Review on Land Management Practices on the Provision of Ecosystem Services: The Case of Ethiopia

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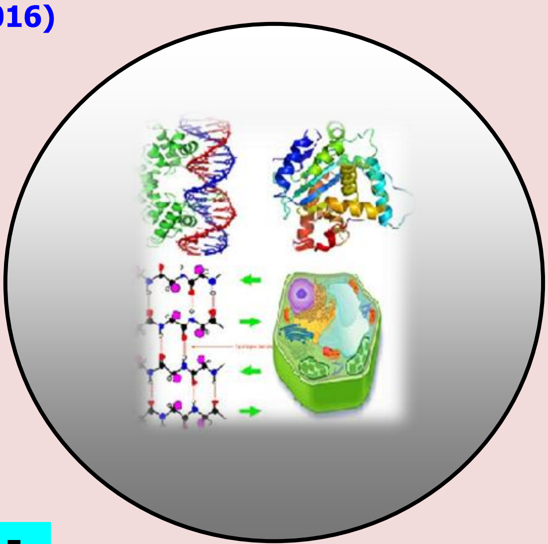

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Review on Land Management Practices on the Provision of Ecosystem Services: The Case of Ethiopia

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ABSTRACT

The effect of land management practices on the provision ofsocio-cultural ecosystem services was identified throughappraises and synthesis of previous research findings. The prior implemented land management practices in the country had optimistic impact on the majority of ecosystem services except, provisionservices on crop productivity.This is due to,the physical soil and water conservation practices reduced theefficiency of private cultivable land. Nevertheless,soil and water conservation practices increase crop yield.This implies that integration of physical and agronomic soil and water conservation practices are essential to improve the provision and regulate the ecosystem services. Besides, environmental and physical factors such as altitude, rainfall, slope and age of conservation practicesarethe determinant factors on ecosystem services of land management practices. Consequently, proper design of physical soil and water conservationpractices,environmental factor and integration of different land management practices should be into consideration during planning and implementation of land management activities.
Keywords: Conservation, Ecosystem, Land Management, Provision and Services.

INTRODUCTION

Ecosystem is a system thatencompassesthe biophysical and human components and their interactions (MEA, 2005; Garbach*et al*, 2014). Biotic and abiotic ecosystem elements and their interaction withenvironment are the resultof ecosystem services and generally described in terms of rates (MEA, 2005). Organisms and guilds are ecological communities serve as biological mediators and ecosystem service providers. In this regards,Garbach*et al.,* (2014) described the functions of ecosystem services are support the benefit for human wellbeing. The multiple benefits that human being receives from environment can be maintained and enhanced using land management practices (Admasu*et al*, 2016). Land use and management practices often influencethe ecosystem services(Garbach*et al*, 2014).

In Ethiopia different land management practices hadimplemented to enhance ecosystem services and reduce the unenthusiasticeffect of land degradation (Sonneveld and Keyzer, 2003; Amsalu and Graaff, 2006). In addition, land management practices improvethe agricultural productivity and addresses food security problems currently we faced (Abera and Dessale, 2016). Land management practices mainly soil and water conservation had given proper attention by the national government, non-governmental organizations and the local communities during 1970s severe drought and famine occurred in the country(Herweg, 1993). Besides, the national government and international donors identified the effect of land degradation as the underlying cause of traumatic drought and famine incidences which Ethiopia experienced (Herweg and Ludi, 1999). To alleviate soil erosion and increase food production in the country, a number of land management technologies, such as physical soil and water conservation (SWC) practices, biological measures and soil management practices, have been introduced and implemented over the last four decades by governmental and non-governmental organizations (Kassie*et al.,* 2008; Nigatu*et al*, 2017). Considerable efforts have been made during this period to rehabilitate degraded lands and prevent further degradation (Anley*et al.,* 2007). The emphasis has been largely on the construction of structural SWC measures in cultivated fields and afforestation of hillsides (Bewket, 2003; Kalkidan*et al*, 2017). However, those achievements are later evaluated as only quantitative with minimal desirable outcomes and largely less effective and often unsustainable (Admassie, 2000, Hengsdijk*et al.,* 2005). After the overthrow of the Derg Regime,investments and land management efforts have also been continued in Ethiopia. For instance, since 2003, 2005 and 2008, huge amount of money allocated to different land management practices mainly for SWC by MERET (Managing Environmental Resources to Enable Transitions to sustainable livelihoods) project, Productive Safety Net Progamme and Sustainable Land Management Program (SLMP) respectively in Ethiopia (Zeleke*et al.,* 2014; Fisseha and Tewodros, 2014).Accordingly, there have been several empirical research results reported on the impact of land management practices on runoff, crop yield, soil, and nutrient loss. Studies of the impact of land management on ecosystem services have the benefit of a larger evidence base, but can only offer generic recommendations for policies. Provision of evidences and information's on how ecological systems respond to land use and management decisions for policy and decision makers is very important in order to inspire further thought and action (Fisseha and Tewodros, 2014). Although, it is important to assess and synthesize the impacts of land management practices within a more systematic basis within the framework of ecosystem services. This review paper and analyses can provide useful information for policy makers and beneficiaries of ecosystem services and their willingness to adjust some of their practices to deliver prejudged ecosystem services at least cost.

Land management practices in Ethiopia

Currently, different land management practices were implemented in Ethiopia, for the past five decades to curve land degradation problems and increase agricultural production via government and NGOs (Bewket, 2003; Kassie*et al.*, 2008). A number ofNGOs and bilateral organizations adopted watershed managementin the last decades and in late 1990, watershed development was considered the crucial point for rural development and poverty alleviation in Ethiopia. Among others, Food and Agricultural Organization (FAO) implemented watershed management projects and gavestrong attention to the institutional strengthen and capacity building for the technician experts and development agents from the ministry of agriculture and natural resource(Lakew *et al.,* 2005; Nigatu *et al*, 2017). The projects entirely focused on sub-watershed as the planning unit and sought the views of local technicians and members of the farming community to prepare land use and capability plans for soil and water conservation practices. This approach was tested at the pilot stage through FAO technical assistance under ministry of agriculture during 1988-1991. This was the first step in the evolution of the participatory planning approach on watershed development in Ethiopia.

Land rehabilitation project with World Food Programme (WFP) and food for work assistance was aimed at addressing the problems of food insecurity through the construction of soil conservation structures, community forestry and rural infrastructure works. The project focused on selected food deficit watersheds in the country where the incidence of steady food insecurity were most severe(Lakew*et al.,* 2005).The Deutsche Gesellschaft for Technische Zusammenarbeit (GTZ) integrated food security program has been also implemented in South Gondar with an integrated watershed management approach. The programme was aimed at improving the nutritional food insecure households through natural resource management by biological and physical soil conservation measures, and crops and rural infrastructure works in different parts of the country. According to Lakew *et al.,* (2005), presently, several donors and development agencies implemented and promoteddifferent natural resource conservation practices in the country. Watershed management was widely considered as a practice of soil and water conservation and the success of the watershed management projects marked as the basis of major watershed initiatives in Ethiopia. According to Desta *et al.,* (2005) there are five types of land management practices; physical soil and water conservation, biological soil and water conservation, agro forestry and forestry practice, gully control and water harvesting (Nigatu *et al.,* 2017). These practices were implemented for many years in Ethiopia and had successful results especially in the northern part of the country (Gebremedhin *et al.,* 1999).

Among various land management practices, SWC measures have been initiated for soil erosion control including the construction of stone bunds to conserve *in-situ* moisture and decrease sheet and rill erosion on arable land and hill slopes, the construction of check dams in gullies and the establishment of enclosures on steep slopes (Nyssen *et al*., 2007; Nigatu *et al.,* 2017).

In the northern part of Ethiopia, soil and water conservation practices had implemented widely (Haregeweyn *et al.,* 2006). The World Bank gives more emphasis on the significance of vegetative measures in watershed development. This might be due to the global trend that favors choosing technologies that are low cost and farmer friendlythus, successful adaptation of this technology in the World Bank projects.According to World Bank (2001) report indicated, local communities were actively involved in the choice of technologies, strategy that helps to implement technologies that are more compatible with existing land uses and environments that meet their needs. This was possible, because the government had mobilized communities and resources for the construction of different physical soil and water conservation structuresthat are suitable to the agro-ecology. Accordingly,crop yield improvement was mainly concentrated within the vicinity of the structures even runoff continued to overtop the structures and no other measures for *in-situ* soil conservation were put in place (Gebreegziabher *et al.,*2009; Fisseha and Tewodros, 2014).

Ecosystem and ecosystem services

Agricultural production is one of the main driving forces for land degradation and contributes about 65% for natural ecosystems trouble (MEA, 2005).According to OMC (2013) assured that balancing the need of enough food for the alarming growing population with maintains healthy ecosystems and habitats are thus arguably one of the most burning issues of the 21st century.

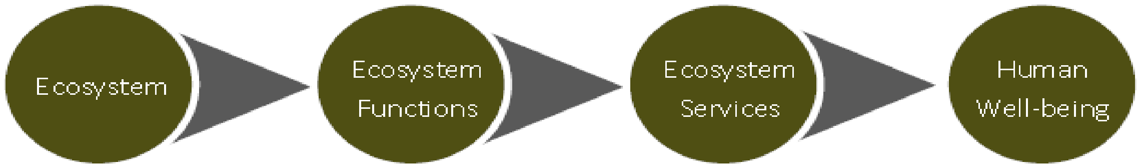

Figure 1.Relationship between ecosystem and human well-being.

Most of the time, ecosystem approach is a strategy to manage and promote conservation and sustainable use of resources in equitable way. The first large scale and widely recognized ecosystem services framework is the Millennium Ecosystem Assessment (MEA) 2003 classification frame work (Maes*et al.,*2013) and also this framework implemented for land management practices.

Table 1.Millennium ecosystem assessment framework classification.

Ecosystem services framework	**Services**
• Provisioning services: products obtained from ecosystems	• Fuel wood; Freshwater (water retention); Food (crop yield); Fiber; Genetic resources; Biochemical's and Medicines
• Regulating services: benefits obtained from the regulation of ecosystem processes	• Erosion control; Runoff regulation; Climate regulation and air quality (Carbon storage, GHG reducing); Water regulation (flood control and runoff regulation); Water quality control (water purification and filtering); Waste treatment; Pest and disease regulation and Pollination
• Cultural services: nonmaterial benefits obtained from ecosystem	• Spiritual and religious values (religious sites and burial grounds); Educational value (learning resources); Aesthetic values and ecotourism (platform for activities) and Cultural heritage values (archaeological records)
• Supporting services: services that are necessary for the production of all other ecosystem services	• Soil formation; Nutrient cycling; Provisioning of habitat and Photosynthesis

Source: Adimasu*et al.,* 2016

Evidences on the influence of land management practices on ecosystem services

Assessing and synthesizing the impacts of land management practices on ecosystem services and complex human environment interactions is the key to inform decisions concerning adaptation to and mitigation of environmental change (Adimasu *et al.*, 2016). Several land management practices preserve and enhance ecosystem services adopted before, during and after cultivation. So far, the benefits of land management practices for preserving and enhancing ecosystem services in agricultural landscapes have not been supported with strong evidences. Land management practices influences the potential for disservices from agriculture and agro-ecosystems benefits (Matzdorf and Meyer, 2014).

Ecosystem provisioning services of land management practices

According to Bekele (2005) in the high rainfall areas, soil conservation measures become profitable, if the land lost because of the construction of these measures on the land such as bunds is compensated through the planting of grass for livestock fodder and trees for fuel and fruits on these bunds. It was also found that soil and water conservation structures are not attractive to most farmers on crop yield provisioning service (Kassie *et al.,* 2008; Tewodros and Belay; 2014). Most soil and water conservation measures and three ecosystem services such as food production, water availability and energy production performing as provisioning services (Kauffman *et al.*, 2014).

Table 2.Effects physical conservation practices on yield of crops (kg ha^{-1}) related to rainfall, altitude and slope.

SWC practices	N	Average annual rainfall (mm)	Average altitude (mm)	Average slope (%)	Yield mean difference (kgha^{-1})
Stone bund	18	1138.7	2122.8	14.1	321.7
Graded fanyajuu	37	1454.3	2344.8	18.7	-53.7
Graded soil bund	43	1417.6	2360.3	16.8	-144.9
Level fanyajuu	44	1307.5	2375.8	20.7	-172.7
Level soil bund	15	1030.2	23313	19.82	-193.2

Source: Admasu*et al.,* 2016

Table 2 described that, many physical soil and water conservation practices are not effective on yield increment. Nevertheless in terms of runoff reduction, moisture conservation and yield increment, agronomic soil and water conservation practices are highly effective. In contrary,the finding of Agegnehu*et al.,* (2012) indicated that the highest barley (*HordeumvulgareL.*) grain yield (2575kgha^{-1}) and total biomass (5185kgha^{-1}) were obtained from the application of the recommended nitrogen and phosphorus (NP) fertilizer (100 kg ha^{-1} UREA and 100 kg ha^{-1} DAP) due to the application of half doses of the recommended NP fertilizer and 3t ha^{-1} Effective Microorganisms (EM) compost. Similarly, a study undertaken to assess the effects of combined application of 46 kg ha^{-1} N and 5 t ha^{-1} farmyard manure on root yield and yield components of sweet potato (*Ipomoea batatas*) at Delbo watershed and found that the combination increased marketable root by 49%, fresh top weight by 48% and total fresh root yield by 46% over the control (Garo*et al.*, 2014; Tewodros and Yared*,* 2014). Therefore, chemical and artificial fertilizer applications on different crops including root crops are increased the total yield and total biomass (Tewodros *et al.,* 2017).

Table 3.Effects of agronomic SWC practices on grain yield (mean difference) of crops (kg ha^{-1}) related to rainfall, altitude and slope.

SWC practices	N	Average annual rainfall (mm)	Average altitude (mm)	Average slope (%)	Yield mean difference (kgha^{-1})
G. strip	29	1378.3	2390.9	18.6	-158.9
MT	62	896.9	1990.3	3.3	108.4
Mulching	17	876.7	2146.6	4.7	629.2
Tied-R	103	695.1	2022.8	4.4	554.3
FYM	78	1048.0	1794.6	3.8	3917.9
Compost	36	1228.9	2268.1	2.2	782.9

Source: Admasu*et al.,* 2016

Most of the time yield and yield components of sweet potato could be enhanced by combining farmyard manure and inorganic fertilizers and also sole inorganic fertilizer increased maize yield by 75, 56 and 244 % in the year 2001, 2002 and 2003 cropping seasons, respectively (Negassa *et al*., 2007). In the central highlands of Ethiopia, average grain yield of barley consistently increased as the total biomass increased. While, the highest yields were achieved from the recommended NP fertilizer rate the integrated soil fertility management options also resulted insignificant yield advantages compared to the control. This implies that inorganic fertilizer had produces immediate benefits. However, from the natural resource management and environmental protection point of view, efficient management and combination of crop residues with other organic nutrient sources and inorganic fertilizers can contribute to the sustainability of agricultural productivity and integrated farming systems in the highlands of Ethiopia. According to Agegnehu*et al.,* (2011) report mixed cropping of *teff* (*Eragrostistef*) with *faba*bean (*Viciafaba*) was compared with sole cropping in the 2002 and 2003 growing seasons at the Holetta Research Center in the central highlands of Ethiopia and the results indicated that *teff*yield equivalent, land equivalent ratios (LERs) and system productivity index (SPI) of the mixture exceeded those of sole crops especially when the seed rate of *faba*bean in the mixture was increased to 50kgha^{-1} (25 %).On the other hand, another study conducted on the influence of a single *F. albida*tree intercrop on the yield of different crops at Melkassa Agricultural Research Center indicated that scattered *F. albida*trees increased the average maize grain yield by 67% near the tree (0-2.8m distance) as compared to 13-15m away in the open area (Agegnehu*et al*., 2011). Farmers also developed agroforestry systems integrating high value fruit trees such as avocado, citrus, mango and coffee on their farms to generate improved incomes, food security and nutrition. The effect of alley cropping on grain yield of different maize varieties was conducted at Alemaya, Ethiopia and overall yield was higher and positively affected (Belay and Gebrekidan, 1998). Intercropping of wheat with *faba*bean may increase total yield and revenue reduced weed and disease pressure, increased land use efficiency and thereby enhanced sustainability of crop production in the highland parts of Ethiopia(Agegnehu *et al.,* 2008). According to Mekonen and Brhane (2011) reported, mostly soil and water conservation measures like terraces are accumulate eroded soil materials on cultivated land. This sediment accumulated behind the terrace may provideproper conditions for plant through conserving nutrients and water in the area(Vancampenhout*et al.,* 2006). In addition to this, different soil and water conservation practices are protect reservoirs and dams from siltation effect; as a result it has superior and longer performance.In this regards, Mekonen and Brhane (2011) stated that the sediment accumulated in the stone bunds is about 65.3tha^{-1}year^{-1}. Similarly,Gebremichael*et al.,* (2005) estimated that 59tha^{-1}year^{-1}sediments accumulated in the stone bund in the northern part of the country. On one hand, the annual sediment load accumulated could be larger with new bunds that have a greater capacity to retain soil than grown-up bunds. On farm land, terraces accumulate sediment 0.2 to 0.9m and the formation of rills and inter-rills decreased yields up to 60%. Haile *et al.,* (2006) stated that plants and plant residues, stones, coarse clods (macro-aggregates) and ripples increase surface roughness that in turn reduce runoff and runoff velocity, accumulation of eroded particles and extend the time for infiltration (Yakob *et al.,* 2008; Nigatu *et al.,* 2017). Furthermore, plants and mulch reduce the effect of rain splash and decrease the amplitude of the surface temperature and thus reduce evaporation losses. Plant cover also increases infiltration in two ways such as; (i) directly through their roots and (ii) indirectly by increasing organic matter and thus improving aggregate stability and the soil structure. A field experiment conducted with vetiver grass hedgerows on different erosion control sites using a runoff plots on a 20% slope and reported that out of the total rainfall of 1034mm, 848mm and 668mm that occurred during the respective in the year 2001, 2002 and 2003 experimental periods 16.2%, 7.7% and 2.58% translated into runoff. During the same experimental period, the runoff in the vetiver grass hedgerow plots decreases by 26%, 64% and 88%, respectively in comparison with that on bare land plots. Soil loss in the vetiver hedgerow plot was decreased by 55%, 77% and 97%, respectively in comparison with that on bare land plots (Hailu, 2009). In 2001 and 2002 growing periods, soil loss was 86.3 and 48.1ton/ha/year in the vetiver hedgerow plot was not in the acceptable soil loss range. The results indicated the effectiveness of the hedgerows in reducing runoff and associated soil loss over time. Similar, studies conducted on the effects of vetiver hedges on water flooding and soil erosion at Jimma, Ethiopia, found reduced flood velocity, limited soil movement and significantly decreased soil erosion (Yakob *et al.,* 2008).

Ecosystem cultural services of land management practices

Ecosystem service becomes a major basis for planning and management. Cultural services and non-use values are included in all primary typologies and present some of the most convincing reasons for conserving ecosystems, though many barriers exist to their explicit characterization (Kai *et al.,* 2012).

Cultural and non-use values are included with ecosystem services in all prominent typologies nevertheless; in practice it has received little attention in the growing body of empirical ecosystem services (Martín-López *et al.,* 2009). Cultural ecosystem service has generally been valued in purely economic and social terms which cannot reflect the full extent of their differences from other ecosystem services while these values have been described gracefully through poetry and prose. In Ethiopia, different agro-ecologies are well managed and treated by farmers' indigenous conservation practices (Nigatu *et al.,* 2017). These community indigenous natural resources management practices are inherited cultures of the communities. These land management practices have been implemented for several hundred years and keep alive cultural landscapes and improve ecotourism sector contribution for economic development of the country (Wainger and Mazzotta, 2011; Adimasu *et al.,* 2016). For instance, in Ethiopia Konso cultural landscape is one of world heritage registered by UNESCO (UNESCO, 2011). Several pocket areas of the country including Konso cultural landscape have been served for cultural services. Educational, aesthetic, ecotourism and cultural heritage values are among cultural services benefited from indigenous land management practices in Ethiopia (Tewodros and Belay; 2014; Adimasu *et al.,* 2016).

Ecosystem supporting services of land management practices

Nutrient recycles and fertility improvement is the major ecosystem supporting service exhibited due to the influences of land management practices. However, declining soil fertility is one of the bottlenecks to sustainable agricultural production and productivity in the highland parts of Ethiopia (Tewodros and Belay; 2014). This is due to low soil fertility and absence of efficient and sustainable soil fertility management practices, continuous removal of crop residues from crop fields, use of cow dung for other purposes and low inherent soil fertility (Abegaz, 2005; Haile *et al.,* 2009). To simplicity the problem, integrated nutrient management is an option as it utilizes available organic and inorganic nutrients to build ecologically sound and economically viable farming (Abegaz, 2005). The integrated use of IF with farmyard manure also improved soil chemical properties and the uptake of nitrogen, phosphorus, and potassium. The use of IF with FYM could improve both maize yield and soil fertility in western highlands of Ethiopia. A study conducted at Maybar soil conservation research site, showed that the terraces on 3 to 8% slopes had statistically significantly higher p^H 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). Due to erosion and leaching of soluble salts from the upper slope and accumulation at the foot slope, soil p^H and exchangeable bases increased with decrease in slope of the terrain (Damene*et al.,* 2012). Some plant types, example those in the legume group, improve soil fertility by fixing nitrogen. Improved soil fertility or soil quality, in turn, improves plant growth (Zerihun *et al.,* 2013). The soil-plant system may stabilize itself ensuring both production and protection functions (Nigatu *et al.,* 2017).

Difficulty of quantifying ecosystem services of land management practices

Different land management practices may affect various ecosystem services in different ways. The services from land management practices would be different in different spatial and temporal. The quality of land management activities and the nature of its technologies also determine the extent and type of services from the ecosystem. For instance, some studies reported that long-term no-till can improve soil fertility, recovery and decrease erosion, but no-till can also lead to soil compaction, limit water infiltration and can hinder seed germination. Physical SWC structures could manage runoff and deposit plant nutrients in soil, but runoff can adversely affect nutrient cycling(Nigatu *et al.,* 2017). There is no holistic method in order to quantify economical, ecological and social benefits and services due to the influence of different land management practices on ecosystem (Kalkidan *et al.,* 2017). The management of ecosystem services therefore requires making judgments about trade-offs, not least, the trade-off between agricultural production and environmental protection. There is no clear way to distinguish the overlapping between ecosystem processes and final benefits due to land management practices influences. This implies proxies of ecosystem processes and indicators of ecosystem services need to be clear concept to quantify the impacts of land management on ecosystem services (Tewodros and Belay, 2014).

CONCLUSION

The Millennium ecosystem assessment framework adopted toassess the influence of land management practices on ecosystem services. The result revealed, there is no available data for many of the ecosystems services and hinders analysis of ecosystem services for each implemented land management practices in the country.

Provision of ecosystem services in land management practices are strongly influenced by environmentaland physical factors. Ecosystem services in different land management practices are varied in the scale of their operation, location, and this may indicate the importance integration of different land management practices for multiple services. Thus, the combined application of mechanical, biological and soil management practices have been vital for the rehabilitation of degraded lands, since they reduce flood risks, nutrient and sediment losses and increase crop yield. Besides, integrated watershed management practices are the possible solution for multiple ecosystem services. By combining trade-off and side-benefit analyses, may achieve substantial increases in natural resources conservation, while conservation of ecosystem services are critical for human well-being. Furthermore, modeling of ecosystem is important to plan thoroughly for multiple ecosystem services. It is important to analyze thedynamics (spatial and temporal),estimate the potential impacts of management and threats on ecosystem services. The influences of land management practices on the provision ofecosystem services are extensive and dissimilarfor the conservation of land management practices. Thus, the conservation strategiesof ecosystem services would involve a major shift toward new geographies and a broadening of current conservation goals.

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