



Indigenous Rain Water Harvesting Practices for Climate Adaptation and Food Security in Dry Areas: The Case of Bahi District

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Indigenous Rain Water Harvesting Practices for Climate Adaptation and Food Security in Dry Areas: The Case of Bahi District

Deusdedit Kibassa
Ardhi University (ARU),
Institute of Human Settlement Studies (IHSS),
Dar es Salaam, Tanzania



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Abstract

This study documents techniques used by communities to improve indigenous rain water harvesting in the villages of Mpalanga and Chipanga A. Through questionnaires, focus group discussions and interviews, data on community's willingness to accept and adapt the improved techniques was collected. The study also conducted analysis of soil types, local and non-local materials such as logs, grasses, cement as well as open spaces surrounding houses and their potential into suiting to improved techniques of rainwater harvesting. The study revealed that community in two villages harvest rain water traditionally by hanging pieces of clothes on the edge of the flat roof tops to collect and drain water into the bucket placed on the ground. They also collected runoff in open spaces surrounding their houses as well as digging shallow wells in river banks during dry season. Although the techniques are not widely utilized, the villagers came up with improvement strategies of cementing the roofs or covering it with the plastic materials as well as constructing cisterns for harvesting runoff. This study concluded that with the proposed improvement, indigenous rain water harvesting techniques have the potentials to improve water availability for domestic and agricultural production in Bahi district specifically in Mpalanga and Chipanga A villages.

1. Introduction

1.1 Background

Indigenous knowledge is the knowledge that people in a given culture or societies have developed over time, and continue to develop. It is a body of knowledge based on experience that has often been communicated through oral traditions and learned through family members and generations, often tested over centuries of use, and adapted to local culture and environment. Indigenous knowledge is not confined to tribal groups or the original inhabitants of an area. It is not even confined to rural people. This recognition is directly related to the growing realization that locally generated knowledge can be used to change and improve, for example, agriculture and natural resource management. Due to high variability of rainfall in both spatially and temporal arid and semi-arid areas, communities in these areas have relied on indigenous knowledge to harvest rain water because such techniques are compatible with their local life styles (Mbilingi et al. 2005).

In Tanzania, more than 50 percent of the country's land area can be categorized as semi-arid (De Pauw, 1984; RLDC, 1987). In terms of rainfall received and available water resources, Bahi district in Dodoma region can be classified as one among the driest districts in Tanzania. Floods and droughts have become major constraints to development in various parts of the country. For the past 100 years, 38 percent of the disasters were caused by floods and 33 percent are related to drought in Tanzania. Among the areas which have suffered such situation are the dry areas of central Tanzania including Bahi district. The district receives region receives a total annual rainfall of 400 to 600mm, mostly falling in a single rainy season from December to March (BDC, 2008). The region is characterized by both hot and dry seasons often resulting in severe water shortage. This problem has also been observed in Southern Africa, a region that suffered massive damages due to floods and drought in 2000 and 2002 (Hatibu, 2003). This situation has threatened water availability for both domestic and agricultural use, restraining the capacity of communities to adapt to the impact of climate variability and climate change. Agricultural production has decreased in the district threatening both food security and income for its people.

1.2 Justification

Rainfall in Bahi district (study area) is relatively low and highly unpredictable in frequency and amount particularly in the month of January in which most crops are generally sown. It is this unreliable rainfall which has imposed a pattern of risks erosion in traditional agriculture and which represents serious constraints on present efforts to improve crops fields. The two villages were picked for study due to their extreme drought condition, very poor water availability and the general poverty of the community. Bahi is also among the few districts in Dodoma where indigenous rain water harvesting techniques are not widely promoted as the case for other districts in the region.

Domestic Rain Water Harvesting (DRWH) which provides water directly to households enables a number of small scale productive activities and has a potential to supply water even in rural and peri-urban areas that conventional technologies cannot supply. In essence, rain water harvesting can supply water to accelerate social and economic development, to alleviate poverty and generate income for rural farmers by enhancing crop yield, modifying the method of production, as well as promoting environmental conservation. The scaling up of such technology will bring about impacts to a larger community through involvement of various stakeholders in Bahi district.

1.3 Problem statement

Over the years, technologies introduced in most parts of the country consisted of roof water harvesting for domestic purposes (drinking and sanitation), runoff collection in ponds for small gardens, trenches for groundwater recharge and afforestation (UNEP, 2009) factor which proved failure to people of Bahi. The reason for the failure was the fact that most roofs of the houses in Bahi are flat and traditionally made with logs, mud and grasses, therefore the rain water harvesting techniques used have lacked potential to improve water availability for agriculture and domestic use. Due to the above reasons, the coping strategies to water stress caused by climate change have also remained a challenge.

1.4 Objectives of the research

The main objective of the study was to identify strategies and scale-up the indigenous rain water harvesting technology for climate change adaptation and food security in dry areas of Bahi district, in Dodoma region.

1.4.1 Specific Objectives

- Document indigenous practices for rain water harvesting in Bahi district
- Strengthen the capacity of youths and other stakeholders in Bahi district in adopting sustainable indigenous knowledge for rainwater harvesting to improve food security in dry areas
- Develop an effective communication strategy for disseminating results from the research project to wider targeted audience including through leaflets, brochures, etc;
- Engage other relevant stakeholders in adopting the evidence-based innovative adaptation technology at the local and national levels.

2. Literature Review

2.1 Climate Change and its Impacts in Tanzania

Climate change is one of the biggest global problems posing challenges to sustainable livelihoods and economic development, particularly for developing countries like Tanzania. The adverse impacts of climate change on environment, human health, food security, human settlements, economic activities, natural resources and physical infrastructure are already noticeable in many countries including Tanzania (URT, 2009). Of all the parts, semi-arid areas of central Tanzania have been hit severely making the adaptation strategies difficult. In 2008 an assessment of climate change impacts in Tanzania was done (URT, 2009). Results of that assessment reveal that temperature measurements from 21 meteorological stations in the country have shown a steady increase in temperature for the past 30 years. Severe and recurrent droughts in the past few years have triggered drop of lake water levels in all lakes in the country while in arid and semi-arid areas most rivers and lakes have dried up contributing to electricity power crisis, poor agricultural yield as well as decreased fish catches. For example, Lake Victoria dropped by 2.57m between 1965 and 2006 while most rivers and lakes in central parts of Tanzania dried up permanently. These impacts have already affected not only the local communities but also economic development at large. Recent estimates show that the average growth rate has well been below 6%. This drop is attributed to severe drought that affected most parts of the country triggering food shortage and a power crisis. The above situation has resulted in to various communities struggling to adapt and reduce the impacts by either adopting various techniques to increase water availability or change agricultural techniques to increase yield and improve their livelihood.

2.2 Indigenous Rain Water Harvesting as a Coping Strategy to Climate Change: Historical Background and Development

The importance of rain water harvesting for various agricultural activities received great attention in the 1970s and 1980s in Africa (Hatibu and Mahoo, 1999). This was caused by the widespread droughts in Africa which led to crop failures and caused serious threats to human and livestock growth. The main aim was to curb the impacts of drought by improving agricultural production and in some areas rehabilitating abandoned and degraded land. However, few of the projects have succeeded in combining technical efficiency with low cost and acceptability to the local farmers. This was partly due to the lack of technical “know how” of the communities as well as the selection of an inappropriate technique with regard to the prevailing socio-economic conditions. Greater efforts therefore should be undertaken to strengthen the capacity of local people to develop their own knowledge base and to develop methodologies to promote activities at the interface of scientific disciplines and indigenous knowledge (Mbilinyi et al. 2005).

Rainwater harvesting has been practiced for more than 4, 000 years, and, in most developing countries, is becoming essential owing to the temporal and spatial variability of rainfall. Rainwater harvesting is necessary in all areas as it brings water closer to the houses more than what even a stream could do. It is also important in areas having enough rainfall but lacking any kind of conventional, centralized government supply system, and also in areas where good quality fresh surface water or groundwater is lacking. Critchley and Reij, 1989, argue that the application of an appropriate rainwater harvesting technology can make possible the utilization of rainwater as a valuable and necessary water resource.

Mbilinyi, et al. (2005) further narrated that people who rely completely on rainwater over the years have developed indigenous techniques to harvest it for agricultural purposes. In Tanzania, experience with RWH has a long history. Individual communities have over the centuries developed traditional water harvesting techniques including the excavated bunded basins also known as “majaluba” for rice production in the Lake Zone, raised broad basins locally called “vinyungu” in Iringa region and water storage structures locally called “ndiva” in Kilimanjaro region. The concept of “Mashamba ya mbuga” where farmers grow high water demanding crops in the lower parts of a landscape using rainwater from the surrounding high grounds has been practiced for a long time in semi-arid areas of Tanzania. These traditional techniques have been sustainable for many years. This is because they are compatible with local lifestyles, local institutional patterns and local social systems. In order to develop sustainable RWH strategies it is therefore important to capitalize on the available local knowledge.

2.3 Rain Water Harvesting Based on Choices of Technology

The potential of RWH in providing water as supplement, to increase crop yield and reduce the risk of crop failure is very high (Oweis et al., 2001; Critchley and Siegert, 1991). Enhancing and stabilizing the crop yield of subsistence farmer will incentivize them to invest in soil nutrient enhancement. Rain water harvesting techniques can be divided into two types depending on source of water collected; namely, the in situ and the ex situ types of rainwater harvesting, respectively. In essence, in situ rainwater harvesting technologies are soil management strategies that enhance rainfall infiltration and reduce surface runoff. The in situ systems have a relatively small rainwater harvesting catchment typically not greater than 5-10 m from point of water infiltration into the soil. The rainwater capture area is within the field where the crop is grown (or point of water infiltration). This technology often serves primarily to recharge soil water for crop and other vegetation growth in the landscape. Malesu et al, (2006) argues that in situ technique emphasizes on water management and conservation structures which are mostly traditionally considered for soil moisture conservation. This approach aims at maximum infiltration and minimum surface runoff to achieve better yields where soil moisture is a constraint.

Hatibu, (2003) defines the ex-situ technique as systems which have rainwater harvesting capture areas external to the point of water storage. The rainwater capture area varies from being a natural soil surface with a limited infiltration capacity, to an artificial surface with low or no infiltration capacity. Commonly used impermeable surfaces are rooftops can provide the platform to collect substantial amounts of water for different uses (Figure 1). As the storage systems of ex situ systems often are wells, dams, ponds or cisterns, water can be abstracted easily for multiple uses including irrigation or domestic, public and commercial uses through centralized or decentralized distribution systems.

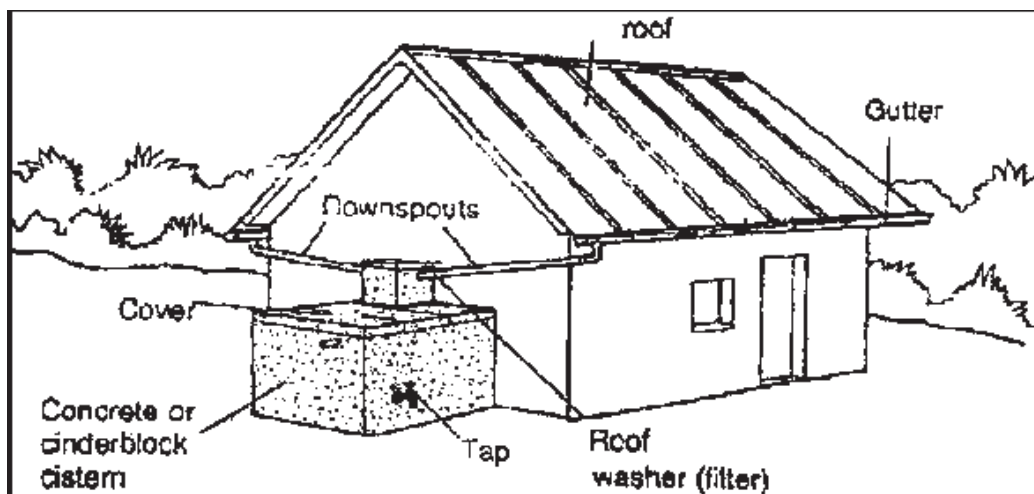


Figure 1: Schematic of a Typical Rainwater Catchment System (Source: José Payero, Department of Natural Resources, Higher Institute of Agriculture (ISA), Dominican Republic).

The storage time of the collected and stored water in cisterns, dams and tanks is more dependent on the size of capture area, size of storage unit and rate of outtake rather than residence time and flow gradient through the soil. Rainwater harvesting systems require few skills and little supervision to operate. The major concerns are preventing of contamination of the tank during construction and replenishing during rainfall. Contamination of the water supply from contact with certain materials can be avoided by the use of proper materials during construction of the system (ibid).

2.4 Rain Water Harvesting in Alleviating Poverty and Curbing Food Security

International Foundation of Red Cross (IFRC), (2004) indicated that the country's food security has had problems for years in the past. Dodoma region has been one among the regions with cases of food shortage in Tanzania due to drought. Tanzania has faced a worsening food security situation following poor harvest in both 2002 and 2003 as a result of inadequate rainfall. This has led to a national food deficit of approximately 500,000 tons of grain for 2003/4 based on an estimated availability of food of 8,000,000 tons with a domestic utilization of 8,500,000 tons. A preliminary crop production forecast by the Ministry of Agriculture and Food Security in May 2003 revealed acute food shortage in 52 districts in 2003 with the worse affected being Dodoma, Singida and Shinyanga.

In order to curb the situation, Baron and Rockstrom, 2003, argued that there are numerous positive benefits for harvesting rainwater. The technique is low cost, highly decentralized, empowering individuals and communities to manage their water. It has been used to improve access to water and sanitation at the local level. In agriculture, rainwater harvesting has demonstrated the potential of doubling food production by 100% compared to the 10% increase from irrigation. Rainfed agriculture is practiced on 80% of the world's agricultural land area, and generates 65-70% of the world's staple foods (Baron and Rockstrom, 2003). For instance, in Africa, more than 95% of the farmland is rainfed, almost 90% in Latin America. Rainwater harvesting increases food production and hence, forms the foundation of many development projects in promoting agriculture and land management (Reij et al., 1996; Lundgren, 1993; Hurni and Tato, 1992; WOCAT, 1997; Mati, et al. 2005). For instance maize yield can be tripled with RWH through conservation agriculture because the technique minimizes the risk of crop failure during droughts, intra seasonal droughts and floods (Baron and Rockstrom, 2003).

3. Methodology

3.1 Geographical location

This study was conducted in the two villages of Chipanga A and Mpalanga in Chipanga ward, Bahi district in Dodoma region. Bahi District is one of the six districts in Dodoma Region. The district has a total area of 5,948 square km with 56 villages and 20 wards, which are divided into four divisions namely Mwitikira, Chipanga, Bahi and Mundemu. It is a dry savannah characterized by long dry season lasting between late April to early December, and a short single wet season from late December to early April.

3.2 Population and other Socio-economic characteristics

The population of Bahi District according to the 2002 national census was 179,704, comprising 85,430 males and 94,294 females. The estimated population for 2007 was 203,313, comprising of 94,944 males and 108,369 females with a growth rate of 1.6%). The population of the two villages according to 2002 census was 8,212 for Chipanga A and 8,095 for Mpalanga. The district is among the least developed district in Tanzania and is the poorest in terms of estimated income per capital which is 178,000 Tanzanian Shillings. The district economic activities are almost entirely dependent on agriculture and livestock keeping. Agriculture is characterized by low productivity resulting from low and erratic rainfall, high evapotranspiration and low moisture holding surface soil.

3.3 Sampling technique

Random sampling method was used to select households. This method was found to be suitable because all households in the two villages are uniform in terms of construction and roofing materials as well as structural patterns and so this type of sampling technique ensured that all households had equal chances of being picked. The technique was used in picking households for questionnaires administration and interviews in both villages of Mpalanga and Chipanga A.

3.4 Data collection technique

Multiple methods were used in collecting primary data. During field visits visual observation as well as resource mapping to indicate the location and distribution of any available resources such as wells, dam, streams or rivers, forests and trees was conducted. This was important in order to identify whether there was any ex situ RWH technique being conducted. The location of farms and settlements was conducted to examine the possibilities of utilizing water harvested at home for agricultural purposes.

Ninety questionnaires (forty five in each villages) were administered to respondents to collect information on the changing water situation in the area and rainfall availability, whether there is any RWH technique conducted in the area, available local materials such as logs, grasses, animal skins, plastic sheets, lime and any other roofing materials as well as the preparedness and willingness of the community to accept and adapt to an improved indigenous technology. Focus group discussion (FGD) was also conducted to supplement and verify information collected through questionnaires and interviews. Extensive literature review was conducted and focus was on the available rain water harvesting technologies and their adequacy in central districts of Tanzania.

3.5 Data Analysis

Data collected through questionnaires was analyzed using Statistical Package for Social Science (SPSS) and Excel for graphical illustration which ran statistical descriptive and frequency analysis that gave more insight into the data. This gave out the variety of percentage presentations, tables and graphs which provided the right illustrations to describe the results. When explaining results and discussions, a combination of information, i.e. from literature reviews and questionnaires were employed.

4. Results and Discussion

4.1 Indigenous Rainwater Harvesting Practices

One traditional practice for rainwater harvesting is hanging pieces of clothes on the roof edge to collect and filter dust and mud particles from the water before it is collected in the buckets placed on the ground. Another technique is tapping runoff through digging shallow holes in open spaces surrounding their houses. This is mostly done in the few areas where soil types have mixture of clay, sand and loam. Water collected in this way is immediately stored in buckets and allowed to settle before it can be used. The techniques described above are not widely spread and were invented by few villagers in their struggle to tap rainwater for their household use. In the two villages, rain water harvested is used for their domestic use after leaving it in a bucket for sometimes for the mud to settle down. Although water collected through such practices is never sufficient, it however supplement household water needs. Improvement of such techniques as well as their cost analysis has revealed their feasibility and reliability in the two villages and the district at large.

As Malesu et al, (2006), argued, accessing sufficient and safe water for rural communities is essential because it will result in increased agricultural yields, thereby improving hygiene and sanitation. This will eventually save time and reduce drudgery and hence releasing women and children from the burden of fetching water and give them more time to participate in other income generating activities. The current rain water harvesting technologies will have a lot of potentials in reducing problems associated with water shortages. This is because the hesitant behavior by other villagers to adapt such technologies is due to the fact that water collected is muddy and very little. After the improvement strategies were revealed during various discussions, more than 90 percent of the households showed willingness to practice rain water harvesting because such techniques will largely improve water availability in the area and their livelihoods at large. In each household, there is a huge open space which would facilitate availability of runoff and provide spaces for reservoir construction hence improve rainwater harvesting. This is supported by Hatibu et al. 2000, who have narrated that apart from other factors, land slope and length (space) are important factors among the surface characteristics which affect availability of runoff.

4.2 Rainwater harvesting through traditional rooftops

In the above regard, this study has established that water collected through rooftops can be increased to a significant amount by using thin plastic sheet or animal skins to prevent water from mixing with mud in the roof tops. This will also prevent water seepage through the roof hence increase the amount of water harvested and make the harvested water clear and suitable for domestic uses. The use of such materials above is seen as a proper improvement strategy due to their availability. While skins can easily be available within the villages, thin plastic sheets can be purchased at affordable prices depending on the sizes from a nearby urban center located as close as 20 km. Also, construction of cisterns in each or in between the houses can help to store water harvested through rooftops and tapped runoffs. The improvement strategies came up as a result of various meetings to discuss water problems conducted in the villages.

Apart from using thin plastic sheets the discussions conducted also suggested that the use of cement which should be mixed with sand before used for roofing can help increase the amount of water harvested. This can be done together with the introduction of a gentle slope on the roof. In so doing, rain water will run smoothly on the roof and collected on the floor.

This modification will not change a traditional roofing system but rather modify it slightly for improved rain water harvesting technique. The modification can be done in any house whose roofs are traditionally made with logs, sand and grasses.

4.3 Rainwater harvesting through open surfaces

Villagers see that due to the huge open spaces surrounding each house in the two villages of Chipanga A and Mpalanga as well as other villages of Bahi district communities can use such spaces for the construction of cisterns. The channels will be used to collect run off and store them in cisterns. The cisterns can either be built in each house or can be built in share to reduce cost i.e. two houses construct one large cistern and these cisterns can be of varying sizes. Communities can use these cisterns to store water and use it during dry season. As narrated in Malesu, et al. 2006, the placement and location of cisterns, materials used, costs, rainfall amount and water demands are critical in describing the rainwater harvesting system employed. The construction of cisterns can be adopted from Chagu, et al. 1997, who provided engineering solutions for the construction of cisterns in Dar es Salaam and other dry areas of central Tanzania, specifically in Maswa and other districts. This included the construction of both above and underground large tanks at village levels and in schools. Some of the reservoirs were built in share in between two or more houses which are located close to each other. Through sharing, the construction cost can be minimized and the open space can efficiently be used. The open spaces surrounding houses can provide surface area for collecting rain water and channel it to the cisterns which will be constructed.

4.4 Cost implication of the roof tops modification

The rooftop modification does not cost much because no huge investments are needed. For example, for a house whose roof is 3m by 7m, the estimated of up to three bags of cement is enough to make the roof top suitable for rain water harvesting as narrated by some of the community members in one of the meetings conducted in the two villages. In Bahi, one bag of cement costs 17,000TZS equivalent to 11USD. This investment is done once and the roof can be used for many years. Another advantage is that the roof becomes strong and can persist for many years. The modification does not need a highly skilled technician because it does not involve any huge engineering work. The same traditional method of roofing is used, only that the sand used is mixed with cement. The sand to cement mixing ratio is just estimated because what is important is to ensure that the roof is compact. It is also intended to introduce a gentle slope so that water can easily flow and thereafter collected and channeled to reservoir or any collection facility. With the above modification, the amount of water collected can increase for up to two to three times the amount which is currently collected.

4.5 Community Resilience to Water Shortage in Bahi

This study has established that households get half of their water demand per day during wet season and less than quarter of their demand during dry season due to lack of water as a result of little rainfall and lack of water collection and storage infrastructure. During rains little water is harvested. Villagers also fetch water from the nearby seasonal streams. There is one stream in each village which is located in between 2 to 12 km depending on the location of the household within the village.

All streams last within rainfall period which normally end in late April to early May. There is little or no water at all during dry season and villagers are forced to dig temporary shallow ponds on the banks of the dried streams to get water. Sometimes the villagers are forced to walk long distances in search of other sources of water. Ponds in the above regard are explained as storage systems which are multi purposes conservation structures depending on their location and size. They are simple to construct and the most common type of pond is the excavated one. It is constructed by excavating a depression, forming a small reservoir or by constructing an embankment in a natural gully to form an impounded reservoir (Malesu, et al, 2006: 23). Figure 2 below shows one of the temporary shallow ponds in Mpalanga during dry season.



Figure 2: Temporary shallow ponds on the dried river bank in Mpalanga village, Bahi district

4.6 Youths and Stakeholder analysis and participation

Potential number of stakeholders for the promotion of the indigenous rain water harvesting technologies in the two villages as an adaptation to climate change is limited due to unfriendly rural environment (harsh economic situation, poor social services and infrastructures) which shun away most people to live in. More than 69% of the community members in the two villages are elderly (from 50 years and above). Figure 3 below shows distribution of community members by age in Chipanga A and Mpalanga villages.

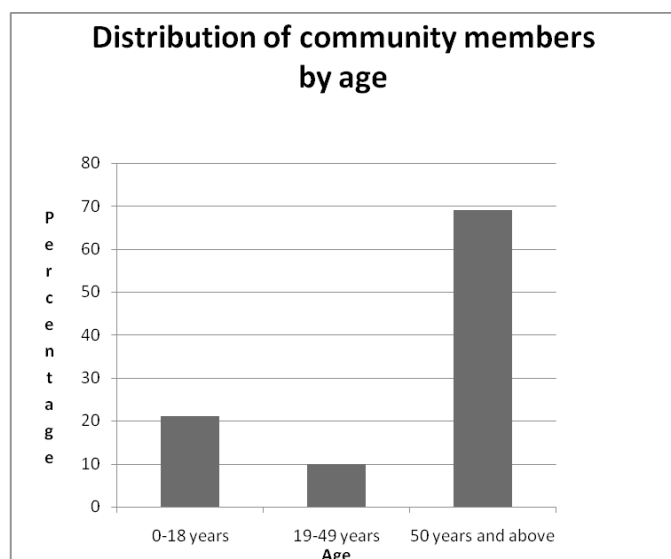


Figure 3: Distribution of community members by age in Chipanga and Mpalanga villages

It was also established that more than 60 percent are primary school leavers while more than 30% are illiterate. The middle class age considered to be productive has migrated to urban centers to seek better living except for few youths who are attending secondary education in the two villages. Women play key roles in both agriculture and in providing water for household use. Figure 4 below shows education level of the community members in the two villages.

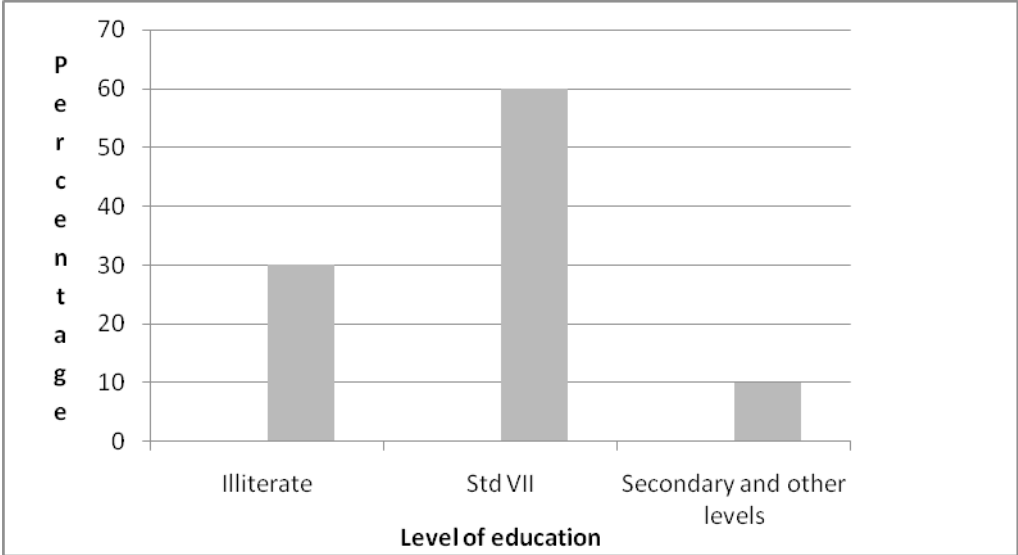


Figure 4: Education levels of community members in both Mpalanga and Chipanga A villages

Gender issues emerge to be of particular significance due to their direct impact on the lives of the rural women when it comes to rain water catchment systems (Malesu, et. al, 2006). The prevailing acute shortage of water has forced both genders to be involved in the development, operation and maintenance of rain water harvesting systems in most parts of the world including Lare division in Kenya (ibid). The same situation exists in Bahi, however a significant percent of men still engage in other activities including petty business as an alternative income generating activities. Other stakeholders are district officials who are very influential and close allies to village communities, Community Based Organizations (CBO's), NGO's and all media.

4.7 Communication strategies for knowledge transfer to empower youths and other stakeholders

Selected women and youth were gone through a series of training workshop on the forum for technical knowledge transformation on rainwater harvesting. Women play key role in the promotion of indigenous rainwater harvesting techniques because apart from taking care of the families they are responsible for farm activities in the two villages including the leading role of fetching water for household use. Through training, women can become a significant driver for change in adopting the technology.

Malesu, et. al, 2006, has revealed that adoption of rain water harvesting technology can best be enhanced and achieved through trainings, excursions and extension packages offered by both local and international stakeholders including NGOs and government institutions. Excursions to other dry areas in central Tanzania who have successfully adopted rain water harvesting will help women in the district to have a practical realization of the technology. District officials and extension officers are very crucial in realizing change in rural water situations due to constant and permanent links they have established with rural communities. Media is of great role in awareness rising. The use of radio which are easily available and

accessed will improve the knowledge of the local communities especially on improvement strategies of rainwater harvesting. Other stakeholders include local authorities, extension officer etc who can make a very significant impact to rural communities. Trainings to women and youths are key aspect in realizing the potentials of the improved technologies. Production of leaflets in simple Swahili will add value towards realization of the improved rain water harvesting technology.

5. Conclusion and Recommendations

Irrespective of soil types in the two villages, villagers still perform rainwater harvesting in a very difficult way. With major improvements which have been identified indigenous rain water harvesting techniques have shown potentials to improve water availability and food security in Bahi district specifically in Mpalanga and Chipanga A villages. Communities in the area have adapted to climate change by planting drought resistant crops such as millet, sunflower and sesame, crops which can tolerate drought condition instead of relying on maize and beans whose water demand is high. The use of cow dung has helped in improving soil water holding capacity and fertility for agricultural purposes. Women play key role in the society in terms of fetching water, therefore empowering them through awareness campaigns and trainings is key to success in curbing problems of water availability.

- There is a need for advocacy for more adoption of rain water harvesting to the larger community members, both at policy and lower levels to foster adaptation strategies to climate change impacts through rain water harvesting technology.
- This study recommends that if villagers in Mpalanga and Chipanga adopt the improvement strategies identified by this study, water availability in the area will highly be improved.
- Increase in water availability will improve agricultural yield and their livelihood at large. Through that way, the adaptation to climate change impacts will therefore be possible.
- It is important that collaborations amongst the stakeholders be cemented to the great extent so that the benefits of the improved technology are clearly observed. Such collaborations can be divided in to informal, formal and mechanism of working together especially in carrying out a certain rain water harvesting practice.

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African Technology Policy Studies Network

Contact the Executive Director at
The Chancery, 3rd Floor, Valley Rd.
P O Box 10081, 00100-Nairobi, Kenya
Tel: (254 020) 2714092, 2714168,
2714498, 2723800
Fax: (254 020) 2714028

<http://www.atpsnet.org>

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