AGROFORESTRY

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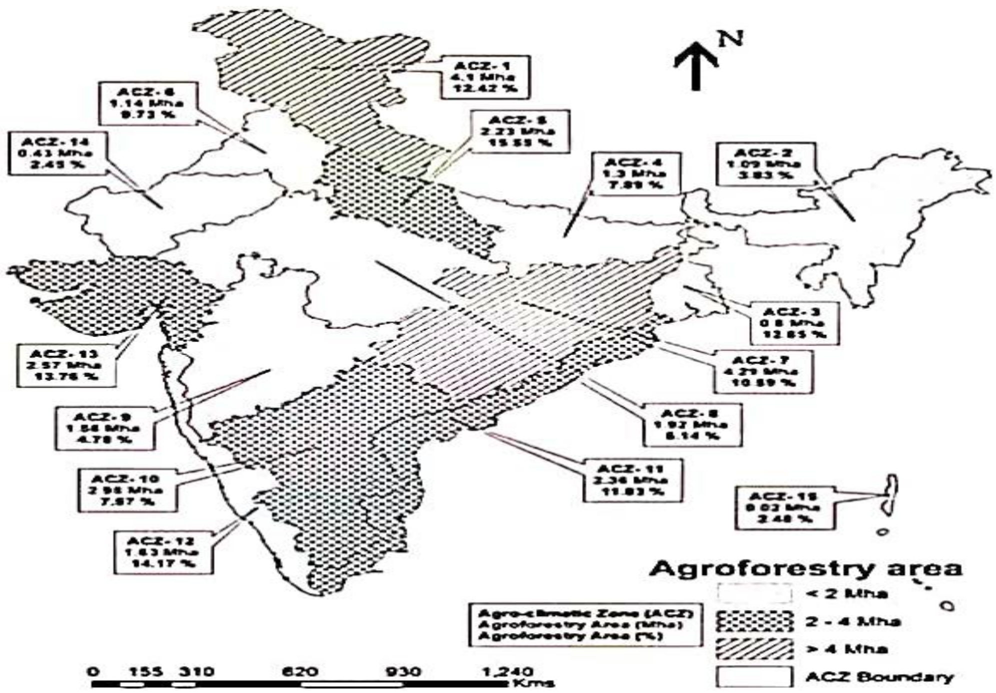
INTRODUCTION :-

The System of raising trees along with agricultural crops has been in vague in forest department for over 100 years. The usual practice has been lease out the land to the cultivators to raise cereal crop after the annual crop has been felled and exploited.

According to Torres (1983) Agroforestry can be defined as the deliberate combination if trees with crop plantation or pastures, or both in an effort to optimize the use of accessible resources to satisfy the objectives of the producer in a sustainable way.

Lundgrean and Raintree (1983) stated that Agroforestry is a collective name for land use system and technologies where woody perennials (Trees, shrubs, palms, bamboos etc.) are deliberately on the same land management unit as agricultural crops and animals, either on the same farm of spatial arrangement or on temporial sequence.

According to Walt (1989) "Agroforestry" has two dimensions. One is the way of thinking. It means looking for ways to maximize the production from land using a mixture of wood fibre, wildlife, recreation and farm crops, both plant and animal, to make the biggest buck possible consistent with keeping the land productive. The second dimension echoes the first. It is the actual management of land according to this ethic.



POTENTIALS OF AGROFORESTRY:-

1. FOOD AND NUTRITIONAL SECURITY

a. Homegarden

The best example of food and nutritional security is provided by homegarden. It is an old age practice in which coconut, arecanut, guava, mango, citrus, tamarind, jackfruit, papaya, banana, moringa, sesbania, custard apple and many multipurpose trees are grown. They provide fruits, vegetables and many of them also support climbers such as betel nut, pepper and cucurbits. Clove and cinnamon are also grown sometimes. In Kerala, coffee and cocoa are quite frequent. Among food crops arrowroot, cassava, dioscorea, sweet potato, taro, elephant-yam and vegetables are frequent. Cardamom, cinnamon, clove, ginger, nutmeg, pepper and turmeric are expensive spices. Pineapple is commonly grown fruit as ground storey crop. Kapok (*Ceiba pentandra*) is common tree along the boundary providing fibre from its fruits. Cattle and backyard poultry are the main components of homesteads therefore, sometimes forages like stylo *(S. guianensis*, *S. hamata*), guinea grass, guatemala, napier and kazungula grasses are also grown frequently.

These trees integrated in the system include mango, teak (*Tectona grandis*) a few jack trees (*Artocarpus spp*.) *Casuarina equisetifolia*, *Ceiba pentandra*, *L. leucocephala*, *Grevillea robusta*, *Bambusa arundinacea* and *Erythrina indica* and *Gliricidia sepium* (both good support to black pepper). *Thespesia populnea* is common in low-lying homesteads and its wood is commonly used for agricultural implements. Mangroves form an essential part of the homesteads of backwater areas in low lands. These are commonly used as fuel wood and provide energy for aquatic or marine food. Coconut and pandanus (*P. ectorius*) can be commonly seen near canals and back waters. Palmyrah palm (*B. flabellifer*) is common multipurpose palm in coastal Andhra Pradesh where, each part of the plant is used in one or in other way. It yield fruits, the germinating radicals are eaten as sweet potato, vinegar, sugar, beverage, and fuel and thatching material. Fish and shrimp culture in backwater channels and in association with mangroves is the main activity

b. Agrohorticulture

This system provides sound farm economy, improved nutrition and health standards of the family and stability of income. In arid region most commonly grown fruit crops are ber (*Ziziphus mauritiana*), pomegranate and anola (*Emblica officinalis*) and intercrops like mung bean, moth bean and cluster bean are grown every year. In semi arid situations mango, sapota (*Manilkara zapota*), guava (*Psidium guajava*), tamarind, cashew, ber and jackfruit are generally grown with crops. Other fruit tree species like phalsa, wood apple, passion fruit, guava etc. are potential alternative for the systems. For Hilly region peach and citrus species are commonly used. A coconut based system prevalent in Andhra Pradesh, Tamil Nadu and Kerala.

c. Agrisilviculutre

The intercropping arrangement of annual food crops and woody perennials in a land use system that tries to enhance productivity and ensure sustainability. At the same time it helps stabilize slopes, minimize erosion and fill some of the farm needs for fuel wood, poles, small timber, fruits and nuts or organic manure and fodder, Agrisilviculture combination depends on the soil, environment and socio-economic conditions of the region.

2. SOIL FERTILITY

In agroforestry, nutrient absorbed by roots from deeper soil layer add in upper surface of soil through leaf litter. Tree roots are harbour many useful organisms and encourage beneficial microbial activity in the vicinity of roots or rhizosphere. Nutrient cycling is another way in which trees draw a large portion of absorbed nutrients from deeper soil layer is returned to soil through crown wash, stem flow and litter fall. The accumulated litter after decomposition releases nutrients for reuse by tree stand. The role of trees in soil productivity improvement is a focal point in ecosystem management aspects. In organic matter addition to the soil, tree roots play an important role and about 25 per cent of the total living biomass of the trees is in roots that add organic matter to the soil through dead and decaying roots.

Trees for soil improvement should possess certain qualities to sustain the fertility status and these are:

1. A high aboveground biomass production.
2. A high rate of nitrogen fixation.
3. A dense network of fine roots either with abundant feeder roots or a capacity for mycorrhizal association.
4. The existence of some deep roots.
5. A moderate to high balanced nutrient content in foliage.
6. An appreciable nutrient content in the root system.
7. Absence of toxic substances in the foliage and root exudates.
8. A capacity to grow on poor soils.

Tree Roots: Role in Soil Fertility

In agroforestry, the role of trees in soil productivity improvement is a focal point in ecosystem management aspects. In organic matter additions to soil, tree roots play an important role. About 25 per cent of the total living biomass of the trees is in roots and there is a constant addition of organic matter to the soil through dead and decaying roots, although it has been recognized that major addition of organic matter to soils is through litter, which constitute nutrient absorbed by roots from deeper soil layer. Tree roots horbour many useful organisms and encourage beneficial microbial activity in the vicinity of roots or rhizosphere. The nitrogen fixing capacity of nodulative organism of the genus Rhizobium and Brady Rhizobium is well known. Some non-leguminous trees, in association with frankia, also exhibit the nitrogen fixing capacity. The common Casuarina belongs to this category. The nitrogen fixing capacity of trees vary widely as some species fix very high amount and some species fix very low.

3. ALLEYCROPPING

In hedge row intercropping also called alley cropping, the tree component is made up of a single or multiple rows of trees but essentially it has to be a dense hedgerow so as to be effective in reducing runoff, increasing infiltration and reducing soil loss through the barrier effect. Variables could be in terms of hedge rows, spacing between hedge rows or width of cropped alleys and management of pruning. Leucaena has been the most common and widely use species and to some extent Gliricidia has been used for hedge row planting. Extensive studies on agronomic and fertility aspects of alley cropping systems have been made by Kang *et al.,* 1984, Kang and Duguma, 1985; Kang *et al.,* 1985 at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, but the effects of alley cropping systems on runoff and soil erosion, nutrient loss, moisture retention and availability to plants, etc. were not studied.

Lal (1989 a & b) reported the results of agroforestry systems and soil surface management of a tropical alfisol on water runoff, soil erosion, and nutrient loss, conducted at ITTA, Ibadan, Nigeria, during 1982 to 1987. Soil moisture content in 0-5 cm layer in agroforestry system was generally higher than that in the control during both wet and dry seasons. Hedge rows essentially served as wind breaks and decreased soil moisture evaporation. Once established hedgerows of Leucaena at 2 m spacing were extremely effective in reducing water run off and controlling erosion. In consist to runoff and erosion, losses of bases (Ca, K, Mg and Na) in runoff from agroforestry treatments were relatively high as compared to non- agroforestry systems, probably due to nutrient recycling by deep rooted perennial shrubs. In their alley cropping studies conducted in the semi-arid tropics, Singh et al., 1989a and 1989b found that moisture competition between hedgerow of Leucaena and associated crops is the major problem especially in drier areas, particularly at close hedgerow spacing.

In the humid zone on acid soils, competition between the hedge rows and crops for nutrients (in addition to light) can be very severe (Kang, 1993). Productivity of annual cropping and agroforestry systems on a shallow alfisol in semi-arid India was studied by Rao et al., 1991 for four years, 1984 through 1988 at ICRISAT. Leucaena suppressed crop yields due to competition for moisture and the severity of competition was high in years of low rainfall and on long duration crops such as castor and pigeon pea. There were indications that alley cropping was beneficial in terms of soil and water conservation with less runoff and soil loss with 3 m alleys than with 5.4 m alleys and root pruning or deep ploughing might be effective in reducing moisture competition.

In semi-arid tropics, the positive effect of alley cropping either for increasing crop yields through improved soil fertility (Singh *et al.*, 1989a) or for increasing biomass production under adequate fertilizer use (Rao *et al.*, 1991), was not obtained. It was explained that the competition of hedgerows with crops for soil water was the main reason for the disappointing results (Singh *et al.*, 1989b). Studies on alley cropping of sorghum with Leucaena during the post rainy reason conducted on vertisols, in semi-arid India, confirmed that alley cropping did not result in increased crop yields because of competition for water between hedge rows and crops. Korwar and Raddar (1997) concluded that the tangible benefits of alley cropping in terms of productivity (LER) are small (20% at o Kg N level and no advantage at 50 Kg N level per ha.), but, in terms of intangible benefits, advantages of alley cropping in soil and moisture conservation in low rainfall areas are definitely there. So, alley cropping might be advantageous in the long run.

4. WATERSHED

Sustainable management of natural resources of land water and vegetation is essential in providing livelihood and environmental security. Ever-increasing demographic pressure coupled with developmental activities are causing tremendous pressure in the utilisation of these resources, leading to various kinds of epokiginal problems, such as droughts foods, landslides, mine spoils, siltation of reservoirs, deterioration of water bodies, s of biodiversity etc. The increasing frequency of these problems is the outcome of excessive biotic and abiotic interferences, which have resulted into considerable degradation of our natural resources. The rapid rate of deforestation is the key factor in increasing the frequency of floods. Deforestation of watersheds, especially around smaller rivers and streams, increases the severity of flooding, reduces stream flows and dries up springs during dry seasons and increases the load of sediment entering the waterways. Ever increasing demand for food and fodder has resulted in conversion of forests and exploitation of fragile and marginal lands into agriculture, migratory grazing and shifting cultivation practices.

Watershed Management

Availability of water in a given soil environment is a critical factor which is adversely affected through surface run-off, erosion, and siltation, due to loss of beneficial plant cover, water management is best done on a natural unit, watershed which a distinct drainage basin of any small or big water course or stream, nullah etc. The rains falling over watershed areas will flow through only one point of exit of the whole watershed. In other words, the area will be drained by only by one stream or water source. Thus, this broadly encompass availability of entire water resource which can be utilised through dug wells, tube wells, small farm ponds, bigger tanks or reservoirs, etc. Siltation prevention is one of the critical factors for the proper management of the water reservoir. About 914 priority watershed of the flood prone areas and 4246 micro-watersheds had been identified in 1982-83. Stabilisation of watersheds, is recommended to be achieved through massive afforestation programmes. Agroforestry systems mimic the major functions of forestry in respect of watershed afforestation. Thus adoption of agroforestry practices is expected to provide the same benefits that are achieved through afforestation.

It is well accepted that aim of management of watershed should be higher productivity of the land in the catchment areas in addition to its traditional aim to prevent surface run-off and soil erosion. Agroforestry approach to watershed management brings about the potential role of trees/shrubs to alleviate some of the physical and economic constraints. Agroforestry mimics the beneficial aspects of forests, horticulture and agriculture in reducing soil erosion, surface run-off, siltation loads of water courses, and nutrient loss of the soil Further, agroforestry system brings about less solar radiation, low soil temperature, higher ambient soil moisture in summer months, improved soil organic matter, soil pH, lower incidence of pests and diseases of crops, and overall improvement in macro and micro-climate. All these are conducive to the holistic management of watershed through judicious admixture of various biological components that would promote an integrated management system so that the system produces goods and services to fulfil the demand of the society.

Agroforestry in Relation to Water Resource Conservation: Issues and Challenges

Agroforestry is conducted by making choices of combinations of species that will grow and interact in ways that provide the desired products and other benefits of management. The different species can coexist if there is an appropriate portioning of resources between them (Caldwell and Pearcy, 1994).

The safest choices of agroforestry species are likely to come from the native vegetation, which has a history of adaptation to local precipitation regimes. In India there are a number of tree-crop combinations, which in turn reflect the differences in the climates and soil fertility of various regions (Sharda *et al*., 2001). The examples of major trees in tree crop combinations are (1) *Grewia optiva* and *Alnus nepalensis* in northern region; (2) Populus, Eucalyptus, Mangifera and *Dalbergia sissoo* in Indo-Gangetic region; (3) *Azadirachta indica*, *Acacia nilotica* and bamboos in Central India,; (4) *Acacia nilotica*, Prosopis cineraria and Zizyphus in Western India; (5) *Tectona grandis, Tamarindus indica,* Para rubber (*Havea brasiliensis*) and cashew nuts; in southern region and (6) Artocarpus, *Azadirachta indica*, *Casuarina equisetifotia* and bamboos in coastal and island region. This would correspond to the high rainfall levels and long rainy seasons in the south, with drought periods comparatively longer for the regions to the West, Indo-Gangetic and Central.

Water is more limiting in regions with seasonally dry soils. In these regions root competition among different components restricts above ground growth. In more severely limiting circumstances root competition among trees, for water is intense. Though tree canopies are open above ground, below ground growing space is fully occupied by roots. In such situations vertical stratification of roots is prevalent with canopy tree species having deep root systems that seek groundwater aquifers, while under story grasses and shrubs more effectively acquire surface water from seasonal rains and often avoid droughts by dormancy and dieback (Ashton and Ducey, 2000).

Agroforestry provides opportunities to link water conservation with soil conservation. Agroforestry has both positive and negative aspects in the management of soil water. In one hand agroforestry can increase water availability to land use systems, on the other hand, tree-crop competition for water reduces the benefits of agroforestry systems particularly in semi-arid and dry sub-humid zones. Young (1997) enlisted means by which positive aspects, may be achieved through agroforestry as,

• Increasing water uptake by using water from different sources at different times of the year-specifically, uptake from depth during dry periods by the root systems of trees;

• Reducing loss by evapo-transpiration, through shading by the canopy and by litter, and reduction in wind speed as in case of windbreak; Reducing loss by runoff and so increasing uptake by infiltration as in contour hedgerows.

5. ALTERNATIVE LAND USE IN RAINFED AREAS

Of the total arable area of 142 m ha in India, 97 m ha is rainfed. Rainfed agriculture contributes 44 per cent food and supports 40 per cent of the population) Excluding maize, cultivation of 92 to 95 per cent of the coarse cereals is rainfed. These regions support 84 per cent groundnut, 91 per cent pulses, 55 per cent rice, 68 per cent cotton and 22 per cent wheat. Productivity of rainfed crops continues to be low, it is one half to one third of that obtained with irrigated crops. Continued population growth has led to the cultivation of marginal and sub-marginal lands that exposes degradation processes apart from low and uneconomical yield. Monocultural cropping systems especially when done improperly often cause rapid degradation of arable land and hold little promise of coping with the needs of increasing human and livestock population. Drylands are characterized by high soil and climatic variability, excessive degradation of soil resources, undulating physiography, poor entrepreneurial ability of the farmers, fragmented smallholdings and absentee ownership.

Climate and soil are the key resources that influence the choice of farming enterprises in rainfed regions. Of the 400 m ha m rainwater received annually, the south-west monsoon contributes 74 per cent to the total precipitation. Only 3 per cent is brought by the north-east monsoon. Pre-or post-monsoon rains add the remainder 23 per cent. With the exception of typical arid eco-zones, rainfall is less often limited in quantity. Its high variability and unreliable distribution are matter of concern for crop production. In tropical environments, rain is received in big storms followed by dry spells that promote drought and crop failures.

Soils of dryland areas are extensively degraded. Undulating topography is a familiar feature of drylands. Soil biological potential has diminished due to over exploitation and improper use. In India, 167 m ha constituting half of the total geographical area suffers from degradation of one kind or the other. In order to prevent further land degradation it is necessary to plan land capacity based cropping and management. Further degradation of sub-marginal lands can be effectively arrested with perennial pastures, trees or their combination with arable crops. In a watershed, the common denominator of rainfed agriculture development, soils of varying capability occur side by side. Normally, soils of varying depth follow a toposequence. For instance, bottom-lands are deep with a flat plane. These are suited to arable farming. Soil depth decreases towards hill top, which can be successfully utilized for perennial arboreal plants. Alternative land use technologies and management strategies are therefore necessary to sustain rainfed agriculture. The hallmark of such an approach is to optimize resource use by enhancing biological productivity and profitability by maintaining the quality of resource base.

Thus, a necessity has arisen to make the best use of land based on its supporting ability keeping in view the short term and long term aspect of the sustainability. The short term refers to the market demand, profitability and the long term denotes the soil health, microclimate, and protection and enhancement of ecosystem at large (Price, 1995) Alternative land use is different from the conventional or the existing land use and may be defined as "effective, appropriate and economic utilization of land without harming the natural resource base". (Alternative land use practices essentially involve a perennial component to impart stability in production from farmlands, as perennials are known for drought tolerance or avoidance characteristics and can withstand late onset or early withdrawal of monsoon and, prolonged dry spells that are akin to drylands.

Network research carried out in India revealed that alternative land use involving perennials (tree/crop, grass shrub or a combination of both) has advantages and conserve natural resources and increase productivity. Some of the advantages perennials are as follows:

- Provides permanent vegetative cover to the soil or land surface and thus substantially control erosion caused by both water and wind.
- Improves microclimate.
- Provides good quality green fodder, which is in short supply to support livestock
- Protects the environment and upgrade soil quality through their deep root system enhances organic matter through litter fall and root turnover.
- Reduces surface evaporation and weed growth and improve water use efficiency and adds nutrients to the soil when pruned material is used as mulch.
- Ensures rational utilization of soil moisture stored in deeper soil layers and substrata through the tree component.
- Provides fuel, timber and minor forest products (e.g. gum) and thus lessens the farmers dependence on forest reserves.
- Supplements the diet of poor farm families by giving the necessary vitamins and minerals, and thus contributes to their nutritional security.
- Generates much needed cash when aromatic and industrial value plants are grown.
- Supports development of soil microbe and earthworm activity.

6. IMPACT OF AGROFORESTRY ON VILLAGE

The huge population in India brings about resource constrain. The land area of the nation being fixed, rapidly increased population coupled with the developmental schemes has necessitated diversion of forest land for non forest uses to a large extent.

The rural people including tribals living in forest areas are dependent upon the forests in several ways. Tribal life and the forest are so closely related that tribals can't visualise life without forests. The twenty-point programme (1986) has delineated a large number of activities in support of struggle against poverty. However, the mutually supportive package of self employment (IRDP, TRYSEM, DWERA) Wages - employment (NREP, RLEGP) and (JRY) and, area development under DPAR/DDP constitute the areas of poverty alleviation strategy.

Agroforestry can have a significant positive impact on villages and the socioeconomic status of people living in rural communities. Here are some of the key impacts:

1. Improved Livelihoods: Agroforestry provides additional income opportunities through the sale of tree products, such as fruits, nuts, timber, and medicinal plants. This diversification of income sources can lift families out of poverty and enhance their overall socioeconomic status.

2. Food Security: By incorporating trees and crops, agroforestry systems can enhance food production and improve the availability of nutritious foods. This can lead to better nutrition and food security.

3. Environmental Protection: Agroforestry practices promote sustainable land management, leading to better soil health and reduced erosion. This helps protect the environment, ensuring the availability of natural resources for future generations.

4. Community Resilience: Agroforestry enhances the resilience of rural communities to climate change and natural disasters. The diversified farming systems are more robust and better equipped to withstand extreme weather events, ensuring a stable livelihood for villagers.

5. Access to Fuel wood and Timber: Agroforestry can provide a sustainable source of fuel wood and timber for villagers, reducing the pressure on nearby forests and promoting responsible resource management.

6. Social Cohesion: Agroforestry often requires cooperation and collective efforts within the community. By working together on these projects, social cohesion and community bonds can be strengthened.

7. Knowledge Transfer: Implementing agroforestry practices can involve training and knowledge sharing among community members, empowering them with valuable skills for sustainable farming and natural resource.

7. ALLELOPATHY

Allelopathy is generally associated with interaction between living plants, a significant role in plant-plant interaction. Growing environmental and public health concern from the use of agricultural chemicals (pesticides) in agriculture has stimulated interest in the search for new and environmentally safe technologies for effective inhibition of weeds (Rice, 1994).) Allelopathy refers to the beneficial or harmful effects of one plant on another plant, both crop and weed species, from the release of bio-chemicals, known as allele-chemicals, from plant parts by leaching, root exudation, volatilization, residue decomposition, and other processes in both natural and agricultural systems. Also refers to the inhibition of growth of one plant by chemical compounds that are released into the soil from neighbouring plants.

Allelopathy in natural weed management

Allelopathy may be a successful tool to manage weed infestation in agricultural production, if it can be exploited appropriately in a rotational cropping system (Khanh *et al.*, 2005a). However, in the case of trees, it is difficult to apply the concept of rotation; therefore, enhancing weed suppression by trees itself through litter fall and isolation of natural plant product may be among the most feasible means of controlling weeds. The isolation and identification of allelochemicals responsible for weed suppression by trees may be helpful for understanding the chemical interactions of trees and other plant communities. Allelopathic suppression of weeds is receiving greater attention in recent years as a possible alternative for weed management. Numerous crops have been investigated for allelopathic activity towards weeds. A suppressive effect on weed, possibly mediated by therelease of allelopathic compounds has been reported for a wide range of temperate and tropical crops. These include alfalfa (*Medicago sativa*), barley (*Hordeum vulgare*), clovers (Trifolium species, Melilotus species), brassica, eucalyptus, sesamum, tobacco, oats, rye, sorghum, sunflower and wheat (Narwal *et al*, 1998) Allelopathy can be used in weed management in different ways. The first is by selecting an appropriate crop variety or incorporating an allelopathic character into a desired crop variety. The second way is by applying crop residues and straw as mulches or growing an allelopathic variety in a rotational sequence that allows residues to remain in the field. The third way is use of allelochemicals as natural herbicides (Rice, 1995).

SUMMARY:-

In this chapter we came to know about various prospective of agroforestry which can play an important role in the ecosystem. The best use of agroforestry can be still utilized in various fields as mentioned like medicinal purpose, food security, etc. It has a very good potential in increasing the standard of living of farming community and henceforth the farming community need to be adopt agroforestry in an effective manner.

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