Project plan Water balance sand dams

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Introduction

As part of the project “Recharge techniques and water conservation in East Africa” a set of measurements will be carried out to determine the working and effectiveness of the sand storage dams in the Kiindu river in the Kitui District, Kenya. This plan explains what measurements are planned to be carried out during a fieldcampaign, which will take place from the end of September 2005 untill the end of November 2005.

Water balance

The water balance of a sand dam consists of the following components:

riverbed

Qbanks

QQuse

QQinfiltration

Qdam_in

Qdam_out

dam

dam

riverbank

bedrock

subsurface

evap-pan

scoophole

precipitation

evaporation

piëzometer

.S = Qprecipitation + Qriver + Qbanks + Qdam_in – Qdam_out – QET - Quse - Qinfiltration

With:

.S Change of storage in sand

Qprecipitation Precipitation

Qriver River water infiltration

Qbanks Recharge from bank (can be negative in case of discharge to banks)

Qdam_in Leakage from upstream dam

Qdam_out Leakage from downstream dam

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Qevaporation Evaporation from the groundwater table

Quse Water use by humans and animals

Qinfiltration Infiltration into bedrock

These components can be measured of estimated as follows:

.S Change of storage in sand

Can be determined by measuring the change in waterlevels in the sediment on the stream bed at the beginning and at the end of the period.

Q

precipitation Precipitation

Can be measured by determining the catchment area, the measured amount of precipitation and the runoff coefficient.

Q

river River water infiltration

Based on the experiences of Sasol and the previous reports the body of sand behind a dams completely fills up with sand after a rainy season.

Because discharge and infiltration measurements in the rainy season are very difficult to carry out, and are also less interesting since the body of sand will be completely filled at the end of the rainy season, it is not necessary to determine the exact runoff coefficients and river discharge.

The main focus will be to check whether the assumption that the sand completely fills up with water is correct. If the sand doesn't completely fill up it might be interesting to look for ways to improve the infiltration rate.

Q

banks Recharge/discharge from/to bank

Can be calculated with the Darcy equation if the gradient of the waterlevel into the banks and the hydraulic conductivity of the soils is known. The gradient of the waterlevel can be determined by measuring the waterlevels in piezometer in a cross-section over the riverbed and –banks. The hydraulic conductivities can be measured and calculates using a pumping test.

Q

dam_in Leakage from upstream dam

Q

dam_out Leakage from downstream dam

Leakage through the dams is difficult to measure. The drop in waterlevel just before a dam might be an indicator for the leakage of the dam, since this drop is only a function of the hydraulic conductivity (which is known) and the leakage. We have to see whether it is possible to measure this.

Q

evaporation Evaporation

Open water evaporation is measured at the Kitui Water Yard (Ministry of Water). Direct evaporation from a shallow groundwater table might be a significant component of leakage.

To get an idea of the order of magnitude of the evaporation from the groundwater we might install a “sub-surface evaporation pan”. A large plastic box will be dug into the sand, filled with water and sand and covered with sand again. By installing a piezometer into the box the waterlevel can be monitored. Since there can be no leakage downward, the only changes in waterlevel will be because of evaporation.

Q

use Water use by humans and animals

Might be estimated by interviews or counting the number of water users over a timespan.

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Q

infiltration Infiltration into bedrock

Hard to measure, an estimation will be made depending on the geology and geophysical measurements.

Chloride-/isotope balance

To check the different methods described before and as a supplement to the uncertainties a chloride and/or isotope balace can be made.

Since chloride ions are conservative (moving with water without being retarded or lost) they can be used to set up a ion balance. Isotopes can be used in slightly different, but comparable way.

.Nreservoir . .S = Nprecipitation . Qprecipitation + Nbanks . Qbanks + Ndam_in . Qdam_in – Ndam_out . Qdam_out – Nreservoir .

Qevaporation - Nreservoir . Quse - Nreservoir . Qinfiltration

Where N stands for chloride or isotope concentration of the specific type of water.

In case of chloride all these concentration can be measured by taking water samples of those waters.

E.g. Ndam_in can be measured by sampling the water just before the dam.

Isotope research

With the use of stable and/or radioactive isotopes different sources and residence times of water can be identified.

A few samples will be collected and send to the Netherlands for analyses. Depending on the results of the analyses a more detailed work plan will be set up.

Measuring the effect of sand dams by remote sensing

Several satellite images of the Kiindu catchment and surroundings will be analyzed to see whether changes in vegetation patterns can be identified.

Images of the following satellites will be used:

Quickbird (0,6 – 2,4 m resolution)

Landsat (15 – 60 m resolution)

Aster (15 – 90 m resolution)

To identify changes in vegetation around dam sites images that are taken at the beginning of the dry season will be compared to images taken at the end of the dry season.

Images of the situation before the dams were built and after the dams were built will be compared to see the influence of the dams on the vegetation.

A second catchment near the Kiindu river, with similar geology, morphology, vegetation and precipitation, but without dams will also be used for comparison.

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