WHaTeR

WP6: Technological Improvement

At a Glance

In drylands of sub-Saharan Africa, access to water is often limited by the available technologies. This affects water use for domestic purposes, livestock and crops. We are exploring knowledge of water harvesting technologies and their use in sustainable intensification of agriculture.

The Challenge

In the drylands of sub-saharan africa, access to water is often limited by the available technologies. This affects water use for domestic purposes, livestock and crops. Achieving future food security will depend mainly on increasing production from rainfed agriculture. Locally appropriate water harvesting technologies offer the best prospect of enabling the required sustainable intensification.

Objectives

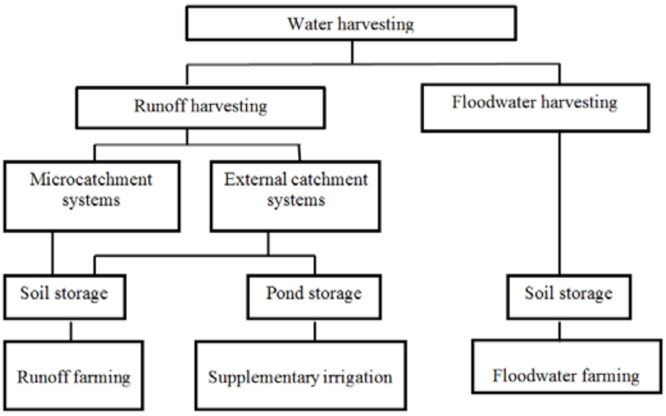
WHaTeR's work package on technological improvement (WP6) will extend and add value to the country work packages by:

- Delivering understanding of the technical performance of water harvesting systems.
- Helping define criteria for assessing knowledge and technical capacity of beneficiaries.
- Integrating lessons from case studies under different hydrological, biological and socio-economic conditions in order to devise guidelines for promoting appropriate WHTs

Methodology

Numerous authors have proposed definitions of water harvesting (or rainwater harvesting), but there is generally very little difference between them. We adopt the definition proposed by Critchley and Scheierling (2012): "The collection and concentration of rainfall runoff, or floodwaters, for plant production".

Similarly many authors have attempted to classify water harvesting techniques (or technologies) into a broad typology. A distinction is often made between techniques on the basis of where the runoff is collected and how far it is diverted. Runoff may be collected from fields, hill-slopes, house roofs, roads and tracks, or ephemeral streams and gullies. Rainfall may be captured locally on the farm where it is to be used, or as runoff from rain that falls beyond the farm boundary. Water harvesting practices may also be distinguished on the basis of how the captured water is stored. We adopt the typology shown below:



Typology of water harvesting systems (after Critchley & Scheierling, 2012)

Within each of the main types of WH there is considerable diversity of techniques and it is not possible for the activities under WP6 to embrace all. The focus is on micro-catchment systems of runoff farming in Burkina Faso (in collaboration with WP9); external catchment systems of runoff farming in Tanzania (in collaboration with WP12) and floodwater farming in Ethiopia (in collaboration with WP10). No activities are currently planned for South Africa but consideration will be given to a comparative study of floodwater farming experience. Work on supplementary irrigation (in Ethiopia) is covered under WP7 /WP10.

RESULTS SO FAR

Ethiopia

Since the 1970s various government agencies and NGOs have established projects to promote adoption of water harvesting. Some 'bright spots' have been documented as evidence of success, but many initiatives were less successful. Between 2001-2009 a national initiative compiled a comprehensive database of known technologies for sustainable land management in Ethiopia using WOCAT methodology. In 2010 an overview was published containing descriptions of 35 techniques and eight approaches considered to represent best practice Techniques were categorised as either indigenous or introduced and as agronomic or structural. Many are located in regions of relatively high rainfall (>1000mm) where water harvesting is not a priority, but nine can be regarded as micro-catchment WH techniques and 1 example of a macro-catchment WH technique is described. Of the 10 WH techniques, five are classified as indigenous and five as introduced.

Ethiopia was not covered by the original SSWHS study but the experience of water harvesting mirrors that in countries which were studied. There is evidence of traditional practices that may be (i) implemented at household level using local runoff, and (ii) implemented at community level using runoff harvested from more extensive catchments. Over the last 40 years there have been many interventions by external agencies (both government and NGOs) to promote the spread of indigenous techniques or to introduce new water harvesting and soil and water conservation technologies. WH development in Ethiopia has largely been a supply driven, technically focused approach. Farmers have reported modest yield increases as a result of rainwater harvesting.

The WHaTeR revisit phase was focused on the Southern Nations, Nationalities and Peoples Region (SNNPR) and Oromia Region. Both are in the southern part of Ethiopia (South of Addis Ababa) and are accessible from Arba Minch. The technologies selected as a focus for the investigation were:

- Household ponds (supplementary irrigation)
- Sand dams (floodwater harvesting)
- Integrated watershed management (runoff farming/supplementary irrigation)
- Spate irrigation (floodwater harvesting)

Available evidence suggests that the lack of appreciation of indigenous knowledge and practices amongst 'experts' and policy makers still persists. Perhaps the most notable example of traditional soil and water conservation technologies, including water harvesting, can be seen in the Konso terrace systems of the SNNPR which achieved UNESCO world heritage status in 2011. Spate irrigation is under active expansion in Ethiopia (including Konso lowlands), but its success depends on overcoming both social and technical challenges. There is scope for investigation in Konso within WP6 to deliver advice on both technical innovations and the best-bet approach to intervention reflecting the social/organisational issues of spate irrigation.

Burkina Faso

Diverse soil and water conservation and water harvesting technologies have been actively promoted in the central and northern regions of the country. External interventions in soil and water conservation began shortly after independence with a project to control soil erosion in Yatenga region. Earth bunds were constructed along the contour by machinery over an area of 120,000 hectares. The same approach was taken up 10 years later by another donor funded project which covered 60,000 hectares. In both cases farmers were not involved and as a result they did not maintain the bunds and often destroyed them. The success story of water harvesting in Burkina Faso really began around 1980 and has been well documented. A participatory approach to water harvesting with contour stone lines (cordons pierreux) was tested successfully by a local NGO with support from OXFAM and the technique was then widely promoted. The success of this intervention (the 'magic stones') became very widely recognized. Alongside this externally supported improvement, farmers began innovating themselves by improving a traditional practice of planting pits (known locally as zaï) in order to reclaim severely degraded land. Since the 1980s many donors and NGOs have promoted stone lines and/or zaï.

Numerous research studies have measured positive impacts with yield increase varying from 40 to 100 per cent, but most have been limited to one to three years. Revisit surveys following WOCAT methodology with key informants confirm that long term average yield increment is 100 per cent for stone lines and 200 percent for zai from a baseline yield of 400 kg/ha. The weight of accumulated evidence over a period of 25 years provides a strong case for the success of these water harvesting techniques in Burkina Faso. These may be implemented at individual household level but generally have been implemented at community level with external support. Both stone lines and zaï are farm scale techniques which collect and concentrate local overland flow. Storage is directly within the crop root zone. This is an example of runoff farming.

Zaï planting pits, in combination with stone bunds, are seen as an important part of the success story of water harvesting in sub-Saharan Africa over the last 25 years. This system has been extensively studied. Their rapid adoption can be explained by the fact that these micro-scale techniques are simple and produce immediate results. Farmers can dig zaï pits incrementally depending on how much labour they are able and willing to invest. They can be applied by individual farmers who treat just their own fields to which they have land use rights. Farmers appreciate that with this technique, little land is lost to the structures and fields treated with WH techniques produce some yield even in years of low rainfall. Attempts have been made to reduce the labour requirement be promoting use of animal traction to produce so-called 'mechanised zaï'.

Questions remain however on the extent to which they can be seen to have spread through spontaneous adoption without external intervention. Appropriate external support (eg. transport to collect stones for stone lines) can make a big difference – but what level of support is 'appropriate'? There is very limited evidence of spontaneous spread of WH technologies without some level of external intervention. There is no convincing evidence of spontaneous spread of the claimed 'farmer-managed agro-environmental transformation'. It is proposed that this issue will be the main focus for research activity under WP6. Farmers are vulnerable and depend upon a range of livelihood strategies to manage risk. It is therefore important to examine WH adoption in the context of risk. Fieldwork has begun at three sites: Boukou, Nagreongo and Peni.

Tanzania

Any attempt to promote sustainable intensification of agriculture in semi-arid areas of Tanzania must tackle the problem of unreliable and highly variable rainfall. The dominant perceptions can be seen as the explanation for official neglect, until quite recently, of water harvesting as a viable option. Firstly, that the only solutions to livelihood problems in the drought-prone semi-arid areas were irrigation or drought-resistant crops. Secondly, that the solution to flooding and soil erosion was disposal of 'hazardous' runoff away from crop and range lands. This led to soil and water conservation programmes that focused on water disposal in areas where agriculture and livelihoods are affected more by shortage of water than anything else. Nevertheless, water harvesting techniques are known to have been in use in Tanzania for generations; some are traditional indigenous practices while others involve exogenous technologies.

Planting pits which have been documented in various countries (notably Burkina Faso and Niger), also exist as an indigenous practice in Tanzania in the Matengo Highlands of Mbinga district where they are known as 'ngoro'. Pits are typically 2m wide and 30cm deep. Smaller pits – more similar to zaï /tassa - have been documented elsewhere in Tanzania also as 'chololo' planting pits. A number of WH systems can be identified which collect local overland flow and deliver it to an adjacent crop area. The short transfer distance ensures that the system offers high runoff efficiency and that it is situated within the land holding of an individual farmer. One variant is strip catchment tillage, which involves alternating strips of crops with strips of grass or cover crops. This technique was introduced during the colonial era primarily as an erosion control measure. A second variant also involves creation of cross-slope barriers (stone lines or earth bunds) to intercept runoff. There are no reported examples of stone lines in Tanzania, but contour bunds are common. This technique was also introduced during the colonial era primarily as an erosion control measure. Trash lines are also reported as a traditional practice in Tanzania.

Water harvesting systems which exploit hillslope runoff processes or divert flood flows from ephemeral streams, gullies and road culverts represent the main focus for WH interest in Tanzania. The catchment generally lies outside the land holding of the farmer and this separation may mean that runoff is harvested at times when there is no direct rainfall in the cropped area. The extent of adaptation and adoption of these external catchment water harvesting technologies was the focus for the revisit investigation in the Western Pare Lowlands (WPLL). This region in the north-east of Tanzania is classified as having low potential for agriculture. The farmers here, many of whom have migrated to the area from the high-potential uplands in the Pare Mountains, have a strong preference for maize and have resisted attempts to introduce sorghum, as a drought-tolerant alternative. This area therefore became the focus for a concerted experimentation, demonstration and modelling effort aimed at promoting adoption of WH practices which began in 1993.

While the main focus of the original research and the recent revisit was on the WH systems introduced to WPLL, there are lessons to be learned from comparison with the 'majaruba' system elsewhere in Tanzania, which is a continuing success story. Despite receiving no external support, this system has demonstrated sustainability over more than 50 years. This WH system is found extensively in Tanzania and is used primarily for production of rainfed lowland rice in bunded basins. Hillslope runoff is collected from stony outcrops and grazing lands in upslope areas with cattle tracks often used as conduits. It is believed to have originated in Sukumaland (Lake Victoria basin). It is arguably not a 'traditional' practice, since it was introduced by Asian migrant workers during the colonial era. Its rapid adoption and spread without external intervention is quite remarkable and can be seen as indicative of the potential of WH practices. It has been identified as the focus for activity in Tanzania under WP6.

<u>South Africa</u>

The WHaTeR revisit phase concluded that WH is an undeveloped water source in South Africa It is not seen as a part of long term traditional knowledge of communities and does not have a long history in South Africa. Most existing WH structures have been implemented by various externally funded research projects or government organisations in the last 10 years to increase water availability to reduce crop failure and alleviate poverty. The revisit sites were at Potshini, near Bergville, in KwaZulu-Natal and Phutadjithaba in the Free State, located in the eastern and central parts of South Africa, respectively. It is a semi-arid region with annual rainfall 600 – 1000 mm falling mainly in the summer months. The main crop is maize with soybean, vegetables and fruit trees also being cultivated, primarily for subsistence agriculture.

The revisit study concluded that there is an urgent need to identify what environmental impacts and how they would might constrain upscaling efforts. None of the community members identified water right access as an issue or constraint to WH, but in the strict application of the SA water law it is an illegal activity. WH may be seen as a 'stream flow reduction activity' which will impact downstream users' access to water. Therefore research into the potential downstream impacts of WH is important in order to quantify and manage potential impacts. Recommendations can be made to policy makers on whether WH is a streamflow reduction activity or not and how to adjust policies to allow for the upscaling of WH as a potential solution to water scarcity.

It is pertinent to note that an independent 'revisit' study was recently completed with the objective of documenting indigenous water harvesting and conservation practices across South Africa through literature review and primary fieldwork (Denison & Wotshela, 2009). The initial scoping study did not deliver any literature on indigenous WH. Active networking of development and irrigation practitioners, researchers and historians who have knowledge of potential sites, was therefore adopted as the research approach. This led to identification of six indigenous (or indigenised) approaches:

- Gelesha (Eastern Cape) is a traditional practice for in situ water conservation, rather than true WH. . The Xhosa terminology *Gelesha umhlaba* is reported as meaning hoeing or the tilling of soil after a crop harvest. The intention of this practice is to ensure that any falling rain or dew or even frost infiltrates the tilled soil so that it would be available for the next planted crop in the form of moisture.
- Stone terracing (Kwa Zulu Natal) is a historical practice that evolved largely through imported knowledge brought by missionaries in the 18th Century combined with land pressure that forced people to move from the flatter, fertile valleys. The practice has been modified over the years and as such, has become indigenised.
- Homestead ponds (Free State and the Eastern Cape) are seen as surviving ideas and techniques of rainwater collection and management that originated in the late eighteenth and early nineteenth centuries.
- Contouring or the construction of contour ridges originated in the twentieth century, particularly the interwar period. Whilst this appeared to be more a soil conservation than water harvesting technique, it is noted that the strips of land in between contour ridges are still used for crop cultivation.
- Saaidamme, which is Afrikaans for 'planting dams' are found in the Northern Cape. This is a floodwater farming (spate irrigation) system. The silt-laden flood-water from the distant mountains (some 100 to 150 km in this case) is diverted with structures into a series of large, flat basins which extend between 1 ha and 100 ha in size each. Each basin is ringed by a low earth bund (1 to 2 metres high) and is effectively a flat, shallow dam. The water is allowed to stand in the basins up to 1 m deep for between 1 and 3 days to infiltrate into the very deep alluvial soils.
- 'Klipplaate en Vanggate' in Afrikaans can be translated as 'paved-rock and catchpits' and is identical to the ancient system of cisterns found across North Africa and in Jordan and Syria. Historically in South Africa, water from the cistern was used for both human and animal consumption.

The study concluded that the main opportunity for future research relates to the transferability of Saaidamme. Early stage experimentation is currently underway at the University of Free State, where runoff from koppies is being transported in channels to fields with level contours several kilometres distant from the source. Another topic suggested for research is the marked difference in prevalence of WH practices between South Africa and countries further north. Activity under WP6 in South Africa is likely to be very limited. Consideration will be given to a comparative study of floodwater farming experience (ie. Saaidamme) in relation to work in Ethiopia.

Expected Outcome

The research will provide answers to the following questions:

Q1. How successful are alternative WHT innovations in increasing availability and reliability of water and raising agricultural productivity through low-cost systems of water control?

Q2. What is the evidence that alternative models of WHT development deliver more or less sustainable outcomes in the context of dynamic global and regional pressures (climate change, population, urbanisation etc.)?

Q3. What can be done to support knowledge transfer and innovation in order to promote adoption of appropriate water management technologies and practices?

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