WAHARA - Report Series

Report on Water Harvesting Inventory, History and Success Stories

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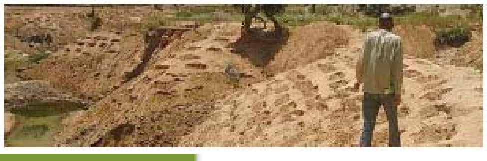

Date: 01-03-2012
IRA, Tunisia

Deliverable D1.3

Report number 05
Series: Scientific Reports

This report was written in the framework of the WAHARA project – www.wahara.eu

SEVENTH FRAMEWORK PROGRAMME

WP1: The potential for WH in an array of biophysical and human environmental settings in rainfed Africa

D1.3 REPORT ON WH INVENTORY, HISTORY AND SUCCESS STORIES

by

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March 2012

1. Context

1.1. Introduction

Water harvesting (WH) presents highly adapted, flexible, easy to understand and implement, low-cost solutions to the productivity, climate adaptation and water security challenges, primarily by building water buffering capacity. WH technologies include centuries-old systems developed by local knowledge but also innovative new approaches. Together, these approaches hold great potential to boost economic development and sustain livelihoods in rainfed Africa. However, to unlock this potential, and despite the fact that WH has over the years received substantial interest from the research community, there is still considerable need for further advancement of knowledge:

Many definitions and classification systems exist of WH technologies. UNEP (2009) defines rain water harvesting as: "the collective term for a wide variety of interventions to use rainfall through collection and storage, either in soil or in man made dams, tanks or containers bridging dry spells and droughts. The effect is increased retention of water in the landscape, enabling management and use of water for multiple purposes". Recent classification systems distinguish between in situ and ex situ water harvesting (Oweis et al., 1999; Ngigi, 2003; Vohland and Barry, 2009), but the first level of classification could just as well be based on the source of water, the type of system applied, the time span between capture and use, and the type of use (Siegert, 1994; SIWI, 2001). In situ WH (also known as water conservation) utilises the local soil as storage medium, while ex situ WH systems include a water storage or retention component which is tapped for both temporally and spatially dislocated usage from the rainfall collection area.

In a more all-embracing definition, in WAHARA project water harvesting technologies are defined as: "the collective term for a wide variety of low-cost interventions which are primarily or secondarily intended to collect natural water resources which otherwise would have escaped from human reach, and buffer them through storage and/or recharge on or below the soil surface. The effect is increased retention of water in the landscape, enabling management and use of water for multiple purposes. Water harvesting technologies can operate either as independent units, or require embedding in a larger system of environmental management interventions, or require specific natural conditions".

In order to assess the potential of WH, WP1 made an inventory of which technologies have been adopted where and how this was achieved. In the study sites, a historical analysis of WH technologies was made using literature and secondary data. Partner 3 contributed with an analysis of successful scaling of WH in selected sites across the continent. This inventory forms the main input for the compilation of technologies (WP2, Task 2).

1.2. Specific aims

* Literature review on WH technologies
* Selection of success stories in the continent with focus on study site countries.
* Overview of WHT that are applied in the WAHARA study sites

2. Methods

2.1 Literature review

This literature review was based on three main components: database research, own sources and *grey* literature documents. In particular, two reports were made as a preparation for deliverable 1.3, one gave

an overview of WHT technologies that are used in Africa, based mainly on Anglophone literature. The other report added to this by focusing on Francophone literature, and in particular on WHT in Tunisia and Burkina Faso:
a. Overview of best practices by Metameta and Acacia Water (2011)
b. Water Harvesting Technologies (WHT) in Africa - a literature review focused on Tunisia and Burkina Faso by Vincent Bardin (2012) (Wageningen Univ.) and supervised by J. de Graaff (Wageningen University), S. Chevalking (MetaMeta Research), and M. Ouessar (IRA Médenine)

Both reports used the same 5 categories of WHT to summarize the available information, which has also been used by some other authors (Prinz, 1996; etc.):
- Micro-catchment to collect water at farm and field level;
- Macro-catchment methods to collect water at the watershed level;
- Flood water harvesting methods;
- Atmospheric water harvesting methods;
- In situ soil moisture conservation methods.

For the present report, we summarized the collected literature further. For each WHT, only the most important indicators as derived from the literature sources are given, as far as this info was available in these sources:

- Climate: bioclimate setting (arid, semi arid, subhumid, sahelian, etc.)
- Country: geographical position
- Buffer: medium for water storage
- Water source: Rainfall, runoff, or flood
- WHT: Name or type of the technology
- Indigenous or new: Traditional or newly introduced technology
- Labour or Mechanic intensive: Implementation constraints.

In addition, the WAHARA partner institutes provided information about WHT in their country, based mainly on a review of grey literature as this kind of literature could not be covered by the 2 reports listed above.

For all literature sources, information was not only gathered for WHT that are currently applied, but also for WHT that have been used in the course of history. This historical analysis provides additional insights into factors that cause WHT to be successful or to fail.

2.2. WHT inventory

Within the WP1 study site description (included in deliverable 1.1), two sections were devoted for WH as follows:
Water harvesting techniques (used in the country/region and with focus on the study site/area)

- Traditional techniques (description, advantages, main problems, potential)
- Farming practices in use influencing water conservation (mulching, windbreaks, conservation agriculture, ploughing)
- Modern techniques (description, advantages, main problems, potential)
- Infrastructure having secondary effect on soil moisture and water retention – such as roads, irish bridges, embankments, sand-gravel pits
- Management practices influencing these water harvesting practices

Past and on-going projects (especially related to water harvesting)

- Trends of land owners investing in water harvesting and land improvement
- Government project (e.g. Extension, Watershed Management Planning etc)
- Development projects
- Research projects

Therefore, an inventory of WHT was held in each of the 4 study sites. The aim was to create an overview of WHT which are already applied in the study sites, and to collect additional data for these WHT. In fact, in the study site description guidelines, the partners have been asked to develop a section on the various WHT used in their countries with more focus on those applied/present in the study site region. However, more detailed guidelines will be done under WP2 prior to the 2nd stakeholder workshop which will be devoted for the selection of WHT to be implemented..

2.3. Success stories

Success stories were defined based on the results of the literature study and the WHT inventory in the study sites. Some success stories were selected based on their degree of adoption by the local population and the scientific evidence shown by the researchers

3. Results

3.1. Literature study

Summary tables of the 5 categories of WHT are given on the following pages, and are based on a combination of information from the two general reports and from the country specific information provided by the WAHARA partners.

The hereafter tables show the main WHT in Africa with focus on the WAHARA study countries.

Micro-catchment to collect water at farm and field level

Climate	Country	Buffer	Water source	WHT	Indigenous / New	Labour/Mechanic intensive
(South Sahelian, annual rain: 400 to 700 mm)	Burkina Faso	Soil storage in-situ	Runoff	Tied stones lines (*Cordons pierreux isohypses cloisonnes*)	I	Low
(South Sahelian, annual rain: 400 to 700 mm)	Burkina Faso	Soil storage in-situ	Runoff	Stone dykes (*Diguettes filtrantes*)	I	Low
(South, annual rain < 200 mm)	Tunisia	Soil storage in-situ	Rainfall/ Runoff	*Hoffra*	I	Low
(centre: annual rain 200 to 400 mm)	Tunisia	Soil storage in-situ	Runoff	Earth dykes + "draining-off" (*Banquettes en terre à extrémité déversantes*)	N	Low
(centre: annual rain 200 to 400 mm)	Tunisia	Soil storage in-situ	Rainfall	Bourrelets	N	Low
(Arid to semi-arid)	Tunisia	Soil storage in-situ+ cistern	Rainfall/Runoff	Enclos-Tabias	I	Low
(Arid)	Tunisia	Soil storage Ex-situ	Runoff	Mescat + Mankat	I	Low
(Arid to semi-arid)	Tunisia	Tank	Rainfall/ Runoff	*Majel/ Fesquia.* (Cisterns)	I	Low
(Sub-Sahelian: annual rain 400 to 700 mm)	Burkina Faso Ethiopia	Soil storage in-situ	Runoff	Stone dykes/rock lines (*Diguettes filtrantes/cordons pierreux*)	I	Low
(North Sudanien rain : 790 mm)	Burkina Faso	Soil storage in-situ	Runoff	Hedgerow barrier system	I	Low
(Sub-Sahelian: annual rain 400 to 700 mm)	Burkina Faso	Soil storage in-situ	Runoff	3 types of Rock lines (*cordons pierreux*) :	I	Low
(Semi- arid)	Burkina Faso	Soil storage In-situ	Runoff/rainfall	Artifical pond: *boulis*	N	Low
(semi-arid)	Burkina Faso, Niger	Soil storage	Rainfall	*Zai*	I	Low
(semi-arid)	Niger, Gambia, Nigeria, Burkina Faso	Soil storage	Runoff	Tied ridges (*billons cloisonnés*)	I	Low
(semi-arid)	Burkina Faso, Niger Ethiopia	Soil storage	Rainfall	Half-moon (*demi-lunes*)	I / N	Low
Various countries		Soil storage	Rainfall	Earth dykes or earth dams (*Diguettes isohypses/diguettes divergentes*)	I	Low
(semi-arid)	Burkina Faso, Niger Various countries	Soil storage	Rainfall/runoff	Bench terrace (*fossé ados*)	I	Low
(semi-arid)	Burkina Faso, Niger	Soil storage	Runoff	Little wall (*Muret*)	I	Low

Various countries (but not Gambia)	Various countries (but not Gambia)	Soil storage	Runoff	Rock lines (*Cordons pierreux*)	I	Low
(Sub-Sahelian: annual rain 400 to 700 mm)	Burkina Faso	Soil storage Ex-situ	runoff/gully flow/rainfall	Farm pond, *Zai*	I	Low
(Sub-Sahelian) and Kenya (semi-arid)	Burkina Faso	Reservoir	Runoff	Reservoir + 2 manual foot-pumps	I / N	Low
(Dori station, annual rain: 461mm/ Sebba station, annual rain : 515 mm (period :1992 to 2003)	Burkina Faso	Soil storage	Runoff/rainfall	Half-moon, stones lines, stones dykes, Tied ridge	I	Low
(Sudanian annual rain: 500 to 1300 mm)	Mali	Soil storage in-situ/groundwater recharge	Rainfall/runoff	*Amenagement en courbe de niveau* (developed by the Institut d'Economie Rurale (IER) and CIRAD) (Gigou et al., 2006)	I / N	Low
(annual rain of 366 mm (1993-2006)	Tunisia	Soil storage in-situ/ groundwater recharge	Runoff	*Contour bench*		Low
(Kirsi: Sub-sahelian Saria: North Sudanian) (3 sites rain: 500 to 700 mm)	Burkina Faso Niger	Soil storage in-situ	Runoff	Zaï/tassa,stone row,grass strips, half-moon	I	Low
(annual rain : of 300 mm, 35 years)	Tunisia	Soil storage In-situ	Rainfall/Runoff	Micro-basins (soil and stones walls)	I	Low
(Sudanian, annual rain : 800 to 1000 mm)	Burkina Faso	Soil storage in-situ	Rainfall/Runoff	Boundary tree planting	I	Low
(North Sudanian, annual rain: 700 to 900 mm)	Burkina Faso	Soil storage in-situ	Rainfall/Runoff	Half-moon, sub-soiling, Zai	I	Low
	Morroco	Cisterns	Rainwater	Rooftop systems	I	Low
(Sub-humid, annual rain 600 to 800 mm)	Morroco	Soil storage in-situ	Runoff	Earth dike (*banquette de terre*)	I	Low
(Arid, annual rain : 100 to 400 mm)	Morroco	Cisterns/ basins	Rainwater	Matfia/Khattara	I	Low

Macro-catchment methods to collect water at the watershed level

Bioclimate	Country	Buffer	Water source	WHT	Indigenous / New	Labour/Mechanic intensive
(Soudan-Sahelian, annual rain : 600 to 1200 mm)	Burkina Faso/Mali	Soil storage in situ	Runoff	Diversion terraces, micro-dams	N	Medium
(Soudan-Sahelian, annual rain : 600 to 1200 mm)	Burkina Faso	Soil storage Ex-situ/ Ground-water recharge	Runoff/rainfall	Hill-barrage (without outlet) (*Barrage collinaire*)	N	Medium
(centre: annual rain 200 to 400 mm)	Tunisia	Conveyance structures	Ground water	*Galleries filtrantes*	I	Medium
(South, annual rain < 200 mm)	Tunisia	Soil storage Ex-situ	Runoff	*Jessours*	I	Medium
(centre: annual rain 200 to 400 mm)	Tunisia/ Sahel	Conveyance structures	Runoff	*Seguia*	I	Medium
(centre: annual rain 200 to 400 mm)	Tunisia	Conveyance structures	Ground water	*Foggaras*	I	Medium
(centre: annual rain 200 to 400 mm)	Tunisia	Soil storage in-situ/ reservoir	Runoff	Contour ridges, hill reservoir (*reservoir colinaire*)	N	Medium
	Various countries	Soil storage/ GF recharge	Runoff	Dykes (*digue de bas fonds*)	I	Medium
(Sahel, annual rain 967 mm)	Cameroon	Soil storage In-situ	Runoff	Micro sand dams	I	Medium
(Sahel, annual rain 967 mm)	Cameroon	Reservoir	Rainfall\ runoff	Rock bed	I	Medium
(Sahel, annual rain 967 mm)	Cameroon	Ground water recharge	Stream flow/runoff	Check dams	I	Medium
(Centre, annual rain : 141 mm, period 1935-1996)	Tunisia	Soil storage Ex-situ, tank	Runoff	*Tabias* + Cistern	I	Medium
(annual rain of 366 mm, 1993-2006)	Tunisia	Soil storage Ex-situ	Runoff	Contour benches (*banquette de terre à rétention totale*)	I	Medium
(South, annual rain: 150 to 230 mm)	Tunisia	Various	Various	Terraces, Tabias, Gabions, Jessours, Cisterns, Recharge wells	I	Medium
(Monthly rain: 0 to 40 mm, period 1969–2000)	Tunisia	Soil storage Ex-situ	Runoff	Jessours	I	Medium
(North, annual rain: 450 mm, 90 years)	Tunisia	Reservoir	Runoff	Dam, hill reservoir	N	Medium
(annual rain of 366 mm, 1993-2006)	Tunisia	Soil storage in-situ	Runoff	Contour benches (*banquette de terre à rétention totale*)	N	Medium
(annual rain of 366 mm, 1993-2006)	Tunisia	Soil storage in-situ	Runoff	Contour benches (*banquette de terre à rétention totale*)	I	Medium
(Sahel, annual rain 129 mm)	Mali	Ground water recharge	Runoff	Underground dams/sub-surface dams	N	Medium
(centre: annual rain 200 to 400 mm)	Tunisia	Soil storage in-situ/ reservoir/ ground water recharge	Runoff	Reservoirs, dams, contour ridges, inter-row	N	Medium

Flood water harvesting methods

Bioclimate	Country	Buffer	Water source	WHT	Indigenous / New	Labour/Mechanic intensive
(Arid to semi-arid)	Tunisia	Conveyance structures	Stream flow	Mgoud	I	Medium
(centre: annual rain 200 to 400 mm)	Tunisia	Soil storage Ex-situ/ Groundwater recharge	Stream flow	Chereb (*épandage direct*)	I	Medium
(centre: annual rain 200 to 400 mm)	Tunisia	Soil storage Ex-situ/ Groundwater recharge	Stream flow	Seguis (*épandage direct*)	I	Medium
Various countries	Various countries	Soil storage Ex-situ/ Groundwater recharge	Stream flow/runoff	Spate irrigation (*inondation dirigée*)	I	Medium
(Sudano Sahelian)/ (Sudanian)	Niger Mali	Soil storage Ex-situ	Runoff	Stone-weirs (*seuil d'épandage*)	I	Medium
Mostly Mauritania	Mostly Mauritania	Soil storage Ex-situ/ Groundwater recharge	Stream flow	Flood plain inondation (*Barrage de retenue*)	I	Medium
(Arid to semi-arid)	Tunisia Egypt	Soil storage Ex	Stream flow	Cascade gabion check dams	N	High
Very Arid	Niger	Soil storage Ex	Flood	Infiltration basins	N	Medium
(Arid to semi-arid)	Tunisia	Soil storage Ex	Stream flow	Recharge well	N	Medium
Semi Arid	Kenya	Soil / Aquifer	Flood	Sand storage dam	N	Medium
Semi arid	Zambia Ethiopia	Soil storage Ex	Flood	Dams	N	Medium

Atmospheric water harvesting methods

Bioclimate	Country	Buffer	Water source	WHT	Indigenous / New	Labour/Mechanic intensive
(Desert, annual rain < 150 mm)	Morocco	Tank	Fog water	Fog collectors (standard type)	N	Low
(Desert, annual rain < 100 mm)	Namibia	Tank	Fog	Fog collectors	N	Low
(Desert, annual rain < 100 mm)	Spain (Canary Islands)	Soil	Dew	Arenados	I	Low
Sub Humid	SoutAfrica (Table Mountain)		Fog	Fog collectors	N	Low

In situ soil moisture conservation methods

Bioclimate	**Country**	**Buffer**	**Water source**	**SWC**	**Indigenous / New**	**Labour/Mechanic intensive**
(Centre annual rain: 200 mm)	Tunisia	Soil storage in-situ	Rainfall/runoff	*Le Nark*	I	Low
(Centre annual rain: 200 to 400 mm)	Tunisia	Soil storage in-situ	Rainfall/runoff	*Le tombeau de Zaafrane + Tabias*	I	Low
(Desert, annual rain: 20 to 100 mm)	Tunisia	-	Groundwater	*Le Ghout*	I	Low
(Arid to semi-arid)	Tunisia	-	Groundwater/ rainfall/runoff	*Le Garaat*	I	Low
(Sub-Sahel)	Burkina Faso	Soil storage in-situ	Rainfall/runoff	*Jachère protégée* (Protected fallow)	I	Low
(Sub-Sahel/ North sudanian)	Burkina Faso	Soil storage in-situ	Rainfall/runoff	*Régénération naturelle assistée (RNA)*	I	Low
(Sub-Sahel/ North sudanian)	Burkina Faso	Soil storage in-situ	Rainfall/runoff	*Le paillage* (mulching)	I	Low
(Sub-Sahel/ North sudanian)	Burkina Faso	Soil storage in-situ	Rainfall/runoff	*Le billonnage* (Ridging)	I	Low
(Sub-Sahel/ North sudanian)	Burkina Faso	Soil storage in-situ	Rainfall/runoff	*Le sous-solage* (Sub-soiling)	I	Low
(Sub-Sahel/ North sudanian)	Burkina Faso	Soil storage in-situ	Rainfall/runoff	*Le scarifiage* (scratching)	I	Low
Semi Arid (500-700 mm)	Ethiopia	Soil storage in-situ	Rainfall/runoff	*Trench bund*	I	Low
Arid to semi arid	Tunisia	Soil storage	Rainfall/runoff	*Subsurface supplemental irrigation*	N	Low

3.2. WHT inventory in study sites and success stories

The study sites made an inventory of the existing water harvesting / soil conservation techniques encountered in their respective countries with major focus on the study sites. They report also on some success stories.

Ethiopia

Woldearegay et al. (2011, 2012) mentioned that to ensure food security and conserve the natural environment, a number of efforts have been made in Tigray region in general and in the study area in particular. There exist indigenous as well as introduced technologies.

Indigenous technologies

Some of the indigenous technologies that communities and farmers have been using as tools for moisture conservation, water harvesting and watershed management include the following:

- Construction of demarcation bunds (Armo) between farm holdings or within a farm to reduce slope length and gradient;
- Plantation of indigenous drought tolerant plants such as "ERE" to stabilize bunds;
- Application of manure to farms;
- Fallowing of farm lands;
- Crop rotation between cereals and legumes;
- Construction of diversion channels to protect farm lands from damage by upstream runoff and drainage channels to safely remove excess runoff from the farm lands;
- Construction of traditional spate diversion systems to divert seasonal flood from highlands to low lying alluvial valleys;
- Construction of earth bunds to harvest moisture and reduce erosion;
- Application of ash to farms to increase the fertility of the soil;
- Planting indigenous trees that can fix nitrogen in the soil;
- Construction of hand-dug wells for household and irrigation purposes;
- Construction of community ponds (Horoye) especially for livestock watering;
- Spring development;
- Incorporating crop residue to farms.

Introduced technologies

A number of technologies have been introduced not only to conserve soil and water but also to harvest water and preserve the natural environment. The government and non-governmental organizations have been at the forefront in introducing these technologies. The moisture conservation, water harvesting and watershed management techniques that have been introduced in the study area include the following:

- Area closures along with plantation of indigenous and introduced grasses, bushes and trees;
- Application of compost to farms;
- Use of organic and stone mulching to minimize evaporation loss;
- Application of inorganic fertilizers;
- Contour ploughing;
- Contour soil and stone bunds;
- Stone faced soil bunds;

- Stone/soil/stone faced soil bund with trenches;
- Hillside stone terraces;
- Bench terraces;
- Stone faced deep trenches;
- Percolation ponds;
- Eyebrow basins;
- Negarim micro-catchments;
- Check dam ponds: concrete, masonry, or mixed;
- Gully rehabilitation check dams: gabion, masonry, concrete or mixed. In many cases gully rehabilitation check-dams are coupled with planting trees (e.g. elephant grass);
- Semi-circular bunds;
- Modern spate systems;
- Drip irrigation systems: conventional and family kits;
- Perennial river diversion weirs;
- Small-scale dams (with size from less than 10m to over 25m heights): for water storage as well for sediment trap;
- Protected spring development;
- Motor pumps;
- Groundwater wells: deep, shallow, hand-dug wells;
- Cisterns;
- Ponds;
- Roof water harvesting;
- Hillside conduits are tried in limited cases and need to be scaled-up.

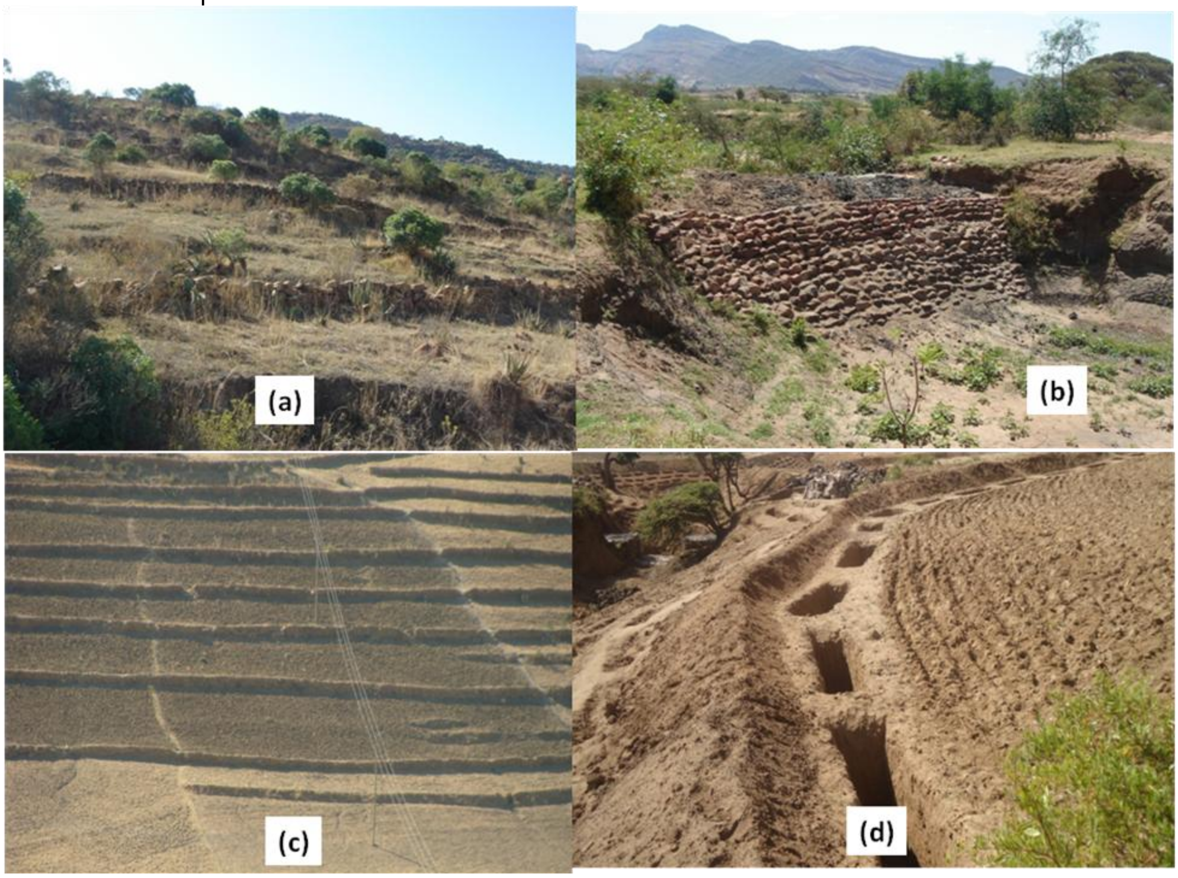
Success stories/best practices in water harvesting and watershed management

Woldearegay et al. (2012) reported that there are many best practices in soil and water conservation and natural resources management in the study area including area closure, gully treatment and deep trenches. For instance, the area closure and participatory watershed management at Abraha Atsebaha and Negash watersheds in Kilite Awlaelo Wereda has resulted in the following large benefits to the environment and the community.

- The advancement of gullies was halted and the gullied area was reclaimed; water stored behind the check dams is used for growing fruit trees;
- The farmland is safe from inundation by flood and silt deposition;
- The groundwater is adequately recharged and is being used for irrigation, livestock and domestic water supply;
- The hillsides are currently covered with indigenous and introduced grasses, bushes and trees;
- Increase in yield and subsequent income:
  - improved harvest of fodder grass from marginal lands has increased the productivity of livestock;
  - production of honey has increased due to the enhanced biomass availability;
  - cereal productivity has increased and vegetable and fruit production introduced.

The area closure and participatory watershed management introduced at Barka Adi-Sebha in Atsbi Wereda followed by partitioning of the watershed to landless youngsters is another exemplary initiative that has converted a conserved land into income generating hub. The youngsters are currently harvesting apple and improving their livelihood.

The increase in the number of best practices and success stories is brought about by implementing various means such as organization of experience sharing visits and use of various awareness creation mechanisms (Invitation of religious leaders and the elderly to play a lead role in the efforts, invitation of newly married couples to spend part of their honeymoon in the watershed and organization of tea party at the watershed). It was, however, noted that the scale of best practices is still limited and needs further effort to scale it up.



Some of the soil and water conservation measures in the study area in Ethiopia: Hillside terraces (a), Checkdams (b), Stone bunds (c) and trench bunds (d)

Burkina faso

The types of the soil and conservation techniques depend on the average precipitation, soil type and the topography. Thus, in wet areas where leaching of nutrients from the soil and water erosion are problems for agricultural production, soil conservation measures are of vital importance. However, in the dry areas where water is the main constraint of the agricultural production, water harvesting techniques are predominant (Bandré and Batta, 1998). According to the agroclimatic zoning of Burkina Faso, a variety of traditional and new soil and water conservation techniques are encountered (Vlaar, 1992) (Table 1).

Table 1 Adaptability *of soil and water conservation techniques in Burkina Faso (adapted from Vlaar, 1992)*.

	Function	Agro-climatic zone			Soil types				Topography	
		Sahelian	Soudano	Soudano-sahelian	Clay loamy	Sandy loam	Sandy	With crusts	Steep slopes	Moderate slopes
Deep ploughing	CE	-	+ +	+	+ +	+	-	+ +	+	+ +
Zaï	CS/CE/CR	+/-	+ +	-	+	+ +	-	+ +	+	+
Half moon	CS/CR	+ +	+	-	+	+ +	-	+	+	+ +
Earth dike	CS/CE	+	+ +	-	+	+ +	-	+	-	+ +
Ditch bunds	CS/CE/CR	+	+ +	+	+	+ +	-	+	+	+ +
Rocky bunds	CS/CE	-	+ +	+	+ +	+ +	+	+	+	+ +
In filtration dike	CS/CR (2)	+	+ +	+	+ +	+ +	+	+	-	+ +
Gully treatment	CS	+	+ +	+ +	+	+ +	+ +	+	+	+
Vegetation strips	CS	-	+	+ +	+	+	+	+	+	+

+ + Highly adapted
+ moderately adapted
- poorly adapted

CS = conservation of soil against water erosion
CE = conservation of water
CR = runoff water harvesting
EE = conservation of soil against wind erosion

Sawadogo et al. (2011) reported that in a study in two villages (Somyaga and Ziga, North West Burkina), the rate of adoption of soil and water conservation measures by farmers ranged between 0% (no adoption) to more than 40%. They found that Zai scored the maxium rates in both villages while half moon was the least adopted, as they are at experimental stage as shown in the following table.

Percentage of the areas treated with SWC techniques in the villages of Somyaga and Ziga, North West Burkina

Village	SWC techniques				
	Without SWC	Zaï	Rocky bunds	Rocky bunds +Zaï	Half-moons
Somyaga	42.1	28.9	18.4	7.9	2.6
Ziga	31.7	51.2	12.2	2.4	2.4
Average	36.7	40.5	15.2	5.1	2.5

Source : Sawadogo et al. (2011).

Sorghum in Zaï pits.

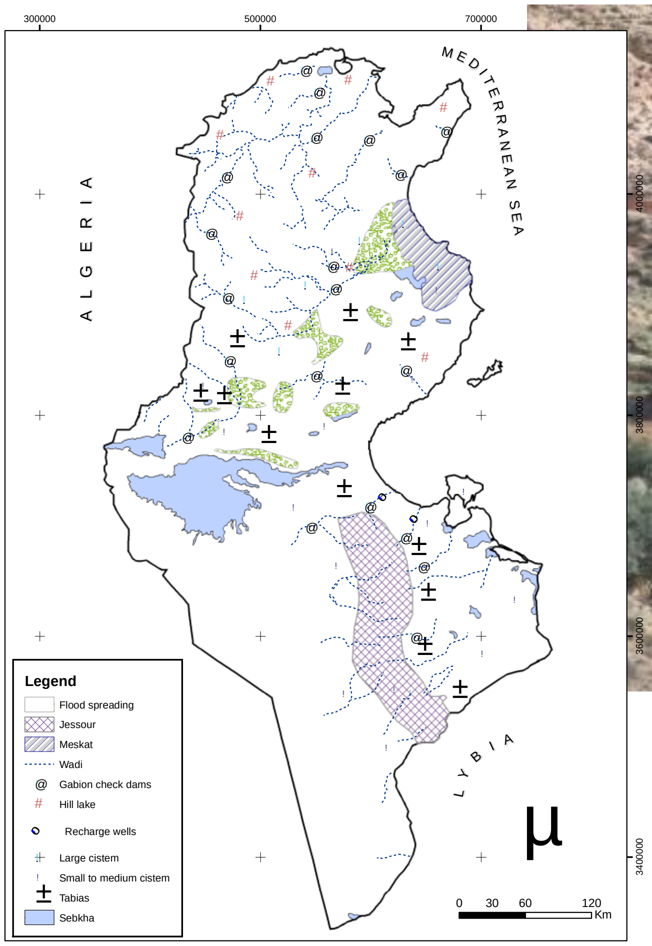
Tunisia

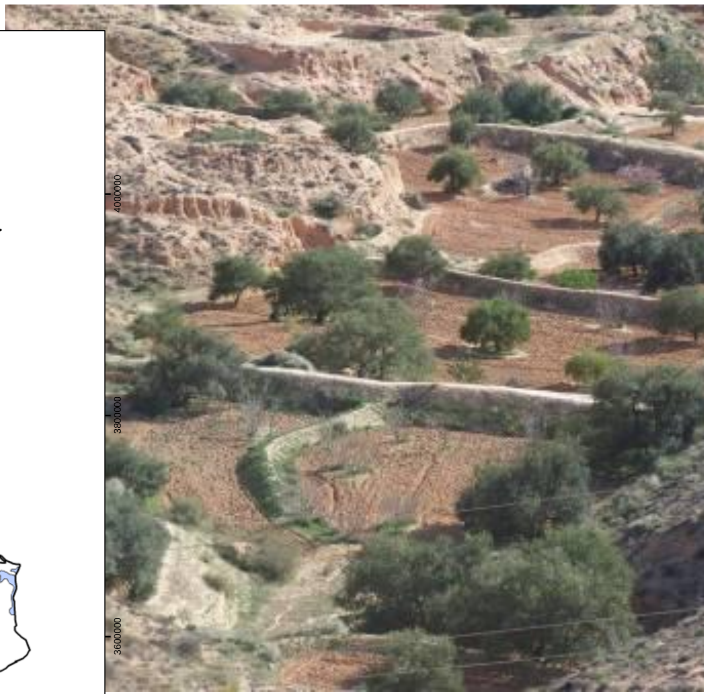
Overview of water harvesting

A comprehensive survey of traditional hydraulic works in the *Maghreb* countries was carried out by El Amami (1982). This document, written in Arabic, was followed by a second document, written in French, on Tunisia (El Amami, 1984). These manuscripts cover all the local small-scale irrigation techniques used in North Africa, with particular attention being paid to Tunisia. The English term 'water harvesting' was not specifically used by these reports to describe the indigenous systems of runoff water capture and use. The term was, in fact, only recently introduced into North Africa, the people in these countries being far more conversant with the French language. The terminology used in these reports refers to water harvesting techniques (WHT) as 'small hydraulic structures or systems'. However, the techniques

described exhibit the three main characteristics of water harvesting listed by Boers and Ben-Asher (1982): (1) they are applied in arid and semi-arid regions, (2) they depend upon local water, and (3) they are relatively small-scale operations. El Amami's fundamental works (1982; 1984) have triggered increased awareness of the potential indigenous technologies have in terms of drought mitigation. Since the works were published, a large number of studies have been made of the methods used to induce, collect, store and conserve local surface runoff for agriculture in arid and semi-arid regions. A compilation of these techniques was recently produced by Ennabli (1993), Ben Mechlia and Ouessar (2004), Ouessar *et al.* (2006), and Ouessar (2007).
Undoubtedly, the various water harvesting techniques (which are used on approximately one million hectares within Tunisia) are considered to be an integral part of the country's national heritage. Not only do these techniques contribute to the country's wealth by increasing agricultural productivity and by enhancing natural vegetation, they play a key role in the protection of its natural resources (MEAT, 1998) and in the maintenance of social equilibrium in the different regions.

The main water harvesting techniques encountered in the country can be subdivided into three major groups: (1) runoff water harvesting that makes use of runoff as it is collected, thus eliminating the need for storage-included among such systems are the related micro-catchment techniques called *meskat* and *jessour*; (2) floodwater harvesting and spreading or spate irrigation using diversion dykes (*mgoud*); and (3) runoff water collection and storage in reservoirs of variable capacities, which provides drinking water for people and animals, as well as water for irrigation purposes.





Main WHT encountered in Tunisia (Ouessar 2007).

Jessour in Southern Tunisia

Success stories
A commonly applied water harvesting technique in Tunisia is the jessr, in which runoff from a micro catchment, called impluvium, is collected on a terrace in order to increase water availability for vegetation (crop and trees). In this study, infiltration and runoff measurements were carried out at the impluvium of the Amrich jessr (southeastern Tunisia) in order to predict runoff and sediment transport for different rainfall events. The simulation results indicated the importance of the jessr in retaining water and sediment. Furthermore, over a period of 3 years, rainfall and infiltration data were used to assess the water balance on the terrace of the jessr. The results showed that especially during dry years the impluvium of the jessr provides an important supplementary amount of water for the cultivation of olive trees (Olea europeae). Finally, it was estimated that the ratio ''impluvium area/terrace area'' (CCR) should be at least 7.4 in order to provide, on average, sufficient water for olive cultivation, taking into account an average annual precipitation of 235 mm (Schiettecatte et al., 2004).

In arid Tunisia, a tabia system is a traditional macrocatchment water harvesting system. It consists of a runoff area, which occupies two thirds of the slope and is traditionally used for grazing; and one to five cropped plots within U-shaped soil banks arranged in a cascade in the third downstream area. These "run-on" areas accumulate and store the occasional runoff. Each soil bank is constructed with a discharge weir that allows modification of the flooded area and discharge of excess water towards downstream plots. Such a harvesting system, located in an area with 140 mm annual rainfall, was instrumented during four hydrological years (1995–1999) and 45 rainfall events were recorded. Eleven of these events gave a measurable inflow to at least one of the four plots. The observations showed that the traditional tabia system reduced total surface runoff from the catchment to essentially zero. The harvesting system significantly reduced peaks of surface runoff within the catchment, which also reduced erosion hazards. The cultivated area of about 5% of the total catchment could be supplied by a harvested water amount corresponding to about seven times the amount of each rainfall event larger than 20 mm (Nasri, 2002).

Zambia

Handia et al. (2003) reported that rainwater harvesting is a technology which is traditional in some parts of Zambia. It is done on an ad hoc, very low tech basis usually by placing buckets under the eaves to catch rain during storms/storing the water in containers such as old 210 l oil drums. Very few RWH systems had been installed, mainly at schools, but this was not widespread. These were roof harvesting systems consisting of a roof catchment, gutters and tank. The water was drawn through a tap from the tank. The water was used for drinking and washing by pupils, teachers and nearby communities. The Ministry of Agriculture had constructed a number of different rainwater harvesting systems for rural areas especially in the Eastern Province. Some of these were roofwater harvesting systems with ferrocement and brick tanks. Some of the installations were at schools whilst others were at individual houses. Livingstone Sustainable Food Programme had also worked with the rural communities. The structures constructed were mainly dams, weirs and boreholes. The local government, with support from UNICEF was planning to start piloting in 10 districts of 2 provinces. A RWH Association of Zambia had been formed to promote RWH in the country.

Water tank in Zambia.

4. Conclusions

The African continent is very rich in various water harvesting and soil conservation technologies. They vary from macro and micro-catchment and floodwater harvesting to atmospheric and insitu water conservation technologies. The existing well known traditional and indigenous practices have been either improved and/or new technologies have been introduced to complement them. The same trends have been also observed in all the study sites. However, as Ethiopia and Zambia study sites are located in more humid climates, more soil conservation technologies are in use whereas the water harvesting practices are frequently encountered in Tunisia and Burkina study cases where the climate is drier.
The high levels of the local know-how of the stakeholders (especially farmers, engineers, etc.) and their willingness to be fully involved in the different steps of the implementation of the project are key signs for good prospects of project progress in the study sites, especially the coming workshop on selection of the technologies to be implemented and monitored in the study sites, which will be implemented in WP2.

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