).

Arid areas receive less than 400mm of rainfall annually and the semi-arid areas receive between 400 –1000 mm annually. Low rainfall, strong variations in rainfall through space and time, high temperature and high evapotranspiration rates characterize these areas.

The topography in the ASALs is gently sloping (usually less than 5° gradients). Soils are usually sandy, fragile and highly erodible. The ASALs lie at low elevations of less than 2000m above sea level and usually have many sandy seasonal streams. Water points in these areas are few and far apart; in some places people and animals have to walk 30km to the nearest water point during the dry season.

The distribution of the rains is very skewed with short to very short, 1-2 months, wet periods twice a year. These are followed by long hot and dry periods. The wet periods are also erratic for one in three rainy seasons is below normal. Occasionally rains fall as high intensity storms resulting in high runoff and thus, low infiltration. Such storms carry off a lot of the highly erodible soils.

The low rainfall, together with the high evapotranspiration, coupled with water lost in run off from catchments where precipitation occurs, greatly reduces the inherent biomass potential of that area. It is in these regions that water harvesting is of paramount importance for it holds the key to improved water supply.

BULK AND PRODUCTION WATER

The people living in the ASALs need two categories of water i.e. bulk water for domestic use and watering their animals and production water for producing their food and animal pasture. Though the ASALs in Kenya are harsh, they produce between 64-80% of all livestock products in Kenya. Figures for crop production in the ASALs are not available but ASAL dwellers produce most of their food and have a balance to sell to the towns. (GoK, 1990). Provision of water in the ASALs will therefore increase the production potential of the ASALs and by extension improve the livelihoods of people in ASALs. Since there are no permanent surface or reliable aquifer sources of water, which are likely to be found, the solution to ASL water shortage lies in the maximum use of the received precipitation in catchment areas.

RIVERS HAVE NO WATER OF THEIR OWN

The key water planning and utilisation issue in the ASALs is not in the absolute amounts received but of how much is retained in the area of precipitation. If a substantial portion of the received precipitation is retained in catchments, the availability situation would be greatly improved. It is usual to see rivers in full flow spate after a rainstorm, but rivers have no water of their own, all their water is run-off from the surrounding lands. It is on record that about 70-90% of the precipitation received in the ASALs is lost through run-off into the drainage channels (Thomas, 1997).

Only about 20% of the precipitation percolates into the soil and is useful for production.

Unless water-harvesting techniques are extensively implemented, and soon, the situation will progress from bad to worse in the near term. Conservation measures taken on the land in the catchments will hold water on the land long enough to allow percolation into sub-surface soil storages. Water will be released slowly from these storages into the river channels thereby reducing storm flows and their damage. The result will be extension of the length of time the soil remains moist for production.

OPTIMISATION OF LAND USE

Water is the limiting factor of production in the ASALs. It is difficult, therefore, to imagine how development will proceed without stable water supplies in these areas. The role of water is central as a precursor to investment in the land for production.

In the ASALs, water is a major limiting factor of production. This is not due to absolute lack of precipitation, but mainly due to low retention in storage structures of the soil. Of the received precipitation, as much as 70% is lost through surface runoff. (Rowland, 1993).

A further significant amount of the received precipitation is lost through evaporation due to factors such as inadequate ground cover and open storages such as surface dams. As a means of increasing and realizing land potential in ASALs it is paramount that the water holding capacity of the soils must be improved. This obviously would involve the removal of factors, which hinder water retention capacities of the soils. Thus, surface run-off must be checked, water retention structures constructed and maintained and vegetation enhanced to provide ground cover and improve water circulation through evapo-transpiration. All these factors will ultimately influence the frequency and distribution of local precipitation.

The role of evapo-transpiration in a localized precipitation scheme is largely ignored. The phenomenon works through the build up of humidity above localized vegetation, which, combined with the moisture from the reservoir sources of the hydrological cycle such as lakes, seas and other open water bodies, leads to the formation of clouds and resultant precipitation. It is deemed that the major part of the rainfall in the forest arises in the manner (Dupriez and Leener, 1998).

Since the frequency and severity of droughts, in many ASAL areas, has increased in the recent past, surface water storage will continue to suffer severe losses due to the high evapotranspiration rates. Sub-surface water storages therefore become much more important in the ASAL areas of Kenya.

LOOKING INTO THE FUTURE

The future should be a situation where several different methods of capturing and storing water from the received precipitation are employed. The synergetic effects created will greatly outweigh the intensification of any single method, however, efficient it might be.

Conservation and management of water on the land, using terraces and contour bunds, will slow down runoff from agricultural lands improving crop and pasture production. Sand dams on the river channels will store bulk water for domestic use and watering of livestock. Bulk water in the dams can be used in growing tree seedlings for re-vegetation. When the trees grow, they play their part in the control of runoff and increase percolation, thereby increasing productivity of the land. The trees and other plants, which grow in the area, add to the stored energy due to evapotranspiration thereby facilitating trapping and storing energy from the sun.

Such a situation will also save the total energy in the system. This energy can be utilized for further development of the system. For example, the calorific and time saving on water chores, which is highly significant, if average distance to water sources for households is reduced from 10km to 2km, could be invested in improving production of the land by instituting more water conservation measure.

The catchment approach is the best system to achieve these aims. For the purposes of water harvesting, and recharge, a catchment is defined as an area bounded by water sheds draining into an outlet. For effective management, large catchments should be divided into smaller units. The main objective in the catchment should be to retain as much water as possible in the catchment to allow percolation, reducing run-off and erosion, whilst allowing excess water to drain off with minimal damage.

All the land belongs to a community. In most rural areas it is their most important resource. Thus, improvement and optimal use of this land is the basis of development. For the recharge systems to be effectively utilized, the community should be the starting point and be fully involved in the planning and execution of development activities.

RECHARGE TECHNIQUES USED IN KENYA

The population explosion in the ASALS, driven by natural increase and in-migration, has necessitated the capture and storage of water. in the ASALs by the new settlers. The survival of this population, estimated as 45% of Kenya's population, is tied to water as it is to air and food.

Since plant growth depends on water flow from roots to leaves, food production is reliant on ground water. Meaningful development is therefore, depended on the ability to capture, store and use the water efficiently and efficiently.

With the increased pressure on land in Kenya, ASALs production has shifted from agro-pastoralism to crop agriculture even though rainfall is erratic and water loss through runoff is also high. Surface run-off, harvested in these areas, is increasingly being used for crops and the limited livestock. With the increased drought frequency and severity of droughts from the 1970s to date, there has been an increased awareness of water harvesting in Kenya. (Thomas, 1997).

There are several techniques used for water harvesting for recharge of ground water in Kenya. Among them are:

Trash lines: These, made of crop residues, are simple and easy. They are effective on low gradients. Grasses and weeds establish along the trash lines and stabilize them in about 2 years. The soil trapped, reinforces the lines.

Grass strips: These are developed by leaving strips of un-ploughed land with or without seeding with grass. As in the case of trash lines above, water and soil is retained along them.

Micro catchments: These are several types of different types of collecting pits, which are used for the establishment of trees and growing of high value crops such as bananas and fruit trees.

Contour ridges and bunds: These are furrows constructed on the contour by throwing the soil downwards. They can be made of earth or stone. They store water in the excavated area. Crops in this system record greater yields especially in seasons of sub-normal rainfall.

Retention ridges: These are large ditches that are designed to catch and retain all incoming runoff and hold it until it infiltrates into the ground (Thomas, 1997:98). They are used where runoff from roads is diverted onto cultivated lands.

Terraces (Fanya Juu): The Fanya juu terrace is made by digging a ditch and throwing the soil uphill to form a barrier ridge. The barrier ridge retains water and soil. They are used to improve retention and control erosion on cultivated lands thereby improving crop production.

Earth dams and pans: These are raised banks of compacted earth, built at the downstream end of a hollow. They are liable to rapid silt up if the catchment is not conserved or denuded by animals. Many examples exist where the structures become completely dysfunctional in ten years. Due to high evaporation, a lot of the water stored in them is lost.

Sand dams: building a wall across a riverbed makes these. The wall traps water in the river's sand. They loose minimal amounts of water due to low evaporation of the trapped water. They not only have a long life but also have high lateral and vertical recharges thereby creating shallow artificial aquifers.

KITUI SAND DAMS: LOW LEVEL TECHNOLOGY FOR SUB-SURFACE RECHARGE

Definition

A sand dam is an impervious barrier across an ephemeral river, which holds water and sand on the upstream side.

Significance of Sand Dams

Although the sand dam technology has been known for 3000 years since the time of the Babylonians Kingdom, it has been used only slightly in history. This might be because it is a low-key technology and there is not grandeur to it. As a result it's full capacity has not been realized and developed even though it is one of the major systems for aiding arid and semi arid lands communities.

Seasonal streams abound in the arid lands in large areas of Kenya, which after the water flows away, are left full of sand. It is in these streams that sand dams can be made. When many of them are made along a stream, the ecological pressure, which would have been placed at a point, if only one water source was made, is spread out. People and animals have their water nearer to homesteads and a wider area is influenced by the local retention of water. This then is the significance of this simple technology.

Sand dams have mainly been constructed in Eastern Kenya. Fewer numbers of dams are found in Western and Northern Kenya.

Sand Dams and People Participation

The participatory methodology is used in the Kitui sand dam programme. Communities build the dams with SASOL as a facilitator. The driving force for the program is the communities desire to invest in their water resources to meet their domestic and production needs.

Location, Design and Construction

The location of a sand dam should satisfy the following pre-conditions: that it is feasible on technical grounds, that it has high storage capacity at a minimum cost and that it is conveniently located from the user community point of view.

When the location of the dam has been selected, the site is excavated to reach a firm impermeable layer in which the dam may be founded. This base may be base rock, clay or murrum and is usually uneven. Only then can the base of the dam be mapped out, a profile and other dimensions made. These include: dam length, dam crest length, and height of dam. A design is made for the dam, allowing unimpeded peak river flow. A bill of quantities is then made based on the design.

Where rubble stone is available, as is the case in Kitui in Kenya, masonry made sand dams is the norm. They are relatively cheap, have a long life and have low maintenance. Some sand dams made fifty years ago, in the district, are still functioning without repairs so far. There are two construction techniques. The first option is to build wall facings, which are filled with rubble stone and mortar. The second option is to construct a timber formwork, which is filled with stone and mortar.

Other materials for dam construction include plastic foil, galvanized iron sheets and clay lugs. These are used where stone is not readily available.

Hydrology of Sand Dams
Currently the view held for water yield from a sand dam is a function of the volume of the sand in the reservoir and extractability of water from sand. The basic assumption is that the sand dam only holds water in the sand. SASOL, however, has always argued that there is much more water held in the dams than that in the sand. In a recent study (Gathuru, 1990; Frima, et al, 2002), the water table was found extend almost horizontally into the banks for distances up to 200m on either side of the dam and 500M upstream. Downstream the water table is lower but equally extensive. Thus the dams hold more water than previously reported in the literature

Synergies Created by Sequential Dams
A series of sand dams built on the same channel have a greater effect on the channel per area and volume of water stores than single dams. As stated earlier, the ecological damage resultant from using a single point water source is avoided. A cascade of dams is more likely to raise the water table higher than a single unit. Further, the rise of the water table is continuous along the channel and recharge into soil storage spaces is hence much more effective.

Cost of Sand Dams
The cost of a 60M^3 sand dam in Kitui, with a minimum life of 50 years and a yield of minimum 2000 M^3 is 6000 Euros. This is equivalent to 6 tanks of 46 M^3 at 1000 Euros each.

Evidently it is cheaper to build one sand dam, which will serve 50 households, even through drought years, at the cost of 6 tanks, which would serve only 6 households without forming a bridge between the dry periods.

Advantages and Limitations of Sand Dams
Storage of water under the sand has many advantages. First, evaporation is limited. Second, they occupy low value land. Third, recharge is automatic and immediate after a storm. Lastly, the structures have low maintenance.

The main limitation is that the yield is determined by the quality of sand and the surrounding soil properties.

The Effects of Sand Dams
Sand dams retain water thereby facilitating infiltration into the ground and sideways into the banks of the channel. Since infiltration into the soil is a factor of time and nature of the soil, sub-surface storage of water is extremely important especially in the ASALs where the rain seasons are relatively short and rain falls in storms.

As the water table rises in the drainage channel the subterranean flow from the surrounding area into the channel is slowed down, as a result of changes in the hydrostatic head. This water is available for plants.

The readily available water in the sand dam firstly increases the amount of water available for domestic purposes, and reduces the amount of time spent on water chores. It facilitates the installation of improved extraction methods such as improved off take wells there by leading to better quality water.

Second, people start to use the water in the dams for small- scale bucket irrigation. In some cases larger scale irrigation systems have been developed with pumps and storage tanks being used. The vegetables improve nutrition of the population. Improved agricultural practices increase land values and prompt the community to further improve their land through conservation of water which in turn increases the yield of the sand dam.

Third, during the second and third year of the dam life, the community is sure the water in the dam will last all year round. This facilitates tree seedling raising leading to replanting and introduction of tree products as economic goods.

Fourth, as the dams mature, in about seven years, wetland crops colonise the river channels. Most of these are fodder crops for livestock and thus enable the populations to diversify by adopting improved livestock breeds, especially for milk. This in turn makes a major contribution to local diets. Simultaneously, in adjoining lands, the high water table leads to improve subsistence crops.
In the median and long term all the effects impact on the food security and incomes of the communities in the catchments where there is systematic construction of sand dams.

CONCLUSION
Sand dams render a low-level technology, which is cheap to make with available resources by the ASAL communities. This technology enables them to solve their water problems and improve livelihoods. Thus, it is recommended that sand dams be implemented on catchment basis systematically and sustainably to fight the poverty endemic in the ASALs.

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