Short visit to Kitui sand storage dams operational research programme 2-5/11/2007

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for
Acacia Groundwater Institute SASOL and Aqua for All

On request of Acacia Groundwater Institute and Aqua for All, I brought a short visit to Kitui and Nairobi:

- To advise the Free University of Amsterdam Master's students presently working on the Sand storage dam research programme (Acacia/Aqua for All/SASOL project name and number…… nr.)
- To talk and discuss with SASOL management on recent and future developments

Arriving from Tanzania a 2 days visit was paid to the student's field work in Kitui (Kiindu dam) and SASOL Kitui field-office and a further visit in Nairobi, meeting SASOL managers and board members. On the last day a visit was brought to ASAL Consultants Ltd. Nairobi.

Preliminary statement (box)

It is stressed that the sand dam research is in no way for the sake of research as such. The "research" is in the direct, practical and shared interest of both SASOL and the ACACIA project:
For SASOL to have an excellent "selling case" that proves, shows and explains the benefits of the integral sand storage dam-based development of Kitui catchments.
For the ACACIA project goals: to disseminate the knowledge and the success/failure criteria of this "concept-case": a smart, low-cost way of groundwater harvesting that will be applied in many other drylands, in other areas and countries.
We are dealing with operational research, based on - and proven by - observations, proper hydrogeological thinking and modelling. Operational and conceptual questions are answered by applying scientifically sound knowledge.

Findings

In the first place it was so nice to meet the "Rafiki in Kitui" again and to see the new team of students working in the field and in their "Kiindu operational research centre" at the Kitui Tourist Hotel.

On the hydrological investigations, field work and monitoring

The work on the Kiindu pilot project (S 01° 27.7' E 38° 0.26' Alt=3881 ft) is progressing quite well:

- By now there is an essential set of observations on groundwater levels and precipitation over a period of one full year. This really is a remarkable result! Although some of the observation wells were destroyed, some of the Diver data loggers disappeared and there were difficulties with the reading rain gauge totalizers, the monitoring programme still holds. This was only possible by having (and paying an allowance to) motivated persons (Mr. Peter and Mrs. Christina) observing in the field and Mr. Joseph Muinde checking on his progress and data quality.

- To bring back the monitoring programme up-to-standard, the team constructed new piezometers, installed Diver data loggers, they re-installed some of the rainwater totalizers and "tipping bucket" rain gauges. For the groundwater model calibration (and any water balance) it is advised to do some additional measurements of the open water (pan) evaporation, to hook up with the evaporation time series from the District Water Office Kitui meteo station or the FAO New_LocClim database.
- To measure the water discharge of the Kiindu pilot dam, SASOL and the student's team have realised a measuring spillway-construction on top of the existing dam. Once there is discharge they will calibrate and verify the relation discharge-waterlevel by velocity observations (Ott-metering and salt-tracering). Although there was some rainfall there has been no discharge yet. The dam discharge will be monitored frequently by a nicely constructed observation box upstream in the river bed, holding a DIVER logger inside. We all hope that this monitoring construction will hold for quite some time, producing a long and frequent time-series of very important discharge data. In case the construction should be vandalised or destroyed by the river, it is important to take immediate action and to know precisely what caused the destruction.
- To investigate the processes and relations between infiltration and runoff 4 test-plots (for different land gradients and land use) were constructed in the banks and upland in the catchment valley. Observed variables are: local totalised rainfall and overland runoff (collected in a tank). In addition the amount of sediments in the collector tank will be measured and sediment samples will be analysed. It is important to store these samples for further research. Although one of the plots was partly destroyed by donkeys, the plots are nicely constructed and look adequate.
- Several tests were done on permeability (reversed auger), infiltration rate (infiltrometer) and soil/sediment samples are taken and will be analysed.
- To generalise and verify on success/failure aspects other dams in the district are visited. The students are advised to go also to the dams that were visited by the 2005 student's team to see how siltation and sand deposits have developed.

Students research objectives and products to be expected

Apart from the general objective to upgrade the knowledge level and the monitoring system of the Kiindu pilot, the students will focus on:

- ***Groundwater model***

  To study, understand and predict the groundwater benefits of the system, a first try of a transient, areal groundwater flow model will be constructed of the dynamic groundwater behaviour of the integrated Kiindu catchment (river bed + water catching valleys). The model should describe the complicated mechanisms and processes between rainfall, evapotranspiration, infiltration, runoff, groundwater baseflow and use of water in the river bed, calibrated on the observed groundwater heads in the river bed and banks and the information coming from the infiltration plots. In addition, the model might give a clue to the unknown (but important) amount of water that is lost vertically into the weathered or open fractured bedrock. This really is a challenge! The intention is to construct this model in MODFLOW code, which is the right choice in my opinion. It is advised strongly <u>not</u> to use any of the other (Dutch) groundwater modelling codes. It may be difficult to find proper MODFLOW components for specific processes such as the (complicated) infiltration-runoff relation. The model should be run and calibrated for the full year period of data. The students are advised to contact Prof. T.Olsthoorn (TU Delft) for advice and assistance on this modelling work.

Once the performance of the model is acceptable it can be used to predict further, future economic and water benefits by plugging in water and land conservation and artificial recharge measures. In addition the model can be used as a demonstration tool, showing and visualising the groundwater flow processes of the integrated sand storage dam-concept.

- ***GIS map of "sand dam potential" areas***
  To assess (and quantify!!) the essential (lowest number of) critical success/failure factors of the sand storage dam concept and to apply these factors, constructing a GIS-based (nation-wide?) map of areas that have a high potential for finding successful sand storage dam (or underground dam) locations. Doing this, it is essential to also visit other sites (failure sites in particular), to verify on these criteria and to discuss the criteria with experts from SASOL, ASAL Consultants and others. It is important to timely look for aggregated, large scale digital data on these decisive factors that are extremely important for SASOL and the dissemination goals. SASOL board member Pieter van Dongen could help/advise and criticize on the geological criteria and geological data sources. Earlier ideas on baseline siting and survey can be found in books (Ake Nillson, Erik Nissen-Petersen,….) The students should check (Government, masterplans?) if any kind of such mapping has already been done in the past.
  It is advised to be specific and concrete on these criteria: try to quantify as much as possible. Ideally each criterion (or weighed combination of criteria) is given by a max/min value on a one variable scale. Maybe the available GIS data allow only giving classes, indicating "suitable" "maybe" and "not suitable".

- ***Sedimentation and dam design***
  To study the dynamic surface water processes of rainfall – runoff – discharge in relation to sediment transport. This will give further detailed information on critical success factors to have maximum storage in the dams: high porosity sands and maximum (but still safe) height of the dams. To use this information for dam-design, the characteristics of the future rainfall characteristics (changing climate) may be a major problem.
  It is important, also for further research, to carefully describe the soils, sediments, land-gradients and to conserve and store relevant samples. The students should properly relate this work (and refer to) to other investigation e.g. done by the REAL-project TU students.

- ***Don't "re-invent the wheel"***
  In general the students are advised not to repeat any work that has already been done before. Add up and just refer to existing research/books etc.

Meeting Erik Nissen-Petersen (ASAL Consultants Ltd. www.waterforaridland.com)

Erik Nissen-Petersen has long time experience in designing and construction of underground dams and sand dams. He has produced many practical handbooks and manuals, mostly published by DANIDA and SIDA. Recently he produced a series of 8 small handbooks on subjects as "water for dry riverbeds (2006), water for rural communities (2006).

ASAL is surveying and engineering new sites for quite a number of new (underground) dams. Next year ASAL has a programme to train young Kenyans on 1) designing and surveying and on 2) contracting/construction.
I tend to believe that ASAL and SASOL are two important "dry riverbed" parties. It is a pity to see that they do not communicate very well. In my opinion they should spend time to meet, communicate and be in for an open discussion.
We met and agreed on the following:

- The Dutch (Kitui) students may contact him tot discuss their work, especially on the criteria for areas to have good potential for sand storage dams (or underground dams)
- Aqua for All can use his material (with proper referencing) in the new booklet to be produced on water harvesting
- I got copies of his booklets to take back to Holland

SASOL handbook
SASOL has finalised a handbook on the construction and operation of (Kitui) sand dams (SASOL 2004). A printout of this book shows "a chronicle of how the people of Kitui have been working on the sand dams programme" in two sections: institutional factors and technical construction and operational principles. Unfortunately, the handbook not yet gives the results of the Kiindu operational research.
In follow-ups this handbook should be edited and combined with other recent information into the sand dams "concept-showcase"

Further activities towards the final Kiindu "concept-showcase "

As it goes, the Kiindu dam pilot case grows onto the best demonstration site to show the success of the integral "dry river bed" catchment development based on sand dams. The Kiindu experiences and research results must be used as a "show case" to demonstrate, prove and disseminate the opportunities of the concept to create water and income for the rural people in ASAL rock based sand rivers. The pilot's information will give the essential criteria for success or failing. It is therefore essential to carry on in the completion of the pilot. To do this, basic next steps should be:

To finish off and publish the Kiindu "concept-showcase" in a professional way:

- Investigate and answer the identified open-end research questions (see under, "short term research activities".)
- Integrate and edit all research results into a professional production (the "showcase") on different publication levels (users, politicians, engineers, scientists). In doing this, it is important to co-operate with and properly relate to other activities and knowledge, such as the works of Erik Nissen-Petersen, the SASOL handbook, the various research reports etc. The showcase must be presented on the Internet in an open way, asking for reactions, comparable (or contradicting) experiences
- Start organising, planning and engineering the next phase for the Kiindu case: an optimal programme of land- and water conservation (or even artificial recharge) in the catchment valleys alongside the Kiindu river bed. Implement this programme in a period of – say – 5 years. Of course these activities must start with discussing the matter with the community, their needs, feelings and their willingness to contribute.
- Combine this conservation programme with continued monitoring and operational research that will prove the additional benefits this integrated approach of catchment development.

- Once the integral catchment development is completed, a final version of the Kiindu "show case" must be produced and disseminated.

Short term research activities

- Verify the robustness of the success/failure criteria and the GIS-based "sand storage potential" map, relating it to other expertise and other countries.
- Improve and professionalize the groundwater model and use the model to predict the benefits of conservation programmes in the catchment and to visualise the water processes.
- Start up (lean and dedicated!) scientific desk-research on specific "open end" issues:
    - Explain the typical behaviour of sediments (silts) in the sand dam river bed: under what conditions are the fine silts discharged over the dam.
    - innovation options to improve the dam-dimensions ("smart dams"): is it possible to build higher, but still safe dams?
    - best practises for water/land conservation or even artificial recharge: to choose the optimal techniques that can be adopted by the community.
    - specific groundwater modelling issues: e.g. how to incorporate overland run-off related to infiltration capacity/soil moisture saturation.

  This research should be done by the best available (Dutch?) professionals.

APPENDIX 1: MISSION STORY

2/11/2006
Arriving (early morning) Kitui town by night bus: field visit Kiindu dam; discussions with students and Sammy Mutiso
3/11/2006
Preparing draft report; discussion with students on their goals and work plan; discussion with S.Mutiso; diner: team + S.Mutiso (Parkside Villa)
4/11/2006
travel Kitui – Nairobi (Heron hotel); discussions with prof. Mutiso and Sammy Mutiso
5/11/ 2006
Nairobi, reporting and visiting Erik Nissen-Petersen (ASAL)

Persons encountered:

- Amsterdam Free University Students:
  - Merel Hoogmoed +254 720110611
  - Cedrick Gijsberts +31646063523 cedrick@hetnet.nl
  - Jasper Jansen
- Kitui, SASOL Field Office: Sammy Mutiso +254 720874594, sasol@kenyaweb.com
- Nairobi, SASOL Board Chairperson Prof G-C.M.Mutiso 8660772, fax 860771, muticon@wananchi.com
- Nairobi ASAL Consultants Ltd., Mr. Erik Nissen-Petersen +254 733 619066 (living in the apartments just behind the Heron Hotel, at nr. 4 (he is considering to move elsewhere), asalconsultants@yahoo.com