Recharge Techniques and Water Conservation in East Africa

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

Sand Dam in Kitui

Acacia Institute /SASOL

Programme Description and Overall Progress

Version 1: September 2005

Project 3002-178

Netherlands Water Partnership

vrije Universiteit amsterdam

Acacia Institute
Solutions in Groundwater

Institute for Environmental Studies (IVM)

aqua for all

ITC

SASOL Foundation Kitui -Kenya

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Foreword,

This document presents a programme aimed to promote the successful upscaling of community based sand dams (and related water conservation techniques) based on the experiences of the 350 sand dams constructed by SASOL in Kenya the period 1995-2005. Upscaling of sand dam construction can significant contribute to provide water to rural communities in arid and semi arid region provided that the dams are properly sited, its construction is appropriate to the local conditions and if the communities are effectively involved in construction and management of the dams. The challenge is to incorporate these requirements in an upscaling process that facilitates the construction of dams in large numbers.

This document gives the background of the initiative, the approach to the programme and the components that are identified. Each component is briefly described and a cost estimate is given for those components of which sufficient details are known.

The programme is initiated by SASOL and the Acacia Institute but is aimed to include sand dam experiences from other organizations as well and to bring together interested partners to develop the programme further and to contribute to the funding and the implementation of programme components. The programme is supported by the Groundwater Group (PMC Groundwater) of the Netherlands Water Partnership (NWP) as part of wider initiative to promote the application of sub surface storage under the name MARS: Managed Aquifer Recharge and Storage.

This is a growing document in which the status is presented of the development, funding and progress of implementation of the various components and sub components. It will be updated on a monthly basis and serve as such as a progress report of the overall programme implementation.

This September 2005 issue is the first report in this context and presents the present status. We are pleased that at this early stage already three partner organizations have confirmed their participation in the funding and implementation of the programme: Aqua4All, Institute for Environmental Studies (IVM) /Vrije Universiteit Amsterdam and the International Institute for Geo-Information Science and Earth Observation (ITC).

We are looking forward to start the activities in the coming month and hope that the work will inspire other partners to join the programme.

September 2005

Acacia Institute
SASOL

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 the main challenge for water managers in reaching the Millennium Development Goals

Water security for urban water schemes may include alternative options such as construction of dams, long distance conveyance of water or desalination. For rural water supply such solutions are generally 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.

Water conservation (or water harvesting) techniques are known since ancient times in arid and semi arid regions for example in the Middle East. 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, 2003[1]).

Although based on the same principle, the technology used in different countries or regions is generally adapted to the site specific (hydro-climatological and socio-economic) conditions. This is also reflected in the different names used in different regions for almost similar technologies (Appendix 1; IAH, 2003 [1]). Regardless the name, small-scale water saving structures have in common that:

- adaptation to the local conditions and circumstances is an important element for the success of these community based systems
- often no use is made of existing good experiences in areas with comparable conditions (reinvention of the wheel effect) because :
  - 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 the Sasol experience in Kitui (Kenya) is the sand dams construction in cascades, providing a substantial source of water in one catchment for drinking purposed and for small scale productive use (livestock watering, small scale irrigation)

This programme is an initiative to use the experiences in Kitui as a case study to upscale the construction of sand dams in other parts Kenya and in the surrounding countries. The challenge is to develop an effective strategy to accelerate the construction 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

[1] 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.

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 productive use. Typically, women walk 10-15 km to water sources in the district. To date, 350 dams have been constructed in central Kitui serving about 50,000 people with water during the dry season with an investment cost of about Euro 35 per capita. 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. Further details are given in appendix 1.

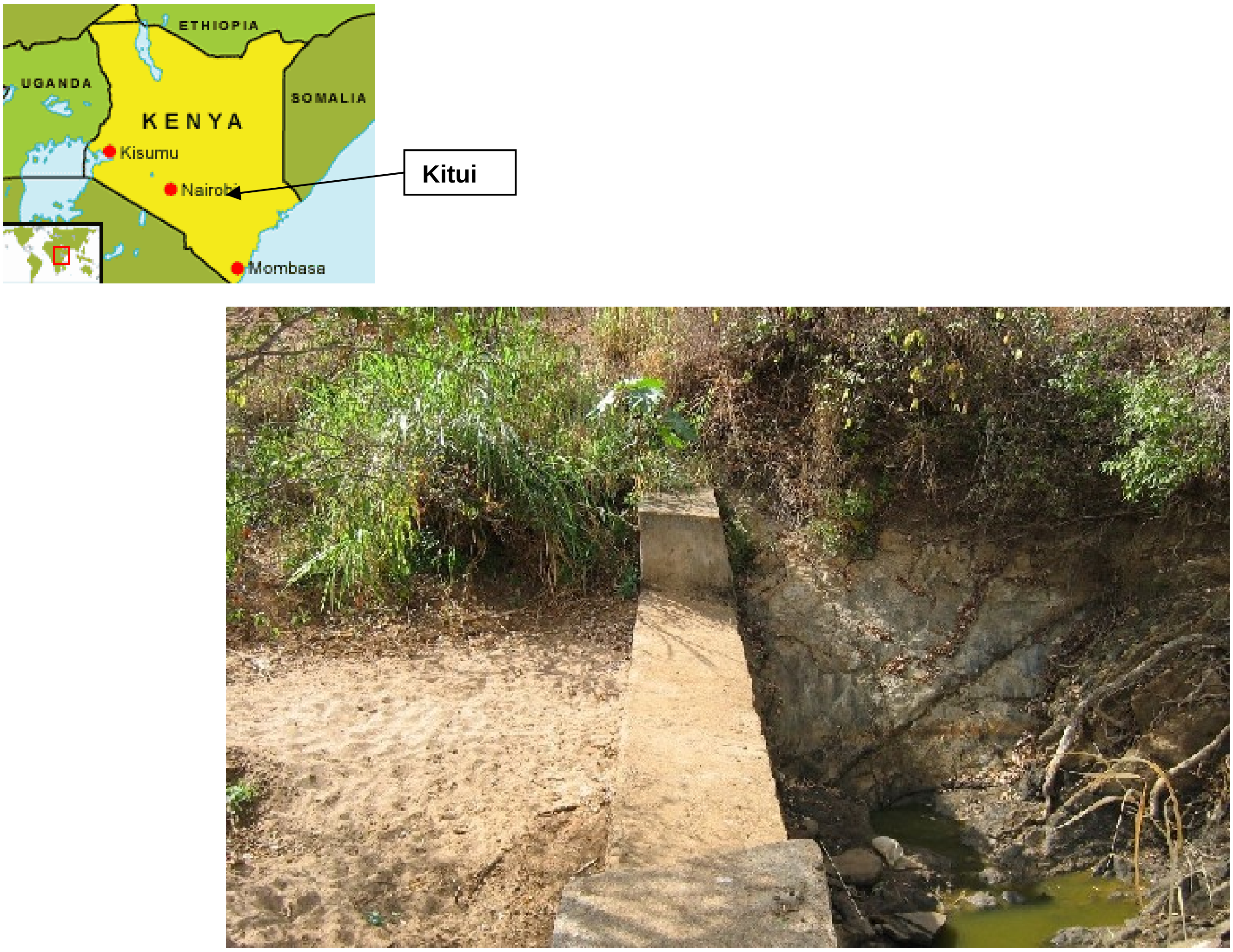

Figure 1: Location map and photo of sand dam

3. PROJECT OBJECTVE AND APPROACH

The overall objective of this initiative is to contribute to scaling up of community based small water conservation schemes in order to reach more consumers but without affecting the principle of the community based approach.

This proposed programme intends to thoroughly evaluate the experiences of SASOL in the last 10 year (component 1) and use it and as input to a seminar (component 2) that will result in action plans for construction of these (or similar) systems in other regions in Kenya and the surrounding countries (component 3 and 6). The workshop will also feed SASOL with information on the establishment of sand dam management groups (component 4) and on long term monitoring requirements (5). The coordination is with SASOL and the Acacia Institute (component 7) but partners are sought to participate in funding and implementation.

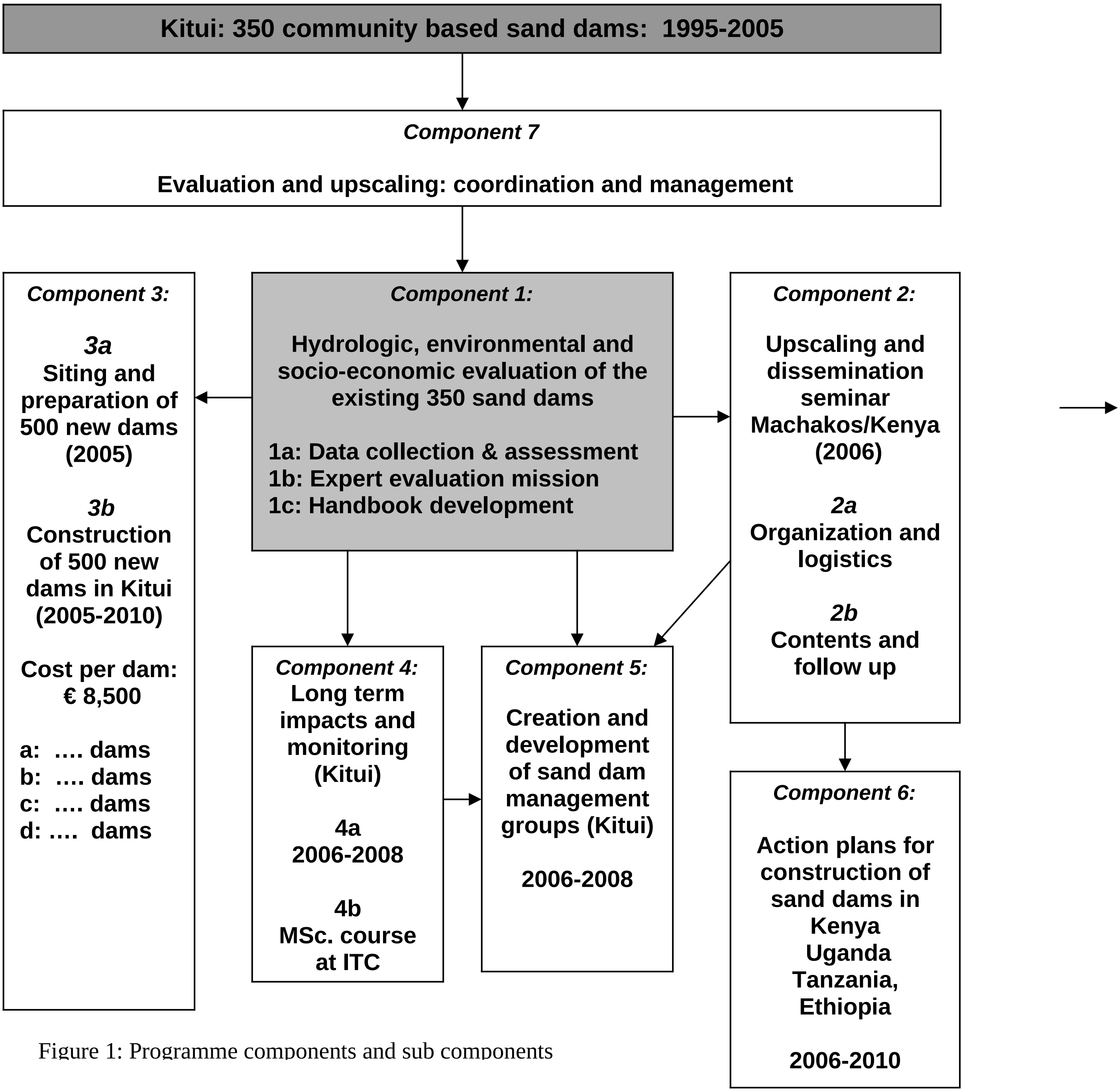

Figure 1: Programme components and sub components

4. PROJECT COMPONENTS

Component 1: hydrological, environmental and socio-economic evaluation

Component 1a: data collection and assessment

This subcomponent is aimed to collect and review all the information needed to come to a balanced evaluation of the functioning of the 350 completed sand dams in Kitui district. The final evaluation itself is accommodated under sub component 1b. The scope of work covers both the hydrological, environmental and socio-economic aspects of the performance of the dams.

Hydrologic evaluation

The hydrologic evaluation includes an assessment of the effectiveness of the dams in terms of water storage. The data collection and assessment will focus on a series of 30 mature dams in the Kiindu stream. 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). Test holes 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 hydrological evaluation will also quantify the effectiveness of the cascade approach. The quality component of the evaluation will focus on the natural water quality and its changes during storage

The hydrologic data collection and processing will be carried out by 2 students from the Faculty of Earth and Life Sciences / Vrije Universiteit Amsterdam (Sander de Haas en Lucas Borst). Supervision will be provided by the Faculty (Prof. Stuyfzand), Acacia (Arjen de Vries, Koos Groen). A fist reconnaissance mission was already carried out in July 2005 by both students and successfully completed.

Environmental evaluation

The environmental evaluation will assess changes in vegetation and land use land patterns before and after completion of the dams using satellite images and making use of data already collected by SASOL over the years. The data collection and assessment will be carried out by a student of the VU and a Kenyan student and supervised by the VU/Acacia (Arjen de Vries) and ITC (Robert Becht). This student will be fielded in the same period as the hydrological students

An important 2nd activity of the environmental evaluation focuses of the execution of an environmental impact analysis (EAI). Water resources projects that require the construction of dams can provide significant economic benefits. However, these projects can also have the potential adverse environmental effects, such as water quality, ecology, risk for erosion and impact on the regional socio-economic and socio-cultural framework. Although the impacts of the small sand dams may be limited, the project design and operation should mitigate or minimise any risks to humans and environment. All potential environmental effects and measures to mitigate these effects will be adequately identified. The EIA will be carried out using a certified EIA checklist.

Socio-economic survey

The socio-economic evaluation will collect complementary field data to quantify the socio-economic impacts on household/village level as well as the impacts on the District level. Use will be made of a baseline survey carried out in 2002 and a recent evaluation in June 2005. This evaluation will involve detailed sampling of the dams in Central Division of Kitui on a catchment-by-catchment basis to establish economic impacts at the individual, household and community levels. The survey will also cover the catchment of the hydrological evaluation

Students for the Netherlands and Kenya will be involved for the field campaigns and initial evaluation. The Dutch students will be recruited from the IVM/VU and supervised by the IVM (through Acacia). Supervision by a Kenyan University is under preparation.

Coordination

Acacia will coordinate the work of the students, participate in the supervision and be responsible for project management and quality control. Arjen de Vries will visit Kenya at the start of the data collection campaign (end of September) to support the students in the planning of their work and to discuss the programme in detail with SASOL. A supervision mission will take place by Arjen de Vries (Acacia Institute) and Harry Rolf (PWN/Aqua4 All) at the end of October 2005. Possible also Robert Becht (ITC) will join the mission for a few days since he is planned to be on a mission in Kenya during that period. The mission will also make an assessment of other sand dam construction activities in the same region, which will be used as a reference for the SASOL experiences.

Outputs

The outputs of these subcomponents are:

- The students reports and data sets (edited and checked on scientific quality)
- A summary report with the main findings and the implications / inputs of the results and outputs for the planning and implementation of the other components.

Time planning

The student campaigns are planned for the period September-December 2005. The final report will be completed in January 2006

Cost estimate

The cost for component 1a is given in appendix 1. Funding is requested from Aqua4All, Vrije Universiteit and the Dutch Embassy in Nairobi (RNE/NRI).

Component 1b: Evaluation mission

The information from component 1a will be the main input for an expert's evaluation consisting of three (international and Kenyan) experts. They will use this material to carry out the final evaluation and recommend on lessons learned and main issues for up scaling. The evaluation mission will also review the sand dam activities from other NGO's in adjacent districts as a reference to the experiences of SASOL. The evaluation will be a main input for the seminar (component 2) and be an important background document to justify the investments in up scaling of the sand dam construction in the Kitui District and adjacent districts.

Time planning
The evaluation mission is scheduled to take place in January/February 2006. Terms of reference will be drafted in November 2005 when the initial results of component 1a are available

Cost and funding
The cost for this sub component is estimated at Euro 70,000. Funding is requested from the RNE/NRI.

Component 1c: Handbook development

Based on the results sub components 1a and 1b and the information from experiences elsewhere, a handbook could be developed to capture the good practices and generic issues in siting, construction, use and maintenance of the dams and to provide guidelines for construction and management of dams.

Terms of reference for this sub component will be drafted upon completion of sub component 1a. During the implementation of sub component 1a, a start will already be made with an inventory of sand dam experiences in East Kenya, other than SASOL.

Cost and funding
The costs for this sub component has still to be worked out and funding sources have still to be identified.

Component 2: Upscaling and dissemination seminar

The good practices and generic elements from the SASOL experience as concluded be the evaluation will be an important input in the 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

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 ands pit falls 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 ands NGO's 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 NGO's/communities working on water conservation development on water (helpdesk function).

The main target audience for the workshop is NGO's 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 NGO's to start (or accelerate) the construction of these systems
- A (global) network and strategy for exchange of experiences and good practices in support to accelerated construction of community based water conservation systems

Workshop organization

Some preliminary ideas concerning the preparation and implementation of the workshop

- Length app. 5 days
    - Day 1: general introductions, Kitui/SASOL case study
    - Day 2: exchange of experiences
    - Day 3: field visit to Kitui
    - Day 4: strategy formulation, action plan and follow up support
    - Day 5: link with national water policy, financing issues / proposal to establish a global water conservation network/ summary and closing

- No. of participants:
    - 5 NGO's from each country, 2 persons per NGO: 40
    - 6* 2 national water planning representatives 12
    - Internacional NGO's, donor agencies etc. 10
    - Representatives from other countries 10
    - Others 10

    Total between 75 and 100 (maximum)

- Venue: proposal is Machakos (accommodation available and close to Kitui)

- Timing: in the dry period: March or September 2006

- The workshop should be output oriented and be a working meeting as should therefore be well prepared and moderated by a professional person (from Kenya)

Cost and funding

The total cost of workshop (preparation and implantation) estimated to be in the order of Euro 150,000. For funding (and participation) we have already approached UNICEF and WB/WSP. It is the intention that at least one of these global organizations is the main sponsor and organizer of the workshop. Other contributions could come from large NGO's and bilateral donors. Sponsoring for the private sector will also be explored.

Component 3: Siting and construction of 500 new dams in Kitui

Component 3a: Feasibility study and initial siting of 500 new dams in Kitui

SASOL is planning a new construction phase of 500 new dams in the Kitui district. The sites form these new dams are in existing streams and in buried riverbeds. Potential sites for new wells will follow from a hydrological and geotechnical investigation. This sub component will make an initial assessment of the locations of these new dams, the principal design and cost estimate and the community willingness to participate in the construction process. A report will be produced to provide potential funding agencies with the necessary information to select the number and types of systems they intend to finance.

Outputs
The output of this subcomponent is a report (and maps) describing the locations, type and main design parameters of the 500 new dams and the communities (name and number) that are going to gain from the dams. The reports will also include a detailed cost estimate of the different dam types and be used to attract funding for the new dams.

Time planning
This sub component can start in November 2005 and will take about 3-4 month. Acacia, SASOl, EarthWater LtD will implement the work. Other partners may join in alter stage.

Cost estimate
The cost is still to be made but will be in the range of 40,000-50,000 Euro. Funding will be requested from the PvW-2 fund.

Component 3b: Construction of 500 new dams in Kitui

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. Financing will come from different financing sources as its implementation can be planned in batches based on the document prepared in component 3a.

The unit cost for an average dam in estimated at Euro 9,000 and includes the overhead cost for SASOL (expansion of the field office, transport and logistics) and the cost for the detailed siting of the new dams. Euro 3,800 is contributed by the community, the remaining has to be funded from outside.

The construction of the dams will take approximately 5 years depending on availability of funds.

Component 4: Establishment of sand dams management groups

One of the plans of SASOL is to establish sand dam management groups in order to optimise and manage the use of the available water. The intention is that these groups manage the water in 10-15 dams in one riverbed. Details of this component are still to be worked out on the basis of the results of the socio-economic evaluation. Support is requested to formulate this component.

Cost estimate and funding
The cost of this component is still to be made. Waterlinks (a cooperation between Aqua4All, SIMAVI and the International Reference Center IRC) will be approached to contribute to the funding and implementation of this component.

Component 5: Long term impacts and monitoring

Component 5a

One of the needs for sustainable operation of the dams is a long-term impact assessment and monitoring plan. This component will specifically look into the effectiveness of the dams future changes in climate and rainfall and may as such be accommodated as one of the pilot basin under the ADAPTS project.

Component 5b

The ITC has proposed to supervise the MSc course for a Kenyan student on a subject related to the long-term sustainability of the sand dams. This MSc is part of the proposed funding from the RNE/NRI to the programme. Details will be worked out by ITC in consultation with IVM and Acacia when the funding is official approved.

Component 6: Action plans for sand dams construction in the region

These action plans will be a main output of the seminar. A framework for these plans will be prepared on the basis of the evaluation and serve as an input in the seminar.

Component 7: Overall coordination and management of the programme

The different components of the programme will be financed by different organizations. Even within one component there can be different financial sources. The overall coordination by Acacia and Sasol will ensure that the specific requirements of different funding agencies are followed (reporting, financial, monitoring) while safe guarding the consistency of the programme, the timing and planning of missions and the information transfer to the different partners. The intention is to provide a periodic progress reporting through a short newsletter distributed by email and for publication on existing web sites. (a.o NWP, Acacia Institute, SASOL).

Funding
Initial funding for coordination was received from the Partner for Water 1 programme and from the Co-operative Programme on Water and Climate (CPWC). These funds were used to develop this programme in 2004 and 2005 as part of a broader initiative to promote the importance of storage in water supply and the application sub surface storage (Management aquifer Recharge and Storage).

Funding for the coordination of the current programme (estimated Euro 50,000) may be included in financing of the various components or can be accommodated in a separate contract.

5. SIGNIFICANCE OF THE PROGRAMME

Sand dams are a cost effective way to provide water to rural communities during period of drought. The experiences in Kitui indicate that main advantages are the community-based construction of the dams, low evaporation losses, the long lifetime of the dams (20-30 years or even longer) and the low maintenance cost.

The 350 dams constructed by SASOL and the local communities in the last 10 years show that on average one dam provides water in the dry season to 150 people on average. The present cost of dam is Euro 8,000-9,000 of which Euro 5, 000- 6,000-investment cost and Euro 3000 contribution of the community (in labour). The investment cost is hence 35-40 Euro per capita.

This programme aims to upscale the construction of sand dams in the East African region through the evaluation of the SASOL dams (component 1) and the organization of a dissemination and up scaling seminar (component 2). Components 4 and 5 are more specifically geared to the situation Kitui but will also generate lessons and experiences that are useful for sand dam programmes in other regions

The programme preparation and coordination cost and the cost of these components (2 and 3) are in total approximately 400,000 Euro. The output of the programme is the successful construction of 500 new dams by SASOL and action programmes for dam construction in other parts of Kenya and in Ethiopia, Tanzania and Uganda. If each of these programmes results in the construction of 500 dams, the total spin-off will be 2500 dams serving almost 400,000 people with a total investment cost of about 14 million Euros.

6. COST ESTIMATES AND FUNDING SOURCES

The overall programme will be coordinated by SASOL and Acacia and implemented together with other partners who are interested to participate in this programme, both in terms of funding and implementation. Table 1 gives a summary of the total cost, potential funding agencies and implantation partners. The costing of project components may be redefined or phased depending on the type of financial support that is received.

Detailed cost estimate for project components are included in cooperation documents with the respective partner

Table 1. Estimated cost and funding source of the project components

Component	Budget (Euro)	Funding (Euro)	Funding Source	Implementation
Component 1				
1a	112,000	84,000	**Aqua4All**	Acacia, SASOL with contributions from VU, IVM, ITC and Aqua4All
		25,000	**Vrije Universiteit**	
		3,000	**NRE/NRI**	
1b	70,000	70,000	**NRE/NRI**	Coordinated by Acacia. Mission members to be selected
1c	TBN			
Component 2				
2a +2b	150,000		*UNICEF*	
			World Bank/WSP	
			UNEP	
			UN-HABITAT	
			others	
Component 3				
3a	+/- 40,000	25,000	*PvW -2 (subsidy)*	Acacia, SASOL, Earth Water Limited
		15,000	tbn	
3b	4,250,000	42,500	Mennonite Church	SASOL
			Others	
Component 4				
4	TBN		*BSIK/Leven met Water (subsidy)*	IVM, Acacia, ITC. Kenyan partners to be selected
4b	27,000	*27,000*	**NRE/NRI**	ITC / Kenyan University
Component 5				
5	TBN		*Waterlines*	Aqua4All, SIMAVI, IRC
Component 5				
6	TBN		*UNICEF*	
			Water Aid	
			Other NGO's	
Component 7				
7			Included in component 1-7 Acacia	Acacia and SASOL Coordination in initial phase (May 2004-June 2005) provided through PvW-1 and CCWP

In bold: funding requested and awaiting final approval
In italic: contacts are made but funding request still under discussion

Appendix 1

THE SIGNIFICANCE OF SUB SURFACE WATER STORAGE IN KENYA

SAMMY MUTISO
SASOL, KENYA.

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 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 (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 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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