Agroforestry Practices in Centeral Ethipoia: Implication for Deforestation and Land Degradation Management

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Abstract

Ecological restoration of degraded ecosystems is a global priority. About two billion ha of land in the world was affected by various forms of natural and human-induced activities. Now a day, water erosion being the main contributor of land degradation and deforestation which threaten the survival of many species, and reduces the ability of forests to provide essential services. However, its impact is especially severe on the livelihoods of the poor, who were heavily dependent on natural resources. Several scientific reports highlighted in this review show the extent to which land degradation is threatening food security as well as ecosystem goods and services and depleting ecosystems in different regions of the world. Agroforestry encompasses a wide range of approaches and technologies for restoring degraded lands through afforestation and reforestation from intensive agriculture, soil erosion, deforestation, rangeland degradation, mining and over extraction at various scales. Agroforestry practices (AFP) also considered as climate-smart agriculture which have been designed for optimization of desired outputs, such as timber or fuelwood (agrisilviculture), or for specific land rehabilitation objectives. However, there is a need to involve different stakeholders to design effective AFP for supporting sustainable productivity of land and enhancing biodiversity and ecosystem services, to identify best practices to diversify AFP and better understand soil properties and land use in degraded landscapes. It play an effective role in improving soil fertility, conserving biodiversity, enhancing carbon sequestration and providing climate change mitigation and adaptation. In general, tree planting through agroforestry should be an integral part of rural development programs and should provide the community with food, fuelwood, income, and environmental benefits. Increasing public awareness through education about forestry and natural resource conservation is vital if Ethiopia wants to maintain the remaining natural forests and biodiversity.

Introduction

Land is one of the major natural resource of a developing country like Ethiopia. Agriculture in natural ecosystems has gradually evolved into more resilient and dynamic systems where trees and crops coexist on the same unit of land (Geist & Lambin, 2001). Most of these practices have evolved from forests. Forests and the benefits they provide in the form of wood, food, income, and watershed protection play a critical role in enabling people to secure a stable and adequate food supply. More than 90% of the population is dependent upon the land for their fulfillment of basic needs (food, fodder, fuel, fiber and timber) (LRMP, 1986).

Land degradation is the result of complex interaction among, physical, chemical, biological, socio-economic and political issues of local, national or global nature while, the scale of global process may be vast, they may be in state of dynamic equilibrium easily up set by human forces (Ghebru, 2010). Land degradation is decline in land quality or reduction in its potential productivity of land. It may occur through different physical, chemical and biological processes which are directly or indirectly induced by human activities. These include soil erosion, compaction, acidification, leaching, salinization, decrease in cation retention capacity, depletion of nutrient, reduction in total biomass carbon and decline in biodiversity. It also includes all process that diminishes the capacity of land resources to perform essential functions and services in ecosystems (Hurni *et al.,* 2010) are caused by two interlocking complex systems: the natural ecosystem and the human social system. Human activities are responsible not only for the degradation of land but also important for improvement of land through prevention, rehabilitation and reclamation (MoEST, 2008). More than 9 million hectares of forest are being converted into non forestland, and at least double that amount of forest ecosystem is being fragmented and degraded each year over the world. Converted land is generally agriculturally unproductive, biologically impoverished, and more flammable than the forests (Uhl, 1987).

Degradation and deforestation in Ethiopia, however, is impairing the capacity of forests and the land to contribute to food security and to provide other benefits such as fuel wood and fodder. Additional research on agroforestry and transfer of technology has been conducted by the International Center for Research in Agroforestry (ICRAF), in collaboration with national research and development institutions on the East African highlands since the mid1970s (Bishaw *et al.,* 1993). As part of this effort, a blueprint for "Agroforestry" Potential and Research Needs for the Ethiopian Highlands" was prepared by the Technical Committee for Agroforestry in Ethiopia, in collaboration with ICRAF scientists. Based on altitude, topography, and intensity of land use systems, the following were identified as agroforestry practices for the Ethiopian highlands: alley cropping, trees in homegardens, fodder tree planting, trees as living fences, farm boundary and road side planting, woodlots and agroforests, trees on contour bands, and gully planting (Bishaw *et al.,* 1993). Plantation forestry can contribute to forest conservation by reducing demands on native forests and slowing the rate of deforestation. Deforestation is a major global concern, in part because it contributes to the loss of biological diversity, and in part because of its potential to disrupt present climatic patterns. Clearing and burning of tropical forest contributed 20% to the recent global increase in atmospheric CO_2 (Schneider, 1989).

Ethiopiais facing rapid deforestation and degradation of land resources. Population increase have resulted in extensive forest clearing for agricultural use, overgrazing, and exploitation of existing forests for fuel wood, fodder, and construction materials. Forest areas have been reduced from 40 % a century ago to an estimated less than 3 % today. The current rate of deforestation is estimated at 160,000 to 200,000 hectares (ha) per year, and fertile topsoil is lost at an estimated rate of one billion cubic meters per year (FAO 1981; UNEP 1983; Constable 1985; Kuru 1990; Yirdaw 1996), resulting in massive environmental degradation and constituting a serious threat to sustainable agriculture and forestry. The primary objectives of this collaborative paper were focuses on the present causes, consequences of land degradation with their management approaches through agroforestry practices.

Agriculture, Land Degradation and Deforestation

Agriculture

Agriculture is the dominant sector of the Ethiopian economy, with 85% of the population living in rural areas. Agriculture provides about 52 % of the country's gross domestic product, 80 % of its employment, and 90% of its export earnings. Ethiopia's economy is largely dominated by subsistence agriculture, and crop and livestock farming are the principal practices. Mixed farming dominates the highlands, with crop and livestock farming practiced in the same management unit (World Bank, 2000). Crops such as barley, teff, wheat, and beans are grown in the higher altitudes, while sorghum and maize are the principal crops in the mid and low altitudes.

In addition, coffee, sweet potatoes, chat, various vegetables, fruits, and groundnuts are extensively cultivated. Cattle, sheep, and goats constitute the livestock in the highlands. Crop and livestock yields in the highlands are very low, and the recent drought has aggravated the situation. Furthermore, population pressures have decreased the size of holdings, including both arable and pasturelands, leading to conversion of forested and marginal areas into agricultural lands (Bishaw *et al.,* 1993).

Land Degradation

Soil degradation in Ethiopia can be seen as a direct result of past agricultural practices in the Ethiopian highlands. The dissected terrain, the extensive areas with slopes above 16 %, and the high intensity of rainfall lead to accelerated soil erosion once deforestation occurs. In addition, some of the farming practices within the highlands encourage erosion. These include cultivation of cereal crops such as teff and wheat, which require the preparation of a finely tilled seedbed, the single cropping of fields, and down "slope final plowing to facilitate drainage (Bishaw and Badege, 2001). Furthermore, sociopolitical influences, especially insecurity of land" and tree tenure, have discouraged farmers from investing in soil conservation practices. Soil degradation is thus the most immediate environmental problem facing Ethiopia. The loss of soil and the deterioration in fertility, moisture storage capacity, and structure of the remaining soils all reduce the country's agricultural productivity. Soil erosion is greatest on cultivated land, where the average annual loss is 42 tons/ha, compared with five tons/ha from pastures. As a result, nearly half the soil loss comes from land under cultivation, even though these lands cover only 13 percent of the country. Not surprisingly, the highest average rates of soil loss are from formerly cultivated lands that are currently unproductive because of degradation and little protective vegetative cover (Hurni, 1990).

The present status and rate of soil erosion in Ethiopia call for immediate action to retard and reverse this degradation process. However, the present population growth rate of 2.9 %, in comparison with the annual agricultural growth rate of 2.4 %, will lead to even more intensive use of cultivatable and pasture land to produce more food and feed for the growing human and livestock populations. Hence, it is clear that intensification of land use must be accompanied by technological innovations that will lead to increased productivity, while simultaneously conserving the soil resource (Bishaw and Badege, 2001).

Land degradation, a reduction in productivity of the land mainly due to human activities, is a serious global problem, but it is grossly impacting developing countries. Agricultural practices are suggested to be the main drivers for about 80% of the global land degradation (Bisaro Kirk *et al.,* 2014). Land degradation has noted among the most serious problems that decline and sometimes leads to total failure of agricultural production in developing countries such as Ethiopia. The agricultural sectors the main economic stay for 85% of the population (>80million people) in the country. However, land degradation is threatening the sustainability of agricultural based development efforts in Ethiopia (Shiferaw & Holden, 1998; Tesfahunegn, 2011), as evidenced by more than 3 million Ethiopians who faced the risk of food insecurity in each year (Gete Menale, 2006; Tesfahunegn, 2011; USAID, 2003). Generally, land degradation is a global problem associated with soil erosion, desertification, loss of biological diversity, and deforestation (Biro *et al.,* 2013).

Causes and consequences land degradation

Land degradation is one of the greatest challenges in the world. Both the natural conditions and human activities have contributed to the degradation of land. Some of the major causes of land degradation are fragile geological structure, forest fire, avalanches and dry landslides in which increasing population, fragile economy and sometimes farm policies add fuel to it in its natural condition. Natural calamities like landslides in the hills, drought and flooding have frequently occurred. Most of all, flooding is a major cause of land degradation leading to the poor socio-economic conditions and the deterioration of the natural ecosystems. Anthropogenic causes such as deforestation, excessive use of chemical fertilizers, overgrazing, construction works, and unscientific farming in the hills (steep slope) have resulted in the loss of flora and fauna, erosion of top soil, occurrence of land slides in the hills and flooding in the plain areas. This has led to severe environmental degradation leading to poor socio-economic condition and disruption of natural ecosystems (Karkee, 2004).

The repeated pressure of grazing on grasslands beyond its carrying capacity, shifting cultivation in the mountains and overgrazing in the open public lands lead to land degradation and damage the ground vegetation and grassland ecosystems. The heavy grazing pressure in the mountain areas has speeded up the soil erosion, which lead to increase run-off and compaction of soil. Development activities such as construction of roads, buildings, dams have added effect to it (Neupane and Thapa, 2001). Land and forest resources have been intensively used to meet the basic requirements of food, fuel-wood, fodder, and small timber (Karkee, 2004).

The extent and severity of damages have increased continuously due to frequent changing nature of mountain-rivers. Farmlands near river banks are washed away by flooding, crops are ruined and widths of rivers

widen every year during monsoon. Example: Nepal's rivers carry around 336 million tons of soil per year to the main river systems entering to India and furthermore, the river-damaged areas of middle mountains of Nepal suffer from excessive grazing pressures of domestic animals(Brown, 1981). The productivity of riverside lands has been seriously affected by silting, flooding and deposition of pebbles. Land degradation due to chemical and physical processes is less than 2% of the total area of the country (Gautam *et al.,* 2003). The land degradation is associated with soil erosion on the hill slopes, sedimentation/siltation in river valleys which reduce crop yields due to decline in soil nutrients, acidification, and pollution. Basically, there are two types of causes of land degradation in the world: a) direct causes: The direct causes of land degradation includes: deforestation, overgrazing by livestock, urban development, while the indirect causes include inappropriate farming practices, population pressure, mining, climate change and, land tenure. These factors are discussed in more detail in the subsequent sections and b) indirect causes: The direct causes of land degradation are strongly linked to the indirect causes or the main drivers such as: increasing economic drive for export and import substitution, increasing population pressure of the Pacific Island Countries; and, and increasing impacts of climate change. Addressing these indirect causes, it will define the way forward to solving the land degradation issues.

Agroforestry practices for land degradation management

Farmers have cultivated trees on farm from time immemorial. Agroforestry system is diversified and integrated with livestock, trees and crops. Any change in any component of the whole system will have effects on the other components. Households keep different types of animals for meeting their livelihood. Household's plant fodder trees on under-utilized lands.

Agroforestry can contribute to human nutrition through increased production and availability of particularly nutritious fruits and leaves. Improving livelihood support in lessening rural poverty along with degraded hill environmental restoration on highly populated lower and mid hills are prioritized (Anil Kumar Acharya, 2009).This has resulted in an increase in forest coverage of up to 70%, and an increase in the income levels of leasehold families during the last seven years. This increase in families' income helps to support children's schooling, health and daily family expenses (Gautam *et al.,* 2003).

Maintenance and enhancement of soil fertility is vital for global food security and environmental sustainability. Ecologically sound agroforestry systems such as intercropping and mixed arable-livestock systems can increase the sustainability of agricultural production. Agroforestry is a useful path, complementary to chemical fertilizers, to enhance soil fertility. The components of agroforestry exploit different vertical layers both above and below ground which signifies greater resource utilization efficiency for optimizing resource use. Farmers can play leading role in development and testing of MPT technology, assessing on-station trials, conducting researcher-designed and farmer-designed trials, and providing feedback to the researchers. Hence, efforts are needed to model and assess the long-term impacts of the multipurpose trees on productivity (Karkee, 2004).

Deforestation

Deforestation is clearing or removal of a forest or stand of trees where the land is thereafter converted to non-forest use. Examples of deforestation include conversion of forestland to farms, ranches, or urban use (Oljirra, 2019). It is taking place through unsustainable commercial logging and land clearing for commercial agriculture because of rapid population growth, large forest and crop areas are required to satisfy the needs of the nation. However, with deforestation, little was done to maintain the vegetation cover, and there was no effective reforestation program. Thus the use of the land as a mine rather than as a source of renewable sources has led to severe degradation problems (Tewolde, 1989). Ethiopia has lost most of its forest resources after mid twentieth century. Today, with estimated annual loss of 160,000–200,000 ha of forest, the country has less than 3 % forest cover (Bishaw, 2001).

Causes and consequences of deforestation

The destruction of the forests is occurring due to various reasons, one of the main reasons being the short-term economic benefits. Corruption at the government institutions, wealth and power due to harvesting of the riches of the forest, population growth and urbanization are some of the common causes, (Oljirra, 2019). Many government agencies are fighting illegal logging to protect the forests. However, any type of logging legal or illegal leads to deforestation. Trees are cut down indiscriminately by logging companies, to fulfill the demands of the wood market, (Hakapaino, 2005). Among the consequence of deforestation, disruption of

the Water Cycle, loss of biodiversity, flooding and drought, climate change, heavy soil erosion and desertification (Oljirra, 2019). Particularly, there are two types of deforestation cause: a)direct causes: burning tree, expanding cultivates land, Wood extraction/ logging and infrastructure development (Ehui and Hertel, 1989) and b)indirect causes: economic factors, political factors, technological factor cultural factors and demographic factors (Kaimowitz, 2003). According to Kaimowitz (2003), more than 50 percent of the tree cover has disappeared due to human activity.

Agroforestry for Deforestation management

There are many benefits of agroforestry, but the two main ones are preventing of soil erosion and provision of nutrients to crops. In a tropical environment the topsoil is often shallow and prone to erosion (Chris Brils, 2021).

Territorial participatory planning of agroforestry and restoration systems, in addition to the institutional development have demonstrated their capacity to benefit environment, farmer's livelihoods and social capital, through their contribution to increase productivity, complexity, diversity, economic value, organization capacities and knowledge, which as a whole may contribute to avoid deforestation (Albuquerque, 2002; Bray, 2008; Swiderska *et al.,* 2008). However, other products, service, process and management innovations are required to have a broader menu of options for farming systems and livelihoods to ensure the permanence of forest systems in a competitive context. Some of the needs to be resolved in order to conceive this process as a territorial development are: the best practices to achieve food self-sufficiency, development of market chains, education, training, infrastructure, financial support, policy arrangements and skills of competitiveness for production systems (Albuquerque, 2002; Ruiz de Oña *et al.,* 2011).

The rapidly growing population poses increasing pressure on natural resources and the environment. Among the natural resources forest will become critical in the future because of over exploitation for firewood and timber. In such conditions agroforestry is an appropriate alternative to combat the situation and reduce the risk and vulnerability of farmer's livelihood. For example, it was observed that homegarden agroforestry increased the production of tree components around homestead and minimized the dependency on natural forest for fuel wood and timber that imposed positive impact on natural forest conservation(Muhammad,

2004). The role of agroforestry in reducing pressure from natural forest and satisfying the basic needs of the rural peoples of Ethiopia is large, but little research has been initiated to identify suitable agroforestry technologies and appropriate tree species for specific areas.

Recommendation

Agroforestry systems have contributed to biodiversity conservation and production of diverse products to maintain the livelihood of the farming households in Ethiopia. The rate at which indigenous knowledge (IK) is transferred from elders to the younger generation is slowing down. It is realized that the balance between the land degradation and restoration rates should be maintained so as not to further degrade the land.

Forest and tree cover is declining at alarming rates in Ethiopia. The land degradation problem is increasingly becoming a challenge for the economy and natural ecosystems. Agroforestry, association of trees and shrubs with crops, livestock or other factors of agricultural production, holds great promise for contributing to sustainable land use systems which can overcome the problem of land degradation and the imminent "food crisis". It provides diversified production and consequently greater food diversity. Agroforestry practices are implicitly assumed to have higher productivity than mono-specific systems, especially on degraded sites.

The potential contribution of agroforestry can be effective if farmers and local communities are fully involved in its planning, development and implementation phase. Since agroforestry plays a great role in the economic benefits, managing a degraded land, and reducing pressures from natural forest, every person should contribute on the issues. In rural areas, the government and NGOs realized that if the deforestation continues the overall condition of the country will worsen.

Because of that, the government has begun teaching the people about the benefits of forests and encouraging the people to plant more trees and to protect what they have by providing them alternative home and agricultural materials. If any person cuts a tree, he or she needs to plant one to replace it. The current government and people are working hard together to make their country a better place. Prohibiting the Ethiopian population to cut trees, especially rural populations, will actually hurt daily life since meeting daily needs becomes more difficult.

The government is trying to provide the Ethiopian people with fuel and electrical machinery so the demand for forest resources is not as high. Additionally, the government is providing flat land with no pre-existing forests to promote agriculture so that deforestation is not necessary for modern agriculture. There are governmental and nonprofit groups working with the government to protect the land.

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