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SOIL EROSION IN ETHIOPIA: EXTENT, CONSERVATION EFFORTS AND ISSUES OF SUSTAINABILITY

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Soil degradation is a global environmental problem which started since the innovation of agriculture by human kind. One third of the world's agricultural soils, or roughly 2 billion hectares of land, was reported as being affected by soil degradation. Water and wind erosion account for 84% of this observed damage. The problem is very high in Africa and Asia. Ethiopia is considered to have one of the most serious soil degradation problems in the world. The average annual rate of soil loss in Ethiopia is estimated to be 12 tons/ha/yr, and it can drastically exceed this on steep slopes with soil loss rates greater than 300 tons/ha/year, where vegetation is denuded. The problem is very much serious in the Ethiopian highlands. In mid 1980's, 27 million ha or almost 50% of the highland area was significantly erchoded, 14 million ha seriously eroded and over 2 million ha beyond reclamation. Recognizing the seriousness of the problem, the Ethiopian government launched a massive soil conservation program beginning the mid-1970s. However, most performance measures of soil and water conservation efforts of the country were failed. In 1980s, the concept of watershed management was implemented as a way of redressing the degradation of the natural resource base and increasing land productivity. From its introduction up to know, watershed management has being implementing in the country. Some success of conservation efforts following watershed management was reduced run off, soil erosion and associated downstream siltation, increased vegetation cover and surface roughness, increased soil depth, increased recharge of groundwater table, increased production area and green environment, increased crop production and productivity and improvement in fodder availability. The successes are indicators of sustainable resource conservation.

Keywords: Soil erosion, Extent, Conservation, Sustainability

INTRODUCTION

Ethiopia is located in the Horn of Africa between 3^0 and 15^0 North and 33^0 and 48^0 East. Altitude ranges from 116m below sea level to more than 4,000m a.s.l. The great altitudinal difference of the country makes it to be endowed with many natural resources, high biodiversity and distinctive ecosystems (Berry, 2003). Ethiopia's base of natural resources is the foundation of any economic development, food security and other basic necessities of its people. Smallholder agriculture is the dominant sector that provides over 85 percent of the total employment and foreign exchange earnings and approximately 55 percent of the Gross Domestic Product (GDP) (EPA, 2012). Therefore, the majority of the people are dependent on natural resources and it leads to land resource degradation (Paulos, 2001). Land degradation has reached a severe stage and has become a major root cause of poverty with significant negative impacts on the national economy (Tadesse, 2001). The major causes are rapid population increase, severe soil loss, deforestation, low vegetative cover, unbalanced crop and livestock production and negative coping strategies such as burning of animal dung and extensive use of charcoal (Girma, 2001; Lakew *et al.*, 2005). Topography, soil types and agro-ecological parameters are also additional factors playing significant role in the degradation processes influenced by man (Paulos, 2001). Similarly, Gebreyesus and Kirubel (2009) explained that the heavy reliance of some 85% of Ethiopia's growing population on an exploitative kind of subsistence agriculture is a major reason behind the current state of land degradation. All physical and economic evidence shows that loss of land resource productivity is an important problem in Ethiopia and that with continued population growth the problem is likely to be even more important in the future (Berry, 2003).

Land degradation takes different forms, which comprise soil degradation, vegetation degradation and water degradation. Soil degradation refers to the decline in soil qualities which encompasses soil erosion, soil compaction, low organic matter of the soil, loss of soil structure, and poor internal drainage system of soils, salinisation and soil acidity problems (Wall *et al*., 2003). Thus, soil erosion is one component of soil degradation. Vegetation degradation refers reduction in biomass, decrease in species diversity, or decline in quality in terms of the nutritional value for livestock and wildlife (George, 2002). Water degradation refers the deteriorations of water quality and quantity. In Ethiopia, soil degradation in the form of soil erosion and soil fertility loss is a serious challenge to agricultural productivity and economic growth, of which soil erosion is the most serious problem (Paulos, 2001). The average annual rate of soil loss in Ethiopia is estimated to be 12 tons/ha/yr, and it can drastically exceed this on steep slopes with soil loss rates greater than 300 tons/ha/year, where vegetation is denuded (USAID CRSPT, 2000). Every year the country is losing billions of birr in the form of soil, nutrient, water and agro biodiversity losses (Paulos, 2001). As a result, poverty and food insecurity are concentrated in rural areas (MoARD, 2010).

Recognizing the seriousness of the problem, the Ethiopian government launched a massive soil conservation program beginning the mid-1970s (Hawando, 1997). Between 1976 and 1990, 71,000 ha of soil and stone bunds, 233,000 ha of hillside terraces for afforestation, 12,000 km of check dams in gullied lands, 390,000 ha of closed areas for natural regeneration, 448,000 ha of land planted with different tree species, and 526,425 ha of bench terrace interventions were completed. However, by 1990, only 30 percent of soil bunds, 25 percent of the stone bunds, 60 percent of the hillside terraces, 22 percent of land planted in trees, and 7 percent of the reserve areas still survived (USAID CRSPT, 2000). The focus was on the highland areas of the country where the problem is more severe and food deficit is prevalent (Lakew *et al*., 2000; Menale *et al*., 2009). The soil and water conservation works were done using the Food-For-Work (FFW) incentives. The FFW incentives were provided by international, multilateral and bilateral organizations of which the European Economic Commission, UNDP and FAO were the major one (Getachew, 2005). Although there has been a great deal of efforts to address land degradation problems in Ethiopia, most performance measures of Soil and Water Conservation (SWC) effort of the country ended up in remarkable failure (Yeraswork, 2000; Solomon *et al*., 2013). The reason for the failures of past extensive soil and water conservation efforts had largely due to poor planning, poor design of structures, lack of participation by the communities, inappropriate conservation methods, poor linkages with livelihoods of the poor and lack of an integrated approach that goes beyond soil conservation to address the interlinked productivity, market access, land policy and resource management problems (Bekele and Holden, 1998; Yeraswork, 2000; Menale, *et al*., 2009). Furthermore, the more emphasis of unfamiliar structural practices with farmers was the reason for the failure of this mass movement of soil and water conservation practices (Belay, 1992). There are also soil and water conservation efforts following watershed management approach since 1980s as a way of redressing the degradation of the natural resource base and increasing land productivity (Gete, 2006). Therefore, the purpose of this review is to present the extent of soil erosion and conservation efforts in Ethiopia and to look into its sustainability.

SOIL: BASIC CONCEPTS AND FUNCTIONS

Soil can be defined as the natural dynamic system of unconsolidated mineral and organic material at the earth's surface. It has been developed by physical, chemical and biological processes including the weathering of rock and the decay of vegetation. Soil materials include organic matter, clay, silt, sand and gravel mixed in such a way as to provide the natural medium for the growth of land plants. Soil comprises organised profiles of layers more or less parallel to the earth's surface and formed by the interaction of parent material, climate, organisms and topography over generally long periods of time. It differs markedly from its parent material in morphology, properties and characteristics (Houghton and Charman, 1986).

Soil is the most fundamental and basic resource. Although erroneously dubbed as "dirt" or perceived as something of insignificant value, humans cannot survive without soil because it is the basis of all terrestrial life. Essentiality of soil to human well-being is often not realized until the production of food drops or is jeopardized when the soil is severely eroded or degraded to the level that it loses its inherent resilience. Traditionally, the soil's main function has been as a medium for plant growth (Blanco and Lal, 2008). However, soil provides four main functions, including production functions, physiological functions, cultural functions and ecological functions (Mitiku *et al*., 2006) (Figure 1).

GLOBAL CONTEXT OF SOIL EROSION

Soil erosion is defined as the wearing away of the land surface by physical forces such as rainfall, flowing water , wind, ice, temperature change, gravity or other natural or anthropogenic agents that abrade, detach and remove soil or geological material from one point on the earth surface to be deposited elsewhere. In the long term, this process leads to stable landforms with low erosion rates (Mitiku *et al*., 2006). There are two main types of erosion: geologic and accelerated erosion. Geologic erosion is a normal process of weathering that generally occurs at low rates in all soils as part of the natural soil-forming processes. It occurs over long geologic time horizons and is not influenced by human activity. The wearing a way of rocks and formation of soil profiles are processes affected by the slow but continuous geologic erosion. Indeed, low rates of erosion are essential to the formation of soil. In contrast, soil erosion becomes a major concern when the rate of erosion exceeds a certain threshold level and becomes rapid, known as accelerated erosion. This type of erosion is triggered by anthropogenic causes such as deforestation, slash-and burn agriculture, intensive plowing, intensive and uncontrolled grazing, and biomass burning (Blanco and Lal, 2008).

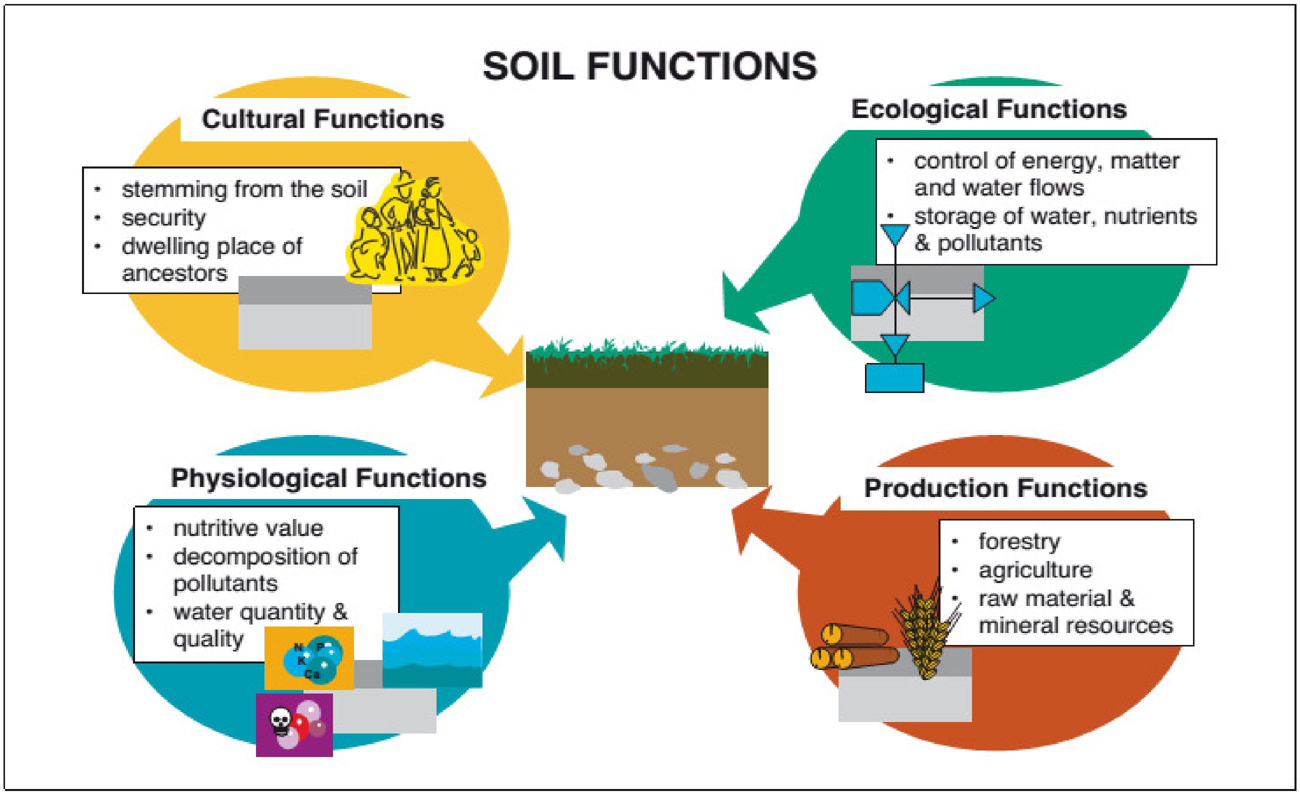

Figure 1: Soil functions (Drawing: Karl Herweg) (Mitiku *et al*., 2006)

Soil erosion is a two-phase process consisting of the detachment of individual soil particles from the soil mass and their transport by erosive agents such as running water and wind. When sufficient energy is no longer available to transport the particles, a third phase, deposition, occurs (Morgan, 2005). Soil erosion affects the physical and chemical properties of soils. The physical parameters are primarily organic matter content, structure, texture, bulk density, infiltration rate, rooting depth, and water-holding capacity. Changes in chemical parameters are largely a function of changes in physical composition. Loss of soil implies loss of productive land, as a consequence it reduce the productivity of agricultural land and crops yield which is actually essential to sustain human life on earth. However, in areas where the topsoil is acid and the organic matter content is initially low, surface erosion may, in fact, increase crop yields due to the exposure of a more favorable subsoil (Mitiku *et al*., 2002).

One third of the world's agricultural soils, or roughly 2 billion hectares of land, was reported as being affected by soil degradation. Water and wind erosion account for 84% of this observed damage (Hurni, 2002). Water erosion representing about 56% of the total degraded land and wind erosion affects about 28% of the total degraded land (Blanco and Lal, 2008). While other forms like physical and chemical degradation are responsible for the rest. Industrialisation and urbanisation have further caused specific forms of soil degradation. Most damage, however, is the result of inappropriate land management in all the diverse farming systems, from subsistence to mechanized farming (Hurni, 2002). Thus, water and wind erosion are the dominant agents that degrade soils (Blanco and Lal, 2008). In terms of severity, worldwide about 38% of the degraded soils is affected to alight degree, 46% has a moderate degree, while around 15% is seriously degraded (Oldeman *et al*., 1995) (Table 1). The problem of soil erosion is severe particularly in the tropics and sub-tropics because of the high population pressure, scarcity of prime agricultural lands, and predominance of resource-poor farmers. It is much severs in Africa and Asia (Blanco and Lal, 2008).

One regional base, measurements of soil loss undertaken from hill slopes in West Africa, ranging in steepness from 0.3 to 4°, yield annual rates of 0.15, 0.20 and 0.03 t ha^{-1} under natural conditions of open savanna grassland, dense savanna grassland and tropical rain forest respectively. Clearance of the land for agriculture increases the rates to 8, 26

Table 1: The extent of the status of human induced soil degradation by type, degree and causative factors for the world and major continents or regions, expressed in million hectors (Oldeman *et al*., 1995)

	World	Asia	Africa	S. America	C. America	N. America	Europe	Oceania
Degradation type								
Water	1094	440	227	123	46	60	114	83
Wind	548	222	187	42	5	35	42	16
Nutrient decline	135	14	45	68	4	-	3	-
Salinization	76	53	15	2	2	-	4	1
Pollution	22	2	-	-	-	-	19	-
Acidification	6	4	2	-	-	-	-	-
Compaction	68	10	18	4	-	1	33	2
Waterlogging	11	-	-	4	5	-	1	-
Subsidence org. soils	5	2	-	-	-	-	2	-
Total	1965	747	494	243	63	96	218	102
Degradation Degree								
Light	749	295	173	105	2	17	60	96
Moderate	910	344	192	113	35	78	144	4
Strong	296	108	124	25	26	1	10	2
Extreme	9	-	5	-	-	-	4	-
Causative factors								
Deforestation	579	298	67	100	14	4	84	12
Overgrazing	678	198	243	68	9	29	48	83
Agri. mis mgt	552	204	121	64	28	63	64	8
Over exploitation	133	46	63	12	11	-	1	-
Industrial activities	23	1	-	-	-	-	21	-

and 90 t ha^{-1}, while leaving the land as bare soil produces rates of 20, 30 and 170 t ha^{-1} respectively. Thus, removal of the rain forest results in much greater rises in erosion rates than does removal of the savanna grassland. These measurements emphasize the high degree of protection afforded by the rain forest but also reflect the erosive capacity of the high rainfalls in the humid tropics when that protection is destroyed. The rates of removal of tropical rain forests over the past twenty years are therefore of major concern with respect to present and future erosion problems (Roose 1971 cited in Morgan, 2005). Similar with the above finding, Schwab *et al*. (1993) have described the function of vegetation in erosion control on a more comprehensive way. According to them, the major effects of vegetation in reducing erosion are 1) interception of rainfall by absorbing the energy of the raindrops and thus reducing surface sealing and runoff 2) retardation of erosion by decreased surface velocity, 3) physical restraint of soil movement 4) improvement of aggregation and porosity of the soil by roots and plant residue, 5) increased biological activity in the soil and 6) transpiration , which decrease soil water, resulting in increased storage capacity and less runoff. Due to the variations of environmental factors and conservation efforts, the amount of soil loss also varies among countries. In addition, soil loss also varies in different land use/land cover classes. It is very high in cultivated land and bare soil than under natural conditions (Table 2). Similarly, studies indicated that land use/land cover changes towards cultivated and degraded land increases the susceptible of the soil for erosion (Gete and Hurni, 2001; Woldeamlak, 2002).

Table 2: Annual rate of erosion in selected countries (t ha^{-1})

Country	Natural	Cultivated	Bare soil
China	0.1-2	150-200	280-360
USA	0.03-3	5-170	4-9
Australia	0.0-64	0.1-150	44-87
Ivory Coast	0.03-0.2	0.1-90	10-750
Nigeria	0.5-1	0.1-35	3-150
India	0.5-5	0.3-40	10-185
Ethiopia	1-5	8-42	5-70
Belgium	0.1-0.5	3-30	7-82
UK	0.1-0.5	0.1-20	10-200

Sources: Browning *et al*. (1948), Roose (1971), Fournier (1972), Lal (1976), Bollinne (1978), Jiang *et al*. (1981), Singh *et al*. (1981), Morgan

(1985a), Boardman (1990), Edwards (1993), Hurni (1993) cited in Morgan (2005)

SOIL EROSION IN ETHIOPIA

Causes of Soil Erosion

In Ethiopia, rapid population growth, cultivation on steep slopes, clearing of vegetation and overgrazing are the main factors that accelerate soil erosion (Hurni, 2002). In the Ethiopian highlands, the population has grown very fast on the limited land area and every possible piece of land is put into cultivation to produce food which results soil erosion (Hawando, 1997). Similarly, as stated by Paulos (2001) the unique topography, type of soil, deforestation, intensive rainfall and low level of land management and the type of land use practiced all have resulted in heavy runoff that induced soil erosion particularly in the northern and central highlands. A study by Tilahun *et al.* (2001) also accounted that declining vegetative cover and increased levels of farming on steep slopes in Ethiopian highlands have eroded and depleted soils, so that soil degradation is now a widespread environmental problem. The severity of soil erosion in the Tigray region and in Ethiopia in general, is the result of the mountainous and hilly topography, torrential rainfall, and low degree of vegetation cover (Esser *et al*., 2002). Similar with the above studies, a study by Temesgen *et al*. (2014) reported that the causes of soil erosion in Dera district, north western Ethiopia were cultivation of steeper slope, intensive cultivation without fallow, lack of soil conservation measures, lack of sense of ownership, deforestation, over grazing, use of crop residues for animal feed and fuel, and heavy rain fall. Thus, there are multiple interacting forces which have caused and are causing soil erosion in Ethiopia. These are the proximate and interacting or root causes (Fitsum *et al*., 1999) (Figure 2).

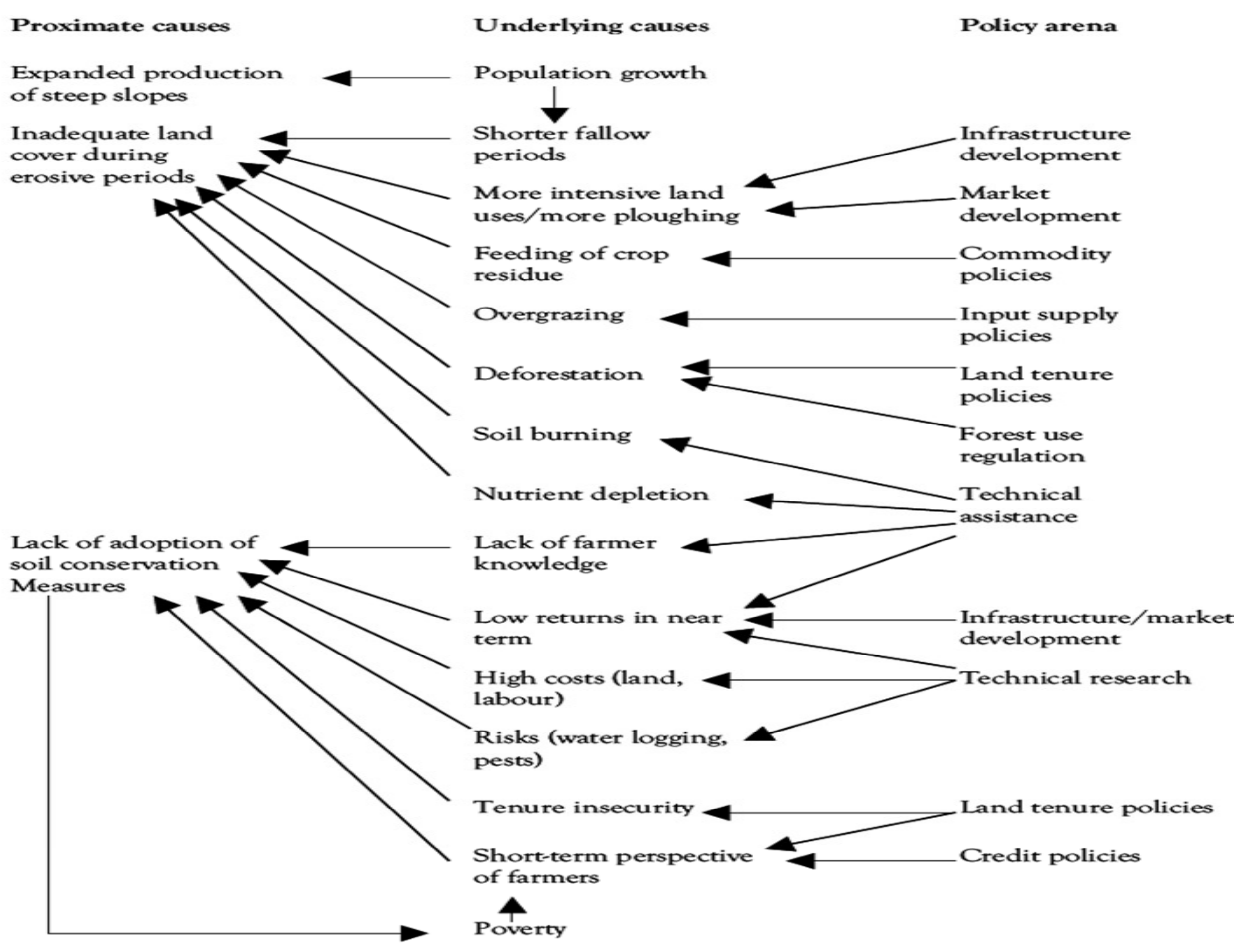

Figure 2: Causes of soil erosion (Fitsum *et al.,* 1999)

Extent of soil erosion

Ethiopia is considered to have one of the most serious soil degradation problems in the world. The average annual rate of soil loss in Ethiopia is estimated to be 12 tons/ha/yr, and it can drastically exceed this on steep slopes with soil loss rates greater than 300 tons/ha/year, where vegetation is denuded. On over 2 million hectares, the soil depth is so reduced that the land is no longer able to support cultivation (USAID CRSPT, 2000). Soil erosion is taking place all over the country but because of the effect of overpopulation on land that is already fragile (steep and mountainous), and mismanagement of the land itself the northern and central highlands are the worst affected (Paulos, 2001). In the highlands of Ethiopia the measurements of soil loss by running water range from 3.4 to 84.5 tons/ha/ year with a mean of 32.0 tons/ha/year (Berry, 2003). The Ethiopian highland reclamation study (EHRS) indicated in mid 1980's 27 million ha or almost 50% of the highland area was significantly eroded, 14 million ha seriously eroded and over 2 million ha beyond reclamation (FAO, 1986). In the Amhara region, part of the Ethiopian highland, soil erosion by water is the dominant form of erosion. The areas that are severely affected can be found in Wag Hemra and North Wello followed by North and South Gonder, eastern parts of South Wello and northern parts of North Shewa zones. The soil depth in these places is very shallow (Leptosols), soil fertility is poor and farmers squeeze a living from pockets of shallow soils. Gullies are a frequent and permanent phenomenon everywhere in the region (Lakew *et al*., 2000). In the region, soil loss ranges 9-300 tons/ha/ year. Of the total land, 10%, 29% and 31% of the region experiences very high, high and moderate erosion hazard respectively (Abegaz, 1995) (Table 3).

Table 3: Estimated erosion hazard classes in Amhara Region (Abegaz, 1995)

Erosion classes	Range of soil loss rate (t/ha per year)	Area coverage	
		ha(x 10^3)	Percentage (%)
Very high	>200	1660	10
High	51-200	4796	29
Moderate	16-50	5284	31
Slight	0-15	5020	30
Total	9-300	16,760	100

As soil degradation in the northern highlands of Ethiopia advanced, people moved southwards, particularly to the Oromiya highlands. This situation is still putting pressure on the highlands of Oromiya region. Increased demand for trees/forests for construction and fuel, and expansion of farmlands to steep and marginal areas has also contributed to degradation. The present extent of soil degradation which is over a very large area of the Hararghe highlands, North and East Shewa, and Wellega, Arsi and other zones is evidence of the unabated spread of soil degradation in the region (Bezuayehu *et al*., 2002). In Ethiopian highlands on agricultural lands, degradation of soil is the most deteriorating process and it reached to a state where the land has turned into badlands and agriculture has abandoned even though different efforts has been undertaken (Hurni *et al*., 2010). Thus, soil erosion is a serious problem in Ethiopia.

Effects of Soil Erosion

The most serious problem of Ethiopia's land resources is soil erosion (Paulos, 2001). Eroded topsoil particles contain a higher percentage of clay minerals, organic matter and nutrients than the remaining (sub-) soil itself. This means that even a seemingly minor loss of topsoil per year can reduce soil productivity significantly in the long run. In addition, spatial soil fertility distribution easily changes to the worse: while fertility decreases by means of erosion on a relatively large area (e.g. ridges and slopes), the eroded fertile material deposits in deep accumulations covering only a relatively small area (e.g. valley bottoms) (Mitiku *et al*., 2006). Thus, as a result of soil erosion, soil organic matter has declined, soil nutrients depleted, and soil depth decreased leading to the decline in yield of crops and forages (Paulos, 2001).

In Ethiopia, the impact of soil erosion combined with loss of soil fertility by burning of dung and crop residues on agricultural yield resulted in forgone cereal production of about 1, 000, 000 tons in 1990. This is equivalent to one-fifth of an average year's grain harvest and would have been sufficient to feed over 4 million people. This loss represents 12% of income foregone for average farmer and the loss increases as more and more cropland reaches the critical minimum soil depth below which crop production will no longer be viable (EFAP, 1994). In 1994, the direct cost of loss of soil and essential nutrients due to unsustainable land management is estimated to be about three percent of agricultural GDP or $106 million. Modeling work suggests that the loss of agricultural value from 2000-2010 will be a huge $7 billion (Berry, 2003). As a result, poverty and food insecurity are concentrated in rural areas (MoARD, 2010). According to EFAP (1993), every year 20,000-30,000 ha of cropland in the highlands is brought out of production from soil erosion and the consequent land degradation and by the year 2000 some 2.4 -3.8 million people were predicted to be affected. Similarly, a study by Shibru (2010) in Limo Woreda reported that the loss of soil productivity leads to reduced farm income and food insecurity, particularly among the rural poor and thus continuing or worsening poverty. In developing countries people are more dependent on natural resources, particularly renewable natural resources, than people in developed countries, and this dependence leads to resource depletion and degradation. The depletion and degradation further intensifies poverty, leading to even more intensive depletion and degradation (Shibru and Kifle, 1998).

In general, soil erosion has both on site and off site effects (Figure 3). On-site effects are particularly important on agricultural land where the redistribution of soil within a field, the loss of soil from a field, the breakdown of soil structure and the decline in organic matter and nutrient result in a reduction of cultivable soil depth and a decline in soil fertility. Erosion also reduces available soil moisture, resulting in more drought-prone conditions. The net effect is a loss of productivity, which restricts what can be grown and results in increased expenditure on fertilizers to maintain yields (Morgan, 2005). This affects about 2.6 billion people worldwide who depend directly on agriculture; the majority of them being subsistence peasants (Mitiku *et al*., 2006). Off-site problems arise from sedimentation downstream or downwind, which reduces the capacity of rivers and drainage ditches, enhances the risk of flooding, blocks irrigation canals and shortens the design life of reservoirs (Morgan, 2005). As rightly noted by Hurni (2002), the degradation of soils is one of the crucial issues of environmental damage, not only at the local scale but also at the global scale. But until today soil degradation has been insufficiently talked at all levels as compared with global climate change and the loss of biological diversity.

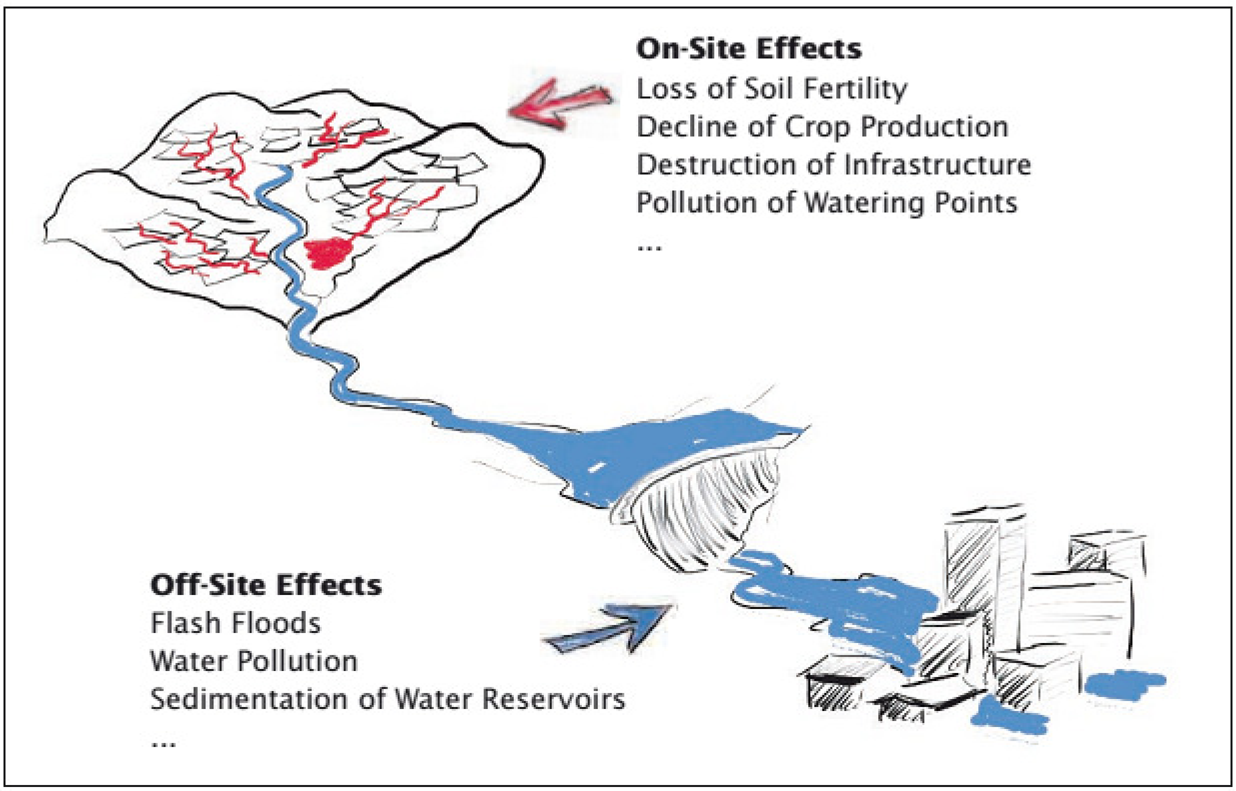

Figure 3: On-site and off-site effects of soil erosion (Drawing: Karl Herweg) (Mitiku *et al*., 2006)

SOIL CONSERVATION EFFORTS IN ETHIOPIA

There was no government policy on soil conservation in Ethiopia prior to 1974. The 1974-1975 famine was the turning point in Ethiopian history in terms of establishing a linkage between degradation of natural resources and famine. There was a more direct linkage in the public eye between highly degraded land and those afflicted by drought and famine in the Ethiopian highlands (FAO, 2003). SWC was introduced and implemented to mitigate food insecurity and to sustain agricultural productivity (Kassie *et al*, 2008). The conservation activity was done by the Food-For-Work incentive (Lakew *et al*., 2005; Gete, 2006). The Food-For-Work incentives were provided by international, multilateral and bilateral organizations of which the European Economic Commission, UNDP and FAO were the major one (Getachew, 2005). The focus was on the highland areas of the country where the problem is more severe and food deficit is prevalent (Lakew *et al*.,2000; Menale *et al*., 2009). This approach has focused on a) soil and water conservation; b) construction of terraces, check dams, cut-off drains and micro-basins, and c) afforestation and revegetation of fragile and hillside areas. The focus was on building physical structures to control soil erosion and to rehabilitate degraded lands and massive efforts were undertaken in this regard (FAO, 2003). Large areas have been covered with terraces, soil bunds, area closures and trees. However, those achievements were later evaluated as only quantitative with minimal desirable outcomes and ineffective and unsustainable. The whole effort was, therefore, regarded as a failure (Yeraswork, 2000). The reason for the failure of past soil and water conservation programs had largely due to poor planning, poor design of structures, lack of participation by the communities, inappropriate conservation methods, poor linkages with livelihoods of the poor and lack of an integrated approach that goes beyond soil conservation to address the interlinked productivity, market access, land policy and resource management problems (Bekele and Holden, 1998; Yeraswork, 2000; Fitsum *et al.*, 2002; Menale, *et al.*, 2009).

In 1980s, soil and water conservation efforts following watershed management approach has started (Lakew *et al.*, 2005; Gete 2006; Tongul and Hobson, 2013). Watershed management is the process of guiding and organizing land and other resources use in a watershed to provide desired goods and services without adversely affecting land resources (Brooks *et al.*, 1994). In 1980s, it was concentrated on selected large watersheds located mainly in the highly degraded parts of the highlands of Ethiopia. The major part of the initiative was supported by the World Food Programme (WFP) through its FFW land rehabilitation project (Gete, 2006). The FFW rehabilitation project is designed to provide employment for chronically food insecure people who have “able-bodied” labour (Tongul and Hobson, 2013).

However, the unmanageable watersheds (too large to monitor and manage) with the top-down planning methodology was less effective (Gete, 2006; Tongul and Hobson, 2013).

The lessons learned from this experience encouraged Ministry of Agriculture (MoA) and support agencies like FAO to initiate pilot watershed planning approaches on a bottom-up basis, using smaller units and following community-based approaches. As a result the minimum planning and sub watershed approaches were introduced (Lakew *et al.*, 2005). In 1993, the WFP and MoA produced a set of guide line known as the Local Level Participatory Planning Approach (LLPPA). With WFP support, the LLPPA was tested in various agro climatic and socioeconomic conditions before being scaled up in 1994/95 through large sale training of trainers and grass roots level development agents in over 60 districts (Woredas). This approach changed the whole picture of soil and water conservation in the country where quality, sustainability, livelihood and environmental impacts of measures were more highly valued than fulfilling quotas. Towards the end of the 1990s, the concept of “sustainable livelihood” began to emerge, with a focus placed on better understanding of household dynamics, livelihood sources and coping strategies used within the rural community (Gete, 2006).

This background paved the way for the fourth phase of the WFP Food-for-Work based environmental rehabilitation program under the name MERET (Managing Environmental Resources to Enable Transition to More Sustainable Livelihoods) in 2002 that strengthened the people centered focus on participatory natural resources management and income generation (Barry *et al.*, 2005). Within the MERET design, special effort was exerted on enhancing the capacity of rural communities to organize them to plan, mange and implement broad based, community wide activities. In comparison to previous land rehabilitation initiatives strong emphasis was placed on household income generating activities. The focus on household and community asset building proved to be an important stage in the evolution of the project itself and the thinking behind integrated watershed management (Gete, 2006). In 2005, the Productive Safety Net Programs (PSNP) was launched across 262 “chronically food insecure” Woredas (districts) in the rural areas of the regional states of Amhara; Oromia; Southern Nations, Nationalities and Peoples; and Tigray to builds community-level assets through the rehabilitation of natural resources, and through soil and water conservation. The soil and water conservation activities practiced under Ethiopia’s PSNP over the past seven years (2005-2012) are also implemented in an integrated manner, following the watershed approach (Chisholm and Tassew, 2012).

SOIL EROSION AND SUSTAINABILITY ISSUES IN ETHIOPIA

The inherent risks of soil degradation for all other natural resources, such as water, biological diversity, and for the feeding of future generations call for a general framework of sustainable use of soils and protection from over-exploitation, pollution and destruction. Such a framework will have to include all concerned stakeholders, all land use types including nature conservation, and all scales from the local action on a field to internationally binding agreements. Protective measures and actions are needed at different levels of intervention in order to be able to ensure that local technology and regulative mechanisms complement each other in a long-lasting and sustainable manner. The various functions of the soil resource, ecological and economic, cultural and social, should be maintained for present and future generations in all nations of the world (Hurni, 2002).

Multilateral Agreements

The growing interest in the concept of sustainability was given attention in the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992. Agenda 21 , a major action plan developed at UNCED, focused attention on the need to make development more economically and environmentally sustainable, and socially acceptable. Chapter 10 of Agenda 21 is concerned with the planning and management of land resources. For these reasons sustainable land management is now receiving considerable attention from development experts, policy makers, researchers and educators (Mitiku *et al*. 2006). There are a number of multilateral agreements with a role that could be used to promote sustainable use of soil but the provisions are generally tangential to the needs of the soil as such many of them pre-dated the 1990s, are predominantly regional in nature and do not establish specific roles for sustainable use of soils. Three international conventions, in order of relevance, have a soil protection role. The Convention to Combat Desertification (CCD) in 2000, the Convention on Biological Diversity (CBD) in 1995 and, to a lesser extent, the United Nations Framework Convention on Climate Change (UNFCCC) in 1997. There are also a group of regional conventions, protocols agreements that have a soil protection role but only one of these is a specific soil instrument. That is "The protocol for the implementation of the Alpine convention of 1991 in the areas of soil protection" (Hannam and Boer, 2002).

Sustainability Goals

The 1992 United Nations Conference on Environment and Development placed a responsibility on States to protect the local, regional and global environment, especially problems shared by the whole community such as soil degradation. The knowledge of the severe degradation situation of the world's soils and of the poor state of the soil legislation led the International Union for Conservation of Nature and Natural Resources (IUCN) to pass a Soil Resolution at its World Congress in October 2000 for the IUCN Environmental Law Program to develop legal guidelines, explanatory material and investigate a global legal instrument for the sustainable use of soils, while paying particular attention to the ecological needs of soil and their ecological functions for the conservation of biodiversity and the maintenance of human life (Hannam and Boer, 2002). Ethiopia has participated in the conference (EPA, 2012). Sustainable land management (SLM) has emerged 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 countries in general and Ethiopia in particular (Mitiku *et al*., 2006). Ethiopia designed sustainable land management program. This program has its objectives to support scaling up of best land management practices and technologies in sustainable land management and the adoption of these management practices and technologies by smallholder farmers in the "high potential/ food insecure" areas that are becoming increasingly vulnerable to land degradation and food insecurity (EPA, 2012).

Sustainable Actions and Indicators

The prevention of soil erosion, which means reducing the rate of soil loss to approximately that which would occur under natural conditions, relies on selecting appropriate strategies for soil conservation, and this, in turn, requires a thorough understanding of the processes of erosion (Morgan, 2005). In Ethiopia, the concern for the proper management of natural resources became clearly visible in the 60's and gained momentum in the 70's. The concern at first was seen as a purely conservationist movement and later it was seen as an issue of development and sustained development. It reached global dimensions by 1972 when the Stockholm Conference on the Human Environment was held (Shibru and Kifle, 1998). To achieve sustainable utilization of natural resources, watershed management has being implanting in the country since 1980s (Lakew *et al*., 2005; Gete 2006; Tongul and Hobson, 2013). The government of Ethiopia in collaboration with international donors implemented various mechanical and biological SWC measures in different parts of the country following watershed approach (Binyam and Desale, 2014). Under sustainable land management program, a total of 35 watersheds in 35 woredas in the six Regional States (i.e. Amhara, Oromiya, Tigray, SNNP, Beneshangul Gumuz, and Gambela) are covered. These watersheds, with an average size of about 8,500 ha, comprise 15 to 20 sub-watersheds. The program treats a total area of about 250,000 ha benefiting 500,000 households (MoA, SLM Project cited in EPA, 2012). Through watershed, reduced run off, soil erosion and associated downstream siltation, increased vegetation cover and surface roughness, increased soil depth, increased recharge of groundwater table, increased production area and green environment, increased crop production and productivity and improvement in fodder availability were achieved (Temesgen, 2015). The successes are indicators of sustainable resource conservation.

CONCLUSION

Soil degradation particularly soil erosion is a very sensitive issue of environmental damage. The soil resource of Ethiopia is going through fast degradation processes. The average annual rate of soil loss is estimated to be 12 tons/ha/yr, and it can drastically exceed this on steep slopes with soil loss rates greater than 300 tons/ha/year, where vegetation is denuded. The direct cost of loss of soil and essential nutrients in 1994 due to unsustainable land management is estimated to be about three percent of agricultural GDP or $106 million. Modeling work suggests that the loss of agricultural value from 2000-2010 will be a huge $7 billion. Soil and water conservation efforts in Ethiopia were began following 1973/74 famine. Beginning the mid-1970s, the Ethiopian government launched a massive soil conservation program. However, most performance measures of soil and water conservation efforts of the country were failed. To change the situations, the concept of watershed management since 1980s has being implementing throughout the country. Some success of conservation efforts following watershed management were reduced run off, soil erosion and associated downstream siltation, increased vegetation cover and surface roughness, increased soil depth, increased recharge of groundwater table, increased production area and green environment, increased crop production and productivity and improvement in fodder availability. The successes are indicators of sustainable resource conservation. Thus, resource conservation following watershed management in Ethiopia has being maintaining its natural resources in a more sustainable way.

REFERENCES

Abegaz G (1995). Soil erosion assessment: Approaches, magnitude of the problem and issues on policy and strategy development (Region 3). Paper presented at the Workshop on Regional Natural Resources Management Potentials and Constraints, Bahir Dar, Ethiopia, 11–13 January 1995. Bureau of Natural Resources and Environmental Protection, Bahir Dar, Ethiopia. 9 pp.

Barry R, David K, Jean-Pierre S and Caroline G (2005). Ethiopia country programme mid-term evaluation, 2002-2006. WFP Addis Ababa, Ethiopia. (Un published). 126 pp.

Bekele S and Holden S (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian Highlands: A case study in Andit Tid, North Shewa. Ethiopia. Agriculture economics. 18:233-247.

Belay T (1992). Farmers' Perception of Erosion Hazards and Attitudes towards Soil Conservation in Gunno, Wolaita, Southern Ethiopia. Ethiopian Journal of Development Research. 14(2): 31-58.

Berry L (2003). Land degradation in Ethiopia: its impact and extent in Berry L, Olson J. and Campbell D (ed): Assessing the extent, cost and impact of land degradation at the national level: findings and lessons learned from seven pilot case studies. Commissioned by global mechanism with support from the World Bank.

Bezuayehu T, Gezahegn A, Yigezu A, Jabbar M and Paulos D (2002). Nature and causes of land degradation in the Oromiya Region: socio- economic and policy research working paper 36. International Livestock Research Institute.

Binyam A and Desale K (2014). The Implication of integrated watershed management for rehabilitation of degraded lands: Case study of Ethiopian Highlands. Journal of Agriculture and Biodiversity Research. 3(6):78-90.

Blanco H and Lal R (2008). Principles of Soil Conservation and Management. Springer Science+Business Media B.V. ISBN: 978-1-4020-8708. 240pp.

Brooks K, Ffolliott N, Gregersen H and Easter K (1994). Policies for sustainable development: The role of watershed management. EPAT/MUCIA Policy Brief No. 6, Department of State, Washington, DC, USA.

Chisholm N and Tassew W (2012). “Managing watersheds for resilient livelihoods in Ethiopia”, in OECD, Development Co-operation Report 2012: Lessons in Linking Sustainability and Development, OECD Publishing.

EFAP (Ethiopian Forestry Action Program) (1993). Ethiopian Forestry Action Program: The Challenge for Development. Volume 2. Ministry of Natural Resources Development and Environmental Protection. Addis Ababa, Ethiopia.

EFAP (Ethiopian Forestry Action Program) (1994). Ethiopian Forestry Action Program: The Challenge for Development. Vol. 2. Ministry of Natural Resource Development and Environmental Protection. Addis Ababa, Ethiopia.

EPA (Environmental Protection Authority) (2012). National Report of Ethiopia, the United Nations Conference on Sustainable Development (Rio+20). Federal Democratic Republic of Ethiopia, Addis Ababa.

Esser K, Vagen G, Yibabe T and Mitiku H (2002). Soil conservation inTigray, Ethiopia. NoragricReport No. 5. 21pp

FAO (1986). Highlands Reclamation Study Ethiopia Final Report. Vol. I & II. Rome, Italy.

FAO (2003). Integrated Natural Resources Management to Enhance Food Security. The case for community-based approaches in Ethiopia. Rome.

Fitsum H, Pender J and Nega G (1999). Land degradation in the highlands of Tigray and strategies for sustainable land management: Socio economics and Policy Research Working Paper 25. International Livestock Research Institute.

Gebreyesus B and Kirubel M (2009). Estimating Soil Loss Using Universal Soil Loss Equation (USLE) for Soil Conservation planning at Medego Watershed, Northern Ethiopia. Journal of American Science. 5(1):58-69.

George H(2002). Land degradation assessment in dry lands. Land and Plant Nutrition Management Service. Land and Water Development Division. FAO.

Getachew A (2005). Determinants of Land Degradation in the Lake Tana Basin and its implications for sustainable land management: The case of Angereb and Gish Abbay Watersheds. MSc. Thesis, Alemaya University, Alemaya.

Gete Z (2006). Integrated management of watershed experiences in Eastern and Central Africa: Lessons from Ethiopia. In Shiferaw B and Rao KPC (eds): Integrated management of watersheds for agricultural diversification and sustainable livelihoods in Eastern and Central Africa: Lessons and experiences from semi arid South Asia. Proceedings of the international workshop held at ICRIS at Nairobi, 6-7 December 2004. 120pp

Gete Z and Hurni H (2001). Implications of land use and land cover dynamics for mountain resource degradation in the Northwestern Ethiopian Highlands. Mountain Research and Development. 21 (2): 184-191.

Girma T (2001). Land Degradation: A Challenge to Ethiopia. International Livestock Research Institute, Addis Ababa, Ethiopia. 815-823 pp.

Hannam I and Boer B (2002). Legal and institutional frameworks for sustainable soils: A preliminary report. IUCN. Gland. Switzerland and Cambridge. Uk. Xvi+88pp.

Hawando T (1997). Desertification in Ethiopian highlands. Norwegian Church AID, Ethiopia, Rala report no. 200. 75-86 pp.

Houghton D and Charman V (1986). Glossary of terms used in soil conservation, soil conservation service of New South Wales and the standing committee on soil conservation. 115pp.
Hurni H (2002). Current international actions for furthering the sustainability use of soils. Symposium paper no.63 on 17th WCSS, 14-21 August 2002. 1-8 pp.
Hurni H, Gete Z, Amare B and Birru Y (2010). Improving ecosystem services for food security in Ethiopia. Evidence for policy series, regional edition Horn of Africa, No. 1, ed. Berhanu Debele. Addis Abeba, Ethiopia: NCCR north-south.
Kassie M, Pender J,Yesuf M, Köhlin G and Mulugeta E (2008). Conservation on Mean Crop Yield and Variance of Yield. Evidence from the Ethiopian Highlands. Environment for Development. EFD DP Discussion Paper 08-08.
Lakew D, Carucci V, Asrat W and Yitayew A (eds) (2005). Community Based Participatory Watershed Development: A Guideline. Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.
Lakew L, Menale K, Benin S and Pender J (2000). Land degradation and strategies for sustainable development in the Ethiopian highland, Amhara region: socio-economic and policy research working paper 32. International Livestock Research Institute.
Menale K, Mahmud Y and Gunnar K (2009). The role of production risk in sustainable land-management technology adoption in the Ethiopian Highlands. Working papers in economics, No 407. University of Gothenburg. Sweden.
Mitiku H, Herweg K and Stillhardt B (2006). Sustainable Land Management – A New Approach to Soil and Water Conservation in Ethiopia. Mekelle, Ethiopia: Land Resources Management and Environmental Protection Department, Mekelle University; Bern, Switzerland: Centre for Development and Environment (CDE), University of Bern, and Swiss National Centre of Competence in Research (NCCR) North-South. 269 pp.
MoARD (Ministry of Agriculture and Rural Development) (2010). Ethiopia's Agricultural Sector Policy and Investment Framework (PIF) 2010-2020. Draft Final Report. 1-15 pp.
Morgan C (2005). Soil erosion and conservation. 3rd ed. National Soil Resources Institute, Cranfield University. Blackwell publishing.304pp.
Oldeman L, Van Lynden J and Van Engelen (1995). An international methodology for soil degradation assessment and for a soils and terrain digital database (SOTER). Paper presented at the regional workshop on assessment and monitoring of land degradation, Cairo, May 13-15, 1995.
Paulos D (2001). Soil and water resources and degradation factors affecting their productivity in the Ethiopian highland agro-ecosystems. Michigan State University Press. 8(1): 1-18.
Schwab O, Fangmeier D, Elliot J and Frevert K (1993). Soil and water conservation engineering. 4th edition. Wiley Johu wiley and sons, Inc. Canada.
Shibru T (2010). Land Degradation and Farmers' Perception: The Case of Limo Woreda, Hadya Zone of SNNPR, Ethiopia. MSc thesis, Addis Abeba University, Addis Abeba.
Shibru T and Kifle L(1998). Environmental management in Ethiopia: Have the National Conservation plans worked? Environmental Forum Publications Series No.1. 13pp.
Solomon A, Goraw G, Yihenew G and Berihun T (2013). Evaluation of watershed development plan and technology adoption level of farmers in Amhara Region, the case of SWHISA project, Ethiopia. International Journal of Scientific and Research Publications. 3(2): 1-10.
Tadesse G (2001). Land degradation: a challenge to Ethiopia. Environmental management. 27: 815-824.
Temesgen G (2015). The implications of watershed management for reversing land degradation in Ethiopia. Research Journal of Agriculture and Environmental Management. 4(1):5-12.
Temesgen G, Amare B and Abraham M (2014). Farming households' knowledge and perception on soil degradation in Dera Woreda, Ethiopia. Agricultural Science, Engineering and Technology Research. 2(3):1-10.
Tilahun A, Takele B and Endrias G (2001). Reversing the degradation of arable land in the Ethiopian highlands. Managing Africa's soils No. 23. International center for research in agro forestry. pp1-20.
Tongul H and Hobson M (2013). Scaling up an integrated watershed management approach through social protection programmes in Ethiopia: the MERET and PSNP schemes.
USAID CRSPT (USAID Collaborative Research Support Programs Team) (2000). Amhara national regional state food security research assessment report.
Wall J, Baldwin S and Shelton J (2003). "Soil Erosion - Causes and Effects " Factsheet.
Woldeamlak B (2002). Land cover dynamics since the 1950s in Chemoga Watershed, Blue Nile Basin, Ethiopia. Mountain Research and Development. 22(3): 263-269.
Yeraswork A (2000). Twenty years of nowhere: Property rights, land management and conservation in Ethiopia. The Red sea press: Asmara.