THE ROLE OF MICRO-CATCHMENTS IN REHABILITATION OF DEGRADED LAND IN ARID AND SEMI ARID LANDS

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Abstract
Land degradation as a result of unsustainable human activities and climatic variations is a serious problem undermining the productivity of arid and semi-arid lands (ASALs). Large portion of these lands are being threatened with desertification. This paper is aimed at identifying the significance of Micro-catchment water harvesting (MCWH) technique in reclaiming degraded lands by reviewing various researches done in the area. The central point of MCWH technique is to facilitate the storage of water in the soil for plants use which may otherwise be lost to runoff. MCWH technique is discovered to work well in controlling degradation for its effectiveness in reducing soil and nutrients movement. It exhibits low conveyance losses and considerable leaching capacity, prevents moisture evaporation, and can be constructed on almost any slope with little construction cost. Plants survival rate was discovered to increase tremendously under normal rainfall condition when micro-catchments are used. Even though the technique appears to be successful in different areas implemented for both crops and trees cultivation, it has not been very popular among farmers and environmental agencies in ASALs. This can be associated with the perception of the initial intensive labor requirement, and low crop density compared to traditional irrigation methods. With adequate awareness programs and financial interventions, a wider adaptation of MCWH technique can help in vegetation of the degraded lands in ASALs.

Key words: Arid and semi-arid lands, land degradation, micro-catchment, reclamation, water harvesting, erosion

List of abbreviations

NGO	Non-governmental organization
MCWH	Micro-catchment water harvesting
GIZ	Deutsche Gesellschaft fur Internale Zusammenarbeit (German Society for International Cooperation)
ASAL	Arid and semiarid land
UNIC	United Nations Information Centers
IFAD	International Fund for Agricultural Development

1.0 Introduction

Large percentage of land in Africa is arid and semiarid whose communities are majorly dependent on livestock production for survival (Beatrice *et* al, 2012). About 73 percent of the land in east Africa is classified as dryland. Annual rainfall in the region ranges from 150mm in the arid and semi-arid areas to 2000mm in the wet regions (Mati, 2005). The rainfall in the region is not uniformly spread, but used to come as intense storms such that sometimes single rainfall event may exceed the average monthly amount (Hussein *et al.*, 2006). Apart from causing soil erosion such irregularity also results in inadequate supply of water for vegetation growth which leads to degradation. Land degradation is a big challenge to this area of Africa. To ensure sustainable productivity of these lands, efficient strategies have to be devised to fight land degradation (Mganga *et al.*, 2010).

To curb with the challenges associated with climate change which is further exacerbating the problems in the dry lands (Barakat, 2009), adequate sustainable land management measures need to be taken which could reverse the effects. Such has been a dilemma to many researchers because efficient soil conservation techniques are usually not priority among farmers due to their indirect and long term benefits to them (Agus *et al.*, 2002).

MCWH which can be used to capture rainwater thereby improving soil moisture and vegetation (Ali and Yazar, 2007) is a promising tool in rehabilitating degraded lands in dry areas. The pessimism that used to ensue following the failure of rangeland improvement projects (Liniger and Thomas, 1998) can be attributed to failure in putting the nature of rainfall in the drylands into consideration. Conventional rehabilitation techniques can only perform in the ASAL area if they are coupled with reliable water source. The paper therefore aimed at studying the performance of MCWH techniques in different dry areas to see if they can be used in wider scale in recovery of degraded lands.

1.1 Land Degradation in ASAL

Degraded lands are characterized by deficiency or loss of components necessary for them to provide expected services to their users. Such lands cannot recover by themselves. Agriculturally degraded lands are therefore those lands deficient in essential nutrients for crop growth. Soil degradation is a process which impairs quantitative and qualitative production potentials of soils. Degradation can occur through water erosion, wind erosion, salinization, chemical degradation, physical degradation or biological degradation (Muchena, 1986). The primary cause of degradation is incorrect land use and poor land use management (Griesbach and Sanders, 1998).

Based on the Global Assessment of Soil Degradation map, 243 million hectares of soil is caused by overgrazing in Africa which half the land affected by human-induced soil degradation in the region (Liniger and Thomas 1998). This may be due to the fact that livestock remains the major user of primary production in ASAL regions (IFAD, 2000).

About 40 percent of the world population lives in dry lands where more than half of the world's livestock are raised (UNIC, 2011). Human impact in form of unsustainable agricultural and land use management has led to further degeneration of the arid lands (i.e. degradation like salinization, water logging, erosion and desertification) affecting almost 70 percent of the region (Barakat, 2009; UNIC, 2011). Soil erosion from wind and water as well as overgrazing from livestock are the major cause of land degradation in the existing pool of resources (Sreedevi *et al.*, 2009).

Rapid population growth in the world, especially in the tropical areas is causing significant increase in demand for agricultural lands. Large areas of forest or woodlands are increasing being depleted in favor of agriculture in both tropical and temperate countries and small holder farms are being turned into larger industrial ones (Lamb and Gilmour, 2003). The agricultural lands are unfortunately not being rested for adequate regeneration resulting in less production (Mwonga and Mochoge, 1986). In many cases farmlands are abandoned when their productivity declined. The consequences of these problems are severe in the ASAL areas of Africa due to their fragile soils, localized high population densities and low input form of agriculture (Mganga *et al.*, 2010).

Focus is now being shifted on sustainable agricultural practices. There are different ways of restoring soil organic matter. Bulmer et al (2007) cited establishment of grass and legume cover crops, conservation and replacement of top soil with organic-rich one, and addition of organic amendments like stumps and waste log as efficient strategies in soil rehabilitation. MCWH technique is another potential tool for soil rehabilitation following it success in different ASAL areas. It could boost crop productivity and diversity, reduce soil erosion and reclaim degraded lands (Ali and Yazar, 2007). The technology is often combined with certain agronomic measures for crops or tree establishment most importantly fertility and pest management (Studer and Liniger, 2013).

1.2 Microcatchment Water Harvesting (MCWH)

Boers (1994) defined micro-catchment as "a small catchment in, the range of a few hundred square meters, comprising a runoff area having a maximum flow distance of 100m and an adjacent basin area with a tree, bush or row crop." The goal of these systems is to collect the water in the basin area (within crop's or tree's root zone) which would rather be lost to runoff and evaporation. In essence, more water is made to infiltrate in the cropping area and water retention capacity of the soils increased thereby resulting in crops suffering less from drought spells at the onset and during the rainy season (Kabore and Reiji, 2004; Cohen, 2002). Rainwater harvesting ensures speedy growth of trees and deep root development after plantation at the same time minimizing mortality rate (Ali and Yazar, 2007).

Soil and water conservation are inseparable (Assmo and Eriksson, 1999). Water conservation structures lay significant role in conserving soils by limiting soil and nutrients transportation. Rainwater water harvesting has brought remarkable successes in drought prone areas of India and Africa (Dahan *et al.*, 2012). Traditional Zaï systems for instance has witnessed significant acceptance by local farmers in Burkina Faso resulting in rehabilitation of more than 8000 hectares of degraded lands in over 400 villages in the late 1980s (Prinz and Malik, 2003). Kabore and Reij (2004) stated that Zaï and contour bunds proved to be efficient in Burkina Faso during the period where the former was embraced intensely by traditional famers and the later by NGO technicians. Talking about the advantage of Zaï systems, they added that:

> "They are used to rehabilitate strongly degraded land, which is of vital importance in a region characterized by high population pressure on limited resources. It allows farmers to expand the size of their farms and to do this on fields where before nothing would grow. In the 'without' situation, yields are 0 kg/ha and in the 'with zaï' situation they range from 300 – 400 kg of sorghum in a year of low rainfall to easily 1500 kg/ha in a year of good rainfall."

Because MCWH structures limit runoff to the local catchments in which crops are grown, loss of soil through water erosion is significantly reduced. Terracing, pitting, conservation tillage practices for example, are commonly employed to counter the soil erosion (Dahani *et al.*, 2012). In places where rainfall is high, microcatchments can be in form of small water retaining structures that could serve as ground water recharge source at the same time preventing erosion from excessive runoff (Barros, 2003).

1.3 Impact of Microcatchments on Land Reclamation

Hussein *et al.* (2006) studied the performance of MCWH systems in combating land degradation at a dry area called Qaryetein in the Syrian steppe with average annual rainfall of 200mm. Three different forms of the water harvesting systems were experimented which are semi-circular bunds, continuous ridges and intermittent ridges. They investigated the performance of three different species of fodder shrubs under the WH systems with respect to a control traditional system. The manually constructed semi-circular bunds recorded slight improvement in the survival of two of the shrubs over the control one. However the two mechanically constructed ridges performed less. The researchers argued that the rainfall season under which the study was conducted was not favorable. Only one runoff event of 14mm was recorded during the period.

A study (Akerman *et al.*, 2012) on the impact of various interventions towards soil conservation by GIZ, a German cooperation, in Burkina Faso discovered significant success of soil-water conservation techniques, specifically contour stone bunds and permeable rock dikes and dams. The techniques were adopted in response to a severe famine in the late nineties which resulted in loss of large areas of cropland, rangeland and forestland. One of the factors that exacerbated the crises was degradation of agricultural soils resulting from poor farming practices and land management systems. The measures succeeded in increasing the infiltration capacity of the soils in the region thereby significantly improving the groundwater recharge. They enabled farmers to increase their yields, incorporate trees into their farming system and intensify livestock rearing (Kabore and Reiji, 2004).

Incorporation of MCWH techniques in the rangeland management is very essential. The process of rehabilitating degraded lands is gradual and is further undermined by rainfall shortage in dry areas. MCWH ensures adequate supply of water for plantations during the recovery process. Fodder shrubs (e.g. *Atriplex canescens* and *Salsola* vermiculata) were observed to possess good potential for establishment of forage reserve blocks under MCWH system in Pakistanis Balochistan area (Ahmad *et al.*, 2012).

Trees play significant role in reducing the negative effects of harsh environments of the dry areas and recovery of degraded lands. The survival of trees in this area under natural condition is usually very poor (Sreedevi *et* al, 2009). MCWH structures prove to be very effective in ensuring trees survival. Cohen (2002) carried out a survey on the effectiveness of microcatchments in tree establishment in the dry high plains of Bolivia where forestry is limited. Among the different treatments considered, microcatchments with pit planting method recorded up to 80 percent survival rate which was almost twice the rate under control (no treatment) condition (45 percent). In addition to conserving adequate water for the plant growth, the pits were found to protect little plants from wind and other weather related attacks. Similar research in the northwest region of Damascus Syria with annual rainfall of 117mm showed impressive improvement in shrub survival when MCWH was used (Ali and Yazar, 2007). Two types of contour ridges were experimented in the area were survival rate of shrub trees was between 2 – 5%. The two water harvesting techniques increase the survival rate up to 92% and 91% respectively (Ali and Yazar, 2007).

Land owners can be very instrumental in soil rehabilitation process. The key driver towards success of land reclamation program is for the land users to embrace it. Linger and Thomas (1998) narrated the successful reclamation of denuded *Acacia/Commiphora* bushland at Wamunyu in Machakos district, Kenya. Land owners with help from their families solely implemented the reclamation project with virtually no outside help in the semiarid area because the lands were under individual ownership. The main technique they used was terracing, a popular MCWH system in Kenya during that period augmented with selective clearance of unwanted bush, rotational grazing, and pruning of trees to encourage grass cover. This is an indication that, it is very much possible to recover denuded lands with only land owners' participation.

The MCWH structures highlighted are however labor intensive but the benefits strongly outweigh the labor and cost required. Farmers can transform their agricultural lands gradually depending of their family labor and financial capability within few years (Kabore and Reiji, 2004). Performance of these systems at different locations promises that with proper sensitization and intervention from governments and relevant NGO, most of the degraded dry lands can be recovered.

1.4 Challenges in the Implementation of MCWH

The major setback in the success of new technologies is usually the lack of acceptance by the key stakeholders involved. Farmers in this case are usually reluctant to invest labor and finances without convincing knowledge of the returns expected. In the present setting, there is absence of land tenure security and water rights in the ASAL areas of Africa coupled with market inaccessibility in some regions which would continue to make the end user hesitant to invest (Studer and Liniger, 2013). It is evident that soil conservation programs have slight chance of success without full participation of the end users in the whole process (Griesbach and Sanders, 1998). Success and benefits of different conservation techniques at other places must be shown to the land users and support be offered where possible.

Another undermining factor is the intensiveness of labor required in constructing MCWH systems. Because the work entailed in preparation of microcatchments cannot be done solely with specialized machineries available plus most farmers cannot afford them, labor requirement becomes an issue. Construction procedure with minimal equipment need is usually recommended (Boers, 1994). It is however important to note that under MCWH system, water and nutrients are concentrated in the reduced planted area, therefore, the yield per invested labor increases considerably compared to conventional field planting (Studer and Liniger, 2013).

Farmers' perception of degradation also needs to be tackled. It is surprising how majority of farmers consider soil erosion and other forms of degradation as a phenomenon that will always be part of the region (Currle, 1998). They usually believe that catastrophes in form of low agricultural yield, famine, etc are natural and they just have to learn to live with it. This perception has to change and they should be educated on the possibility of avoiding such catastrophes through proper land management.

2.0 Conclusion

Continuing degradation and desertification of ASAL areas is big challenge to development and poverty alleviation. There is however great hope of reclaiming vast derelict area in the region abandoned due to lack of fertility. If different microcatchment techniques could work in extreme conditions, like Zaï in West Africa, then by extension, rehabilitation is possible in all of the rainfall conditions in ASALs. The issue then relies on choice of technology for different conditions and ensuring its implementation and acceptance. Farmers' perception can be changed through enlightenment and revealing the success stories of different rehabilitation projects. Support from governments and relevant NGOs where necessary would also very important.

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