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Impact of Rainwater Harvesting Technologies on Agricultural Productivity in Ethiopia

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ABSTRACT

Rainfall in the arid and semi-arid areas is generally insufficient to meet the basic needs of crop production. Hence, overcoming the limitations of these arid and semi-arid areas and making good use of the vast agricultural potential under the Ethiopian context is a necessity rather than a choice. There is now increasing interest to the low-cost alternative generally referred to as 'Rain water harvesting (RWH)' especially for small scale farming systems. Even though government efforts of household level water harvesting schemes are wide spread in the country there is little information and analysis on the feasibility and effectiveness of these rainwater harvesting technologies. This review tries to assess the impact of rainwater harvesting technologies on agricultural productivity in Ethiopia. Papers assessed by this review indicate that the direct impact of micro catchment RWH technology on agricultural productivity is quantitatively visible and statistically significant. On the other hand, the impact of macro catchment RWH technology on agricultural productivity shows mixed result. In some area it shows significant effect on crop productivity where as in other area not. This result related with the design, application and socio-economic factors and needs further study.

Keywords: *Rain water harvesting, Micro catchment RWH, Macro catchment RWH*

INTRODUCTION

Since ancient times, the rain fed agriculture has remained to be the mainstay of the livelihood of most rural poor people in many developing countries. However, these areas are characterizing by diminishing natural resource base and environmental degradation coupled with high population pressure, lack of capital, inappropriate policies, and civil unrest. In particular, the irregularity and variability in the distribution of rainfall, especially in the semi-arid and dry sub-humid parts of the Sub-Saharan African (SSA) countries, has made the sector unable to sustain food production to meet the increasing demand in the region. Recurrent drought and food insecurity have become a common phenomenon, which threatens the lives of millions of poor people in this region (Shiferaw et. al., 2005).

The arid, semiarid and dry sub-humid lands of Ethiopia occupy approximately 65% of the total land mass close to 700,000 km^2 of the country and 46% of the total arable land (EPA, 1998; Yonas, 2001). Particularly, semi-arid areas cover 301,500 km^2 or 27 % of the country and represent the crop production zone suffering from a serious moisture stress (Engida, 2000). Hence, overcoming the limitations of these arid and semi-arid areas and making good use of the vast agricultural potential under the Ethiopian context is a necessity rather than a choice. Thus, there is need for appropriate interventions to address the prevailing constraints using suitable technologies for improved and sustainable agricultural production. With regard to agricultural water development, small scale irrigation seems to be preferred than large scale schemes. (Turner,1994). There is now an increasing interest for the low-cost alternative generally referred to as 'water harvesting' especially for small scale farming systems.

Collection and storage of rainwater for different purposes has been a common practice since ancient times. Various methods of rainwater harvesting are available through which rainwater is captured, stored and used at times of water scarcity. The system was used thousand years ago in many parts of the world. There are also evidences indicating ancient churches, monasteries and castles in Ethiopia used to collect rainwater from rooftops and ground catchments (Nega, 2004). Ethiopia had allocated a significant amount of budget for food security programs. Of the total budget, most of it was for the construction of rainwater harvesting technologies (Rami, 2003). However, there is little information, and analysis on the feasibility and effectiveness of these rainwater harvesting technologies.

The impact and performance of the different RWH technologies in the country has also not been well assessed. Thus, reviewing some of the works focus on the impact assessment of RWH technologies in agricultural productivity in Ethiopia is crucial. Therefore, the objective of this paper is to review the impact of rainwater harvesting technologies on agricultural productivity in Ethiopia.

Rain Water Harvesting Technologies

In the past, the broad term 'water harvesting' has been used more frequently than 'rainwater harvesting'. Many authors have defined water harvesting and rainwater harvesting interchangeably, as 'the collection and storage of any form of water either from runoff or creek flow for irrigation use' (Falkenmark et al., 2001; Oweis et al., 1999). Although the ancient practices were primarily designed to meet domestic water needs, gradually the technologies also came to be used for agricultural purposes. In recent decades, scientists in SSA, the Middle East and Southeast Asia have made efforts to develop and test a wide variety of techniques for collecting, storing, and using natural precipitation for agricultural purposes (Humphreys and Bayot, 2009; Oweis et al., 2004). Agricultural uses include the supplemental irrigation of crops, the provision of water for livestock, fodder and tree production and, less frequently, water supply for fish and duck ponds. Recently, the concept has been extended to encompass in situ techniques and appropriate land management practices which enhance infiltration and reduce surface runoff and soil evaporation (Rockstrom et al., 2002; Temesgen, 2007).

In this paper, the term 'rainwater harvesting' (RWH) is used to encompass only the basic practices of rainwater collection, storage and efficient utilisation for crop production RWH practices being employed in SSA. The two categories are collection of surface runoff from micro-catchment systems with water storage in the soil for dry-spell mitigation and collection of surface runoff from macro-catchment systems with water storage for supplementary irrigation (Ngigi et al., 2005; Rockstrom et al.,2002).

Impact of RWH Technologies on Crop Productivity in Ethiopia

In spite of all the efforts and commitment of huge resources to construct physical water-harvesting structures in Ethiopia, there has been limited effort to quantify the impact of these interventions on crop productivity. There is also a serious lack of data as to whether rain water harvesting technologies actually contribute to household welfare.

Crop Productivity Performance of RWH

Promising crop and water productivity performance has been observed from field evaluations of micro-catchment RWH techniques. In the eastern drylands of Ethiopia, a field experiment was conducted to study the growth of four multipurpose tree species intercropped with grass (Panicum maximum) grown in plots with 25 m^2 and 100 m^2 micro-catchments (Abdulkadir and Schultz, 2005). The overall mean moisture content in the plots with micro-catchments was 31% higher in the wet season and 24% higher during the dry season, compared to that for plots without micro-catchments.

The crop and water productivity performance of in situ rainwater harvesting techniques has also been examined in a number of on-farm studies. A 3-year experiment conducted in the drought-stricken areas of Wollo region, Ethiopia, revealed that tied-ridging, open-ridging and sub-soiling improved soil water content in the root zone by 24%, 15% and 3%, respectively, as compared to traditional tillage during the cropping season (McHugh et al., 2007).

In the semi-arid region of northern Ethiopia, where a significant proportion of the rainfall is lost as runoff, tied-ridges reduced surface runoff by about 60%, improving the soil–water content in the rooting zone by at least 13% (Araya and Stroosnijder, 2010). Accordingly, the grain yield of barley (Hordeum vulgare) could be improved by at least 44%. The use of improved tillage through adaptation of the existing traditional maresha ploughing practices in semi-arid Ethiopia increased the yield of tef (Eragrostis tef) by 13–19% as compared to traditional tillage (Temesgen, 2007).

Birhane et al. (2006) confirmed that tied-ridging before or at planting in arid areas of Tigray, Ethiopia resulted in a better soil–water status and the best crop performance, compared with tied-ridging after planting, especially when planting was in the furrow. Accordingly, preplanting rain storage efficiencies could be improved by 2–37% by increasing the fallow period. On the other hand, Temesgen (2007) revealed that in the semi-arid Rift Valley of Ethiopia, the longer the interval between tied-ridging and sowing, the less were the water-conservation efficiency and the maize yield, provided that there was minimum rainfall in the interval.

The use of macro-catchment systems for rainwater irrigation has shown positive crop and water productivity responses in semi-arid areas of Ethiopia as well. More recently, three woredas, each in Oromia, Amhara & SNNP; two in Tigray; five in Somali and the rural areas of Dire Dawa administration were assessed to quantify the impact of water harvesting structures on crop productivity and household welfare (ERHA, 2011). A total of 141 RWH sites were selected and visited. Out of these, 41 are roof RWH, 38 ground catchments with sub-surface tanks, 40 ponds, and 22 sand/subsurface dams. The selected regions consist 86.7% of the total population of the country where most of the RWH systems are built and practiced so that, these regions, woredas and sites are believed to give a good picture of RWH practices at national level.

The result summarized in the chart shows the overall significant of benefits obtained from RWH for crop production. The response obtained from the various users of these technologies demonstrate that, 37.5% farmers confirm significantly benefit on their crop production because of the technology, the other 17.5% respond medium benefit whereas the 25% of farmers responded low benefit on their crop production (ERHA, 2011).

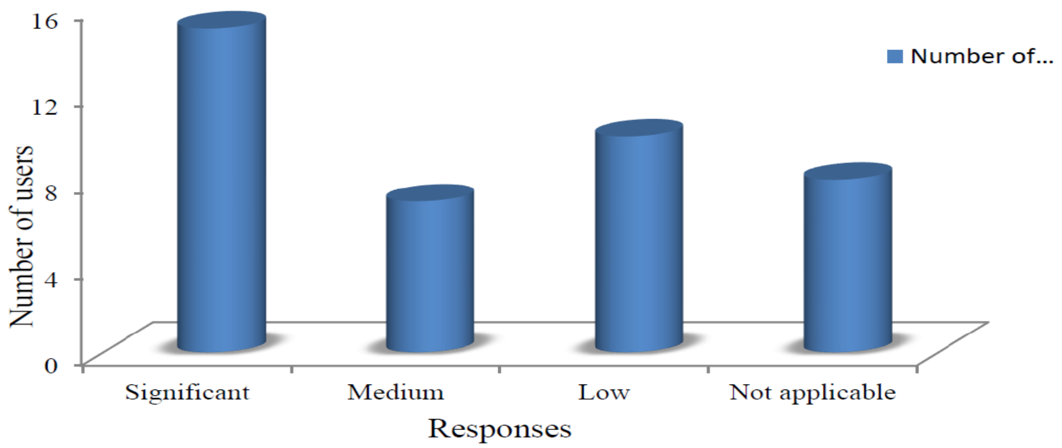

Fig1. *Overall significance of benefits obtained from RWH for crop producti*

Economic Performance of RWH

A case study of Alabawereda, SNNP, indicates that in accordance with government's target, the impact of RWH technologies on agricultural productivity is shown to be significant in the study. The cropping pattern has shown that farm households have started to grow crops which were not previously grown in the area. The crops are those which are highly priced and marketable ones implying the potential of RWH technologies to enhance a farm household's income. However, the benefit depends on market and infrastructure accessibility, and diversification in the types of the crops.

The average estimated value of crop yield per hectare for the surveyed plots is found to be 1095.02 birr/ha, with less variation among farming systems. The variation among farming systems range up to 191.76 birr/ha, with the lowest crop yield (around 997.26 Birr/ha) being in the Tef/ haricot bean /Livestock farming system and the highest (1189.02 Birr/ha) in the pepper/Livestock farming system. Moreover, on average, the variation in the estimated value of crop yield per hectare on plots with RWH technology is 1142.39 Birr/ha with the lowest (around 1030.307 Birr/ha) in those without RWH technology and the highest (2172.696 Birr/ha) in those with RWH technology. This might imply that adoption of rainwater harvesting technology is expected to have incremental impact on yield (Rebeka, 2006).

Another study has been undertaken to investigate the economic costs and benefits of rainwater harvesting in Ethiopia. A detailed socioeconomic assessment was undertaken, with 1517 households in the four main administrative regions of Ethiopia, to examine the impact of micro-catchment and macro-catchment agricultural water-management techniques (Awulachew et al., 2008). The agricultural income (from both crops and livestock) was significantly ($p < 0.0001$) higher for users than for non-users of the techniques.

On the other hand, the case study in Tigray, Ethiopia has shown that even thought, the Federal government and Regional states, and NGOs working in research and development, have invested huge resource in various yield enhancing and RWH technologies (ranging from large dams to RWH ponds at household level). However, the impact of these interventions on agricultural productivity and level of living at household-level is minimal.

Results of the crop – mix analysis as indicated by the shift in farm household's crop choice decision towards highly priced and marketable agricultural products; witnessed the potential of the RWH technologies to enhance a farm household's income as well as level of living, though there is some variation among farm households. However, the level and magnitude of benefit accrue to the farm household will significantly depend on market and infrastructure accessibility, and diversification in the type of these highly priced agricultural products supplied (Ephrem, 2006).

A different case study in Tigray, applies advanced econometric evaluation techniques to assess whether households with ponds and wells are better off compared to those without. The simple mean separation tests and matching results show that there is no statistically significant difference in welfare standing between households having access to ponds/wells and those that do not have access. Although this study does not fully explore the reasons behind such unexpected results, it, however, points out to the fact that ponds and wells are not fully exploited to show impact on people's livelihood. It could also be related to the issue of still limited access of households to ponds/wells and the time span since such technologies are introduced. Households learn by doing and it may take some time until water is used in its most efficient way (Fitsum et al., 2006).

Conclusion

It is known that there would be no life and development without water. It is also an established fact that RWH can address the water needs of communities with limited ground and surface water sources. Ethiopia, unlike many countries, is blessed with adequate rain resources that can be harvested in most parts of the country, including pastoralist communities who have no other options but harvest rainwater. In recent years however there has been a reasonable level of awareness and commitment built among the government, NGOs and donor partners in the need to promote RWH in Ethiopia. This has resulted in the initiation, planning and implementation of numerous RWH projects. In spite of all the efforts and commitment of huge resources to construct physical water harvesting structures in Ethiopia, there has been limited effort to quantify the impact of these interventions on household welfare. There is also a serious lack of data as to whether rain water harvesting technologies actually contribute to household welfare or not.

Papers assessed by this review indicate that the direct impact of micro catchment RWH technology on agricultural productivity is quantitatively visible and statistically significant. On the other hand, the impact of macro catchment RWH technology on agricultural productivity shows mixed result. In some area it shows significant effect on crop productivity where as in other area not. This result related with the design, application and socio-economic factors and needs further study.

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