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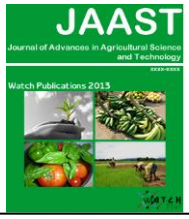

ECOSYSTEM DEGRADATION NEXUS IN ETHIOPIA

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Abstract

Origin and effect of ecosystem problems are often not easily definable. Ecosystem degradation has already resulted in noticeable and wide-ranging effects on the Ethiopian community-both rural and urban. Due to depletion of forests and the resultant increase in runoff, the storage of water has greatly diminished and a large number of water points for human and animal use have dried up. Ecosystem degradation leads to decrease in both the quality and number of livestock due to absence of fodder; any change in livestock sector has tremendous effects on the living standards of the rural people as a whole. Where agricultural land livestock production reach very low levels as a result of reduced cultivable land and yields, a situation will be created where there is insufficient land leading to shrinkage of average farm size which, in turn, creates a disguised unemployment. Ethiopia may stand number one in Africa (perhaps in the world) to witness the power of land degradation deriving people out of their homes. In 1984/85, more than half a million people were forced to leave their homes mainly in the highly eroded northern regions to the south and southwestern parts, which are less degraded so far. Plots have been abandoned and given up to grazing owing to the persistent erosion. The consequence is use of marginal lands on steep slopes or relatively unsuitable soils. New plots tend to be in remote areas, so more time has to be spent for travelling. Burning of dung as a result of depletion of forest resources reduces Ethiopia's crop production while decline in the humus content of the soil causes a further fall in crop production of about one percent. The consequence is obvious: shortage of food and malnutrition. Where there is no forest resource at all, one cannot simply talk about the economic cost of getting fuel wood because there is no possibility to get it even if money is available. Over much of northern Ethiopia most of the land is absolutely treeless, so much so that in some rural areas only stones are used for building houses, and cow dung for fuel. Conflicts between different pastoralist communities have occurred frequently in history and continue up to date. They can have serious consequences too but are covered even less by the press.

Keywords: *Ecosystem degradation, drivers/causes of degradation, Ethiopia, Agricultural expansion, soil /land degradation, deforestation, population growth.*

INTRODUCTION

Ecosystem degradation is extensive in Ethiopia. But not all areas of the country are equally suffering. Both the extent and severity of the problem manifest spatial variations depending on difference in relief, ecology, rainfall, land use, land cover and soil types. Ecosystem degradation in Ethiopia is especially severe in the highlands where the average soil loss from farmland is estimated to be 100 tons/hectare/year (FAO, 1986). Ecosystem degradation in Ethiopia replicated in the form land degradation and degradation of water resources as well as loss of biodiversity (Demel, 2001).

Some forms of ecosystem degradation are the result of normal natural processes of physical shaping of the landscape and high intensity of rainfall. The scale of the problem, however, dramatically increased due to the increase in deforestation, overgrazing, over cultivation, inappropriate farming practices, and increasing human population. Removing vegetative cover on steep slopes (slopes ranging between 15 and 50 percent) for agricultural expansion, firewood and other wood requirements as well as for grazing space has paved the way to massive soil erosion (Yihenew, et al., UD1).

Main direct threats to Ethiopia's ecosystem are habitat conversion, unsustainable utilization of biodiversity resources, invasive species, replacement of local varieties and breeds, climate change and pollution (Figure 1). Indirect causes of biodiversity loss in the country are demographic change, poverty, and lack of

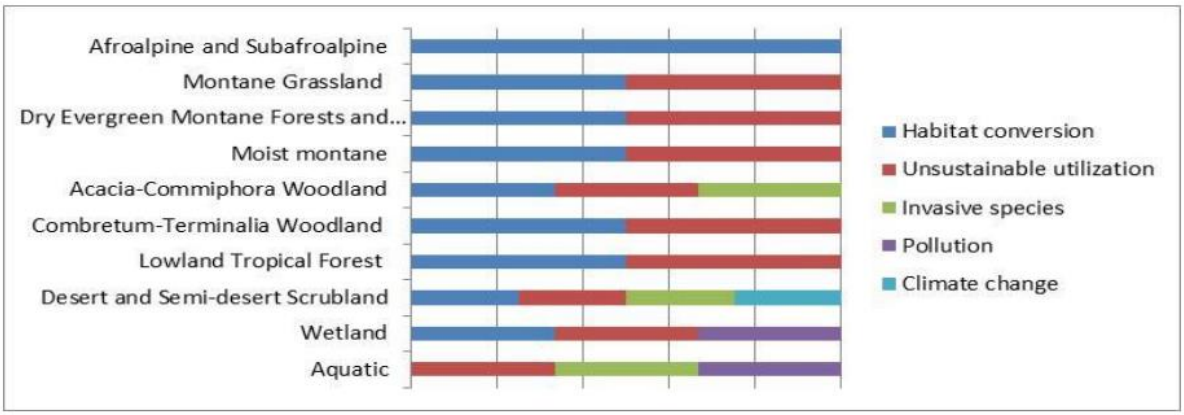

Figure 1: Summary of major threats by ecosystem in Ethiopia (IBC, 2014)

awareness and coordination. Due to direct and indirect pressures, ecosystems and a number of wild plants and animals including endemic species, as well as farmers' varieties and indigenous animal breeds are declining. Therefore, one hundred three tree and shrub species, thirty-one bird, one reptile, nine amphibian, two fish, and fourteen other invertebrate species are threatened (IBC, 2014).

STATUS AND EXTENT OF ECOSYSTEM DEGRADATION

Conversion of natural forests, grazing lands, woodlands, and wetlands to agriculture and settlement are some of the threats to ecosystems and biodiversity in Ethiopia. In agricultural sector alone, the growth achieved between years 2005 and 2010 was due to 40% yield increment and 15% agricultural land expansion. In order to achieve targets set for the growth of agriculture sector for years 2010 through 2030, land expansion of 3.9% per annum is required. Under "business as usual" scenario, this will continue to affect ecosystems and biodiversity of the country, especially of the high woodland forest areas (MoFED, 2011).

Unsustainable utilization (over grazing/browsing, harvesting and hunting) of biological resources is one of the major threats to biodiversity and ecosystems in Ethiopia. Fish species such as Labeobarbus (in Lake Tana), timber tree species such as *Hagenia abyssinica* and medicinal plant species such as *Taverniera abyssinica* are notable examples that have been threatened due to over-utilization. Overgrazing/browsing by livestock in many ecosystems has also contributed to the degradation of rangelands and forest ecosystems. The consequences of these impacts include ecological disturbance, loss of species and ecosystem services thereby affecting livelihoods of local communities. Furthermore, over pumping or drainage of water from lakes and wetlands has resulted in loss of habitats and species as is the case of Lake Haromaya. The increase in human population along with the increased demand for water in Harar town and its surroundings and pumping water of unsustainably to irrigate chat (*Catha edulis*) was the prime cause of the disappearance of Lake Haromaya (Brook, 2011).

Invasive species cause biodiversity loss by competing native species for feed and habitat and altering the physical environment in a way that excludes native species. So far, close to 35 invasive weed species are identified in Ethiopia, and they are posing negative impacts on native biodiversity, agricultural and range lands, national parks, water ways, lakes, rivers, power dams, road sides and urban green spaces with huge economical as well as social consequences. Some of these species include: mesquites (*Prosopis juliflora*), parthenium weed (*Parthenium hysterophorus*), water hyacinth (*Eichhornia crassipes*), lantana weed (*Lantana camara*), *Acacia* species, and other weeds such as Orobanche and Cuscuta species that are identified as major plant invaders. Recent surveys found also emerging plant invaders such as *Cryptostegia grandiflora, Parkinsonia aculeata, Mimosa diplorotricha,* and *Nicotiana glauca* (Rezene et al., 2012).

Prosopis juliflora is aggressively invading pastoral areas in the Middle and Upper Awash Valleys, Western and Eastern Harerge zones, Afar and Somali national regional states; driving out more nutritive browse and grazing plant species by forming a thick mono specific scrub, thereby increasing incidence of crop pests and damage to eyes and hooves of both domestic and wild animals eventually leading to death of the affected animals and reduction in the overall biodiversity of the areas. *Parthenium hysterophorus* is spreading rapidly in many rangeland areas and farm lands of Afar, Somali, Oromia, Amhara and Gambella national regional states, causing enormous reduction in crop and forage production. Its impact in natural habitats poses a major threat to the biodiversity in these areas. Yield losses due to *Parthenium* weed in sorghum production reached 46-97% depending on location and year (Rezene et al. 2012; IBC, 2012).

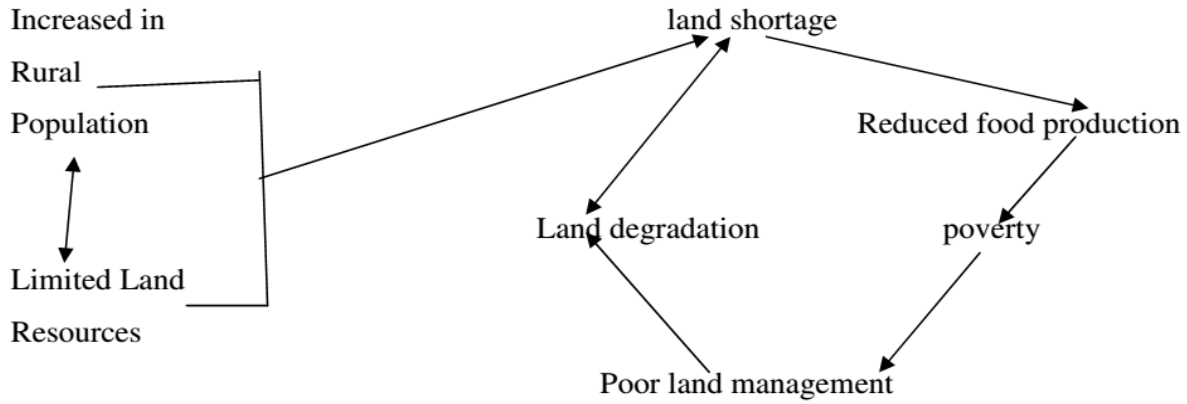

Figure 2: Linkages between population, poverty and land degradation (FAO, 1994)

Water hyacinth is also becoming a serious threat especially in Wonji and Koka reservoir areas of the Awash River system and Lake Tana, obstructing irrigation, affecting productivity and biodiversity of the infested aquatic ecosystems. At Wonji Shewa Sugar Estate, impact assessment of water hyacinth infested areas of 116.4ha of irrigation water reservoirs, secondary and tertiary irrigation water supplies, border and central drains indicated that the weed inflicted excess water loss that is estimated in ranges from 393,660 to 2,945,160 m3, restricting water flow and incurring significant management cost (Rezene et al., 2012). Invasive weeds such as *Argemone mexicana*, *Lantana camara*, *Cryptostigma grandifolia* and *Mimosa Sp*. have caused severe damage by reducing crop and forage yields, displacing indigenous species, and favoring the spread of crop pests. Some areas in Borena woodlands, which are known for gums and resin production are deteriorating due to encroachment by such bushes as *Acacia drepanolobium, A. oerfota* and *A. mellifera*. Carmine cochineal (*Dactylopius coccus costa*), the insect that was introduced into the country in 2001 for production of cochineal dye (Tesfaye Belay and Zimmermann, 2006), is reportedly causing heavy damage on cactus species (*Opuntia ficus-indica*) in northern Ethiopia.

Understanding the state of environmental degradation with its root causes, nature and consequences as well as previous management practices is critical to look for options to mitigate the problem and its impact. Due to varied topographic and climatic conditions, Ethiopia is known to be rich in biodiversity and has been a source of agricultural development and other basic needs for millennia. However, this biophysical potential has been threatened by interlinked and reinforcing problems of land degradation and extreme poverty (Gete et al., 2006).

According to Ethiopian Environmental Protection Authority (EPA) (2005), 75% of the Ethiopian livestock populations graze in the highlands often at the expense of remnant vegetation causing to serious degradation on the environment. Studies predicted that nearly 1.9 billion tons of top soil has been washed away mainly from the highlands, every year in Ethiopia (FAO, 1986) and its onsite effects significantly reduced agricultural production with an estimated cost ranging from 2 to 6.75% of the Agricultural Gross Domestic Productivity (AGDP) per annum (FAO, 1986; Sonneveld, 2002). Land degradation, mainly manifested with deforestation and soil erosion, has become an alarming ecosystem problem deteriorating biodiversity and land productivity in Ethiopia. These further caused reduction in agricultural production, loss of biodiversity, water quality depletion, disturbed hydrological conditions, poverty and food insecurity (Danano, 2002) as indicated in Figure 2.

CAUSES OF ECOSYSTEM DEGRADATION

Biggs et al. (2004) define a driver as any factor that can change the structure and/or function of an ecosystem. These changes may in turn lead to reductions in biodiversity and ecosystem services, with major adverse implications for human well-being. Drivers can operate at all scales from local to global depending upon how widespread they are, and at what level, they can be addressed.

The cause of ecosystem degradation can be grouped in to proximate and underlying causes. The proximate causes are the indicator of inappropriate resource management practices and the underlying causes of ecosystem degradation include a complex of social, political, economic, technological, and cultural variables that constitute initial conditions in the human-environment interaction. In Ethiopia, both causes are the reason for farm and grazing land degradation and forest degradation.

EXTRACTION OF WOOD/DEFORESTATION

Ethiopia is one of the world's most fuel wood reliant nations (Horne and Frost, 1992). The traditional fuel

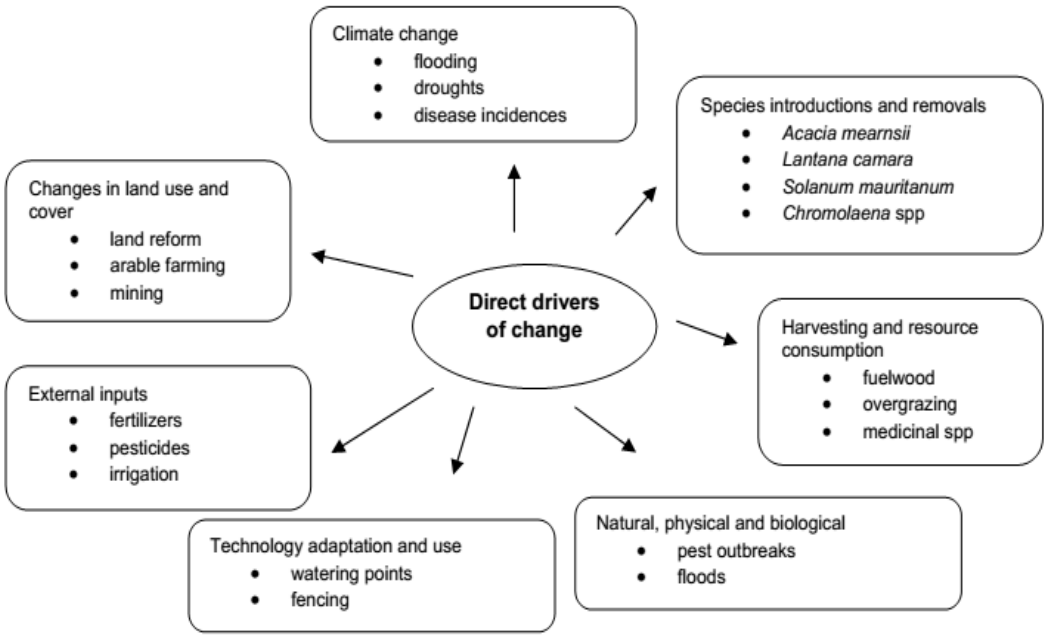

Figure 3: Examples of global direct drivers influencing ecosystem changes (adapted from MA, 2005a)

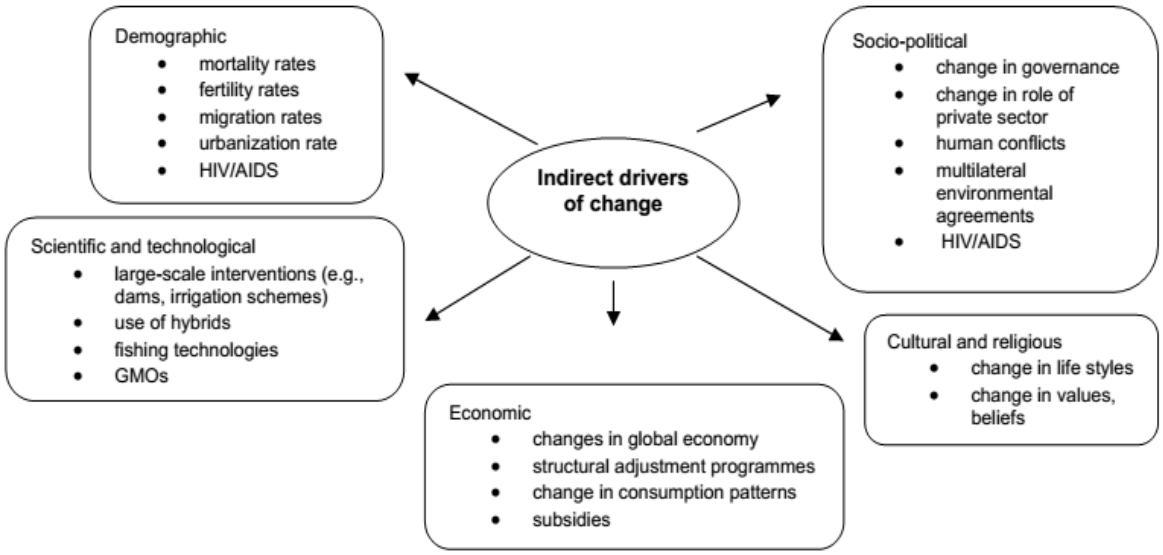

Figure 4: Examples of global indirect drivers influencing ecosystem changes (adapted from MA, 2005a)

sources (woody biomass, crop residues, dung and charcoal) put together are reported to have claimed 95.3% of the total domestic energy consumption in Ethiopia whereas the modern sources (petroleum and electricity) accounted for only 4.7% in 1990/91 (Mekete, 1996). Nearly 37% of the housing units in the urban areas used only firewood for cooking purposes. Another report shows that 97% of the household energy comes from biomass. About 74% of the housing units in the rural and 72% in the urban areas were reported to be ordinary houses with walls made of wood and mud (Mekete, 1996). In the case of rural houses, practically all the parts of the house are of biomass.

Deforestation and consequent land degradation are global menaces, and so are they in Ethiopia. The forest degradation in Ethiopia is closely linked to the ongoing population growth. More people generally lead to an increasing demand on land for living and for agricultural production. The situation got more severe in the eightieth when large numbers of people moved to South West

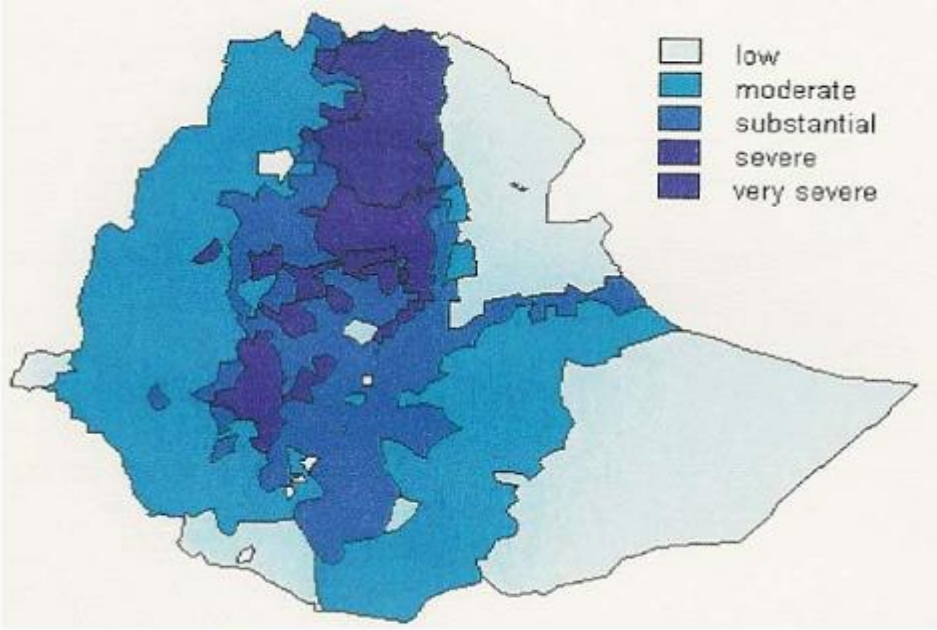

Figure 5: Extent and intensity of soil degradation (Hakkeling, 1989)

Ethiopia in scope of organized resettlement programs. Consequently the pressure on the forest resources themselves increased due to a higher demand on fuel wood and construction timber. Finally, uncontrolled logging and the illegal export of wood stems to urban centers like Addis Ababa is a threat for the natural high forest of the country. The extensive deforestation has also led to the extinction of various biotas resulting in significant biodiversity loss (Hurni, 1988; Bishaw, 2001).

AGRICULTURAL EXPANSION

The complex relationship between human development and the environment is what causes ecosystem degradation, in which the use and management of the natural resources is a central issue. The two dominant agricultural change theories, which have been debated over the years and across disciplines, are the Malthusian and the Boserupian theory of agricultural change. Malthus in 1817 argued that the power of population growth is indefinitely greater than the power of the land to produce subsistence for man. If unchecked, population continues to grow in a geometric ratio while subsistence (agricultural production) increases in an arithmetic (linear) ratio, yet population is dependent on agricultural production. As population density increases and land becomes scarce, the fallow period that farmers allow their land to rest decreases, and eventually farmers will expand production into marginal areas. When expansion is limited by the scarcity of the land resource, production extends through more intensive cultivation of existing fields. Such intensification (frequent cropping of a given land) decreases production and productivity, ending in food scarcity. Unless emigration or colonization of new land is possible, overpopulation leads to overexploitation and eventually to land/environmental/ecosystem degradation.

Critiques of the above mentioned treatise argue that the Malthusian perspective underestimates the capacity of human ingenuity and technology to overcome the constraints. Agricultural development, in this case, is viewed as a process of gradual change to better and better tools, whereby output per man-power in food production was increased and part of the population was made available for nonagricultural activities. This is the Boserupian perspective, which emphasizes more faith in technological development and states that shorter fallow will induce labor intensification and technological innovation, i.e., agricultural development is dependent on population growth (Boserup, 1965). Boserup argues that extensive agriculture with low overall production is practiced when the density of population is low enough to allow it. When forced by rising population, production becomes more and more intensive, and adoption of technology increases. Better knowledge of land preservation and increased inputs improve yield, increase the value of land, and increase investment on land conservation and maintain productivity.

However, the Boserupian intensification requires the existence of ideal preconditions such as favorable environment, access to resources (access to capital, access to market, infrastructure), and supportive organizational structures (favorable policy) (Stone and Dawnum, 1999; Hunt, 2000). Such conditions are characteristic of ‘industrial’ agriculture and rarely exist in ‘resource-poor’ stagnant agriculture. Thus, the Boserupian intensification varies among environments

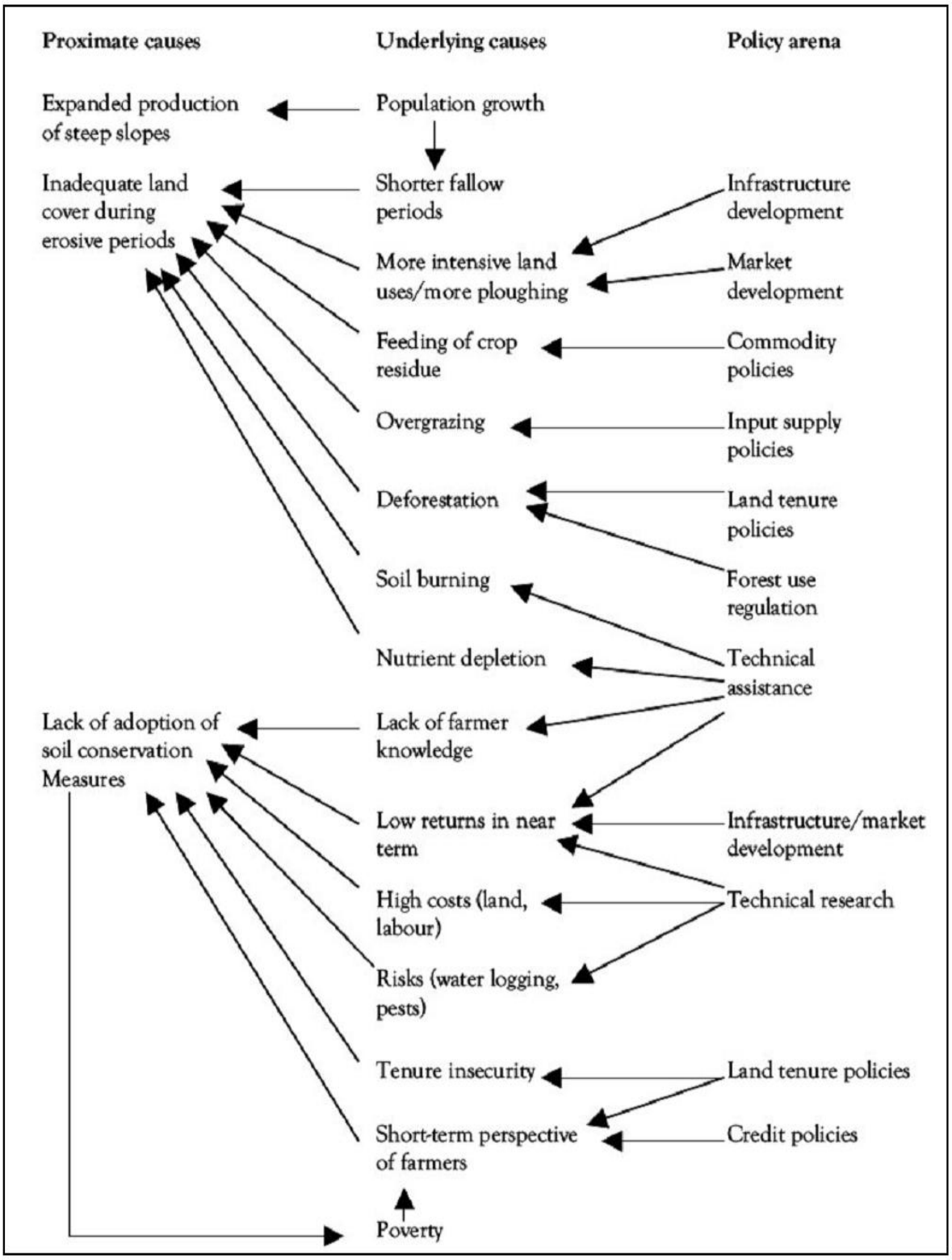

Figure 6: Causes of soil erosion (Fitsum et al. 1999)

(Turner et al., 1977).

Tiffen et al. (1994) highlighted a situation where population increase and intensification of agriculture resulted in less erosion in the Machakos District of Kenya. While Ovuka (2000) reported an increase in population and intensive land use, which resulted in

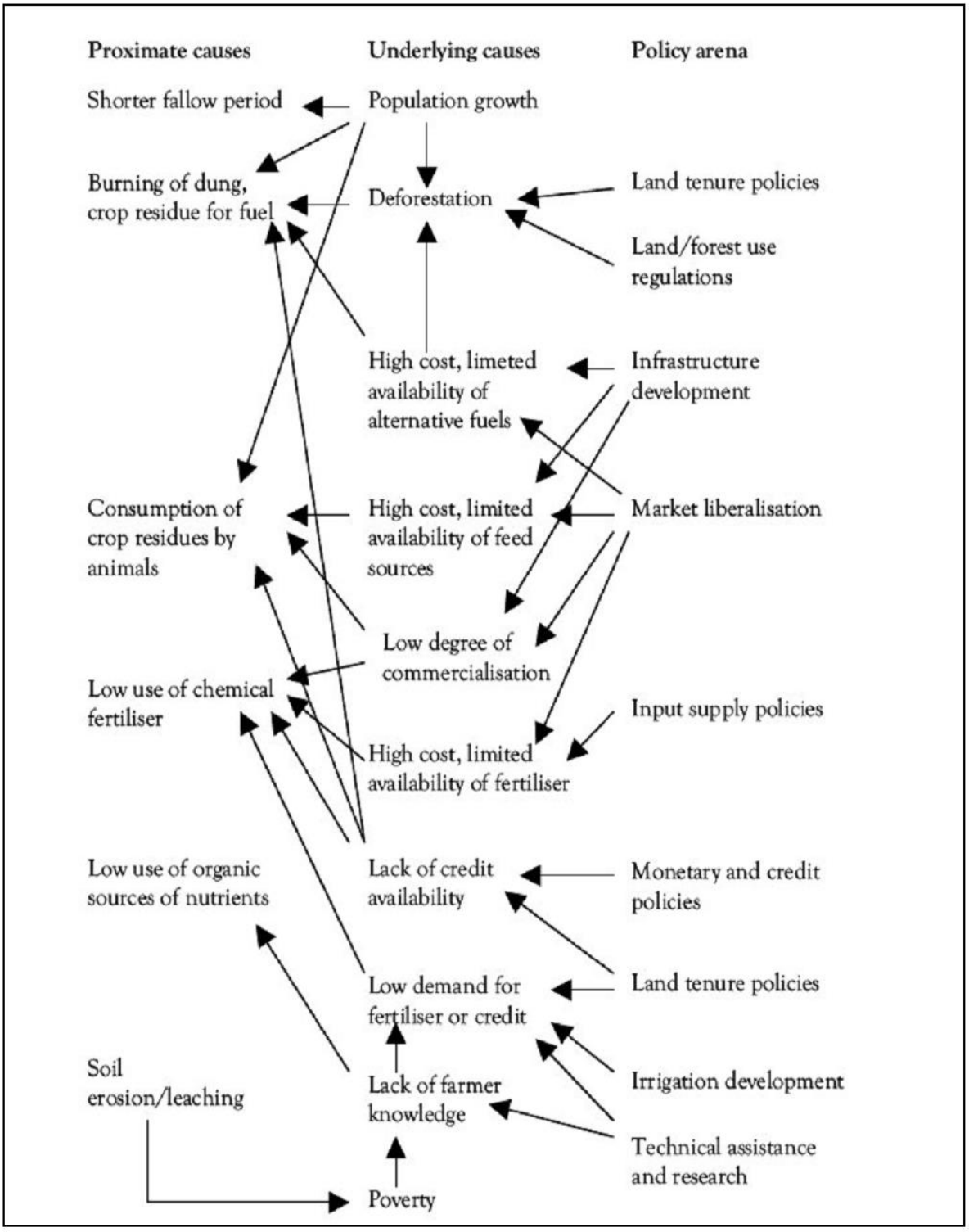

Figure 7: Causes of nutrient depletion (Fitsum et al. 1999)

higher soil erosion in the Murang'a District of Kenya. Boyd and Slaymaker (2000) examined the "more people less erosion" hypothesis in six case studies of African countries and concluded that there is little evidence of reversal of natural resource degradation and no evidence of trends of environmental recovery. In most of the African conditions, the empirical evidences are indicative of the Malthusian crisis rather than the Boserupian optimism.

In Ethiopia both theory works in different regions. For

example more people more tree is working in Tigray and Gurage areas, whereas, more people less tree works in Guraferda (Bench Maji Zone), North Shewa, Wollo and in various resettlement areas of the country.

LAND USE CHANGE

Land use change is an alteration of land in terms of syndromes of human activities such as agriculture, forestry, and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity (Ellis et al., 2007). Man modified the ecosystem to suite his own needs with little or no regards to the effects these conversions had on the natural processes. Consequently, the modified ecosystems become different from what would have been there if the human disturbance had not occurred (Mooney et al., 1996; Franklin, 1993). Several studies documented that the changes in the land use, habitat fragmentation, and environmental stress often led to reduced plant biodiversity in almost all natural ecosystems (FAO, 1986; Mooney et al., 1996). For instance, areas of high human activity and significant human land transformation are spatially matching with areas of high species richness or endemism (Easterling et al., 2001).

The consequence of such link illustrates the augmented negative implications for land degradation and loses of biodiversity (Ehrlich et al., 1991; Mulugeta, 2004). On the other hand, there could be a possibility of positive outcome from such link as for example, when man sustainably intensifies land use for better management, or applies intensive conservation methods to provide better grazing lands for domestic and wild herds (Tiffen et al., 1994). Implicitly, to design a sustainable natural resource management plan it is important to investigate how land use change can contributes to land degradation and biodiversity loss.

LAND/SOIL DEGRADATION

Land degradation generally signifies the temporary or permanent decline in the productive capacity of Ecosystem (UN/FAO definition). In the context of productivity, land degradation results from a mismatch between land quality and land use (Beinroth et al., 1994). Being biological, chemical and physical, the major types affecting productivity includes degradation of vegetation cover, soil degradation, and nutrient depletion (Eswaran et al., 2001).

The unique topography, type of soil, deforestation, intensive rainfall and low level of land management and the land use type practiced have resulted in heavy runoff that induced soil erosion particularly in the northern and central highlands of Ethiopia. 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. Estimation made on the amount of soil that leaves the plot and deposited elsewhere or that leaves the country is unpredictable. This is expected because the Ethiopian topography, agro-ecology, type of soil associations, land use type etc. vary from one location to another. Measuring the source of variation in estimation of ecosystem degradation is difficult. However, the estimations made by the Ethiopian Highlands Reclamation Study (EHRS) and Soil Conservation Research Project (SCRP) are 100 t/ha with 1.8% loss of productive cropland (Constable and Belshaw 1989) and 42 t/ha with 2% loss of productive cropland per annum (Hurni 1988).

Since 95% of the cultivated land is under smallholder peasant agriculture…, it is clearly the cumulative impact of the actions of these land users that has eventually led to the degradation and depletion of ecosystem Shibru and Kifle (1999).

Land degradation, due to soil erosion and loss of soil fertility, is one of the most visible phenomena on agricultural or deforested sites in Ethiopia (FAO, 1986; Hurni, 1988). It involves physical, chemical and biological degradation, i.e. loss of the overall productive capacity of a land. The most important soil chemical degradation involves plant nutrient depletion and loss of soil organic matter. Although, the soils of Ethiopia, like other tropical countries, are naturally poor in N and P, erosion induced losses are also tremendous. For instance, an agro-ecosystem nutrient balance study at a continental scale revealed that Ethiopia is one of the countries having the highest rate of the three macro-nutrient (N, P, K) depletion, with aggregated national scale nutrient balances of - 41 kg N, - 6 kg P and - 26 kg K per ha (Stoorvogel and Smaling, 1990).

POPULATION GROWTH

Population growth is associated with increase in resource consumption, which causes expansion and intensification of land use, overutilization of biological resources and exploitation of marginal lands and the breakdown of traditional resource-management systems. As indicated in figure 8, Ethiopia's population is increasing steadily over the last three decades from 42.6 million in 1984 to 83.4 million in 2012, and is expected to reach 130 million by 2020 (CSA and ICF International, 2011). Uncontrolled population growth puts undue pressures on all natural resources of the country and would undoubtedly have serious impact on ecosystem.

EXPANSION OF INFRASTRUCTURE

Settlement patterns: In some regions, resettlement is a major driver of deforestation (Behailu, 2006; Mulugeta et al., 2007). Although the objective of the resettlement

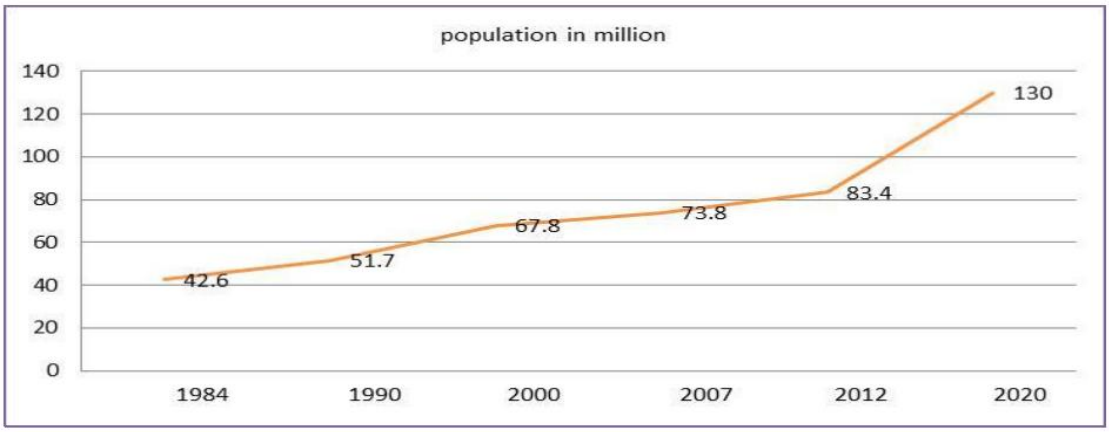

Figure 8: Trends in human population growth

program is to assist food insecure households get access to productive farmlands, the strategy, in most cases, is taking place through the clearing of natural vegetation, particularly forested areas. For instance, between 2000 and 2004, about 220,000 household heads or 1.2 million people were resettled in the four National Regional States of Amhara, Oromiya, SNNP and Tigray. These households carved out cropland and made settlement housing by clearing areas of their natural vegetation and using the woody resources unsustainably.

In Ethiopia, many areas are densely settled resulting in a tremendous pressure on resources. The water-ways constructed at road sides are rapidly turning into deep valleys consuming a considerable part of arable land and vegetation. Tracking of livestock and people is also contributing to formation of gullies (Aklilu, 2001).

CLIMATE CHANGE

The increasing occurrence of late rains and droughts is consistent with scientific assessments on the impacts of climate change in Ethiopia. Although there is lack of quantified data that ascertain climate change as the cause of biodiversity loss in Ethiopia, the late rain and droughts which have been occurring are observed to lead to loss of crops, including the improved varieties and livestock, damaging the gene pool of these genetic resources. Climate change also causes high disease prevalence such as Pasterolosis and favors invasive species like *Acacia drepanolobium* to invade rangelands (Keller, 2009).

POLLUTION

Major causes of pollution to aquatic and wetland ecosystems in Ethiopia are large and small scale factories such as brewery, textile, chemical, tobacco, thread and garment, and paint factories. Most of these factories do not have proper waste disposal systems and are dumping and/or draining their wastes into nearby aquatic and wetland ecosystems. This results in causing major damages to the biodiversity of the ecosystems through deposition of heavy metals as it is the case in Akaki River, and Abasamuel and Koka reservoirs. The other most important large-scale human activities producing dangerous pollutants in Ethiopia include garages, petrol stations, tanneries, slaughterhouses, market centres, hospitals, oil and flour mills, metal works and car washing.

POVERTY

Poverty and ecosystem degradation have two way relationships. In one way, ecosystem degradation like deforestation, soil erosion, water and air pollution, and loss of biodiversity etc. have a declining impact on the potential production capacity of individual and society, resulting in different degree of poverty. In the other way poverty is the cause of ecosystem degradation. Poverty together with other factors may foster unsustainable development due to the fact that the poor people are mostly directly dependent on the natural resources than the riches. Thus, they degrade the natural resources to get food, fuel woods, and income as well as to survive since poor people do not have access to modern and, efficient technologies.

CONCLUSION

The changes in ecosystem structure or function may be either positive or negative, i.e. some drivers serve to increase ecosystem services (or a single one) whilst others lead to a decrease. This is also dependent upon the state of the ecosystem. Drivers of change in largely unexpected ecosystems are usually negative for several

ecosystem services. Drivers of change in an already degraded ecosystem may act to degrade it further, or to reverse previous degradation. Additionally, drivers can be direct or indirect. Direct drivers cause direct changes in ecosystem services whereas indirect drivers exert their influence by affecting direct drivers. The drivers are further classified into endogenous and exogenous. Endogenous drivers are within the control of policy makers while exogenous drivers are outside their control. Direct drivers include climate change, species introductions and removals, changes in land use, external inputs, technology adaptation and use, harvest and resource consumption, and natural, physical and biological agents or events. Indirect drivers are usually complex, longterm and anthropogenic in origin. Interactions between direct and indirect drivers often result in unpredictable changes in ecosystem services.

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