

LAND DEGRADATION AND CONTROL MEASURES WITH SPECIAL REFERENCE TO PLANTATION CROPS

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ABSTRACT

The land degradation is an important global issue that reduces natural quality and productive capacity of the land. About 40-50% of the total land extent in Sri Lanka too has been reported to degraded or under the threat of land degradation. Nuwara Eliya, Kandy, Badulla, Matale, Kegalle and Ratnapura are the main administrative districts with lands that come under mid and up country (>300 m amsl) elevations in the hill country. The plantation crops such as tea and rubber cover large extents of hill country and found in sloping terrains. Coconut are also found in small extents in some areas of the mid country elevations mostly as home gardens. The land degradation in plantation crops occurs due to physical, chemical and biological processes. Of them, soil erosion is the most commonly occurring process of physical land degradation while acidification due to frequent use of chemical fertilizers is the major cause of chemical degradation. Losses of biodiversity and soil organic matter are the major causes of biological degradation. In addition, use of pesticides can also contribute to land degradation. The plantation crops grown in mid and up country provide most needed foreign exchange to the country and livelihood to a large number of people in the country. The central highlands above 300m elevation is the watershed feeding major rivers in Sri Lanka that immensely contribute to agriculture, power generation and water for human consumption. Therefore, land degradation due to human induced physical, chemical and biological processes should be prevented by adopting proper agricultural and land use policies.

INTRODUCTION

Land comprises of soil, environment, water and living beings of the plant and animal kingdom. Declining of the natural quality and productive capacity of the land is referred to as land degradation, which is an important global issue. Land degradation can be attributed to a number of physical, biological and chemical processors (Lal, 1994). Of the physical processes causing land degradation in Sri Lanka, soil compaction, crust formation, anaerobism and soil erosion take high priority. Acidification, leaching, salinization and depletion of soil fertility are few important chemical processes. Loss of bio-diversity and biomass carbon are the two biological processes that degrade lands in Sri Lanka. It has been reported that about 40-50% of the total land extent in Sri Lanka has been degraded or under the threat of land degradation. The land degradation due to human activities is mostly irreparable and the consequent loss of productive land is a threat to the agriculture and life of future generation.

Nuwara Eliya, Kandy, Badulla, Matale, Kegalle and Ratnapura are the main administrative districts with lands at higher elevations above 300 m elevations with a greater danger of land degradation. These districts cover about 20% of the total land area and have 20% of water bodies in Sri Lanka (Punyawardena, 2008). It is also important to note that the central highlands above 300m elevation is the watershed feeding major rivers in Sri Lanka that immensely contribute to agriculture, power generation and water for human consumption. The most commonly found plantation crop in the mid

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and high elevations is tea. Rubber and some other mixed cropping lands are also found in these regions. Majority of the tea extent of mid and up country elevations are found in Nuwara Eliya, Badulla and Kandy districts. These three districts have more than 100,000 ha of tea lands (Ministry of Plantation Industries, 2008) of which around 80% is managed by corporate sector management companies. Half of the tea extent of the corporate sector estates is seedling tea while seedling extent of tea smallholdings is less than 15%. By nature, the cultivation of crops in hilly and mountainous terrains in these elevations is conducive for soil erosions. Apart from slope of the terrain, the impact of erosive storms on exposed ground with poor crop and land management practices also accelerates soil erosion.

LAND DEGRADATION IN HILL COUNTRY PLANTATIONS

The plantation agriculture in Sri Lanka started in 1820s in the mid country with coffee and they were converted to tea in late 1860s. The tea was first commercially planted along the slope with a plant density of about 6000-7500 bushes/ha. Poor ground cover with large vacant patches, wider spacing of seedling tea planted along the slope, clean weeding and lack of maintenance of basic soil conservation measures such as drains and terraces were the main contributory factors for accelerated soil erosion in tea lands on slopes. Abandonment of unproductive & steep tea lands with poor soil conservation measures had also lead to heavy soil losses in the past causing an ecological threat to the environment (Humbel, 1990). Diversification of perennial crops like tea into some other short-term crops like potatoes and vegetables etc has also led to soil erosion & water pollution in the central highland. Wijeratne, et al. (2008) highlighted that neglect of some good agricultural practices in croplands and some anthropogenic activities on central highlands and watersheds have contributed to soil erosion and water pollution.

The land degradation in plantation crops involves physical, chemical and biological processes. Of them, soil erosion is the most commonly occurring process of physical land degradation while acidification due to frequent use of chemical fertilizers is the major cause of chemical degradation. Loss of biodiversity and soil organic matter due to monocropping and inadequate ground cover are the major causes of biological degradation.

Soil erosion

The most common sign of soil erosion is the loss of top soil layer reducing the actual depth of soil horizon. An adequate soil depth is essential to anchor plant satisfactorily during its growth. The light weight particles such as silt and clay fractions are more vulnerable to be carried away by runoff water than heavy particles such as gravels that are left on the soil surface. As a result, soil texture, graveliness, bulk density and porosity of agricultural lands are greatly affected by soil erosion. Loss of much needed soil organic carbon and plant nutrients are also grave consequences of heavy soil erosion affecting fertility of land and crop production.

Pesticides applied to plantations can also find their ways into water bodies with run-off water causing water pollution. Frequent use of fertilizers on erosive and steep lands can cause eutrophication of water bodies i.e. accumulation of nutrients in excess of naturally available levels in water. Much of the fertilizers added to poorly managed plantations also washed off into the streams and rivulets feeding the

major reservoirs by runoff water. Such losses of nutrients are more pronounced from degraded lands and acidic soils. Increase in plant nutrient concentration in water bodies is beneficial for the rapid growth of algae covering the water surface and reducing oxygen concentration of water bodies polluting water.

Acidification

Although tea soils prefer acidic soils with pH in the range of 4.5-5.5, very low pH levels (<4.5) causes problems related to soil fertility. Soil acidity in the plantation sector became more pronounced with the use of inorganic fertilizers such as Sulphate of Ammonia. In addition, leaching of bases from top soil layers in heavy rainfall areas is also responsible for acidification of tea soils. Due to acidification of tea soils, availability of major nutrients such as N,P,K etc., is reduced and some soil nutrients such as Al and Mn can be available in toxic levels. In addition, very low levels of soil pH can cause disruptions to soil structure and microbial activities thus reducing the overall soil fertility and use efficiency of applied fertilizers.

Loss of bio-diversity

The density of plants in a natural forest is reduced from over 240,000 plants/ha to less than 14000 plants/ha due to cultivation of plantation crops such as tea while it is largely reduced with the cultivation of other plantation crops such as rubber and coconut. This is true even for other perennial crops and however, the loss of biodiversity is less severe in tea than in the case of other agricultural crops.

MEASURES FOR CONTROLLING LAND DEGRADATION

Measures for controlling physical land degradation

i). Soil erosion control measures:

There are many physical, biological and cultural practices for soil conservation. Two types of drains (leader drains and contour drains) and stone terraces are the commonest physical soil conservation measures in plantations. Covering of soil surface with mulches (mulching or thatching) can also be considered as an efficient form of physical soil conservation during early periods of crop establishment. Planting of rehabilitation grasses, contour planting, establishment and management of shade trees, planting of covercrops and establishment of Sloping Agricultural Land Technology (SALT) hedge rows are the main biological soil conservation measures that can be adopted in plantations. Complete ground cover prevents soil erosion. Therefore, all good agricultural practices reducing death of plants (casualties) and increasing the rate of growth of plants can be considered as cultural practices controlling soil erosion.

a). *Physical soil conservation measures*

Leader drains are established along a natural line of drainage on slopes, The lateral drains known as contour drains (45 cm wide and 45cm deep) are cut with a gradient of 1 in 120 across the

slope (contour). All contour drains open into a leader drain so that none of them from opposite sides meets together at one point of the leader drain. Contour drains can be either lock and spill type or lock and spill with a silt pit. The sides and the bottom of the leader drain are paved with stones and brim of the contour drains are strengthened with a row of densely planted grasses (eg. Vetiver; *Vetivaria zizanoides*, African Love grass, *Eragrostis curvula*). The bottom of the leader drain is paved as reverse slope to reduce speed of run-off water. The contour drains should be regularly de-silted and soils collected should be spread on the upper slope. Contour drains not only conserve soil reducing run-off but also it helps rainwater harvesting and prevents run-off losses of plant nutrients from the land. Stone terraces can be established on steep lands to control soil erosion. They are made along the contours so that the upper surface of the terrace/bund raise above ground to break the slope and catch soil being eroded.

Covering soil surface with dead mulch is one of the commonest and most effective methods of conserving exposed soils such as in young tea lands. The ground is largely open soon after planting until tea attains full ground cover in about 2-3 years after planting. Soil erosion during this period can be minimized by mulching with grass loppings (30-40 t/ha) 2-3 times a year. This practice not only prevents soil erosion but also improves soil fertility by adding organic carbon and plant nutrients, conserving soil moisture and smothering weed growth.

b). Biological soil conservation measures

Planting of rehabilitation grasses (before planting of tea), contour planting, establishment and management of shade trees, planting of cover crops and establishment of SALT hedge rows are the commonest biological soil conservation measures in plantation agriculture.

The soil is exposed for rain after land clearing. Soil cultivation practices such as deep forking to remove roots, cutting of drains and leveling the ground often predispose the land for excessive soil erosion. However, planting of soil rehabilitation grasses such as Mana (*Cymbopogon confertiflorus*) and Guatemala (*Tripsacum laxum*) at closer spacings will not only form an early ground cover within few months, but also bind soil particles firmly by their root system preventing soil erosion. The grasses are lopped 2-3 times a year and loppings act as a mulch adding organic matter and improving physical, chemical and biological soil properties. This in turn, helps faster establishment and growth of young tea achieving an early ground cover.

Establishment of shade trees gives an additional ground cover reducing run off. Canopies of shade trees greatly reduce the speed of raindrops reaching ground thus minimizing their impact on soil surface. In addition, shade trees supply large amount of organic matter that contributes to soil improvement and moisture conservation.

Planting of covercrops in the inter-rows of main crop, road sides/banks and other open areas ensures an additional ground cover minimizing soil losses in plantations. In addition, selective weeding to leave non-competitive herbs (soft herbs) on ground also provides a partial

groundcover. This should be achieved by selective manual weeding and judicious use of weed killers at proper rates and frequencies. Planting of covercrops are also helpful in increasing bio-diversity of plantation crops. Further, such live ground covers cut down the quantity of herbicide used to control weed thus protecting the environment.

SALT is one of the effective biological soil conservation and improvement measures suitable for agricultural lands on slopes. In this system, fast growing plant species with a high coppicing ability, favourably leguminous species are established as a double hedge row along the contours of the steep lands at about 7-8m intervals. The inter-row space of closely planted double hedge rows is used to keep parts of loppings of plants, stones and other plant debris forming a bund, which acts as an effective barrier against run-off. The plants in the hedge rows are periodically lopped and loppings used as thatching material. Establishment of SALT hedge rows also enriches bio-diversity of plantation crops.

c). *Cultural practices controlling soil erosion*

Other cultural practices, in addition to those discussed above, that aim at increasing growth rate of plantation crops and reducing casualties contribute to soil conservation indirectly by forming a full ground cover. Soil fertility management, proper training of plants (eg bringing into bearing, pruning and plucking of tea), soil moisture conservation measures and infilling of vacancies etc. help maintaining a complete ground cover reducing soil losses.

ii) *Controlling other forms of physical land degradation*

Soil compaction, crust formation and water logging (anaerobism) can be minimized by cultural practices such as envelop forking, burying of prunings/compost/green manure in the inter-rows, discontinuation of scraper weeding, and cleaning and de-silting of drains.

Measures for controlling chemical land degradation

Soil acidification can be minimized by reducing the application of nitrogenous chemical fertilizers (by improving soil conditions, proper timing of application, correct doses and frequencies etc). Use of urea in place of Sulphate of Ammonia as a source of N and application of dolomite (liming) also reduces acidification of agricultural lands. Liming not only raises soil pH but also supplies Mg and Ca to the crop lands. Liming also increases biological activity of soils.

Loss of naturally occurring plant nutrients is also a form of chemical land degradation. Plant nutrients removed by the harvested crop should be essentially replenished to maintain nutrient balance in soils. This is usually done by application of chemical fertilizers. In addition to chemical fertilizer application, use of green manure and compost etc are also helpful for adding soil nutrients and improving soil fertility. Further, measures should be taken to minimize nutrient losses from soils through leaching, run-off, soil fixing and evaporation etc.

Measures for controlling biological land degradation

Mulching, soil moisture conservation and minimizing chemical use helps increasing earthworm and other micro-organism population in soils. Crop diversification converting unproductive lands into fuelwood, timber, tree crops, fruit crop plantations, intercropping to improve plant density and mixed cropping to improve ground cover and increase plant density are some other practices that can be adopted to combat biological land degradation. These practices will increase bio-diversity, soil organic carbon levels and population of living organism including micro-flora & fauna.

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