EUROPEAN COMMISSION / European Research Area / Environment

Water Harvesting Technologies Revisited
Project No 266360

WHaTeR

WP11: Catchment Study: South Africa

At a Glance


Water quality sampling and system maintenance surveys taking place at the Potshini catchment in KwaZulu-Natal, South Africa.

Main facts:

1. WH takes place under a much wider range of conditions than currently reported, and therefore the potential for upscaling may be much larger than anticipated
2. Remote sensing has already been used to access many of the physical landscape characteristics that are considered important to identifying the best location for WH sites
3. Preliminary water quality results show that the chemical composition of rooftop and runoff harvesting water is better than catchment runoff and groundwater and meets the WHO standard for drinking water, however pathogen analysis is still needed.
4. Detailed understanding of hydrological flow paths provides a means to assess potential downstream impacts on streamflow, as well key nutrients fluxes.

The Challenge

Historically water harvesting (WH) has not played a major role in the provision of water for domestic or agricultural use in South Africa. However, interest in WH is quickly gaining momentum. WH is one of only two specific strategies highlighted in the South Africa National Climate Change Response White paper (2011) as an adaptation strategy to provide water for both small scale and subsistence farmers as well as rural and low income households. However, before extensive upscaling of WH takes place it is important to fully understand the upstream-downstream impacts of WH in terms of both water quality and water quantity.

Objectives

1. Analyse benefits, impacts and potential trade-offs of WH on hydrological functioning and ecosystem services, based on upstream-downstream interactions
2. Develop methods for determining additional ecosystems service synergies and/or trade-offs emerging from WH for multiple scales using a catchment as starting point
3. Develop methods and tools to assess the impacts of WH on catchment water quantity and quality, including upstream and downstream interactions.

METHODOLOGY

Local landscape conditions dictate the type of WH that can be implemented as well as the quantity and quality of water that will be collected. The measurement and understanding of how these landscape characteristics influence the hydrological function of WH systems and how WH can potentially impact catchment hydrological function are important to understand. Figure 1 gives an overview of the different components forming this Work Package.

1. Identifying existing and potential WH sites

A Principle Component Analysis (PCA) was performed on 28 WH sites gathered from literature to try and identify which landscape characteristics are most important in determining the location of WH sites and how similar or different the WH sites were. Although it would have been beneficial to assess many more sites in the analysis, many articles and reports on WH do not describe the physical characteristics of WH sites adequately for this level of analysis. Remote sensing (RS) technology is also being utilised to identify existing and potential WH sites mainly in South Africa and Tanzania. The hypothesis that existing sites can be identified by measuring total evaporation (ET) in the landscape, using RS, is currently being tested. This follows an assumption that WH sites will have a larger ET relative to the surrounding landscape and therefore can be identified by applying a surface energy balance model such as Surface Energy Balance System (SEBS) model to RS images. Once existing WH sites have been positively identified, the landscape characteristics in which they are located will be analysed and used as inputs into a model to identify potential WH sites.

2. Water quality implications of WH

Water quality samples are being collected from water harvested from the roof, the yard surrounding the homestead as well as from small impoundments in the catchment and local wells, using sterilized bottles and stored at low temperature before laboratory analysis. Turbidity, electric conductivity (EC), and pH of the water samples are measured using turbidity meter, EC meters and pH meter, respectively. A standard analytical method is applied to determine the concentrations of dissolved organic carbon (DOC), Sulfates (SO42-), Phosphate (PO4-) and total metals (Al, Mg, Na, Ni, Zn, K, Cr, Ca, Mn, Cu, As, Cd, Se, Pb, Fe, and B). Biological water quality issues will also be tested.

3. Runoff generation and nutrient flux relationship

The water sampling sites for flux relationship analysis consist of fifteen 1×1m^2 micro-plots, 10 shallow (1m) piezometers and three deep (40m) boreholes installed at different landscape positions. Fluxes of runoff and of dissolved organic carbon exiting the catchment are evaluated, using an automatic water level recorder coupled with a water sampler. The so-called end members mixing approach, using Si and Na as tracers, is being applied to estimate the contribution of the different water compartments. Subsequently, different scenarios of water abstraction from the catchment will be simulated to evaluate their impact on runoff.

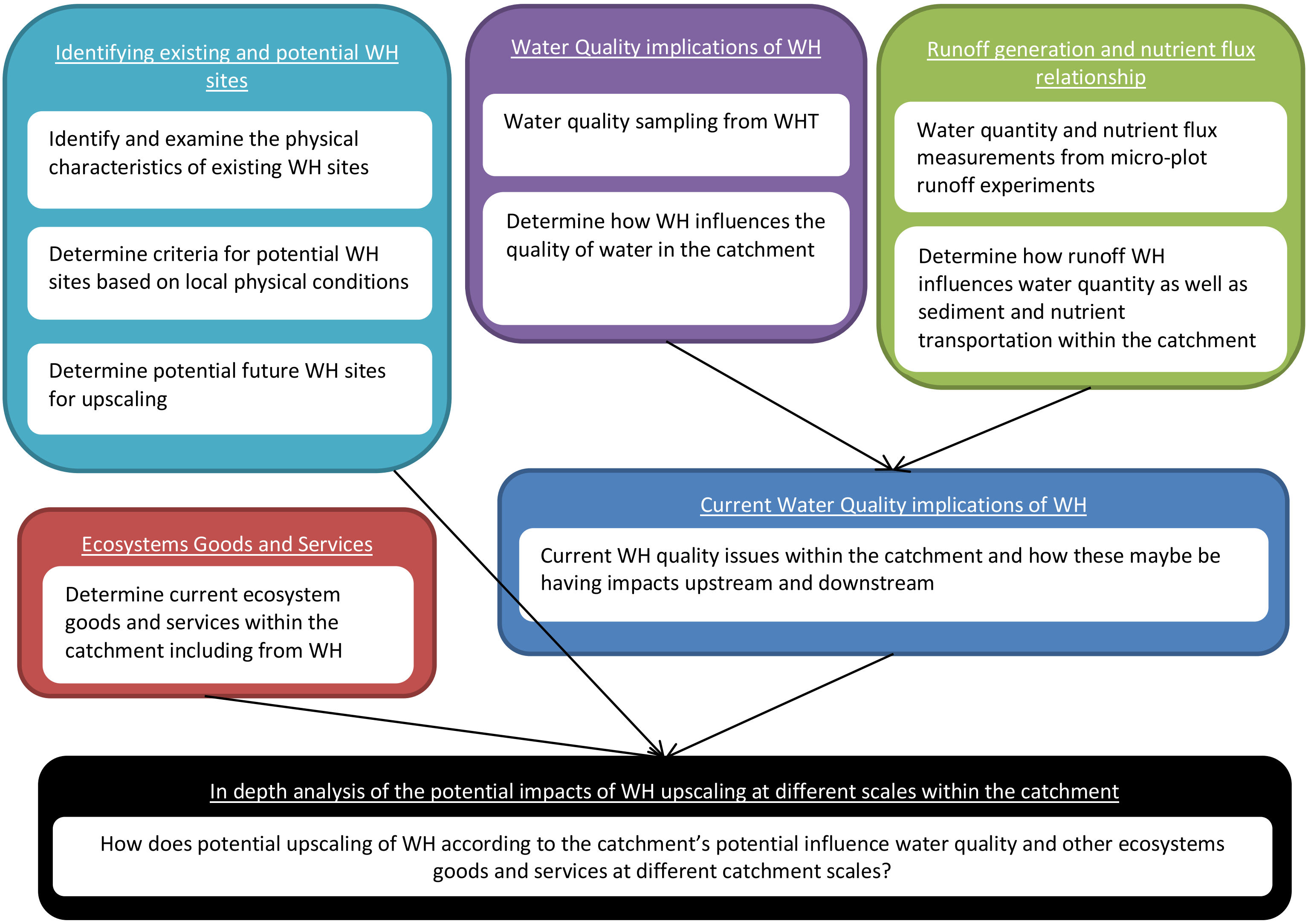

FIGURE 1: FLOW DIAGRAM OF WP11'S RESEARCH METHODOLOGY

RESULTS SO FAR

Site revisits, a national workshop and an extensive literature review have revealed that WH is still an under developed in South Africa. Although many communities recognise and appreciate the benefits of the WH systems, uptake and upscaling has been limited. However, interest in WH is quickly gaining momentum. Results from a review of policy indicate that WH is one of only two specific strategies highlighted in the South Africa National Climate Change Response White paper (2011) as an adaptation strategy to provide water for both small scale and subsistence farmers as well as rural and low income households.

A review of existing WH sites, cited as study sites in WH literature from developing countries around the world have revealed that our current understanding of the conditions under which WH can take place is limited. A principle component analysis revealed a strong positive correlation between slope, soil depth and the amount of loam in the soil. The results suggest that deep soils on gentle slopes with high amounts of loam are the most suitable sites for WH. However, the PCA also revealed that WH is currently taking place under a wide variety of conditions. This implies that our understanding of the criteria for the landscape conditions of WH sites is currently too limited and needs to be broadened. The implication of this is that many more potential WH sites may be identified for upscaling efforts within a catchment, further reinforcing the priority to better understand the potential upstream and downstream impacts of WH.

Some of these potential impacts include issues surrounding water quality.

Analytical result of the inorganic compounds measured during water quality sampling to date reveal that the concentrations of ordinary ions in rainwater harvested from both yard and roof catchment systems are narrowly fail to meet the WHO guidelines for drinking water. On the other hand, samples collected from the dam and a well within study the catchment are even lower levels of ordinary ions than the water from WH systems. This implies that water harvested from WH has increased levels of inorganic compounds as opposed to regular runoff. Although these levels are not alarming when considered individually, further studies into whether these compounds are reaching the river system after being applied to crop fields is needed and whether up-scaled WH could lead to increased chemical water pollution in the catchment. It is important to measure the pathogen content of harvested water and whether WH is increasing the potential for development and transfer of water borne diseases. Water quality must also continue regularly within and between seasons. A more intensive and regular water sampling regime will begin in 2013.

The quantitative relationships between runoff generation on one hand and sediment, organic carbon and nutrient fluxes on the other hand are still not well understood and this could influence the transfer of pollutants into the river system. Understanding the impact of water harvesting on overland flow, interflow and river runoff and dynamics of dissolved organic matter, nitrogen and phosphorus in headwater catchments can be extended to improve water and land management, and also to enhance soil and water quality and ecosystem functioning as a whole. Results to date from the study site, indicate that base flow contributed to 68% of the yearly runoff (specific value of 290 l m2), followed by overland flow (25%) and ground water (7%). DOC was highest in base flow (15.2 ±1.6 mg C l-1), followed by overland flow (11.9±0.8 mg C l-1), runoff (4.7 ±2.5 mg C l-1) and ground water (2.3±0.6 mg C l-1). The observed DOC was 2.80 g C m2 y-1.

Expected Outcome

1. A draft paper titled "A Review of the Current Status of Water Harvesting Knowledge" which aims to determine under what range of conditions WH is currently taking place by examining existing WH sites has been completed and will be submitted to a scientific journal shortly.
2. A model which will be applied at a catchment scale to identify existing WH sites and a publishable paper discussing the development, testing, verification and application of this model.
3. A model to identify potential WH sites within a catchment for upscaling purposes
4. A inter- and intra-seasonal analysis of water quality from the WH systems and how WH is influencing the quality of water being released into the catchment
5. An improved understanding of the impact of WH on river fluxes of water and organic carbon in headwaters and ultimately of land management on the hydrologic and global C cycles.
6. Analysis of whether WH can positively and negatively influence ecosystems goods and services both at their immediate site and upstream and downstream
7. Guidelines to inform decisions and policy makers on the potential impacts of WH at different levels within the catchment to ensure that upscaling activities are done in a sustainable manner

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