

Nature and Properties of Soils in Relation to Agroforestry

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Abstract

This paper explores current knowledge on relation between trees and soil, based on agroforestry systems research, and natural environment that demonstrates effects of trees on soil. Soil transects frequently show higher organic matter and better physical properties of soil under trees. Soil properties also govern that what type of plants grow in a soil or what particular crops grow in a region. Agroforestry establishes a symbiosis among agricultural crops, tree species and livestock raising. It is a land management system. Agroforestry systems are widely classified based on nature and arrangement of the components and ecological or socio-economic aspect. Agroforestry systems can be utilized in restoration of degraded land, wherein the interspaces between two rows of forest tree species are utilized for cultivation of grasses, legumes and other crops. Agroforestry has immense potential for carbon sequestration, improving soil quality and increasing productivity. **Keywords:** agroforestry, degraded land, carbon sequestration, soil quality, increasing productivity.

Introduction

The potential of trees to bring improvements in nutrition, income, housing, health, energy needs, and environmental sustainability in the agricultural landscape, with the presence of trees being the principal component is remarkable. Within the array of benefits brought by trees, an important element is the positive effect of trees on soil properties and consequently benefits for crops. This paper explores current knowledge as to this relation between trees and soil, based on agroforestry systems research and natural environments that demonstrate effects of trees on soil. The capacity of trees to maintain or improve soils by the high fertility status and closed nutrient cycling under natural forest, the restoration of fertility under forest fallow in shifting cultivation, and the experience of reclamation forestry and agroforestry. Soil transects frequently show higher organic matter and better soil physical properties under trees. Soils have many different properties, including texture, structure or architecture, water holding capacity and pH (whether the soils are acid or alkaline). These properties combine to make soils useful for a wide range of purposes. Soil properties govern what that

type of plants grows in a soil or what particular crops grow in a region.

About Soil:

“Soil is a dynamics natural body developed as a result of pedogenic processes during and after weathering of rocks, consisting of mineral and organic constituents, processing definite chemical, physical, mineralogical and biological properties, having a variable depth over the surface of the earth and providing a medium for plant growth for land plants” (Joffe, 1949).

“The soil is a natural body of mineral and organic constituents differentiated in to horizons of variable depth which differs from the material below in morphology, physical make up chemical properties and composition and biological characteristics”.

To the farmer; Soil is that portion of the earth's surface which he can plough and grow crops on to provide him with food and fiber for his own needs and that of his animals.

To the poor man; Soil is that forms the major ingredient of the mud walls of his house.

To the rich man; The same soil is used for making bricks to be used as building material.

To the potter; Soil is the raw material with which he fabricates earthen wares and utensils of daily use as well as objects of art.

To the sculptor; Soil is the basic material with which he carves his models.

To the civil engineer; Soil provides the foundation for all construction activity-roads, highways, buildings, runways, canals and drains etc.

The interest in soil as a natural body originated from its ability to produce and sustain crops.

Functions of Soils in our Ecosystem

In any ecosystem, whether your backyard, a farm, a forest, or a regional watershed, soils have five key roles-

- Soil supports the growth of higher plants.
- Soil properties are the principal factor controlling the fate of water in the hydrological system.
- The soil functions as nature's recycling system.
- Soils provide habitats for a myriad of living organisms.
- In human-built ecosystems, soil plays an important role as an engineering medium.

Formation of Soils from Parent Materials

The processes of soil formation that transform the lifeless regolith into the variegated layers of the soil profile.

By Weathering of Rocks and Minerals:

The process of weathering of rocks and minerals is the physical and chemical breakdown of particles by transferring agents from one place to another place.

Characteristics of Rocks and Minerals:

The rocks in the earth's outer surface are commonly classified as

- Igneous rocks
- Sedimentary rocks
- Metamorphic rocks
- Igneous rocks origin is formed from Molten Magma and includes such common rocks as Granite and Diorite.
- Igneous rock is composed of primary minerals such as light colored Quartz, Muscovite and feldspars and dark colored Biotite, Augite and Hornblende. Dark-colored minerals contain Iron and Magnesium and are more easily weathered. Therefore, dark-colored igneous rocks such as Gabbro and Basalt are more easily broken down than are Granites and other lighter-colored igneous rocks.

■ Sedimentary rocks consist of compacted or cemented weathering products from older, pre-existing rocks e.g. Quartz sand weathered from a Granite and washed in to the Ocean may settle on the ocean floor and eventually become cemented into a solid mass called Sandstone.

■ Metamorphic rocks are those that have formed by the metamorphism or change in form of other rocks through the high Heat and Pressure.

Soil Degradation / Wastelands

Loss of soil fertility and land degradation has been a serious problem due to water and wind erosion. Removal of forests cover, encroachment of forestland and excessive biotic interferences are the major reason has subsequently increased the pressure on the forests of India. It is estimated that about 12 million tons of soils are being removed annually in India through erosion (Vohra, 1985).

In olden days the wasteland was considered to be the vacant land, which was not used for agricultural crops or for other purposes.

Soil Science Society of America (1936) has defined "Land not capable of producing materials or services of value **"A miscellaneous land type."**

According to Hegde (1994) wasteland in the country include the degraded forests, overgrazed revenue wastelands, hilly slopes eroded valleys, drought stricken pastures, over irrigated 'Usar' and 'Khar' soils and water logged, marshy lands. Crop production on such soils is not economical at all.

Wasteland formation is the continuous process and causes of degradation as below:-

1. Soil erosion
2. Lack of greenery
3. Unlimited and non-systematic animal grazing (Over grazing)
4. Mis-management irrigation systems (Excess irrigation)
5. Insufficient water drainage (Compactness of soil)
6. Mining Activity
7. Industrialization (Urban Industrial life style)
8. Illicit felling of trees (Lopping of fodder and fuelwood, removal of forest floor & litter etc.)
9. Increasing population
10. Lowering of water table

According to World FAO the geographically 167 million hectare area out of the total geographical area 329 million hectare is affected with different degradation causes in India as below.-

Water erosion	-	30.3%
Wind erosion	-	16.8%

Alkaline and Saline - 02.4%

Approximately 50% land is affected by degradation. In the same manner approximately 2.1 hectare land is being tree less in every year which is very serious problems.

The causes of forest degradation are the over exploitation of resources, shifting cultivation, encroachment of forest lands, overgrazing, forest fires. The extent of degraded forest in the country is as high as 35.89 million ha which 46.6% of the total area of the country (Annon, 1993).

As per estimation of Singh and others (1992) the area of wastelands in India is approx. 175 million hectares. But accordingly NWDB (1985) has depicted 120 million hectare land as wasteland out of which 40 million hectare comes in forestland while remaining 80 million hectare in the agriculture land. If the rate of decreasing continued or efforts are not made for changes positively of its management same may cause several problems of food, fruits, fuel wood, and fodder.

Wasteland Position:

Planning Commission divided waste land in two parts.

(A) Agricultural wasteland-

1. Revine/Gully lands
2. Usar soils
3. Water logged soils
4. Desert soils
5. Barren lands & unutilized soils

(B) Non-Agricultural wasteland-

1. Rocky waste lands
2. High hills (Sloppy lands)
3. Ice lands

Total affected area is about 187.7 m. ha. (57.1%) out of 329 m ha land.

Soil is one of the most important natural resources to suffer as a result of tree cutting. If it is not protected, its productivity declines and it may become difficult to sustain the human and animal population even at its present level. Therefore, protection of this resource is important and an understanding of how this resource is influenced in an agroforestry system is necessary.

Improvement of Wasteland through Agroforestry

Agroforestry establishes a symbiosis among agricultural crops, tree species and livestock raising. In other words, these are complementary and beneficial to each other. Agroforestry has been defined in different ways -

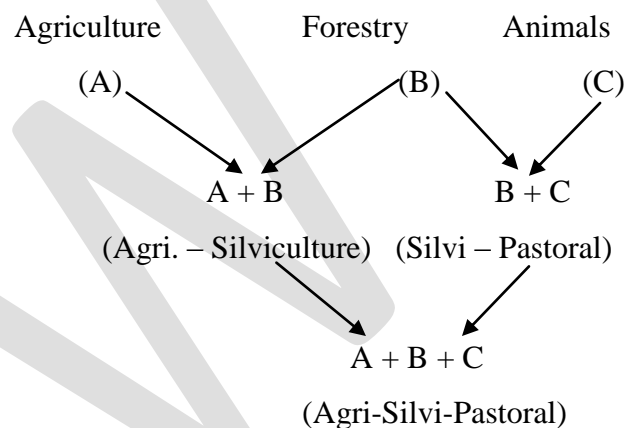
“Agroforestry as a sustainable land management system, which increases the yield of the

land, combines production of crops (including tree crops) and forest plants and or animals simultaneously or sequentially, on the same unit of land, and applies management practices that are compatible with cultural practices of the local population” (Bene *et al.*, 1977).

Agroforestry has three basic components.

1. Agricultural crops/herbaceous plants.
2. Woody perennials (tree crops/forest plants).
3. Animals.

When combined the above mentioned three components together form three basic agroforestry systems.



Again these three main agroforestry systems make another system as per requirements and availability of the resources to the particular regions in India. Agroforestry systems are widely classified based on nature and arrangement of the components and ecological or socio-economic criteria. But no single classification scheme can be accepted as universally applicable. The complexity of the problem can be reduced if the structural and functional aspects of the systems are taken as the criteria for categorizing the system and agro-ecological and socio-economic aspects as the basis for continuing them further.

Agroforestry Systems:

The main systems of agroforestry are as below.

- (i) Agri-Silviculture systems.
- (ii) Silvi-Pastoral systems.
- (iii) Agri-Silvi-Pastoral systems.
- (iv) Silvi-Horticulture systems.
- (v) Agri-Horticulture systems.
- (vi) Agri-Silvi-Horticulture systems.
- (vii) Multipurpose forest tree production.
- (viii) Apiculture with trees (Flowering trees + bee keeping).

(ix) Aqua-Silviculture or Aquaforestry (Fish + Tree).

(x) Agri-Silvi-Aquaculture (Tree + Crop + Fish).

These agroforestry systems provide food, fuel, fodder, manure, paper, pulp and packing materials for the rural people. Agroforestry systems can be utilized in all regions and these systems also are land management systems, wherein the interspaces between two rows of forest tree species are utilized for cultivation of grasses, legumes and other crops. Under arid conditions of Rajasthan, *Sesbania grandiflora* and *S. sesban* increase the storage production of *Cenchrus ciliaris*, *Setaria anceps* and *Chrysopogon fulvus* and provide higher yields when grown with *Eucalyptus hybrid*.

Promising tree species for salt affected soils

Alkali Soils	Saline Soils	Bio-drainage Species
<i>Prosopis juliflora</i> , <i>Acacia nilotica</i> , <i>Tamarix articulata</i> , <i>Casuarina equisetifolia</i> , <i>Eucalyptus tereticornis</i> , <i>Pongamia pinnata</i> , <i>Terminalia arjuna</i> , <i>Prosopis alba</i> , <i>Dalbergia sissoo</i>	<i>Prosopis juliflora</i> , <i>Tamarix troupi</i> , <i>Tamarix articulata</i> , <i>Acacia farnesiana</i> , <i>Acacia nilotica</i> , <i>Acacia tortilis</i> , <i>Casuarina glauca</i> , <i>Eucalyptus camaldulensis</i> , <i>Leucaena leucocephala</i>	<i>Eucalyptus tereticornis</i> , <i>Populus deltoides</i> , <i>Terminalia arjuna</i> , <i>Acacia auriculiformis</i> , <i>Syzygium cumini</i> , <i>Albizia lebbek</i> , <i>Dalbergia sissoo</i> , <i>Pongamia pinnata</i>

Salinity tolerant crops

High salt tolerant	Medium salt tolerant	Low salt tolerant
Sesbania	Castor	Linseed
Rice	Cotton	Sesamum
Sugercane	Sorghum	Sunhemp
Barley	Wheat	Pulses
Sugarbeet	Bajra	Pea
Oat	Mustard	Gram
Berseem	Maize	
Lucerne		
Fenugreek		
Senji		

Suitable trees and agriculture crops in Agri-silviculture systems

S. No.	Trees	Agriculture crops
1.	Babul	Muli, Gajar, Bhindi, Barbati, Palak, Tomato and Brinjal
2.	Safed Siris	Turmeric, Muli, Gajar, Bhindi, Barbati, Palak, Tomato, Urbi and Brinjal
3.	Poplar	Maize, Haldi, Arhar, Wheat and Sugarcane
4.	Shisham	Muli, Gajar, Bhindi, Barbati, Palak, Tomato, Guarfali and Brinjal
5.	Khamer	Wheat, Arhar, Maize, Bhindi and Guarfali
6.	Teak	Tomato, Brinjal, Guarfali, Gajar, Redish and Brinjal
7.	Eucalyptus	Wheat, Tomato, Brinjal, Guarfali, Gajar, Redish and Brinjal
8.	Melia (Drek)	Groundnut, Masoor, Mustard, Muli, Gajar, Bhindi, Barbati, Palak, Tomato and Brinjal

Conclusion

The natural resources such as land, water and vegetation occupy center-stage for the welfare and development of people. Besides increasing the tree cover, restoration of degraded lands through agroforestry has immense potential for carbon sequestration, improving soil quality and increasing productivity. Agroforestry is economically viable, environmentally sound, socially acceptable, sustaining soil health and biomass productivity, proven land use system meeting multiple needs of stakeholders for the utilization and improvement of salt-affected soils. Many of agriculture crops can be grown with multipurpose tree species and enhance the properties of soils through agroforestry systems.

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