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Potential of Agroforestry in Biodiversity Conservation

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Abstract: **India is one of the seventh largest country and 17 mega diverse countries and shares 8 per cent in world's biodiversity. The basic needs of the country's 1.210 billion human population which accounts 16.7 per cent of the world's human population (Census, 2011) are mainly based on the biodiversity and their services. The increasing human and live stock population increases pressure on the natural resources and causes their degradation and biodiversity loss as well. Agroforestry is very complex system and has potential to conserve biodiversity. Through different beneficial effects and components diversification helps in biodiversity conservation.**

Key words: Biodiversity, Diversity Levels, Diversity Measures, Agroforestry, Protected Area Network

I. INTRODUCTION

Biodiversity is the totality of genes, species and ecosystems in a region. It includes all organisms, species, and populations; the genetic variation among these; and all their complex assemblages of communities and ecosystems. First time, it was defined by Norse and McManus (in 1980) and the term coined by Walter Rosen in the year of 1986. It also refers to the interrelatedness of genes, species, and ecosystems and their interactions with the environment. Usually there are three levels/elements/ types of biodiversity [1, 2].

- **Genetic diversity** is all the different genes contained in all individual plants, animals, fungi, and microorganisms. It occurs within a species as well as between species.
- **Species diversity** is all the differences within and between populations of species, as well as between different species.
- **Ecosystem diversity** is all the different habitats, biological communities, and ecological processes, as well as variation within individual ecosystems.

A. Biodiversity in India

India, a mega-diverse nation, is one of the richest in terms of biological diversity and ranks among the top ten species-rich nations and shows high endemism [3, 4]. Country has a great diversity of natural ecosystems in fertile river plains, coastal region, Deccan plains and Himalayan region. The diverse physical features and climatic situations have formed ecological habitats like forests, grasslands, wetlands, coastal and marine ecosystems and desert ecosystems, which harbour and sustain immense biodiversity. Following points gives biodiversity potential of the country [3, 4, 5, 6, 7].

- Nearly, 91212 species of animals (7.43% of the world's faunal species) and 45500 species of plants presents in 10 bio-geographic regions
- More than 300 wild ancestors and close relatives of cultivated plants
- Four global biodiversity hot spots (Eastern Himalaya, Indo-Burma, Western Ghats and Sri Lanka and Sundaland)
- Endemic rich fauna is manifested most prominently in Amphibia (61.2%) and Reptilia (47%)
- India, being third largest fish producer in the world, includes two endemic families and 127 monotypic genera
- As per the International Union for Conservation of Nature (IUCN) Red List (2008), India has 413 globally threatened faunal species, which is approximately 4.9 % of the world's total number of threatened faunal species
- **New discoveries** – 41 plant species reported by Botanical Survey of India (BSI) in 2007

- The unique features of the plant diversity, among others, include 60 monotypic families and over 6000 endemic species. Recent estimates indicate the presence of over 256 globally threatened plant species in India
- Crop biodiversity has been impressive with repositories of over 50000 varieties of rice, 5000 of sorghum, 1000 varieties of mango, etc.
- The National Gene bank, primarily responsible for ex-situ conservation of unique germ-plasm on long-term basis, holds 366933 unique accessions of plant genetic resources
- The repository includes 2517 cultures of filamentous fungi, bacteria, Actinomycetes and yeasts
- With over 16 major forest types and 251 subtypes, the total forest and tree cover of the country constitutes (78.29 million ha) 23.81 % of the geographical area with most north-eastern states maintaining more than 75 % of the forest cover
- The extent of species endemism in vascular plants alone ranges from 32 to 40% in the mountain ecosystems
- India's major strength in in-situ conservation lies in its impressive PA network, which currently comprises 668 PAs [National Parks (NPs) (102), Wildlife Sanctuaries (WLSs) (515), Conservation Reserves (ConR) (47) and Community Reserves (ComR) (4), established under the Wildlife (Protection) Act (WPA), 1972] covering approximately 4.86% of the total geographical area of the country
- India also has special flagship programmes for the conservation of tiger and elephant. India's PAs grew by 15% since the adoption of the Programme of Work on PAs in 2002
- There are total 18 BRs, 41 tiger reserves, 32 (27 notified and 5 proposed) elephant reserves, 25 Ramsar sites and 5 Heritage sites

B. Importance of biodiversity

Biodiversity is valuable and important for our emotional, psychological and spiritual well-being. It is considered as an important human responsibility to be stewards for the rest of the world's living organisms. The diverse system allows organisms to take advantage of the available resources. For example, trees provide improved soil and microclimate conditions to avoid negative interactions in agroforestry systems and produce yield more without deteriorating resources. Humans have always depended on the Earth's biodiversity for food, shelter, and health. Biological resources that provide goods and services for human use include [1, 2, 8]:

- Food- species that are hunted, fished, and gathered, as well as those cultivated for agriculture, forestry, and aquaculture
- Medicines- both traditional medicines and those synthesized from biological resources and processes
- Drinkable water, clean air, and fertile soils
- Genetic diversity is also important in terms of evolution
- The Earth's biodiversity contributes to the productivity of natural and agricultural systems. Insects, bats, birds, and other animals serve as pollinators
- Parasites and predators can act as natural pest controls
- Various organisms are responsible for recycling organic materials and maintaining the productivity of soil
- Various plant and animal species play an important role in industrial production
- Source of energy (biomass and biofuel)
- Tourism and recreation
- Aesthetic and cultural benefits

C. Threats to Biodiversity

- Biodiversity is a fragile thing, susceptible to all sorts of threats (human and natural), however it supports all life on earth through their various services. The population explosion and natural disasters in the twentieth century had reached new dimensions. The earth is losing its biological resources at an ever-increasing rate, a trend that began with the emergence of humans. Threats to biodiversity come from many sources, most human but some natural. Historically, humans have always taken what they needed from the earth itself and from its plant and animal species, without their conservation. During middle of the 1980s, as species started becoming extinct at a record rate, that starts threatening to biodiversity [1, 2, 8].
- Habitat loss and fragmentation

- Habitat destruction, degradation and pollution
- Extension of agriculture
- Shifting or jhum cultivation
- Uncontrolled commercial exploitation
- Invasion of Alien species
- Destruction of coastal areas
- Rapid increase of populations and global markets
- natural and manmade disasters (Climate change and desertification)

D. Measures of biodiversity

There are many mathematical indices used for the measuring biodiversity. Alpha, beta and gamma diversity indices are used mainly for measurement [1, 2].

1. **Alpha diversity:** The number of species in a single community.

(i) Shannon-Weiner index (H') [9]

$$H' = -\Sigma[(pi)(\ln pi)] \quad \text{and} \quad Pi = \frac{Ni}{N} \qquad \text{..... (1 and 2)}$$

Where,

H' = Shannon Weiner index
N = Total number of individual of all the species
Ni = Total number of individuals of i^{th} species

(ii) Simpson's index [10]

$$C = \sum (Pi)^2 \quad \text{..... (3)}$$

Where,

pi = the proportion of individuals in the i^{th} species

2. **Beta diversity:** The species composition changes along an environmental gradient.

(i) Whittaker's beta diversity index (*βw*) [11]

$$\beta w = (S/\alpha)\text{-1} \quad \text{..... (4)}$$

Where,

S = total number of species and
α = average species richness of the samples

(ii) Wilson and Schmida's beta diversity (βT) [12]

$$\beta T = \frac{[g(H)+l(H)]}{2\alpha} \quad \text{..... (5)}$$

Where,

α = average species richness of the samples
g(H) = number of species gained and
l(H) = number of species lost

3. **Gamma diversity (γ)**: The rate at which additional species are encountered as geographical replacements within a habitat type in different localities. It is regional or landscape diversity. It is also considered as product of alpha and beta diversity [2].

$$\gamma = \alpha \times \beta \times \text{total number of habitats or communities} \qquad \text{..... (6)}$$

Where,

α = alpha diversity
β= beta diversity

E. Biodiversity conservation methods

There are main two conservation strategies or methods viz., in-situ and ex-situ conservation, which was widely using from many decades.

(i) *In-situ* conservation

Conservation of resources through their maintenance within natural or even man-made ecosystem where they occur. It includes biosphere reserve, national parks, wild life sanctuaries, world heritage sites, sacred groves, national monuments and cultural landscapes (agroforestry).

(ii) *Ex-situ* conservation

Conservation outside their habitats, which includes, botanical garden, arboretum, herbal garden, seed (germplasm) banks, ovum banks, biotechnology use (tissue culture, genetic engineering etc.)

II. AGROFORESTRY

"Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence". In agroforestry systems there are both ecological and economical interactions between the different components [13]. Agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is a woody perennial. It always has two or more outputs and the cycle of an agroforestry system is always more than one year. Even the simplest agroforestry system is ecologically (structurally and functionally) and economically more complex than mono-cropping system.

III. AGROFORESTRY AND BIODIVERSITY CONSERVATION

As natural ecosystems shrink and remaining patches of natural vegetation are increasingly reduced to isolated habitat islands (protected or not in parks) in a matrix of agricultural land, it becomes crucial to understand what land use systems replace the natural ecosystems and the nature of the matrix surrounding the remaining fragments. The concept of agroforestry contains many land use forms, where trees still cover a significant proportion of the landscape and influence microclimate, matter and energy cycles, and biotic processes. A number of recently completed reviews suggest ways in which agroforestry contributes to the biodiversity protection and conservation, including that of both wild species and agricultural crop species. Agroforestry has been widely promoted in India as a natural resource management strategy in the last three decades, which attempts to balance the goals of agricultural development with the conservation of soils, water, local and regional climate, and, more recently, biodiversity [14]. In these fragmented landscapes, agroforestry could play a role in helping to maintain a higher level of biodiversity, both within and outside protected areas (buffer agroforestry), when compared with the severe negative effects resulting from more drastic land transformations. Where landscapes have been denuded through inadequate land use or degraded agricultural areas have been abandoned, re-vegetation with agroforestry practices can promote biodiversity conservation [15].

All agroforestry systems may conserve and improve the natural ecosystems, either through outright clearing and replanting with crop and tree species or through variable degrees of "domestication" of the original landscape and ecosystem. However, when compared with other non-forest land use options, such as modern, intensively managed monocultures of coffee, rubber, or oil palm with little genetic and structural diversity, or even vast stretches of pasture or annual crops with little tree cover or none at all, agroforestry systems may offer a greater potential as auxiliary tools for biodiversity conservation strategies while attaining production goals. The areca-nut based traditional agroforests and the natural tropical rainforests have multi-layered vegetal structures with comparable tree density, but showed significant differences in soil nutrients and microbial biomass that recorded lower values in traditional agroforests as compared to the tropical forests. Increased biodiversity has a direct link with productivity [16].

Information on complex biotic interactions such as the importance of diversified tree cover in pest and disease dynamics on plot and landscape scales is less available [8, 15]. The microclimate amelioration and improving productivity with biodiversity conservation through agro-ecological management which could be

achieved by planting shade trees on the lines of the rice-agroforestry system practiced in Bali. A system that harmonises agricultural production in the terraces, with rice as the main crop integrated with moderate sized economically important trees, with a crown that can be manipulated, could give dual benefit of increased productivity and create opportunities of generating carbon credits and thus serves as a measure of both adaptation to the warming climate as also mitigation and increased earnings through carbon credits [17].

In Mandya district of southern dry agro-climatic zone of Karnataka, trees of the genus Ficus have been integral components of traditional rain-fed agro-ecosystems, providing farmers with numerous direct benefits (fodder, firewood, small timber and shade) and crucial ecosystem services (soil and water retention, soil fertility enhancement and supporting local biodiversity) [18].

IV. CONCLUSION

Hence, the agroforestry can enhance connectivity and landscape heterogeneity in multi-functional conservation landscapes and their expansion in degraded lands. It helps to restore productivity and biodiversity of marginal lands. Agroforestry is increasingly being acknowledged as an integrated land use that can directly enhance agro-biodiversity and contribute to the conservation of landscape biodiversity, while at the same time increase, diversify and sustain rural incomes.

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BIOGRAPHY

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