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A Review Paper on: The Multi-Functional Implication of Integrated Watershed Management: The New Approach to Degraded Land Rehabilitation in Ethiopia

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1. Introduction

Land degradation is a major cause of Ethiopia's low and declining agricultural productivity, persistent food insecurity and rural poverty. Above all, the degradation of the endowed natural resource is continuously affecting the productivity of the agricultural sector which is the backbone of the country' economy. Therefore, to curb the situation, community based watershed management is being launched throughout the country in collaboration with government and other concerned bodies (Lakew et al., 2005; MaA, 2013; Gebregziabher, et al., 2016).

In the past due to insufficient knowledge base, some misguided agricultural policies, coupled with a rapidly growing population, chronic poverty, and capricious rainfall have caused severe food security challenges for farm families and natural resource degradation. The present government taking lessons from the past, started community based integrated watershed management program removing all the shortcomings through the instrument of new policies for improved livelihood and living conditions of rural communities (Worku and Tripathi, 2015).

The major advantages of community based integrated watershed management approaches are involvement of those most affected by the decision in all phases of the development of their watershed and holistic planning that addresses issues which extend across subject matter disciplines (biophysical, social, and economic sciences) and administrative boundaries like village, woreda etc.(Lakew et al., 2005). However, despite the government and other concerned bodies commitment to the implementation of this drastic new approach that leads to improvement of food security and a lessening of the dependence on food aid, to the scape of this paper, it was found the multi-functional implication of integrated watershed management is not well reviewed. ***Thus, the objective of this paper is to provide valuable information for scholars, policy makers and others thoroughly reviewing cases studies in different parts of Ethiopia.***

2. Concept of Watershed and Integrated Watershed Management

As a new paradigm in development interventions integrated watershed management is cropping in areas where the inclusion of communities is required. But, what do "watershed", "" and "integrated watershed management" really mean? There is no unanimity between the views of different scholars; the term watershed is a topographically delineated area that drains water from rainfall and snowmelt to a common point such as a stream, lake or ocean (Lal, 2000; Weber and McKenneny, 2008). It is separated by a narrow elevated tract of land called ridge or water dived. However, if a permeable soil covers an impermeable subsurface, it is important to consider the underground stream unit to get hydrological boundary.

While the term "integrated watershed management" can be viewed from the biophysical and socio-economic perspectives. Thus, from the biophysical perspective watershed management is organizing unit for the interactions between land use, soil and water resources as well as upstream and downstream linkages. From the social perspectives, it is the genuine involvement of the local populations and coordinating the actions of numerous land users in a watershed who may have multiple and conflicting objective for the sustainable resources management (Lal, 2000; Wondeamlak, 2003). Watershed encompasses multiple stakeholders with diversified interest and natural resources. Therefore, the process of watershed management plan development need to identify the stakeholders and their interest, list the existing resources, find the gap in the light of the local peoples objectives and need, develop plan and implement it for verification of feasibility. The process requires complex natural resources questions and participatory approach tools (Gaddis, 2008; Weber and McKinney, 2008).

Therefore, watershed management implies the judicious use of natural resources such as land, water, biodiversity and biomass in a watershed to obtain optimum production with minimum disturbance to the environment. The new integrated development approach encouraged decision-makers to pay more attention also to the economic and social implications of watershed management, which became "integrated watershed management" (FAO, 2006). Thus, watershed management has gone through a period of experimentation until it has been conceptualized as a way of looking at relationships among people, land and water. This is the time of paradigm shift to the new generation watershed management which promotes the involvement of local community as the center management planning (Yoganand, 2008).

3. Watershed Management in Ethiopia

3.1. Historical Background

Ethiopia has a history of watershed management initiatives dating back to the 1970s. In Ethiopia, experience in watershed management initiative which is dating back to the 1970s focusing on soil and water conservation and reforestation was started by FAO technical assist to shift the basic top-down technical solutions based approaches to community-based approaches at pilot watersheds(Tesfaye, 2011). Then, gradually the need to integrated participatory watershed management has been being recommended to reduce sediment inflow in sustainable pattern to hydroelectric power reservoirs by sheet, rill, gully bank and bed (Kebede, 2012). In the successive national development plans, the Ethiopian government has put sustainable natural resource management among the top priority development agendas. The commitment of the government to address land degradation is supported by the actions that are undertaken through different initiatives such as the PSNP[1] and MERET[2] projects.

The Ethiopian government has for a long time recognized the serious implications of continuing soil erosion to mitigate environmental degradation and as a result large national programs were implemented in the 1970s and 1980s. However, the efforts of these initiatives were seen to be inadequate in managing the rapid rate of demographic growth within the country, widespread and increasing land degradation, and risks of low rainfall and drought (Meshesha et al., 2015).

Taking in to consideration the pros and cons of each initiative, the government of Ethiopia has been insisted on putting the issues of sustainable natural resource management among the top priority development agendas. In this regard, sustainable land management has emerged as an issue of major national concern. This is not only because of the increasing population pressure on limited land resources, demanding for increased food production, but also by the recognition of the fact that the degradation of land and water resources is accelerating rapidly in many parts of Ethiopia(Mitku et al., 2006) as shown in the figure. For practical commitment of the initiative, community-based integrated watershed development is becoming practical approach to sustainable land management mainly through soil and water conservation (MoA[3], 2013).

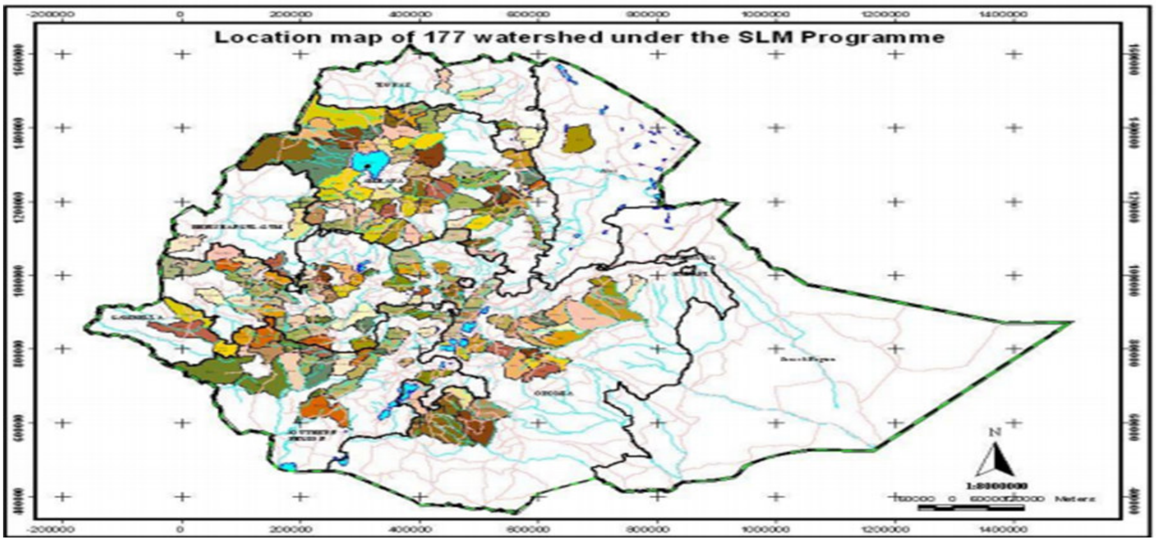

Figure1: Showing watershed under sustainable land management MoA(2013)

3.2. Site Specific Technologies for Integrated Watershed Management

Many recent studies indicate that community based integrated watershed management could be sound and bring tangible change on the ground if the technologies implemented are appropriate and site specific. According to Kedede (2015), appropriateness and site specific of a given technology (for instance soil and water conservation) can be evaluated by considering agro ecology, soil type, rainfall, slope and mean annual rainfall of the site.

Therefore, special emphasis is given to appropriate and site specific technologies in current community based watershed management of Ethiopia which is attempted as foundation of harmonizing often conflicting objectives of intensified economic and social development, while maintaining and enhancing the ecological and global life support functions of land resources. According to MoARD[4] (2010), appropriate and practical approach to integrated watershed management requires different site specific technologies including indigenous

[1] Productive Safety Net Project
[2] Managing Environmental Resources to Enable Transition to more Sustainable Livelihoods
[3] Ministry of Agriculture
[4] Ministry of Agriculture and Rural Development

and introduced **physical (structural)**, **vegetative** and **agronomic land management practices**, hillsides and gully rehabilitation measures, runoff water harvesting practices, agro-forestry systems, grazing and vetiver hedge land management.

Furthermore, MoA (2013) indicates that other measures like the introduction of agro-forestry, conservation agriculture technologies, soil fertility improvement techniques and use of organic manure, improved practices for grazing and animal fattening systems are considered as appropriate practice. Recent studies show that restoration and rehabilitation of degraded land requires, among others, to integrate different physical and biological soil and water conservation measures. In this regards both physical and biological soil and water conservation measures are being implemented in Ethiopia.

3.2.1. Physical Soil and Water Conservation Measures

Physical or mechanical conservation include a wide variety of practices and structures in most cases are aimed to reduce slope of the land so as to stop or slow down the velocity of water that will cause erosion. Moreover, physical structure is implemented to control runoff and soil erosion in fields where biological control practices alone are insufficient to reduce erosion. According to Alemu and Kidane (2014), and Kebede (2015) mechanical structure such terraces, check dams, stone or/and soil bunds, trenches and micro basins modify terrain through changing slope length and angle, which in turn reduce runoff velocity, enhance water infiltration and trap sediments washed down the terrain.

Figure2: Different soil and water conservation structures in Tigray, Ethiopia, Kifle (2012)

3.2.2. Biological Soil and Water Conservation Measures

Water and land are managed at multiple scales and levels, such as farm plots, small or micro watersheds nested in larger watersheds, and ultimately large river basins. At all of these levels, integrated management of agronomic and vegetative measures of soil and water conservation (Alemu and Kidane, 2014). Thus, the principles in using biological conservation is that soil only becomes subject to erosion if it is bare and exposed to the erosive forces of wind and water.

Vegetative measures

Soil and water conservation practices require integrating vegetative and physical measures for successful and tangible changes on the ground. Vegetative measures are widely implemented practices. The aim different soil and water conservation measures are to reduce the effect of soil erosion, improve environmental conditions and stabilize or improve agricultural productivity(Amsalu and Graaff, 2007). Constraints during establishment include high seedling transportation cost, poor handling while planting and transporting, livestock interferences, moisture stress, uncontrolled livestock movement hindering proper growth and survival of plants. Improvement measures for this include: establishing nurseries for production of seedlings in the nearby plantation sites, practicing area enclosures and fencing and planting in time or early planting (MoAR, 2010). Vegetative measures are used for soil fertility improvement, firewood, fodder, fruit and additional income sources. Practical integration of some examples of vegetative measures are depicted in the below successive figures.

Figure3: Farmland terraces vegetated by various vegetative measures in Omo Sheleko Woreda. Source: Sustain land management best practice photo of MoA(2013)

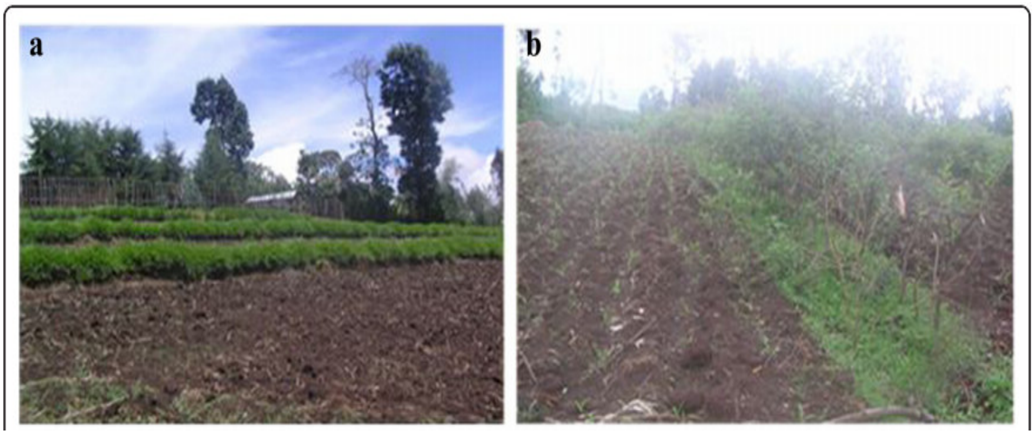

Figure4: (a) Introduced fodder grass in Zobcho kebele (b) cajanus cajanin Gendo Walcha kebele examples of biological soil and water conservation measures Kebede(2015)

Agronomic land management practices

Agronomic land management practice, which involves the growing of different kinds of crops in the same field. The crops grown together are, however, harvested at different times. Different agronomic measures (such as mixed, strip, and inter cropping, fallowing, contour cultivation, mulching). According to MoA (2010), in Konso farmers are used to growing of 10-15 types of crops on the same field. The aim is to avoid risk of crop loss and reduce vulnerability to food shortage. Some crops are more resistant to or escape the adverse conditions of drought, pest and diseases. Annual crops are sown or planted in two seasons. Annual and perennial crops are planted and managed according to their seasonal calendar. Low fertility status, unpredictable and erratic rainfall, pest and diseases are some of the constraints limiting crop production.

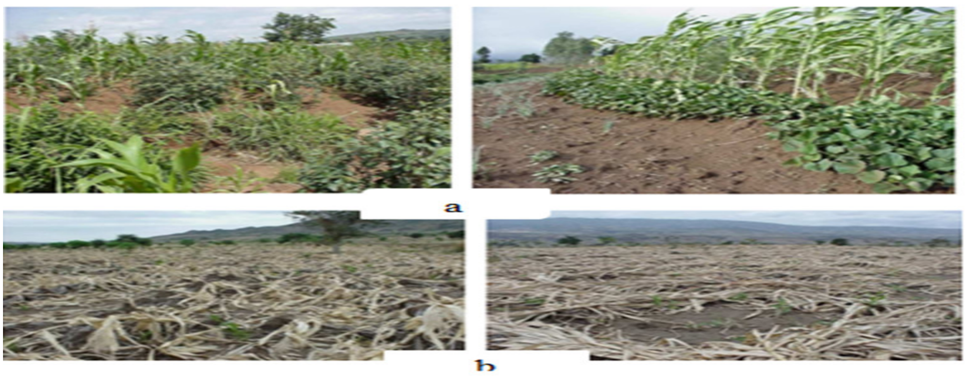

Figure5: Cha-sorghum-sweet potato, bean intercropping in Harereghe (a) and crop residue management (Konso) Source: Source: SLM best practice photo of MoA (2013)

4. Multi-Functionality of the Integrated Watershed Management

Many recent studies made in Ethiopia showed that integrated watershed management is found being effective in improving the biophysical and socio-economic aspects of the target site as well as bettering the conditions of the vulnerable social groups. Therefore, case studies which are made by different scholars are reviewed so as to provide value information on the performance of pilot integrated watershed management. Moreover, as presented below the critical review focused on the impact of the integrated watershed management on soil fertility, water availability forest coverage, crop production, livestock production, environmental impacts, emergence of wildlife, household income and local people participation.

4.1. Soil Fertility Improvement

Soil fertility decline is one of the main problems facing Ethiopia which is expanding both in scope and magnitude in all parts of the country. The decline in soil fertility is severely limiting crop production (Abdullah, 2008; Fanuel, 2015). Conversely, the new integrated watershed management is showing improvement in soil fertility status. Thus, the study conducted in Chena Wereda[1] indicated that soil has showed improvement in its PH, oil organic carbon, total nitrogen and available phosphorus. As indicated in the laboratory and The independent t-test analysis the soil showed increment in tis PH from 4.49 to 6.63, oil organic carbon from 2.99 % to 3.15%, total nitrogen from 0.29% to 0.32% and available phosphorus from 19.02 ppm[2] to 19.22ppm respectively (Meshesha et al. , 2015).

Study conducted at a Maybar soil conservation research site showed that the terraces on 3 to 8% slopes had statistically significantly higher pH and EC values than those on 8 to 30% slopes. Bulk density was significantly different at the three terrace positions; the highest value (1.60 g/cm^3) was obtained at the mid position, followed by the up-terrace (1.24 g/cm^3) and low-terrace (1.21 g/cm^3) positions (Damene et al., 2012).

The performance of participatory pilot watershed management has been assessed in six study sites of Tigray, Amhara and Oromia. The study showed that the overall economic and social status of the communities in the study areas improved following watershed interventions in terms of soil loss which in turn contributed to soil fertility improvement and crop production increment. According to Gebregziabher et al. (2016), soil fertility improvement measures, such as the use of compost and nutrient-fixing plants, are mostly used on cultivated lands. Key community informants from Bechyti, Goho-Cheri, Kereba, Bedesa Kela, Abraha-Atsbaha and Gerebshelela perceived that watershed management in their communities has contributed to a reduction in soil erosion by 60%, 75%, 90%, 35%, 80% and 50%, respectively.

Table 1: Multiple impact of integrate watershed management in Ethiopia

Watershed	Average farm size of households (ha)	% reduction in soil loss	Increased Production area (%)	Crop Productivity increment (%)	Improvement of Fodder availability (%)
Abraha Atsbeha	0.75	80	20-50	300	100
Gereb Shilina	0.75	50	5	20-50%	80
Bechyti	0.4	60	5-20	250	50
Goha Cheri	0.36	75	5-20	20-50%	60
Karaba	0.25	75	20-50	200	95
BedesaKela	0.5	35	5-20	5-20%	50

Source: Gebregziabher et al. (2016)

4.2. Water Availability

In many parts of Ethiopia particularly in rural areas local people were facing lack of water which is resulted from continuous degradation of natural resources (Lakew et al, 2005;MoA, 2013). Due to such scarcity of water the dwellers were forced to dig deep wells in order to use clean water which was very expensive and unaffordable by most of the households. Moreover, many children in rural families were spending more time and walking long distance to fetch water from rivers which sometime exposes them to physical damage (Belete, 2014).

However, after commencement of integrated watershed management the situation is being changed. For instance, study conducted in Chena Woreda showed that among the surveyed household majority of them rated good water availability. Furthermore, the independent t-test result indicated variation in water availability before and after watershed management intervention (Meshesha et al., 2015). Similarly, study made at Berki catchment water access to the local community is achieved through improved to technologies like drip irrigation, construction of community ponds, and roof top rain water harvesting (Kidanemaraim, 2009).

Moreover, according to Mekonen and Tesfahunegn (2011), in the Medego watershed, ground water increased up to 2.5 m and the number of hand dug well also increased (Table 2). Before implementation of soil

[1] Woreda which is also referred as District is the fourth level administrative body, from topdown, in Ethiopian administration system coming next to Zone
[2] PPM- parts per million

and water conservation, it is not possible to water by digging 3 - 4 m deep, but after project implementation, communities have the possibilities of having plenty water at this depth. Study conducted by Sebhatu (2010) at the Mai Zeg Zeg watershed of Degua Tembein Woreda in Tigray, Ethiopia showed increased water availability and majority of surveyed households witnessed that as they benefited from the water specially it alleviated the problem of wondering their children in search of water for their domestic use and livestock.

Table 2: Impact of soil and water conservation measure on water resource

Performance criterion	Indicators
Surface water storage capacity and spring development	Increased many times from almost nil to the present situation
Extent of irrigated area	Increased by more than 300 times
Water level in wells	Increased by 0.5 m to 2.5 m
Ground water recuperation rate	Increased 15 times

Source: Mekonen and Tesfahunegn (2011)

4.3. Forest Coverage Improvement

Because of lack of systematic coordination between different actors, unsustainable utilization, growing pressure to agricultural expansion, unfavorable policies of the prevailing government and low attention to the protection of local people forest coverage of Ethipia has been repeatedly reported for its dwindling (Abayneh et al., 2004). In contrary to this trend, current study made on the impact of pilot integrated watershed management at Lenche Dima, Tsegur Eyesus, Dijjil and North Western Lowlands of Ethiopia showed that there is significant improvement in forest coverage after implementation (Tesfaye, 2011; Alemu et al., 2015). The improvement is shown mainly because of the engagement of the households at homestead forest development activities on their private land for construction materials, fuel wood and wind break.

Furthermore, the natural and plantation forests coverage of Ethiopia are being reported for increasing temporary and spatially. The increments are the results tree planting by individuals and communities especially during annual plantation campaign. For instance, as studied by Meshesha et al. (2015) in Chena Woreda, trees on the farmers land are either planted by farmers themselves or grown naturally. For instance, plantation of eucalyptus is one of the trees widely planted by the farmers. According to Gebregziabher et al. (2016) despite species variations are observed in the six pilot watersheds in Tigray, Amhara and Oromia regions. Thus, the integrated watershed managements have resulted different tress species. For example, *Olea europaea subsp. africana, Becium obovatum, Leucas oligocephala, Euphorbia abyssinica, Acacia etbaica, Opuntia ficusindica, Echinops hispidus, Calpurnia aurea, Eucalyptus, Acacia saligna and Dodonaea angustifolia*.

4.4. Crop production improvements

Due to land degradation and intensified soil nutrient depletion together with removal of crop residue, low external inputs and absence of adequate improved technologies low crop productivity has common phenomena in Ethiopia (Tesfaye, 2011). This in turn was resulting lack of food and low income of rural households. However, the situation is being reverted by the current community based watershed management. For instance, study conducted in Chena Woreda showed that the cereal crop production have showed increment after watershed management. Thus, production of Sorghum from 614.2 to 357.8, Teff 798 to 429.9, Sorghum 237.3 to 141.3, Faba bean 560 to 259.8 and Wheat 464 to 219.4 Kg/ha/year improvement was observed in intervention site respectively(Meshesha et al. , 2015).

Food availability of the households was improved due to the different conservation measures and application of improved agricultural inputs. As the survey data revealed, before the intervention 38.8%, 44.7%, 5.88% of the households harvest was able to cover the household's food demand for < 6, 6-8, 8-10 months respectively. This indicates that more than 80% of the households were covered their food demand for less than 10 months from their harvest (Meaza, 2015). The finding of Gebregziabher et al. (2016) also indicated that since the implementation of watershed management, a 200-300% increase in crop productivity has been observed in Abraha-Atsbaha, Kereba and Bechyti watersheds (Table 1). Generally the integrated watershed management practices undergoing in different parts of Ethiopia are proven for enhancing crop productivity at household level (Alemu and Kidane, 2014).

4.5. Livestock and forage production

As in many developing African countries, livestock farming (animal husbandry) is one of the main livelihoods sources of majority of rural households. Despite its importance the sector is facing challenges especially related to lack of fodder and climate change. Realizing this problem the new approach to watershed management is being practiced in different parts of Ethiopia livestock and forage production (Lakew et al., 2005). The study conducted in Lenche Dima and Dijjil watershed Northern Ethiopia showed that the livestock possession and fodder production of the local farmers has been improved by providing them with local varieties if chicken, sheep, goat and forage (Tesfaye, 2011).

According to MoA(2013) the current sustainable land management has contributed for the improvements of livestock production in its intervention kebele. The comparative studies between watershed intervention and non-intervention area showed that the total livestock unit in the intervention area is greater than the nonintervention one. As all focused group participants and key informants have mentioned, the SLMP[1] has contributed to livestock management in its intervention area by providing fodder seedlings for better livestock production.

4.6 Environmental impacts

Here environmental improvements are used to refer to the improvements studied by different scholars in terms of reduction in erosion, wildlife status and microclimate. In this regard, the assessment made in Damota Watershed showed majority (90.757%) of the local dwellers indicated that the erratic rainfall and lengthy temperature conditions are decreasing and the reverses (optimum microclimate) have become common (Belete, 2014). Developing countries, such as Ethiopia, will be more vulnerable to climate change mainly because of the larger dependency of their economy on agriculture. Therefore, watershed based integrated water resources management should be the core part of the adaptation options (Zeray, 2007).

The pilot integrated watershed managements in different part of Ethiopia are becoming opportunities for the government and non-governmental organization for implementing ambitious climate resilient green economy strategy (Mekonen and Tesfahunegn,2015). The study by Assefa (2011) in Choke Mountain in East Gojjam of Ethiopia reported that the status of climate hazards like flood, drought, frost, soil erosion and landslide were reduced and in decreasing trend due to the various watershed management practices.

The implementations of soil and water conservation in different parts of Ethiopia are showing significant reduction in severity of soil erosion. For instance, studies conducted on the effects of vetiver hedges on water flooding and soil erosion at Melko, Ethiopia, found reduced flood velocity, limitted soil movement, and very significantly decreased soil erosion in the third year(Yakob et al., 2008). Key community informants from Bechyti, Goho-Cheri, Kereba, Bedesa Kela, Abraha-Atsbaha and Gerebshelela perceived that watershed management in their communities has contributed to a reduction in soil erosion by 60%, 75%, 90%, 35%, 80% and 50%, respectively(Gebregziabher et al., 2016).

4.7. Households income

Recently many studies on impact of the integrated watershed management on income are being reported. For instance, in the Mai Zeg Zeg watershed of Degua Tembein Woreda in Tigray, Ethiopia showed that food security programs though the watershed management approaches has shown significant impacts in terms of household income. In figurative terms the program participants have enjoyed an average annual gain in the total household income between ETB 566.170 and ETB[2] 340.098(Sebhatu, 2010). In line to this, study conducted in Adwa, Central Tigray Zone showed that food availability and income the local people have improved after the implementation watershed (Meaza, 2015).

The socioeconomic impacts of watershed management were assessed based on income, income diversification, assets owned by farm households and employment opportunities. Study conducted in Abrha Atsbha Woreda indicated that income the local farmers are gaining in come from honey production increased by 300% over three years and incomes from vegetable and spice production has also tripled. Farmers also developed agro-forestry systems, integrating high value fruit trees such as, avocado, citrus, mango, and coffee on their farms to generate incomes, food security and nutrition(Chisholm and Woldehanna , 2012).

4.8. Watershed management for local people participation

Community based integrated watershed management has been proven for its effectiveness of empowerments and improving the conditions of vulnerable groups. Even though some recent studies still reveal the participation is poor. For instance, Azmeraw (2010) in Chemoga watershed of Amhara regional state and Meaza (2015) assessed in Adwa, Central Tigray Zone lower participation of marginal groups, the integrated watershed management is contributing for participation of local people.

Community participation in natural resource management at watershed level is process which requires the establishment of a multi-stakeholder platform – a platform that brings together all stakeholders – at various levels for consultation, experience sharing, promotion and coordination. In this regard, the integrated watershed management at Berki catchment in Tigray in Northern Ethiopia played a significant role in facilitating the involvement of all stakeholders at grassroots and various levels. As result the people speak out about equitable water allocation between up-and downstream users. But before participatory intervention local communities used

[1] Sustainable Land Management
[2] Ethiopian birr

to think that any water that flowed in their fields was their own property. Thus, the involvement of all at all stages of the water management enabled to resolve the conflict that was escalating due to the limited water in the catchment (Kidanemaraim, 2009). Furthermore, Kifle (2012) indicated that Watershed management has been carried out in two public mobilized systems: free labour and productive safety net programs contributed dramatic change in Tigary region which created watershed with zero runoff.

5. Challenges in integrated watershed management

Integrated watershed management is assumed as right technique to achieve judicious use of natural resources such as land, water, biodiversity and biomass in a watershed to obtain optimum production with minimum disturbance to the environment. However, according to some recently published research findings, practical implementation of community based integrated watershed management is facing some challenges.

Concerning some of the challenges study conducted by Meaza (2015) indicates the major challenges in the watershed management were shortage of land, lack of awareness in resource management, disagreement between the households and local leaders, unwillingness of youngsters to participate in conservations due to landlessness, climate variability, lack of follow up, lack of knowledge and means of utilizing the available resource, water scarcity, low skill of using agricultural technologies and inputs, lack of integration between sectors. Similarly, Tongul and Hobson (2013) and Mekonen and Tesfahunegn (2015) mentioned constraints like, lack of professionals, poor sharing of information between different departments, inappropriate technological and lack of site specific technologies and policy implementation constraint.

Several challenges were also identified that threaten the success of watershed management. These include the lack of technical advice and information to support the selection of interventions suitable for the local context; uncoordinated interventions, institutions and actors within a watershed; and, importantly, the uneven distribution of the water management costs and benefits (Gebregziabher et al., 2016). Generally, integrated watershed programmes might not have address the issues existing social stratification based on gender, caste, religious groups, and socioeconomic status and its influence in ensuring tangible economic benefits to individual farmers, women and vulnerable group members.

6. Conclusion

Land degradation is a major cause of Ethiopia's low and declining agricultural productivity, persistent food insecurity and rural poverty. To tackle this problem, community based integrated watershed management is being implemented by the government in collaboration with other concerned bodies. The practical approaches focus on disseminating site specific physical and biological soil and water conservations measures. Accordingly, the integrated application of mechanical, biological and soil management practices have been vital for the rehabilitation of degraded lands since they reduce flood risks, nutrient losses and increase grain yields. Despite the challenges it has, up to the scope of this review, integrated watershed managements practices are the only possible solution for rehabilitation of degraded lands. Therefore, an integrated use of physical, biological and agronomic soil and water conservation measures through active participation of the local people could be the basis of improving biophysical and socio-economic aspects at a watershed level.

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