



Agroforestry for Combating Land Degradation and Desertification in Dry Area of Bundelkhand Region

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Agroforestry is a farming system that integrates crops and or livestock with trees and shrubs. Agroforestry provides many benefits that includes favorable microclimate, reduction in erosion, enhanced biodiversity, increased water quality, more infiltration leading to effective groundwater recharge, enhanced and elongated dry flow, improvement in habitat, soil fertility, etc. Agroforestry is promising for a sustainable solution in response to soil conservation, land degradation, and also can bridge the gaps between climate change and mitigation strategies. Agroforestry has the immense capacity to provide sustainable agricultural benefits and approximately 1.2 billion people of the world is practicing agroforestry one way or the other way. It has high potential to balance between the demands and requirements of population growth and natural degradation. The present review investigated the potential and opportunities of agroforestry in combating soil and water degradation and the role of agroforestry in climate change mitigation.

Characteristics of Trees suited for Agroforestry system

The properties, which are likely to make a woody perennial suitable for agroforestry system in a water shed, are that it Should be a Multipurpose tree, having a nitrogen fixing tree property, it should possess thick and dense crown in conical shape, A well-tailored root system with deep roots, dense fine roots and abundant mycorrhizal association, Resistance to severe pruning and high leaf biomass production, A reasonable balanced nutrient content in the foliage, Rapid and faster litter decomposition to enhance nutrient release, Absence of toxic substances in the litter or root residues, Resistance to pests and diseases, Tolerance to protracted moisture stress, Low invasive ness, Satisfy Productive functions or service functions other than soil improvement.

Land degradation

Land degradation is one of the major ecological issues of the world. Land degradation means the decline in the soil's productivity through adverse changes in nutrient status, soil organic matter, structural attributes, and concentrations of electrolytes and toxic chemicals. Land degradation leads to the losing the capacity of a given land to support the growth of useful plants on a sustained basis, land degradation is the temporary or permanent lowering of the productive capacity of land. Land degradation may occur through different physical, chemical and biological processes which are directly or indirectly induced by human activities. Main Causes of land degradation include inappropriate agriculture practices, deforestation, overgrazing, careless Forest management, improper irrigation, increasing biotic pressure, improper management of industrial effluents and wastes, surface mining, urban extension, and commercial/industrial development. Inappropriate agricultural practices include excessive tillage and use of heavy machinery, excessive and unbalanced use of

inorganic fertilizers, poor irrigation and water management techniques, pesticide overuse, crop residue burning, inadequate organic matter inputs and poor crop cycle planning. Social causes of land degradation are land shortage, decline in per capita land availability, economic pressure on land, land tenancy, poverty and population increase while natural causes include earthquakes, tsunamis, droughts, avalanches, landslides, volcanic eruptions, floods, tornado, and wildfires.

Agroforestry Systems Suitable for Degraded Lands

Agroforestry is mainly practiced on degraded landscapes, which otherwise remain unutilized and, therefore, play a very vital role, particularly in developing countries. Agroforestry encompasses a wide range of approaches and technologies for restoring degraded lands, thereby contributing to landscape restoration. Agroforestry systems, particularly in degraded landscapes, not only have enormous benefits in the provision of food for local people but also provide multiple environmental services and influence the sociocultural values. Some agroforestry systems suitable for rehabilitating or restoring degraded landscapes affected by soil erosion, salinization, physical degradation, loss of nutrients and/or soil organic matter (SOM), waterlogging and mining are briefly discussed in the following sections.

- 1. Agroforestry for Reduced Soil Erosion:** In India, the sloping lands are planted with alley crops, such as *Gliricidia sepium*, *Leucaena leucocephala*, *Cassia siamea*, *Morus alba*, and *Cajanus cajan*, and fodder grasses as intercrops. In North China, *Ziziphu sjujuba* is intercropped with agricultural crops and is an important pattern of agroforestry, which is distributed widely throughout the whole country. Agroforestry is the most effective way to restore the degraded lands on the Loess Plateau and to develop the poor local economy. Green manure crops are also grown in space left behind the trees.
- 2. Agroforestry for Degraded Dry lands:** At global level, 349.6 million ha of land in arid zone are affected by light to moderate degree of soil degradation and 42.8 million ha by strong to extreme. Sand dunes are dominant land formation principal of hot arid zone (Africa accounts for 46.1% followed by Asia 35.5% and the rest 19.4% spread over in Australia and North America). The hot Indian arid zone (Thar Desert) is spread in 31.7 million ha. More than 34% (11 million ha) of the total area of Indian hot arid region is covered by drifting or semi-stabilized sand dunes, sometimes up to 100 m in height, however, their intensity varies from place to place. The most important measures for sand dune stabilization are covering the area under trees and providing a surface cover of grasses followed by their protection against biotic interference. Besides fixing the sand dunes, it is important to check the movement of loose sand by applying windbreaks and mulch. Locally available brush woods like *Leptadenia pyrotechnica*, *Ziziphus nummularia* and *Aerva tomentosa* and grasses like *Cenchrus sciliaris*, *C. setigerus*, *Lasiurus indicus* and *Saccharum munja* are being used frequently. In arid regions, *Prosopis cineraria*-based Silvopastoral system has been found most suitable for sand dune stabilization in Thar Desert of Indian subcontinent. *Acacia tortilis*, *A. senegal*, *Calligonum polygonoides*, *Ziziphus nummularia*, *Carissa carandas* and *Haloxylon salicornicum* among woody species are found useful in these habitats. The Silvopastoral systems in arid regions is considered as lifeline for the poor stakeholders of the region. The vegetation for sand dune stabilization is highly drought tolerant with deep root system capable of extracting moisture from lower soil depths.
- 3. Agroforestry Systems for Acidic Soils:** Acid soils occupy approximately 30% of the world's total land area and it has been estimated that over 50% of the world's potential arable lands are acidic, Aluminum (Al) in these soils is solubilized into ionic forms, especially when the soil pH falls to lower than 5. These ionic forms of Al have been shown to be very toxic to plants, initially causing inhibition of root elongation by

destroying the cell structure. On the other hand, phosphorus (P) is easily fixed by clay minerals that are rich in acid soils, including various iron oxides and kaolinite, and hence rendering it unavailable for root uptake. Thus, increased solubility and toxicity of Al, Mn and Fe, deficiency of Ca and Mg reduced availability of P and Mo, and reduced microbial activity with decreasing pH are the characteristic features and constraints for crop production in these soils. In India, acid soils cover an area of about 90 million ha out of which about 7% are strongly acidic (pH < 4.5), about 28% are moderately acidic (pH 4.5–5.5), and rest 65% are slightly acidic (pH 5.5–6.5).

- 4. Silvopastoral Systems on Degraded Lands:** Silvopastoral systems are agroforestry arrangements that purposely combine fodder plants, such as grasses and leguminous herbs, with shrubs and trees for animal nutrition and complementary uses. Silvopastoral systems are part of traditional farming systems throughout India for the various ecological benefits, including sustainability. The main SPS comprises scattered trees in pasturelands timber plantations with livestock grazing areas, pastures between tree alleys, windbreaks, live fences and fodder banks with shrubs. Agroforestry can diversify and increase agricultural production while also providing land users with other economic, social and environmental benefits.

Desertification

It is a serious environmental problem and it potentially affects 35% of the land surface of earth and 32% of the human population. Desertification is land degradation in arid, semi-arid and dry sub-humid areas and includes degradation of vegetation cover, soil degradation, and nutrient depletion. Over cultivation, increased fire frequency, over drafting of groundwater, livestock grazing, deforestation, water impoundment, poor irrigation management, increased soil salinity, and global climate change are the main causes of desertification. The different processes involved in desertification include wind erosion, soil erosion, salinity-alkalinity, and waterlogging. Desertification occurs when the tree and plant cover that binds the soil is removed. It occurs when trees and bushes are stripped away for firewood and timber, or to clear land for cultivation. It occurs when animals eat away grasses and erode topsoil with their hooves. It occurs when intensive farming depletes the nutrients in the soil. Wind and water erosion aggravate the damage, carrying away topsoil and leaving behind a highly infertile mix of dust and sand. Africa, Asia, Latin America, and the Caribbean are the most threatened regions by desertification. The impacts of desertification include environmental impacts, economic impacts, and poverty and mass migration. A number of methods have been used in order to reduce the rate of desertification. These methods include restoring and fertilizing the land, reforestation, developing sustainable agricultural practices, and adopting different agro forestry system.

Beneficial effect of Agroforestry in rehabilitation of degraded land

Agroforestry systems involve planting of multipurpose leguminous trees that are tolerant of adverse soil conditions and suggested as a management option for reclamation of degraded area. Agroforestry has potential for improvement in the physical, chemical and biological conditions of soils through reduction of loss of soil by reduction of run-off, addition of organic carbon, nitrogen enrichment by nitrogen fixation through nitrogen-fixing tree and shrubs, improvement of physical conditions of soil such as water holding capacity, permeability, drainage, etc., release and recycling of nutrients by affecting biochemical nutrient cycling, more microbial associations and addition of root biomass, moderately effect on extreme conditions of soil acidity and alkalinity, creating more favorable microclimate by windbreak and shelterbelt effect and lowering effect on the water-table in areas where the water table is high

Conclusion

Land degradation is a major problem which threatens ecological health, social stability, and economic prosperity because it corrodes the three pillars of sustainable development: environmental, social and economic sustainability. Agroforestry, an association of trees and shrubs with crops, livestock or other factors of agricultural productions, holds great promise to rehabilitate degraded land and promote afforestation to support livelihoods, improve food security, restore ecosystem services and ease pressure on forests on the sustainable basis but achieving these gains is not easy. Selection of suitable species, selection of appropriate technology, sufficient inputs and effective organization etc. should be kept in mind during the initiation of agroforestry program minimizing the land degradation. Agroforestry systems which provide solutions for today's land degradation problems will need to evolve in both diversity and intensity if they are to remain relevant and effective for future.