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Recharge Techniques and Water Conservation in East Africa



Up-scaling and Dissemination of the good practices with the Kitui sand dams

POSITION PAPER AND PROJECT PROPOSAL

1. Back ground
2. The Kitui Sand Dams
3. Up-scaling and Dissemination
 - 500 new dams
 - Hydrologic, environmental and socio-economic evaluation
 - Dissemination seminar
 - Overall objective and linkages
 - Cost estimates

Appendices

- I The significance of sub surface water storage in Kenya: the Kitui experience
- II Project summaries and cost estimates

1. BACKGROUND

Storage of water to bridge periods with low rainfall and dry rivers is a key element in securing water supply to rural and urban populations. This is particular the case in semi-arid and arid regions outside the reach of perennial rivers and where there is no groundwater available. Storage needs are sharply increasing due to growing population and water demand, catchment degradation and changes in climate variability. Provision of sufficient storage capacity will be main challenge for water managers in reaching the Millennium Development Goals

For urban water schemes the solution may also include the construction of dams and/or long distance conveyance of water (from a dam or from a river or far away groundwater reserves), but for rural water supply such solutions are too costly and complicated. Storage provisions for rural water supply require low cost systems with easy maintenance that can be constructed and operated with a high degree of community involvement. Such water conservation systems generally use the subsurface as storage medium or small tanks (underground or surface tanks) to store excess water from rain, river streams or surface run-off.

Water conservation (or water harvesting) techniques are known since ancient times in arid and semi arid regions for example in the Middle East (ACSAD, 1998). Also today there are numerous examples of rural communities, often with the help of NGO's and local water authorities, which have developed such systems in many countries. These systems include a variety of recharge and storage techniques and include both rainwater harvesting and conservation of surface run-off through (direct or indirect) groundwater recharge (IAH, 2002). In this paper we focus on the conservation (recharge) and storage of run-off water.

Although based on the same principle, the technology used in different countries or regions is generally adapted to the site specific (hydro-climatologically and socio-economic) conditions. This is also reflected in the different names used in different regions for almost similar technologies. Adaptation to the local circumstances is an important element for the success of these community based systems, but has the side effect that often no use is made of existing good experiences in areas with comparable conditions (reinvention of the wheel effect). This effect has to sides:

- in areas where water conservation schemes are developed there is generally no incentive to explore if use can be made of experiences elsewhere and
- in areas where good practices exist, there are generally no triggers to disseminate these experiences

Community based water conservation systems are generally cost effective but serve a small number of families (20-50). The significance of this type of solutions is largely determined by the number of systems that are installed on a regional or national level. The challenge is to develop an effective strategy to accelerate the construction of the systems without affecting the community based approach. Such a strategy should be based on an exchange of existing experiences and the dissemination of good practices.

2. THE KITUI SAND DAMS

One of the successful examples of a rural water conservation programme is the construction of sand dams in the Kitui district in Kenya. This programme is a co-operation between the community and the Sahelian Solution Foundation (SASOL). SASOL, founded in 1990, assists Kitui communities to address household and production water scarcity through the sand dam technology.

The planning objective was to shorten the distances to water sources to below two kilometres whilst making water available for alternative production systems. Typically, women walk 10-15 km to water sources in the district. To date, 320 dams have been constructed in central Kitui. The key success factors of the Kitui sand dams are (i) the high degree of community participation in the planning and construction and (ii) to concept of cascades (many dams constructed in one river bed), creating a substantial volume of storage in a small area and hence reaching a larger part of the population. Details of the Kitui sand dams can be found in appendix 1 and the references.

3. UPSCALING AND DISSEMINATION OF THE KITUI SAND DAMS

Siting and construction of 500 more dams

SASOL has the intention to scale up the activities in the Kitui area with the construction of 500 new dams. The proposal for this new construction phase is under preparation (Appendix 2). The funding for this new phase could come from different financing sources as its implementation can be planned in batches. The total duration of the project is expected to take 5 years. One of the preparatory activities for the new project is a geological and hydrogeological reconnaissance study to site the locations of new dams. Some of the new dams may be constructed outside current stream beds into ancient (buried) river beds.

Evaluation of the existing dams

The functioning of the current sand dams and its positive socio-economic impacts are confirmed by SASOL through their internal evaluation and monitoring system. The different papers produced by SASOL clearly illustrate the positive impacts on poverty alleviation, income generation and health. But with completion of over 300 dams and the planned upscaling with another 500 dams, there is a need for a comprehensive hydrological, environmental and socio-economic evaluation. The hydrological study would include a monitoring campaign of at least one year in a number of the mature dams to verify how far the groundwater has migrated in the river banks and how much water is stored behind a mature dam (and its seasonal fluctuation). The hydrological evaluation will also quantify the effectiveness of the cascade approach and shine light on the question how much run-off water is intercepted and what the impact is on downstream users. The environmental evaluation will be conducted according to international EIA guidelines and include an evaluation of the water quality, its pollution hazards and possible pollution protection measures. The socio-economic study will collect complementary field data to quantify the economic impacts on household/village level as well as the impacts on the District level.

The evaluation will serve an important background document to justify the investments in up scaling of the sand dam construction in the Kitui District and adjacent districts and including the proposed 500 new dams proposed by SASOL.

Dissemination workshop

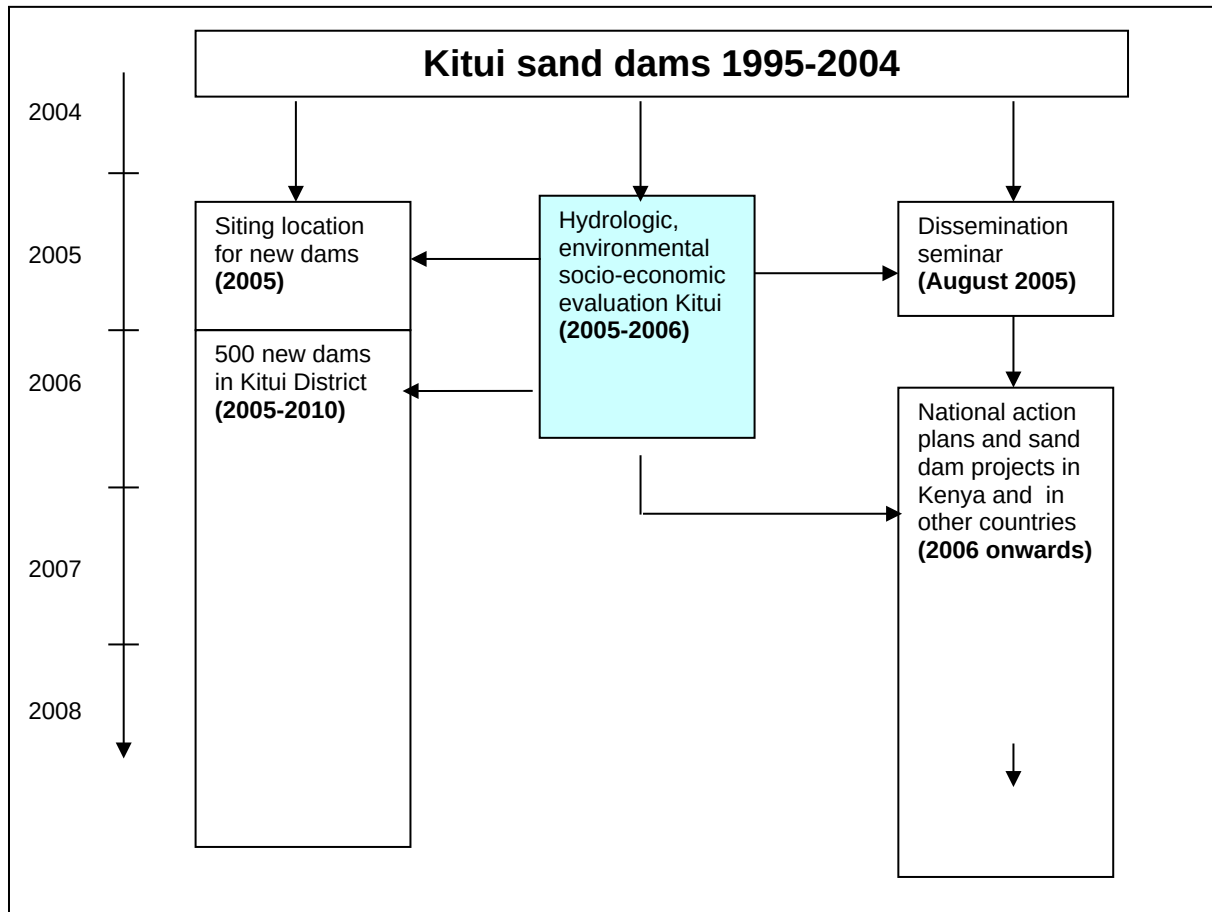
The evaluation study is also a strong tool to extract the good practices and generic elements from the SASOL experience and use it as an input for regional workshop aimed to initiate similar programmes by NGO's in other provinces in Kenya and in the neighbouring countries and to develop promote the construction of sand dams becomes part of the national water resources management strategies. The workshop could also be used to share experiences with countries outside the region and to establish a global sand dam network. Details of the proposed workshop are provided in Appendix 2

Overall objective and linkages

The three proposed activities are linked in the sense that they are all directed the overall objective which is: the scaling up of community based small water supply schemes in order to reach more consumers but without affecting the sustainability of the community based approach.

Figure 1 shows the inter relation between the three activities and the preferred timing. The evaluation serves both the preparation of the 500 new dams project in KLitui and the dissemination seminar. It should preferably start in March 2005 in order to have the first outputs ready fir use in the seminar. The timing of the seminar is at the end of the longest dry period and hence the best suitable time to demonstrate the functioning of the dams to the participants of the seminar.

Figure 1: Projects and linkages



Financing

The cost estimates for the four projects described above are given in Appendix 2. The projects will be managed by SASOL and Acacia and implemented with the help of third parties. Both Acacia/IVM and SASOL have a limited budget available for the implementation and are exploring additional finance to cover the project cost. Table 1 gives a summary of the total cost, our contribution and the remaining funds to be covered. The projects may be redefined or phased depending on the type of financial support that is received.

Table 1 Project components and financing

Project	Leading partner	Total cost	Contribution SASOL	Contribution Acacia/IVM	Contribution from other sources
Siting 500 new dams	SASOL	50,000	5,000	5,000	40,000
Evaluation existing dams	Acacia/IVM	190,000	5,000	15,000	160,000
Construction 500 new dams	SASOL	4,100,000	1.800,000 (incl. contribution of the communities)		2,300,000
Seminar organization and logistics	SASOL	100,000	10,000		90,000
Seminar content	Acacia/IVM	60,000	5,000	5,000	50,000

References

ACSAD (1995); "Rainfall Water Management in the Arab Region" State of the Art Report, ROSTAS, Cairo

IAH-NCC (2003), "Management of Aquifer Recharge and Sub Surface Storage, *Making use of our largest reservoir*". Seminar 18-19 December 2002 in Wageningen, The Netherlands. A – attached as appendix 1

Appendix 1

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). The Kenya Government states as follows: "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 50 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 surfaces 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 runoff, 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 (see box):

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 60M³ sand dam in Kitui, with a minimum life of 50 years and a yield of minimum 2000 M³ is 6000 Euros. This is equivalent to 6 tanks of 46 M³ 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 sustainable to fight the poverty endemic in the ASALs.

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Appendix II Project description and cost estimates

1. Dissemination Seminar

The proposed seminar is a regional workshop in Machakos (1 hour from Kitui) with the following objectives:

- to present the Kitui experiences as a detailed case study in which all the success factors and pitfalls of the programme are addressed
- to exchange these experiences with the participants and explore the generic elements of a successful approach and the elements that are location specific
- to develop a strategy for local communities and NGOs in selection of the technology and for the implementation of water conservation programmes
- discuss the embedding of the strategy in the national water policy
- to discuss financing options (credit system, community contribution, grants)
- to discuss the need for a permanent structure for exchange (global network)
- to assess the need for (technical and institutional) support to NGOs/communities working on water conservation development on water (helpdesk function).

The main target audience for the workshop is NGOs working in rural water supply in the East African region (Kenya, Tanzania, Uganda and Ethiopia) and representatives from the national water ministries of these countries.

In addition we propose to invite a selected number of persons from countries outside the region where water conservation is widely applied (India, Brazil, South Africa, West Africa,) to share the practices in these countries with the experiences in East Africa.

Expected output

The desired output of the workshop should include:

- Strategy and action plans for the participating countries and NGOs to start (or accelerate) the construction of these systems
- A (global) network and strategy for exchange of experiences and good practices aimed to support the accelerated construction of community based water conservation systems

Workshop organization

Some preliminary ideas concerning the preparation and implementation of the workshop

- Length appr. 5 days
 - o day 1: general introductions, Kitui/SASOL case study
 - o day 2: exchange of experiences
 - o day 3: field visit to Kitui
 - o day 4: strategy formulation, action plan and follow up support
 - o day 5: link with national water policy, financing issues / proposal to establish a global water conservation network/ summary and closing
- no. of participants :

o 5 NGOs from each country , 2 persons per NGO:	40
o 6* 2 national water planning representatives	12
o International NGO's, donor agencies etc	10
o Representatives from other countries	10
o Others	10
- Total between 75 and 100 (maximum)
- Venue: proposal is Machakos (accommodation available and close to Kitui)
- Timing: in the dry period: August/September 2005
- The workshop should be output oriented and be a real working meeting. Therefore the program should be well prepared and moderated by a professional person (from Kenya)

Preliminary action plan and cost estimate

Cost items to be covered for preparation, implementation and follow up of the workshop:

- approaching organizations participation and financing of the workshop
- logistical preparation (selecting and approaching participants, workshop design, venue and accommodation, circular and inviting participants, travel arrangements, selecting moderator, fieldtrip, social programme)
- Preparation of status report on the experiences of SASOL in the past 5 years with special emphasis on the (technical and institutional) successes and problems encountered. This report serves as the basis for the case study (day 1)
- preparation of detailed workshop programme
- implementation of the workshop (including travel and accommodation cost for participants, cost for venue, moderator, fieldtrip, social programme,
- follow up activities (preparing and printing, other follow up activities)

Estimated cost:	€
<i>Organisation and logistics</i>	
Participants; accommodation and DSA (100*5*50)	25,000
Participants: travel cost (100 * € 250 at an average)	25,000
Local transport an field visit	10,000
Secretariat (sub contracted in Kenya)	20,000
Moderator (Kenyan, 2 month @ € 5000)	10,000
Miscellaneous and unforeseen	10,000
	=====
Total	100,000
<i>Contents (preparation, implementation and follow up)</i>	
International experts (8 weeks @ € 4000)	32,000
National experts (4 weeks @ € 1500)	6,000
International travels and DSA (4 * € 2500)	10,000
Miscellaneous and unforeseen	4,000
	=====
Total	50,000

2. Hydrologic, environmental and socio-economic evaluation

The hydrologic evaluation includes an assessment of the effectiveness of the dams in terms of water storage. All dams will be inspected and 3-4 representative mature dams will be selected for a detailed inspection of the size of the aquifer, the infiltration rates, the inflow of water into the banks, depletion (and leakage) during the dry periods and water quality (changes). Testholes will be drilled and water level observed using divers. Data on stream level will be collected (rainfall, river flows) to quantify the total run-off, the percentage of water intercepted and the impact on the downstream users

The environmental evaluation will be carried using a certified EIA checklist. Satellite images will be used to assess changes in vegetation patterns before and after completion of the dams. The EIA will also address the water quality pollution and protection issue.

The socio-economic evaluation will make use of a baseline survey carried out in 2002, complemented with information from an additional field data campaign. The data sets will be used to give an accurate picture of the socio economic benefits on household level and for the district economy.

Students for the Netherlands and Kenya will be involved for the field campaigns and initial evaluation. Professional support will be given by Kenyan and international experts. The duration of the study should be approximately one year in order to cover one hydrologic cycle

Cost estimate

<u>Hydrologic evaluation</u>	€
Students (4 students for 6 month, travel, accommodation and allowance)	30,000
Drilling of 30 observation wells	20,000
Other equipment, sampling, analysis and local transport	15,000
Supervision and reporting: international hydrogeologist (4 weeks)	18,000
Travel and accommodation international expert (2 travels)	5,000
Supervision and reporting: Kenyan hydrogeologist (4 weeks)	6,000
<u>Environmental evaluation</u>	
Students (2 students for 2 month, travel, accommodation and allowance)	7,000
Satellite images	20,000
Other equipment and sampling, local transport	5,000
Supervision and reporting: international EIA expert (2 weeks)	9,000
Travel and accommodation international expert (1 travel)	2,500
Supervision and reporting: Kenyan EIA expert (3 weeks)	5,000
<u>Socio-economic survey</u>	
Students (2 students for 2 month, travel, accommodation and allowance)	7,000
Transport	5,000
Supervision and reporting: international socio-economist (3 weeks)	13,000
Travel and accommodation international expert (1 travel)	2,500
Supervision and reporting: Kenyan socio-economist (4 weeks)	6,500
Miscellaneous and unforeseen	13,500
Total	190,000

3. Siting and construction of 500 new sand dams in Kitui

SASOL is planning a new construction phase of 500 new dams in the Kiuti district. The sites for these new dams are in existing streams and in buried riverbeds. Potential sites for new wells will follow from a hydrological and geotechnical investigation. The community mobilization process will then determine where new dams will be constructed and in which sequence. The construction of the dams will take approximately 5 years and may be implemented in badges, depending on availability of funds.

Cost estimate siting 500 dams

For the siting of new wells, a extensive field inspection is needed with the support of satellite images, The cost estimate for the siting of potential new dams is:

	€
2 junior geologist (4 month)	24,000
1 senior geologist (2 month)	12,000
satellite images (Regional Remote Sensing Facility, Nairobi)	10,000
miscellaneous and unforeseen	4,000
	=====
Total	50,000

Cost estimate construction 500 new dams

Based on the experiences with the construction of the existing and using the 2005 Kitui price level the cost for a new dam is estimated as follows:

Standard dam (requiring 350 bags of cement)	€
- Community input (Labour, sand, stones and water)	3,600
- External financing (cement, bars, masonry and supervision)	4,600
	=====
Total for one dam	8,200

Total cost 500 dams:	4,100,000
Community/SASOL contribution	1,800,000
Contribution form other sources	2,300,000