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Sustainable Soil Management in the 21[st] Century

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ABSTRACT

In managing soils of Sri Lanka in a sustainable manner in the 21[st] century, many problems that cause soil degradation has to be overcome. The major soil degradation processes are listed as soil erosion, fertility decline and salinization. The soil erosion problem has to be overcome by providing incentives for small scale farmers to practice soil conservation and urging the private companies that reap the benefit of land to reinvest in protecting the soil. The Soil Conservation act has to be amended to include non-agricultural activities that cause soil erosion. Soil conservation activities of all government and semi-government agencies involved in agriculture must be brought under one umbrella as a Soil Conservation Authority, for farmers to be provided with a package, according to their needs. As agricultural extension activities are devolved, more assistance and training must be provided to officers in Provincial Councils on soil conservation. In addition, plantation forests must be relocated in hydrologically critical areas releasing some of these suitable lands for agriculture. The fertility decline, mainly caused by low soil organic matter content has to be addressed by the introduction of agro-forestry models in each agro-ecological region. Compost making from urban waste has to be encouraged which will solve a long standing environmental problem and make available more organic materials that could be added to the soil. Use of balance fertilizer mixtures and liming of acidic soils in the wet zone are other strategies that could be adopted. Development of a soil data base that could be used in land use planning is a real need, if we are to manage our soil resources in a sustainable manner in the 21[st] century.

Key words: soil degradation, soil conservation, soil data base, landuse planning

INTRODUCTION

Soil is defined as the unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of plants. Soil is different from the material in which it is derived, in many physical, chemical, biological and morphological properties and characteristics (Anonymous, 1997). Alternatively, land is a much more wider term defining a three dimensional body, including the uppermost part of the earth's crust including soil, atmosphere above it, geology and hydrology below it, topography, plants and animals even where the major component is still the soil. Using the soil in a sustainable and conservational manner is an important issue as the world population of 5.5 billion are now using only 11% of the land area to raise crops and livestock, which place a great strain on the soil resource (Oldman *et al.* 1990). When used in such a manner, 'Biological Potential of the Land' will decline irreversibly which ultimately reduce its ability to produce food and fiber, a process known as soil degradation.

Global situation in land management shows high degree of soil degradation due to human activity where impact of food security and environmental degradation is eminent. Eawaran *et al.* (2001) categorized land degradation process to physical, chemical and biological degradation. Soil crusting, compaction, erosion, desertification, anaerobiosis and pollution were listed as processes of physical degradation. Chemical degradation processes include acidification, leaching, salinization, decreasing of cation exchange capacity, and fertility depletion. Reduction of carbon and declining of land bio-diversity were documented as processes of biological land degradation. According to the world map of the status of human induced soil degradation, about 58 % of soil degradation are associated with erosion by water, while 26% are due to erosion by wind. From the balance, 12% and 4% of soil degradation are due to physical (other than erosion) and chemical degradation respectively. No estimations are available for global biological soil degradation at present.

It is estimated that in Asia, out of 18.8 million km^2 of land, about 13.4 million km^2, or approximately 71%, are already degraded (Dragnet and Chou, 1994). UNEP (1994) documented that the economic loss in South East Asia due to nutrient loss and soil fertility depletion amounted to US $ 600 million and US $ 1200 million per year, respectively, and in this context Sri Lanka is no exception.

The objective of this paper is to review the present soil degradation status in Sri Lanka and, to propose future strategies to manage the soil resources in a sustainable and conservational manner in the 21st century.

Sri Lankan Situation

The reasons for soil degradation are reflected from the pressure on land resources of Sri Lanka. From the total land area of about 6.5 million ha, only about 3 million are arable due to unsuitable terrain, forest reserves and inland water bodies. The gross land/man ratio, which was 2.7 ha in 1871 with a population of 2.4 million, has been reduced to 0.35 ha with about 19 million people in 2000. According to Maddudma Bandara (2000), the directly available land for human use is estimated at 0.15 ha per person. The pressure on land is also reflected from the forestry perspective where the forest cover declined throughout the years. The forest cover which was 90% of the country during 1900 when the population was 3.5 million, declined to 50% in 1953 with the increase of population to 8 million and further reduced to 23% in 1982 with the population rising to 15 million. At present, the forest cover is estimated at less than 20%. Out of this, only 9% are in the sensitive watershed areas showing the importance of relocating them with proper planning.

Main reasons for soil degradation in Sri Lanka are listed as soil erosion due to water, fertility decline resulting from reduction of organic matter and plant nutrients, salinization resulting from improper water management and soil compaction.

Soil Erosion

Nayekekorale (1998) listed soil erosion as the major soil degradation processes in Sri Lanka where more than 33% of the land are exposed to erosion. The Central Environmental Authority of Sri Lanka, which is the major body dealing with environmental issues, listed soil erosion as the major cause of soil degradation in Sri Lanka. They documented that soil erosion resulted from encroachment of forests, disturbing of hydrologically critical areas, shifting cultivation, inadequate attention to lands higher than 1500 meters from mean sea level. They also highlighted that the fragmentation of responsibilities of soil conservation among different agencies is a drawback in controlling this problem (Anonymous, 1991). As pointed out by many environmental economists the estimation of losses due to environmental degradation is a very complicated process (Gunathilaka, 2003). The most recent estimate about losses due to soil erosion in Sri Lanka is documented by Griggs (1999), where on site and off site losses add up to about Rs. 3000 to 4000 million annually. The adverse impacts on irrigated agriculture mainly due to sedimentation is estimated to be equivalent to Rs 320 million annually. These are only conservative estimates, as the intangible off site events as flooding, detrimental impacts on human health and recreation are not taken into account.

Even though the major cause of soil degradation is soil erosion, not much published data are found on erosion rates and related soil conservation. The tolerable soil erosion rate, which is the allowable soil erosion rate without declining the soil productivity was estimated by Krishnarajah (1984) and is given in Table 1. These were estimated using the existing rooting depth, soil organic matter contents and soil formation rates and served as guidelines to understand the need for establishing soil conservation methods.

Table 1. Estimated rates of tolerable soil loss for different soils of Sri Lanka

Agro-Ecological Region	Soil Order	Potential Rooting(cm)	Tolerable Soil Loss(t/ha/y)
Up Country Wet zone	Ultisols	180-240	13.2
Mid Country Wet zone	Ultisols	120-150	9.0
Low Country Dry zone	Alfisols	90-150	6.7

How the actual soil erosion rates exceeded the tolerable limit in most land use systems are given in Table 2, as documented by Stocking (1992). These data also highlight the importance of simple agronomic conservation measures such as mulching and planting on the contour in decreasing the soil loss below tolerable limits. The lowest soil loss rates were observed in the mixed home gardens in Mid Country Wet zone which is a mixture of crops producing canopies at different levels in taking off the erosive power of raindrops at different heights.

The soil erodibility (K) factor, which shows the inherent susceptibility or resistance to soil erosion by water was worked out for selected soil by Joshua (1977). These erodibility values are related to the clay and organi matter contents of soil, soil structural types and aggregate stability. These values are given in Table 3. The Sandy Regosol great soil group which is classified as Entisols in Soil Taxonomy showed the highest susceptibility to erosion, while Reddish Brown Latosolic soils showed more resistance to erosion by water. This highlights the fact that soils with lower soil erodibility values could be cultivated with less hazards of soil erosion, while soils with high erodibility values need extensive soil

Table 2. Soil loss in different land use systems in Sri Lanka

Agro-Ecological Region	Location	Land Use	Soil Loss (t/ha/y)
Mid Country Wet zone	Peradeniya	Seedling tea no conservation	40
		Well managed tea- in contour	0.24
		Mixed home gardens	0.05
Up Country Wet zone	Talawakele	Clean weeded VP tea	52.6
		VP tea with mulch	0.07
Mid Country Intermediate zone	Hanguranketha	Tobacco no conservation	70.0
		Capsicum no conservation	38.0
		Carrots no conservation	18.0
Low Country Dry zone	Maha-Illuppallama	Sorghum & Pigeon pea	21.3
		Sorghum & Pigeon pea with mulch	3.9
		Cotton	22.2
		Cotton with mulch	2.0

Table 3. Soil erodibility values (K factor) of selected soils in Sri Lanka

Station	Great Soil Group	Soil Taxonomic Equivalent	Soil Erodibility (K)Factor
Ratnapura	Red Yellow Podzolic	Rhodudults	0.22
Katugasthota	Reddish Brown latosolic	Ultisols	0.17
Katunayake	Sandy Regosols	Entisols	0.48
Anuradhapura	Reddish Brown Earths	Rhodustalfs	0.27
Kankasanthurai	Red Yellow Latosols	Oxisols	0.33
Batticaloa	Noncalcic Brown soils	Haplustalfs	0.35

conservation methods to be used for agricultural activity in a sustainable manner

Soil Fertility Decline

Soil fertility decline in Sri Lanka is mainly due to the depletion of soil organic matter. Being a tropical country, soils of Sri Lanka contain low activity clays with mostly kaolonitic and oxidic mineralogy (Mapa, 1992). The cation exchange capacities in soils other than Entisols and Inceptisols show values, sometimes even lower than 10 cmol/Kg even in the top soil. The water retention values of such soils are also low with less than 120 mm of available water in one meter depth of soil. In such instances the organic matter plays a major role in retaining soil nutrients and water. If organic matter is not added periodically, the fertilizer use efficiency will decrease. The removal of most fertile topsoil, which causes lowering of soil depth also, contributes to the fertility decline. The removal of first 5 cm of the top soil reduced crop yields by almost 50%. The depletion of soil nutrients due to leaching and run off is also a major cause of fertility decline. The loss of nutrients in a five month observation period from a tea land in the Up Country Wet zone of 30% slope was documented by Basnayake (1985). The loss during the five months period amounted to 0.37 kg of N, 0.87 kg of P and 0.045 Kg of K per hectare of land. As many farmers do not apply adequate fertilizers according to recommended rates, the depleted plant nutrients are not replenished, thus accelerating the fertility decline.

Salinization

Development of salinity is another soil degradation process, which is mostly related to improper irrigation without adequate drainage facilities. This is very common in many irrigation systems and about 45,000 ha in Sri Lanka are affected by salinity at present. Punyawardena (1990) reported electrical conductivity values of about 32 ds/m in Kirindioya irrigation system. According to the FAO classification if the electrical conductivity exceeds 8 ds/m these are classified as high salinity water affecting crop production.

Overcoming problems

One of the major challenges in the 21st century will be to reclaim degraded soils and to manage it in a sustainable manner. As the main causal factor of soil degradation is soil erosion, agronomic and mechanical soil conservation methods must be introduced to reduce it. One of the major needs is to amend the present Soil Conservation Act to prevent new cultivation in lands higher than 30% slope as well as above the 1500 meter contour line. Soil erosion due to non agricultural activities such as road and building construction must also be addressed in the act. Incentives must be provided to small farmers to undertake soil conservation measures. As most of the agricultural extension activities were devolved to Provincial Councils, more training facilities and assistance are needed from the central government for these organizations to initiate and maintain soil conservation activities in their areas. In addition, agricultural activities in environmentally vulnerable areas should be shifted to other, more suitable areas. There are some plantation forests situated in lands suitable for agricultural activity. Upon harvesting the forests, these areas should be released for agriculture and forests relocated in hydrologically critical areas. The private companies, which deal with agricultural activities, must me encouraged to re-invest some of the income in soil conservation activities. Finally the soil conservation activities of various agencies must be brought under one umbrella and designated as the Soil Conservation Authority.

The fertility decline can be overcome by short and long term measures. Application of organic matter should be encouraged by helping to develop standards for compost. Better harvesting methods have to be introduced where other than the economic yield, the plant residues to be left in the field. As long term strategies, shifting cultivation must be discouraged, while agro-forestry models must be introduced in each agro-ecological region with availability of planting material of suitable species, knowledge of spacing and methods of pruning. The most environmental friendly way is converting urban waste to compost, which can be used to increase soil organic matter content. Where ever fertilizer is added, farmers must be encouraged to use recommended doses of fertilizers and liming material in acidic soils.

Proper monitoring of salinity levels in soils and irrigation water is a need, especially in the dry zone of Sri Lanka for reclaiming salt affected soils. Most of the drainage water is used again and again in irrigation and therefore proper monitoring is very essential. In addition to electrical conductivity values, further analysis must be done to find out the ionic composition of saline water. The drainage channels in irrigation systems must be cleaned regularly to facilitate drainage.

One of the major needs to manage soils in a sustainable manner is to have proper land use plans in the country at farmer, regional and national levels. This could be only achieved by developing a national soil database, which should be available for the planners, which is considered to be a major drawback in sustainable land use planning for the 21st century.

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