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The Effect of Soil Loss on Selected Ecosystem Services in the Northwestern Highlands of Ethiopia

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Abstract
Ecosystem services are vital for the wellbeing of all life on the earth's surface. Among these productivity, availability of water and fuel wood access, land use/cover and natural hazard regulation are the most prominent ecosystem services. However, soil loss resulted from soil erosion affects the environment. This study was conducted in Quashay watershed to analyze effects of soil loss on ecosystem services. Face-to-face interview and focus group discussion was used for data collection. Statistical Product and Services Solutions version 20 was used to analyze impacts of soil loss through Chi-square test and Rank index was used for prioritizing watershed problems. The result shows soil loss have high significant impacts on productivity of land, availability of water and fuel wood access ($p<0.01$) and have significant effects on land use/cover change ($p<0.05$). Crop diseases with rank index of 0.16 and soil erosion by water with rank index of 0.16were the major problems. Soil loss rate was very severe and have substaintial negative impacts on the ecosystem servies.We recommend that intensive work is required on soil erosion control and crop disease management.
Keywords: Ecosystem service; Quashay watershed; Soil loss; Ethiopia

1. Introduction
We all know that ecosystem services are the key element for human welbeing. Without it we wouldn´t be able to sustain life. Contemporary soil erosion is a natural geological phenomenon resulting from the removal of soil particles by water or wind and have negative impacts on the environment (Gitas et al,. 2009). This natural process can be accelerated by human activities creating soil loss that exceeds the soil formation rate in a given area. Human activities that change land use from a comparatively higher form of permanent vegetation cover, to a state of lesser vegetation cover, have increased soil erosion (Cebecauer and Hofierka, 2008).

Soil erosion has negative impacts on agricultural activities and on the physical environment (Pimentel, 2006). It reduces crop productivity by reducing the availability of nutrient, water, soil organic matter, and crop rooting depth. The removal of fertile topsoil and decline in fertility of the soil as a result of loss of essential nutrients and organic maters causes a sharp decline in crop and livestock yield and farmers may be obliged to fertilize their plots of land (Pimentel, 2006).

In Ethiopia, land degradation in the form of soil erosion by water, and nutrient depletion substantially reduce agricultural productivity and thus poses a serious problem on the rural human population by reducing (Getachew Adugna and Wagayehu Bekele, 2007; Ahmed Amdihun et al., 2014). The cost of nutrient loss amounts to 14.4 billion ETB per year (Hurni et al., 2015). Soil erosion has thus becoming an alarming ecosystem problem deteriorating land productivity, reduction in agricultural production, poverty, food insecurity, which further caused loss of biodiversity, change in land use/cover, and water quality depletion (Danano, 2002).

Soil erosion and declining soil fertility is a serious challenge to agricultural productivity and economic growth and also threatening biological resources (Mulugeta Lemenih, 2004). Soil erosion by water not only removes nutrients but also may reduce soil depth and the volume of water storage and root expansion zone. Soil erosion has multiple and complex impacts on the global environment through a range of direct and indirect processes affecting a wide range of ecosystem functions and services (Global Environmental Facility, 2006). The principal environmental impacts of soil erosion include a rapid loss of habitat and biodiversity, modifications of water flows, and sedimentation of reservoirs and coastal zones (Project Development Facility, 2007).

Land use and soil cover are considered as the most important factors affecting the intensity and frequency of overland flow and surface wash erosion (Garcia, 2010). Soil erosion and its impacts also vary in the upper and lower catchment area, as compared to the upper catchment; the lower catchment has got moderate soil erosion because of the lower runoff velocity and low slope gradient (Thomas Tolcha, 1989). The soil eroded from the upper catchment is redistributed in the lower slope as long as the slope is gentle (World Bank, 2006). This process might be good at the early stage of erosion since it transports fertile soil from the upland but after the fertile soil is removed coarser materials and boulders will continue to move down and that will have a hampering effect on the lower catchment (Hurni, 1988; World Bank, 2006). The removal of fertile top soil could be affecting the productivity of the land, which could, in turn, increase production costs due to the need for more inputs to address the negative impacts of soil erosion. This leads to forced expansion of the agricultural border to other land use types, such as grazing and vegetation lands (Garcia, 2010).

The consequent ecological impacts of soil erosion in Ethiopia include loss in the chemical, physical and/or biological properties of soil which directly affects the type of plant that are grown on the area, reduced availability of potable water, lessened volumes of surface water, depletion of aquifers due to lack of recharge, and biodiversity loss (Berry, 2003). Soil erosion also interrupts the regulating and provisioning services of ecosystems, in particular nutrient cycling, the global carbon cycle and the hydrological cycle (Global Environmental Facility, 2006). Soil erosion may cause excessive siltation in rivers and inland lakes, causing reduced water storage capacity in lakes, as well as eutrophication and water quality problems (Project Development Facility, 2007).

Ecosystem services are the benefits provided by ecosystems (MEA, 2005). These include; provisioning services, regulating services, cultural services and supporting services. The provisioning services refers to the products, such as food and fiber derived from plants, animals, and microbes, as well as materials such as wood, jute, hemp, silk, and many other products derived from ecosystems (MEA, 2005). "Regulating includes the benefits obtained from the regulation of ecosystem processes, including climate regulation, erosion control, natural hazard (flood and drought), disease, and water quality as well as waste treatment that provide benefits to society well beyond the boundaries of a wilderness area as the regulating services of managed ecosystems become degraded" (MEA, 2005). Cultural services provide a sense of place and identity, aesthetic or spiritual benefits, and opportunities for recreation and educational value (MEA, 2005 and WRI, 2008).

Supporting services are necessary for the production of all other ecosystem services (MEA, 2005). They differ from provisioning, regulating, and cultural services in that their impacts on people are either indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people (MEA, 2005). Some services, like erosion control, can be categorized as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people (MEA, 2005). For example, humans do not directly use soil formation services, although changes in this would indirectly affect people through the impact on the provisioning service of food production (Arico et al., 2005).These include soil formation, pollination and nutrient cycling (Arico et al., 2005).

The strength of linkages between categories of ecosystem services and components of human well-being that are commonly faced with and include indications of the extent to which it is possible for socioeconomic factors to intervene the linkage (MEA, 2005). In addition to the influence of ecosystem services on human well-being depicted here other environmental factors as well as economic, social, technological, and cultural factors influence human well-being, potential for intervention by socio-economic factors and strength of linkage between ecosystem services and human well-being are influenced by environmental quality and human adverse effect to satisfy their needs (Arico et al., 2005).Including life on earth (biodiversity) the constituents of human well being security areas are (personal security, secure resource access and security from disaster); basic material for food life (adequate livelihoods, sufficient nutritious food and access to goods); health (strength, feeling well, access to clean air and water); good social relations(social cohesion, mutual respect and ability to help others) and freedom of choice (opportunity to be able achieve what are individual value doing and being (MEA, 2005).

According to MEA (2005) there are two aspects of managing ecosystem services at the water food interface: First, managing those water related ecosystem services that are required in order to sustain increased agricultural productivity (e.g. improved water retention by soils). With these, there is an incentive for agricultural policies and in particular for farmers, to manage these services (MEA, 2005). Second, managing those services that are under the influence of agriculture but do not benefit agricultural communities directly (downstream impacts) (MEA, 2005). Here, there are limited or negative incentives for agriculture, and especially for farmers, to manage such impacts. For example, asking farmers to manage land better (to benefit downstream users, perhaps through improved water quality) is unlikely to be popular with them if they incur increased production costs (WRI, 2008). Solutions to this dilemma, other than regulation, include: (i) identifying behavioural change that benefits both farmers and other stakeholders (win-win outcomes); and (ii) in particular, identifying ways and means to improve incentives for farmers to change their behaviour through payments for ecosystem services (MEA, 2005).

In the study area effects of soil erosion on ecosystem services were not studied as well as the perception of farmers were not tested. Therefore, this study aimed to assess farmers' perception on the impacts of soil loss on ecosystem services and to provide professional recommendation for land users, policy makers for maintaining ecosystem services in the study area and used as a base line for other researchers in different part of our country even in the world.

2. Materials and method

2.1. Description of the study area

The study was conducted in Quashay micro-watershed Burie District, West Gojjam Zone of Amhara National Regional State, Northwest Ethiopia. The study area covers 327 hectare, lies between 10°45'0" to 10°46'0" N and

37°3'0" to 37°4'0"E.

2.2. Sampling Technique and Procedures

The study area was selected purposively because of the following reasons; (1) the steep slope part of the area was used for crop production, (2) indicators of land degradation (rill, inter-rill, land slide and gully development) was clearly visible on cultivated lands, and (3) farmers depend entirely on crop and livestock production. Therefore, the study area was purposely selected for analyzing perception of farmers on soil erosion and its effects on the selected ecosystem services.

2.3. Data Sources and Data Collection Methods

2.3.1. Socio-economic Data

These data were collected from key informants, such as *Kebele* Agronomist, Natural resources expert, Irrigation expert and Land administration expert. Since, they have clear idea about the socio- economic condition of the study area. Focus group discussion was also conducted with 12 representatives as source of data based on their economic and ethical criteria as Development agents were used to collect secondary data and face- to-face interview was also conducted with key informants. The effect of soil erosion on ecosystem services i.e. provisioning services; productivity, fuel sources, production condition, water access and regulating services; flood, erosion regulation and land use/cover change, educational status, existing problem and biophysical condition of the study area, perception of farmers on trend, sign and extent of soil erosion, average landholding, livestock type, agricultural practices, major crop grown, vegetation type and household information were collected).

2.3.2. Data analysis

All the data collected were entered organized and managed using EXCEL spreadsheet for Windows 2007. All statistical analyses were performed with (SPSS version 20 statistical computer packages. Data on ecosystem service variables such as water and wood access, land use land cover, erosion and natural hazard regulation, sign of land degradation perception data were gathered from respondents and analyzed by Chi-square test. Socio-economic data were analyzed qualitatively, using Chi-square test and Paired samples (T-test) method. Both Qualitative and Quantitative data analysis were used.

3. Results and discussions

3.1. Perception of farmers on effects of soil loss on selected ecosystem services

3.1.1. General household information

The major source of labor in rural society of Ethiopia is household members. So as to fulfill their demand farmers are mainly depends on their land intensively. In areas having large population but limited land resource, they forced steep slope land or non-agricultural land either to cultivate the land or to get environmental benefits for their wellbeing. Therefore, growing population pressures forced to expansion of agricultural land and high demands for fuel and construction wood. To make an agreement of the above two dilemma intensive land resource management is required by improving soil fertility through agronomic practices (crop rotation, contour farming and intercropping). This is because it might cause overexploitation of forest resources in Ethiopia including the study area has left less than 3% of the country native forests untouched (World Bank, 2010). Most farmers also choose for expanding cropland through conversion of forests and woodlands when they experience financial strains to access farm inputs like fertilizer and plough (Gray, 2005). The general household information influence livelihood condition of the study area and could also used to assess their perception towards soil erosion and its effects on ecosystem services as shown in Table 1.

In the study area 91% of the respondents were male headed while the remaining 8% were headed by females (Table 1 In the study area the sampled households have different educational background. The majority of them (67%) were able to read and write while (33%) were illiterate. According to the respondent, the overall proportion of married, widowed and single households were 75% 17% and 8%, respectively. As the study result shows the major job of the respondent was farming practice (100%) and the average household size was 6 per household (Table 1).

Table 1: Socio economic information

Variables	Quashay Watershed		
	N	Percent (%)	M±STD
Sex structure			
Male	11	91.16	
Female	1	8.33	
Age structure			
<31	2	16.77	35.58±10.45
31-40	6	50.00	
41-50	0	0	
51-60	4	33.33	
>60			
Marital status			
Married	9	75.00	
Widowed	2	16.77	
Single	1	8.33	
Educational level			
Illiterate	*4*	*33.33*	
Read and write	*8*	*66.66*	
Average household size	6		

M=mean, N=number of respondent and STD=standard deviation

3.1.2. Sources of water

In the study area the major source of water for human consumption was Quashay and Beftan river but as the information obtained from face to face-interview, previously more than three streams were available for 6 years ago but now they became dry, this is as a result of land degradation as information is obtained from group discussion. The existing two small rivers are not too much for using irrigation purpose even, *Beftan* river getting dry during winter season so females forced to watch water far away from their settlement. The other problem in rainy season was sediment problem in streams that they get drinking water for their household. As information obtained from focus group discussion seven years ago water availability for animal was not a problem in the study area. Based on the analysis 100% of the respondent get water access from Quashay river for animals and 58% of the respondent get water access from hand well and stream for household consumption (Table 2).

Table 2: Water access in the study area

Sn.	Water access		Code	Frequency	Percent (%)
1	For animals	From hand well	2	0	0
		River	1	12	100
2	For human drinking	From hand well	2	7	58.33
	Water	River	1	5	41.67

Code; 1= river and 2= hand well

The availability of water at any time or place, in terms of both its quantity and quality, is also a service provided by ecosystems, and it is important to agriculture and human health (Pimentel, 2006). Because water is required for ecosystems to function, all ecosystem services (excepting some of those provided by marine environments, particularly oceans) are underpinned by fresh water (Aylward et al., 2005; UCC Water, 2008).When soil water availability for an agricultural ecosystem is reduced from 20 to 40% in the soil, plant biomass productivity is reduced from 10 to 25% depending also on total rainfall, soil type, slope, and other factors (Evans et al., 1997). Major reductions in plant biomass not only diminish crop yields, but also adversely affects the overall species diversity within the ecosystem (Heywood, 1995; Walsh and Rowe, 2001).

3.1.3. Sources of fuel wood energy

As shown in Table 3, the main sources of energy for fuel wood in the study area was farm forestry; crop residues, natural forest and animal dung. To satisfy their needs farmers thus have farm land near to natural forest and grazing land, expansion of cultivated land to insufficiency of fuel wood source and they also negatively affect natural forest. Most of the households use three stone stoves and their consumption of fuel wood was high. They mainly depend on natural forest, crop residue, to some extent farm forest. This situation leads the soil to be bare land and may cause soil erosion and finally loss of top fertile soil. Due to this reason the use of crop residues and animal dung for household fuel sources has been identified as the other important cause of soil erosion and diminish ecological services in Ethiopia including the study area, this idea is in line with (Zenebe Gebreegziabher et al., 2006).

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Table 3: Sources of fuel wood in the study area

Sn.	Main sources of fuel wood energy	(%) of respondents
1.	Farm land forest	22
2	Crop residues and animal dung	58
3	Natural forest	20

Regarding with sources of fuel wood from natural environment and its ecological effects were analyzed by different researchers in qualitative and quantitative terms. Crop residues, animal dung and other decomposable biomass incorporated into soil can improve soil organic matter (OM) and promote soil particle aggregation. Fertile soils typically contain about 100 tons of (OM) per hectare (or 4% of the total soil weight) (Follett et al., 1987; Young, 1990; Sundquist, 2000). About 95% of the soil nitrogen and 25-50% of the phosphorus is contained in the soil organic matter (Allison, 1973). Because most of the soil OM is found close to the soil surface as decaying leaves and stems, erosion significantly decreases soil OM (Allison, 1973). Soil erosion selectively removes the fine organic particles in the soil, leaving behind large soil particles and stones. Soil OM is a valuable resource because it facilitates the formation of soil aggregates and thereby increases soil porosity. The improved soil structure in turn facilitates water infiltration rate and ultimately the overall productivity of the soil (Langdale et al., 1992). In addition to this OM aids cation exchange (CE), enhances plant root growth, and stimulates the increase of important soil biota (Allison, 1973; Wardle et al., 2004).

3.1.4. Trends, extent and sign of soil loss

According to semi-structured questionnaire and focus group discussion, the perception of the respondent on the trends of soil erosion in the study area during the study period 67% of the respondent perceived as it was moderate while 5 years ago 67% of the respondent perceived as it was also moderate and 10 years ago 75% of the respondent perceived as soil erosion problem was very severe. Based on the analysis from the respondent soil loss by soil erosion was slight to very sever classes, this is the same as the result obtained from RUSLE analysis (Table 4).

Table 4: Trends of soil degradation in the study area

Sn.	Trends of soil erosion	Code	Frequency	Percent (%)
1.	2015/Recent condition	3	1	8.33
		2	8	66.66
		4	2	16.66
		1	1	8.33
2.	5 Years ago/2010	1	1	8.33
		3	8	66.66
		2	2	16.66
		4	1	8.33
3.	10 Years ago/2005	4	9	75
		1	1	8.33
		3	1	8.33
		2	1	8.33

Code; 1= slight, 2= moderate, 3= severe and 4= very severe (Sonneveld, 2002)

Based on the analysis 58 % of the respondent, the extent of soil erosion during the study period was present on vulnerable land units while 5 and 10 years ago 67% and 58% of the respondent perceived as it was worse everywhere in the study area (Table 5). Therefore soil erosion and its effects were very sever just like the result analyzed from RUSLE.

Table 5: Extent of soil erosion in the study area

Sn.	Extent of soil erosion	Code	Frequency	Percent (%)
1.	2016/ research period	1	2	16.66
		4	1	8.33
		2	7	58.33
		3	2	16.66
2.	5 Years ago/2010	2	3	25
		1	1	8.33
		3	7	58.33
		4	1	8.33
3.	10 Years ago/2005	3	2	16.66
		1	2	16.66
		3	7	58.33
		2	1	8.33

Code; 1= no, 2= to some extent and 3= bad

Based on the analysis 33% of the respondent; the sign of soil loss by erosion during the study period perceived as the presence of rill, inter-rill and developed gully (this was also observed during field observation), 41 % of the respondent vegetation degradation problem was present 5 years ago, 50% of the respondent soil fertility problem was the cause of yield reduction in 10 years ago (Table 6). Based on the perception of the respondent soil loss due to soil erosion was hot issue during the study period compared with other problems.

Regarding with the natural environment (particularly the soil, water, and forests) of low potential areas has improved over the last decades as reported by Asnake Mekuriaw and Hurni (2015). However, all three environmental resources have degraded in high potential areas including the study area and there was a significant variation of perceptions ($p<0.01$) in this areas.

Table 6: Sign of soil loss in the study area

Sn.	Sign of soil loss	Code	Frequency	Percent (%)
1	2015/Recent condition	1	3	8.33
		2	4	33.33
		3	2	16.66
		4	3	25
2	5 Years ago/2010	1	2	16.66
		2	2	16.66
		3	5	41.66
		4	3	25
3	10 Years ago/2005	2	2	16.66
		3	6	50
		4	4	33.33

Code; 1= soil erosion, 2= gully formation, 3=vegetation degradation, 4= decline soil fertility and 5= water stress

3.1.5. Existing farm land problems and their rank

A soil degradation index was defined as a qualitative variable (nil, low, moderate, severe, very severe) for each problems, based on the qualitative judgment of experts on erosion hazard (Sonneveld, 2002). Based on the analysis of data obtained from focus group discussion and key informants, the major problems in the study area includes soil fertility problem (25%) of respondent perceive as it was slight but 50% of the respondent perceives it was moderate, 58 % of the respondent consider soil erosion status was moderate, 42% of the respondent perceived as it was slight and 8% of them perceived as it was highly sever. On the other hand 58% of the respondent plant disease was sever while 8% of the respondent perceived as it was sever and 16% of them perceived that it was moderate (Table 7). However, rank index (RI) was high for crop disease and soil erosion by water so first priority is needed.

Table 7: Existing watershed problems in the study area

Sn.	Existing production problems	Severity	Frequency	(%)	Rank of the problem	RI
1	Soil fertility	1	3	25		0.04
		2	6	50	3rd	0.08
2	Soil erosion by water	2	7	58.33	2nd	0.08
		1	5	41.66	4th	0.04
		4	1	8.33		0.16
3	Crop disease	3	7	58.33	2nd	0.12
		1	2	16.66		0.04
		4	1	8.33		0.16
		2	1	8.33		0.08
4	Water access for human	3	10	83.33	1st	0.08
		2	2	16.67	5th	0.08
Total problem weight		25				

Code; 1= slight, 2= moderate, 3= sever and 4= highly sever (Sonneveld, 2002)

3.1.6. Effects of soil loss on production

Inspite of the fact that, the high crop diversification and potential of the study area, we observed that there was soil erosion problem which shows signs of rill, inter-rill and gully erosion, which might affect agricultural activities. Based on the analysis 75% of respondent perceived that soil erosion reduce productivity of land while 25% of the respondent perceives soil loss reduce soil fertility and leads to reduce yield. This indicated that the effect of soil loss on crop yield have significant impacts.

Abay Ayalew (2011) reported that conserving of degraded natural resource means conserving the soil and can improve agricultural ecosystem services. Besides with other ecosystem services because the ecosystem services are inseparable when improving production by maintaining agricultural ecosystem it can be improve supporting, provisioning and regulating services. In addition to this regarding to the effect of soil erosion on productivity, implementing of soil and water conservation measures in the degraded highlands and stabilizing with multipurpose plant species reduce soil loss rate and improve productivity, and maintain soil fertility besides, it increase crops yields as reported by Abay Ayalew (2011).

As shown in Table 8 the soil loss have high significant impacts on productivity of study area, water access and fuel wood access, respectively ($p<0.01$) and have significant effect on land use/cover change ($p<0.05$) while it has no significant effect on erosion regulation and natural hazard regulation, respectively ($p>0.05$) rather it accelerate the problem.

Table 8: Perceptions of farmers' on impacts of soil loss on ecosystem services

	Six selected Ecosystem services					
	Production	Water access	Wood access	Erosion regulation	NHR	LULCC
Chi-Square	8.333[a]	8.333[a]	8.333[a]	3.000[a]	1.333[a]	5.333[a]
Df	1	1	1	1	1	1
Asymp. Sig.	0.004**	0.004**	0.004**	0.083	0.248	0.021*

** = high significant effect, * = significant effect, NHR=natural hazard regulation and LULCC=land use/cover change

4. Conclusions

This study shows that soil loss due to soil erosion have high significant impacts on productivity of watershed, fresh water access, fuel wood access and have significant impacts on land use/cover change while, it has no significant effect on erosion regulation and natural hazard regulation ($p>0.05$), rather it aggravates the problem of these ecosystem services. On the base of this result we recommend land resource management planners or governments or non-governmental stakeholders should identify proper watershed management plan for maximizing its productivity including integrated watershed management as physical, biological and soil management should be practiced, doing in watershed intensively (improve vegetation coverage on the upper catchment) to improve water access in downstream part and can make beneficiaries of the watershed communities, soil erosion have negative effect on vegetation degradation by scouring plant roots and have negative influence on land cover condition finally erosion problem results poor land cover situation of the watershed, so improving vegetation coverage and protecting the existing natural forest and plantation forest will improve the ecosystem services of natural flood and erosion problems through improving infiltration rate and reduce its potential of eroding soil and it increase horizontal movement and loss its kinetic energy to erode soil particles.

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Additional Information and Declarations
Competing Interests
The authors declare there are no competing interests.

References
Abay Ayalew., 2011. Construction of Soil Conservation Structures for improvement of crops and soil productivity in the Southern Ethiopia. Vol 1, No.1, ISSN 2224-3216.
Ahmed Amdihun., Ephrem Gebremariam., Lisa M.R. and Gete Zeleke., 2014. Suitability and scenario modeling to support soil and water conservation interventions in the Blue Nile Basin, Ethiopia. Environmental Systems Research, 3,3:23.doi:10.1186/s40068-014-0023-9.
Allison F. E., 1973. Soil Organic Matter and Its Role in Crop Production, New York, Elsevier.
Arico S., Bridgewater P., El-Beltagy A., Harms E., Program S., Hepworth R., Watson R. T., 2005. Millennium Ecosystem Assessment, Ecosystems and Human Wellbeing: Synthesis. Island Press, Washington, DC.
Aylward B., Bandyopadhyay J. and Belausteguigotia J.,2005. Freshwater ecosystem services. In: Chopra K., Leemans R., Kumar P. and Simons H. (eds). Ecosystems and Human Well-being: Policy Responses, Vol.3. Findings of the Responses Working Group of the Millennium Ecosystem Assessment.

Millennium Ecosystem Assessment and Island Press, Washington, DC, pp. 213-256.

Berry L., 2003. Land degradation in Ethiopia: its impact and extent in Berry L, Olson J. and Campbell D: 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.

Cebecauer & Hofierka.,2008. Cebecauer T, Hofierka J. The consequences of land cover changes on soil erosion distribution in Slovakia. Geomorphology. 2008;98:187–198. doi: 10.1016/j.geomorph.2006.12.035.

Danona D., 2002. Soil and Water Conservation Technologies and Strategies for Food Security and Poverty Alleviation. Addis Ababa.

Evans R., Cassel D. K. and Sneed R. E., 1997. Soil, Water, and Crop Characteristic Important to Irrigation Scheduling, <http://www.bae.ncsu.edu/programs/extension/evans/ag452–1.html.> (12/17/2002).

Follett R. F., Gupta S. C. and. Hunt P. G., 1987. 'Conservation practices: Relation to the management of plant nutrients for crop production', in Soil Fertility and Organic Matter as Critical Components of Production Systems, Special Pub. 19, Madison, WI, Soil Science Society of America and American Society of Agronomy, pp. 19-51.

Garcia R. J., 2010. The effects of land uses on soil erosion in Spain: A review. Catena, Vo 81, no.1, pp. 1-11, ISSN 03, pp. 41-8162.

Getachew Adugna and Wagayehu Bekele., 2007. Determinants of Land Degradation in the Lake Tana Basin and its Implications for Sustainable Land Management: The Case of Angereb and Gish-Abbay Watersheds. Ethiopian Journal of Agric. Econ, 6, pp.70:101.

Global Environmental Facility (GEF)., 2006. Land degradation as a global environmental issue: a synthesis of three studies commissioned by the global environment facility to strengthen the knowledge base to support the land degradation focal area. Scientific and Technical Advisory Panel, Washington, DC.

Heywood V. H., 1995. Global Biodiversity Assessment, Cambridge, UK, Cambridge University Press.

Hurni H. 1988. "Degradation and Conservation of Resources in the Ethiopian Highlands." Mountain Research and Development 8(2/3), pp. 123-30.

Hurni K., Gete Zeleke., Minale Kassie., Berhan Tegegne., Tibebu Kassawmar., Ermias Teferi., Aderajew Moges., Deme *Tadesse*., Mohamed *Ahmed*., Yohannes *Degu*., Zeleke Kebebew., Elias Hodel., Ahmed Amdihun., Asnake Mekuriaw., Berhanu Debele., Deichert G. and Hurni H., 2015. Economics of Land Degradation (ELD) Ethiopia Case Study. Soil Degradation and Sustainable Land Management in the Rainfed Agricultural Areas of Ethiopia: An Assessment of the Economic Implications. Report for the Economics of Land Degradation Initiative, pp. 94.

Langdale G. W., West L. T., Bruce R. R., Miller W. P. and Thomas A.W., 1992. 'Restoration of eroded soil with conservation tillage, Soil Technology 5, pp. 81-90.

MEA (Millennium Ecosystem Assessment)., 2005. Ecosystems and Human Well Being:
Synthesis. Island Press, Washington, DC.

Mulugeta Lemenih. 2004. Effects of Land Use Changes on Soil Quality and Native Flora Degradation and Restoration in the Highlands of Ethiopia: Implications for sustainable land management. Doctoral Dissertation. Swedish University of Agricultural Sciences ISSN 1401-6230, ISBN 91-576-6540.

Pimentel D. C., Harvey C., Resosudarm O.P.,Sinclair K., Kurz D., McNair M., Crist S.,Pimentel D., 2006. Environment, Development and Sustainability Vol.8, pp.119-137 College of Agriculture and Life Sciences, Cornell University, Ithaca, New York.

Project Development Facility., 2007. Strategic Investment Programme for Sustainable Land Management in Sub-Saharan Africa: Assessment of the Barriers and Bottlenecks to Scaling-up sustainable land management investments throughout Sub Saharan Africa. Revised Draft.

Sundquist B.,2000. Topsoil Loss Causes. Effects and Implications: A Global Perspective, 4^{th} ed.,<http://www.alltel.net/bsundquist1/> (10/8/2002).

Thomas Tolcha., 1989. Aspects of soil degradation and conservation measures in Agucho-Catchment.Western Harergie. University of Bern, Switzerland: Soil conservation projects, Research paper 19.

UCC Water., 2008. Addressing Environmental Aspects of IWRM. Concepts and Issues Paper No. 1, UNEP Collaborating Centre on Water and Environment, Horsholm, Denmark.

Walsh K. N. and Rowe M. S., 2001. Biodiversity Increases Ecosystems Ability to Absorb CO_2 and Nitrogen, <http://www.bnl.gov/bnlweb/pubaf/pr/2001bnlpr041101.htm.> (8/10/2002).

Wardle D. A., Bardgett R. D., Klironomos J. N., Setala H., Putten W. H. and Wall D. H.,2004. Ecological linkages between above ground and below ground biota, Science 304, PP. 1629-1633.

World Bank. 2006. The Cost of Land Degradation in Ethiopia: A Review of Past studies. Workshop, May 2-4, Addis Ababa.

World Resources Institute (WRI)., 2005. From the reports of the Millennium Ecosystem Assessment, 2005, The Cost of Policy Inaction, 2008: The Corporate Ecosystem Services Review, 2008, The Economics of

Ecosystems and Biodiversity, 2010. www.wri.org/ecosystems/esr.

Young A., 1990. Agroforestry, environment and sustainability, Outlook Agriculture, 19, pp. 155-160.

Zenebe Gebreegziabher.,Vankooten G. C. and Vansoest D. P., 2006. Land Degradation in Ethiopia:What do strive have to do with it? Contributed paper at International Association of Agricultural Economists, Gold Coast, Australia.