Water Harvesting and Agricultural Development in Jebel Mara Massif in Sudan

Elyas Mansour Ahmed Mohammed*

Abstract

This research investigated the potentiality of Jebel Mara Massif for growing fruit and crops, to supply the country with, such as potato, onions, garlic, papers, legumes, tomato, …*etc*, to reduce the imported amount to its least limit. So the main field of this research is to investigate the water supply for the purpose of irrigation, in term of water harvesting in a very special circumstances of Jebel Mara Massif in its geology, geomorphology and soils.
The research carried out some methods to harvest water in Jebel Mara Massif, and presented some solutions for the problems that face water harvesting.

Introduction:

Rainwater harvesting has been used since ancient times throughout the world. Some of the oldest evidences of roof catchment systems date back to Roman times. Roman villas and even whole cities were designed to take advantage of rainwater as the principal water source for drinking and domestic purposes since around 2000 B.C. In Israel, tanks for storing runoff from hillsides, for both domestic and agricultural purposes, have allowed housing and farming in areas with as little as 100mm of rain per year. The earliest known evidence of the use of the technology in Africa comes from northern Egypt, where tanks ranging from 200-2000m³ have been used for about 2000 years – with many operational today. The technology also has a long history in Asia, where rainwater collection practices have been traced back almost 2000 years in Thailand. The world's largest rainwater tank is probably the Yerebatan Sarayi in Istanbul, Turkey. This was constructed during the rule of Caesar Justinian (A.D. 527-565). It measures 140m by 70m and has a capacity of 80,000 cubic meters.(www.crd.bc.ca).

This research tackles the topic of rainwater harvesting in Jebel Mara Massif in Darfur state, Sudan.

In spite of it's high parameters of rain fall, and huge storage of water inside it's rocks, Jebel Mara experiences a lack of water, not only for irrigation, but also for domestic use, especially at high altitudes, such as Golo area .(Ahmed, 2003).

Mountain areas are fragile ecosystems , especially when they experience high density of population , such as Nepal in Asia. Although Jebel Mara - so far- has no high density of population, but it should be developed, particularly in the field of agriculture, to meet the needs of increasing population in the adjacent areas in Darfur and the country as a hole , mainly in fruit and vegetables.

Although Jebel Mara has a great potential to grow many field and horticultural crops, the number of crops cultivated seems to be very little in comparison to it's potentiality . So all agricultural development programs stakeholders, are looking for water for the pre-mentioned uses, as a first step to plan for every development program in Jebel Mara Massif.

Water harvesting in Jebel Mara Massif adheres to many aspects , of which are climate, geology, soil, geomorphology, and drainage system. Some of these aspects play a vital and positive role in water harvesting in Jebel Mara Massif, but most of them constrain water harvesting.

Thus, the main aim of this research is to investigate the positive and negative factors of water harvesting in Jebel Mara Massif, and to find out some suggestions in term of methods and techniques, to implement water harvesting methods and techniques in Jebel Mara Massif.

Concepts of water harvesting:

The concept of water harvesting appears through many definitions found through the time, for example (www.k4rd.org) web site considers rainwater harvesting as "the deliberate collection of rainwater from surface and its storage to provide a supply of water". Also the international water and sanitation center (Lee.&Visscher, 1992) defines rainwater harvesting as "the collection, concentration and storage of water that runs off a natural or man-made catchment surface". Another definition of this concept is "rainwater harvesting is the accumulating and storing water of rainwater for reuse before it reaches the aquifer" (Ahmed and Elnaggar,2003,p.7.)

* Department of Geography - Faculty of Arts -Omdurman Islamic University.

As appears from the above mentioned definitions, the concept of rainwater harvesting is a process of collecting and storing water for future use. But by the time the concept seems to be widened to include the water that directed – anyway- to replenish the ground water, to enable hand –dug wells and bore wells to yield in a sustained manner, to support growing forests and agriculture, or to make contour schemes and terraces to slowdown the movement of water runoff, to enable water to be used for a longer period op time, for agriculture and to reduce the soil erosion.

The following definitions and explanations show the broadness of the concept as pre-described;(Jessica) said "most of all, rainwater harvesting (RWH) is environmentally sound as it assist in recharging ground water, enhances wetlands, assist forests conservation, encourages ecological farming, and slows down construction of new dams for water supply helping the ecological flow"(www.ricsa.org).(Worm, & Hattum, 2006) defines water harvesting: "water harvesting in its broadest sense can be defined as the collection of runoff rainwater for domestic water supply, agriculture and environmental management." And at Wikipedia, rainwater harvesting is described as "the collection and storage of rain from roof or from a surface catchment in tanks or directed into mechanisms which recharge ground water.

Water Harvesting Techniques:

There are different types of rainwater harvesting, including rooftop harvesting, surface runoff harvesting and underground harvesting. According to (Lee and Visscher, 1992,pp.14-20), these types are as follows:

Roof water harvesting:

Rooftop and tank systems provide an on-site source of water supply next to homes or public buildings such as schools or health centers. They can be also constructed wherever there are permanent settlement experiencing difficult conditions of water supply conditions.

Surface harvesting systems:

Surface harvesting systems catch rapid runoff from natural or man-made surfaces, then concentrate and store it at strategic locations. The water thus collected is often used for different purposes including drinking water, water for cattle and agriculture.

Surface harvesting techniques take many forms, of which are contour ridges, small runoff basins, contour bench terraces wadi bed cultivation and water spreading (Ahmed and Elnaggar,2003,p.7)

Underground harvesting systems:

Underground harvesting systems exploit water already infiltrated and concentrated through natural hydrological process into the sand rivers that fill valleys. River beds are traditional watering points.

Anyhow people use the surface flow during rainy seasons and dig shallow unprotected wells into the bed each dry season once surface flow has dried up.

d)Rainwater harvesting through artificial ground water recharge

in places where the withdrawal of water is more than the rate of recharge, an imbalance in the groundwater reserves is created. Aquifers are recharged for various reasons. (UNDP, water harvesting 1993) to:

- maintain or augment natural groundwater as an economic resource.
- conserve excess surface water underground.
- combat progressive depletion of groundwater levels.
- combat unfavorable salt balance and saline water intrusion.

Advantages of water harvesting:

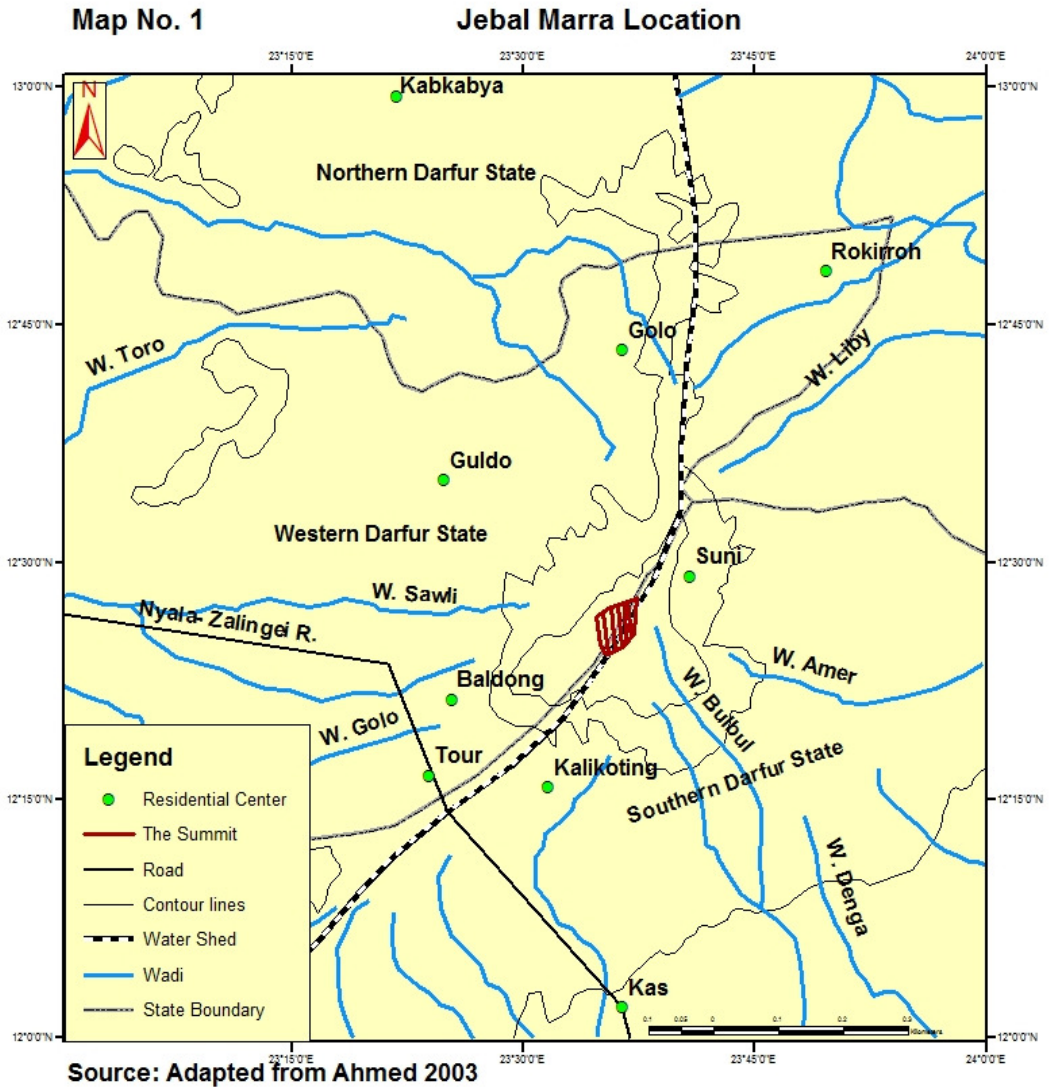
Rainwater harvesting has many advantages, some of them are summarized by (Ahmed and Naggar, 2003, pp.9-10) as follows;

a) Rainwater harvesting succeeds in providing good quality water for both irrigation and domestic use.
b) Rainwater harvesting solves to a great extent the problem of satisfying water requirements with time by smoothing out the variations in water availability.
c) Rainwater harvesting replenishes the ground water table and enables our dug wells and bore wells to yield in a sustained manner.(www.aboutrainwaterharvesting.com).

Geographic aspects of Jebel Mara Massif:

a) Location:

The location of Jebel Mara Massif is in the Western Sudan, in the African Sahel Zone that extends across Africa from west to east- in western Sudan , in Darfur States, between latitudes 12:30 and 13:40 N and between longitudes 23:40 and 24:45 E on a distance estimated to 95kms with maximum width around 90kms at extreme southern en (Wickens, 1976, p.6) (map no. 1)



b) Geology:

Generally, Jebel Mara is a dormant-late tertiary, volcanic massif resting on a base of archaean rocks at the summit of an up warping between the Chad and Nile basins, i.e. straddles the Nile and Chad watershed.(Wickens, 1976, p.6). It consist of igneous rocks including lavas and ashes, the igneous rocks in their present form are termed collectively schist and gneisses and they have been invaded from time to time from below by various deep- seated igneous rocks of which the most important are granites and related rocks types.(FAO, 1968,p.17).

Jebel Mara Volcanic complex has been built up of several eruptive phases, interrupted by a period of erosion and a major explosive phase.(FAO, 1968,p.17).

c) Geomorphology:

Jebel Mara Massif is rises to over 300 meters above sea level and culminating in a high plateau and crater; the slopes

are steep, especially on the eastern face, while the piedmont lands extend to the West and South. This volcano rises above the gently sloping landscape of the basement complex between 600 to 1000 meters above sea level.(FAO,1968,p.11).

d) Soils:

As Jebel Mara Massif varies in topography, the soils are described as follows:(FAO,1968,pp.22-23).(map no.2)

1-Datum soils of the piedmont plains:

These are only ash loams on the surface of a once continuous piedmont plains, but now they are seen as plateau interfluves separated by deeply incised drainage lines and flanking gullies.

2-Ash loams of the lower mountain slopes:

These soils are found mainly on the western flank of the Massif between the foot of the steep terraced hill lands and the piedmont plain soils, the topography is gently slopping but deeply dissected by the perennial streams.

3-Terraced mountain soils:

These vary gently in character but are generally shallow, stony ash loams.

4-Soils of the lava plateau:

These are found in the level tops of old lava flows at the mountain foot, now they are deeply dissected, these soils often stand 100 meters or more above the plain or valley floor, capping hills of the basement complex. The soils are generally very stony and clayey, sometimes with a surface layer of ash.

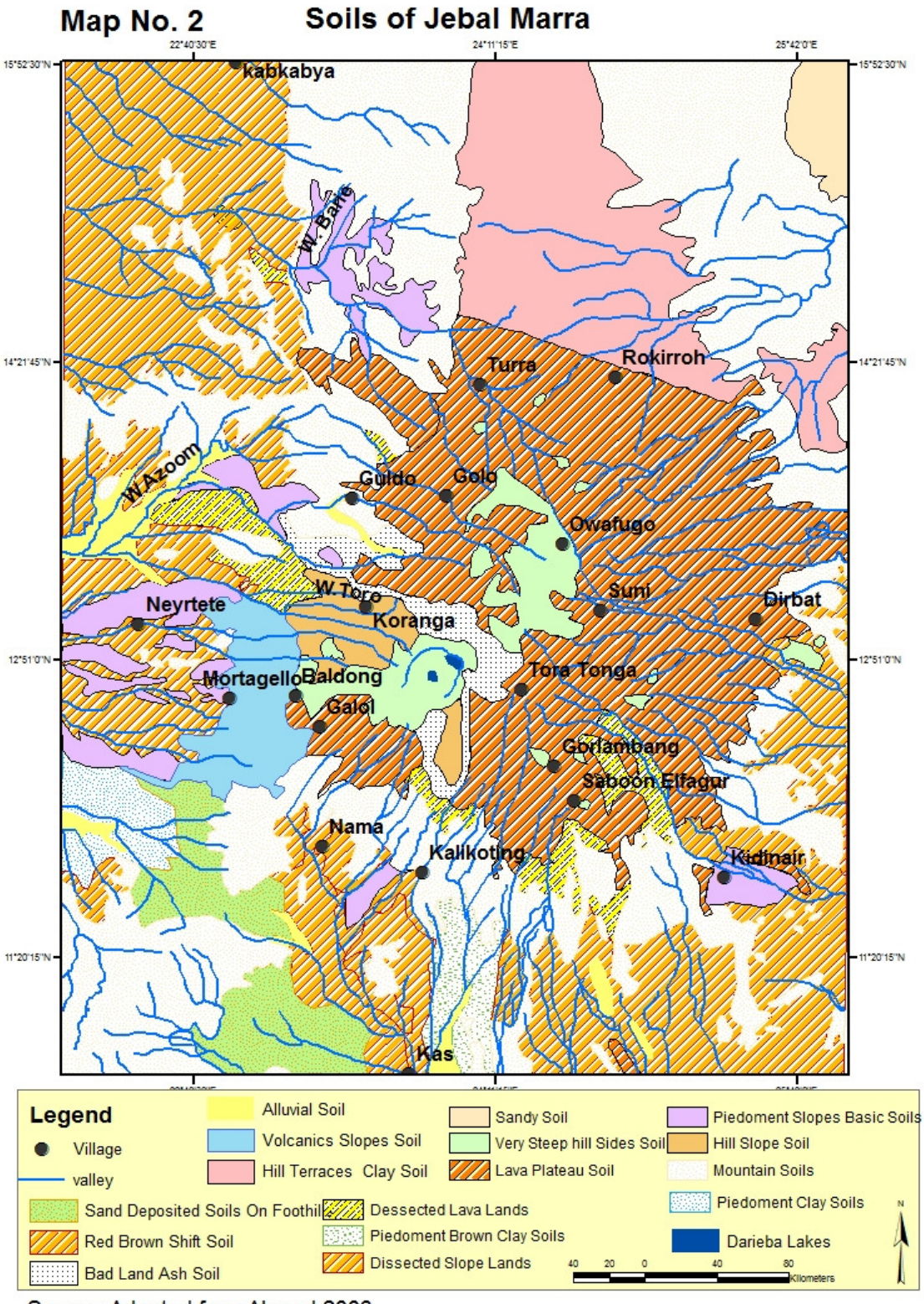
5- Soils of the high- altitude ash plains:

These are found on deep ash deposits in flour relatively level areas: the water-laid ash deposits in the Deriba crater and the smaller crater above Gur Lambang, the gently rolling ash and pumice plain at Tora Tonga and the deep ash and pumice plain of Tereng.

(6) Miscellaneous Units:

In severe eroded parts of the volcanic complex, the soils are stripped, truncated or gullied. They include dissected piedmont lands, broken lava lands, ash badlands and steep mountain slopes.

All types of the pre-described soils have a good potentials for agriculture and forest plantation, except the last one has just a potential for grazing and forestry.



Source: Adapted from Ahmed 2003

e) Hydrology:

1- Precipitation:

Jebel Mara is a climatic island inside the hot semi-arid zone, with rainy Summer and dry Winter (Ahmed, 2003,p100), this situation is related to its altitude, which ranges between 1000 to 3042m a.m.s.l., this makes its annual rainfall averages exceed 900mm, while the average of rainfall on the adjacent areas of its latitudinal belt is not more than 600mm.(Ahmed, 2003,p.119).

The rainy season in Jebel Mara extends from April to October. Roughly two thirds of precipitation fall during July and August, and over 89 percent thorough June to September (Hunting,1958, p.14).

2- Ground Water:

The water which comes out of Massif thorough various springs and drains thorough streams as tributaries of the main valleys which flow to Chad and the Nile basins, indicates that Jebel Mara is a magnitude reservoir, recharges annually by the beginning of the rainy season. These streams tend to run short shortly after the end of the rainy season, and comes to be recharged during the first month of the rainy season (a visit to Jebel Mara, 2001).In this connection, Hunting (1958) stated that ground water storage occurs in the volcanic rocks. Also reported that it's difficult to predict the behavior of ground water in the volcanic rocks- particularly the lavas- because the fissures, cavities and interstices in which the water moves are irregularly distributed.

f) **Population:**

Man has been living in Jebel Mara area for many thousand of years. The oldest known traces of Man found so far, are stone tools of the Paleolithic ca, 1.5m.y, to 0.8m.yBP in age, but remains of the settlement and cultivation in the area appear much later, during the Neolithic from 6000BP. As yet in fact the archaeology of Jebel Mara area is barely known, but it's likely that excavation of settlement will provides important data on cropping and cultural practice in the very center of Africa.(Hunting, 1995, p.14).

The Fur people were the earlier inhabitants of Jebel Mara, and they gave their name to the area now called Darfur (the home land of Fur).

Fur people as an economic group, are settled cultivators, either on the upper slopes of the Massif or on the foothills.

Potentials of Agricultural Production in Jebel Mara Massif:

Jebel Mara Massif has many potentials for agricultural production, of which are the following :

a) Fertile Volcanic Soils: These found on the upper slopes and the foothills, although they vary in depth and experience washing and eroding by perennial streams.

b) High parameters of rainfall: Jebel Mara has high averages of annual rainfall which exceed 900 mm, whereas the averages of its latitudinal belt not more than 600 mm. (Ahmed, 2003, p. 19).

c) Favorite climate for agricultural production: Jebel Mara Massif, in term of climate, suits growing of more than twenty species of horticultural trees (fruit), more than fifty types of field crops, and many forest trees of temperate areas. They are similar to the Mediterranean's, due to the decreased temperature that related to its elevation above sea level. The temperature of the summit is bellow 0Cº. (Ahmed, 2003, p. 214).Citrus in Jebel Mara Massif (orange, grape fruit, and lemon,…*etc*.) are fruitful throughout the year, and mango gives its fruit twice a year.

d) Skilled farmer: As Jebel Mara people are settled cultivators,- back dating to their ancestors- they built very good terraces on very steep slopes or the upper areas of the Massif.(a visit, October 2001)

Cultivating fruit trees on terraces on very steep slopes at Dursa area (2500m.a.m.s.l.)2003

Cultivating wheat on terraces at Kairu area (2500m.a.s.l.) 2003

The origin of the terraces suggest links with both West Africa (for example , the Joss plateau of Nigeria) and Southern Arabia (the well tiered nature of some terraces is very similar to those in Yemen). So the origin of Tora people of Jebel Mara were descending from the Berber origin and introduced terracing and irrigation.(Hunting, 1995, p. 14).

A close-shot photo at Sorrong area to show stone size and a good building style of terraces To cultivate Mango trees. (2500m.a.m.s.l.)2003.

Cultivating Beans and Wheat on terraces on a gentle slope areas at Logi area (2800m.a.m.s.l.) 2003.

The Methods of Rainwater Harvesting in Jebel Mara Massif:

People of Jebel Mara have traditional water harvesting methods , related to their ancestors. The most famous method is terraces, which are used to cultivate field crops during the rainy season. Among these crops are, sorghum, beans, red papers, tomatoes, potatoes, papers and okra…*etc*. In addition to this Method, they practice contour irrigation from springs so asto irrigate fruit gardens, and crops during dry seasons.

By the intervention of the developing programs, which started in the late fifties through the co-ordination between the European and the Sudan Government, modern water harvesting activities were started to construct the dams by Jebel Mara Rural Development Program (JMRDP) , that included all the region of Jebel Mara, even its Volcanic Massif.

After an intensive studies by Hunting Technical Service (HTS), a series of dams were constructed during 1990 to 1995, at Nyertete,Tur, Golo Shawfugu, and Togi, to store for irrigating orchards and dry season crops, and for potable uses (HTS,1995, p.37).

During a visit to the area in 2001, the dams at Golo, Tur and Shawfugu sites were considerably silted up after a few years (as the natives said). Because they we built without gates to pass the eroded materials(see the photo).

The man is standing on the Golo dam, and the storage area was silted completely and cultivated by Millet (2001)

The Shawfugu provides some benefits, although it has silted up. A broad stretch of floodplain now extends upstream of the dam. The alluvial consist of course textured sand and gravel, and supports a shallow aquifer from the base flow in this (wadi) valley. The villagers from Shawfugu take their water supply from hand- dug open wells in the alluvial sediments throughout the year. This indicates that in some areas of the Massif, the dams can be constructed to recharge aquifers to exploit its water in irrigation and household uses, as a type of water harvesting in the areas with cracks and permeable soils.

Moreover, Neyertete dam was constructed at Neyertete in a gentle slope area in the foothill at altitude of 1800m a.m.s.l., with central gates to pass the erode materials and to prevent silting the dam. Now it provides water for irrigation, domestic use and animal drinking as well.(see the photos).

The storage area of Neyertete dam(2001)

The central gates appear at the bottom of Neyertete dam body.

Togi dam which constructed in a small catchment within the Beldong forest, was aged-in1994- to about 6years. As reported by HTS has another problem, the dam barely has any silt in it, it does not hold water, because of percolation into fractured volcanic basaltic and trachytic rocks that causes the lack of storage,(HTS:1994:38), but now has a considerable amount of silt in it rising below its crest, and has no water (a visit , September 2012). However the investigations of the natives revealed that the water table in the adjacent well was raised. This means that the percolated water through the rocks of the dam recharged the aquifers.

In 2001 another dam was constructed at the eastern slopes of the Massif at Kidingar in a gentle slope wadi with gates and expected not to be silted and store a great amount of water, but it was collapsed with the next rainy season because of technical problems in its construction.

Also people extract water from aquifers by means of hand pumps installed in bore wells at Golo area (2300m.a.m.s.l.) , (a visit to the area 2001).besides, there are many open hand dug wells supply villagers with water for domestic use, animals drinking and irrigating fruit gardens and field crops. (see the photo).

An open hand-dug well at the left side of the photo uses to irrigate onions, red papers and apples at a depression near Kairu village (2400m.a.m.s.l.)

The problems of water harvesting in Jebel Mara Massif:

Water harvesting in Jebel Mara Massif encountered physical and human problems, the physical problems adhered to its geology, geomorphology, and soils, while human problems are related to the human activity of making terraces.

- The physical problems:

1- Geology: In many places of Jebel Mara Massif, the rocks consist of fissures and tunnels on the old lava flows; this makes water of dams to be percolated in the bed and the adjacent rocks, like the case of Togi dam.

2- Geomorphology: the Massif slopes are very steep, this causes water currents in streams during the rainy season to be in a very high speed, which results in a severe erosion of materials of fragment rocks, which will deposit in the dams and fill them with silt, as the case of Golo dam.

3- Soils: soils of the Massif in general, have textured nature, they consist of course materials (stones, gravels, and sands) with ash and loams, so the soils have a property of percolation and have no ability to hold water in case of constructing dams.

- The human problems:

The human activity of making terraces results in making the soil very loose and exposes to erosion by the water flow, to be deposited in the dams.

The Future of Water Harvesting in Jebel Mara Massif and Agricultural Development

Jebel Mara Massif is a prospective area in Sudan for producing various - types of fruit and crops because of the potentials mentioned in this paper that are revealed by many studies.

Since agricultural development needs water, water harvesting programs are very essential in spite of the pre-reported obstacles and problems. So people should overcome those problems by:

1) Promoting contour irrigation , by making many channels stem from the springs fringing the main stream, going parallel to it, and to divert some channels to go a long distance from the stream to irrigate as large area as possible, to cultivate fruit trees and field crops.

2) Implementing local water legislations precisely to justify water distribution and to avoid expected problems of misdistribution of water.

3) Constructing dams at very deep gullies in the streams to make aquifers and recharge groundwater, in order to rise the water table in hand-dug wells and support fruit gardens and forestry, where the soils and rocks have a potential to do so.

4) Constructing dams across wadis with gentle slopes, in the areas of un-percolated rocks, with central gates to pass the eroded materials by the first flow at the beginning of the rainy season.

5) Hand-dug Wells:

People should be encouraged to expand hand-dug wells in the depressions with ground aquifers, to cultivate fruit and crops. Also they should be encouraged to make new terraces and to maintain the old ones to enlarge cultivating areas. Encouraging people will be by:

a) Extensive agricultural extension programs.
b) Supplying people with seeds and seedlings.
c) Establishing community funds, to be sponsored and managed by community members themselves. These funds should carryout projects and give loans, in a systematic way by following specific terms and precise laws.
d) Funding water harvesting projects by (NGOs) and the Government to provide agricultural water supply.
e) Marketing:

Marketing is a cornerstone in agricultural development, even in good water supply circumstances, hence, if there is a market, production will be doubled, if not, the farmers will linger and the production will reduce. So the Government and the institutions should seek markets anywhere, inside the country and abroad.

Conclusion and results:

As appeared from the research, Jebel Mara Massif has a good potential to agriculture, but it suffers a lack of water for both agriculture and domestic use.

Water harvesting projects are needed for carrying out agricultural development programs.

Water harvesting problems should be solved considering the physical aspects and characteristics of Jebel Mara Massif, and human culture and inheritance.

Agricultural development can be carried out by solving related problems, such as, funding, supplying seeds and seedlings, marketing, and agricultural extension, beside water supply.

References:

1- Ahmed, A. Abdalsalm, and Naggar, O. Mohammed, "Rainwater Harvesting: Concepts and Techniques", a paper submitted at Conference on water harvesting &the future of development in Sudan, UNESCO chair in water resources, Khartoum,2003.

2- Ahmed, Elyas Mansour, The Climate & its Impact on Agricultural Development in Jebal Mara, Unpublished PhD. Thesis,(in Arabic), Omdurman Islamic University, Omdurman, 2003.

3- FAO, Land and Water Resources Survey in the Jebal Mara Area, Rome, 1968.

4- Hunting Technical Service, Jebel Mara Investigations, Technical Report,London,1958.

5- Hunting Technical Service, Jebel Mara Rural Development project, Land-use Planning Studies, Technical Report, 1995.

6- Lee, Michael D.&Visscher,J. Teun, Water Harvesting , A guide for planners and project managers, Tehnical paper, International Water and Sanitation Center (RIC) The Hague, Netherlands,1992.

7- Worm, Janette & Hattum, Tim Van, Rainwater harvesting for domestic use, Agromisa Foundation and CTA, Wageningen, 2006.

8- Wickens,G.E.,The Flora of Jebel Mara, London1976.

Web sites

1- www.k4rd.org/water. Visited, 25 August 2011.

2- www.wikipedia.org. Visited, 22 August 2011.

3- www.crd.bc.ca Visited, 22 August 2011.

حصاد المياه في جبل مرة في السودان

إلياس منصور أحمد محمد

الملخص

تناول البحث قابلية كتلة جبل مرة لإنبات الفاكهة والمحاصيل الأُخرى، لإمداد القطر ، وتتمثّل تلك المحاصيل . بجانب الفاكهة في البطاطس والفلفل والثوم والبقوليات والشطة والطماطم ، وغيرها، وذلك لتقليل الكميات المستوردة منها إلى الحد الأدنى. ولذلك فإنّ المجال الرئيس للبحث هو دراسة الإمداد المائي، فيما يعرف بحصاد المياه ، في ظل الظروف الخاصة بكتلة جبل مرة ، والمتمثّلة في الجيولوجيا والجيومورفلوجيا والتربة.

أورد البحث بعض الطرق لحصاد المياه، كما قدّم بعض الحلول للمشكلات التي تواجه حصاد المياه في كتلة جبل مرة بالسودان.