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An overview of agroforestry related land use systems

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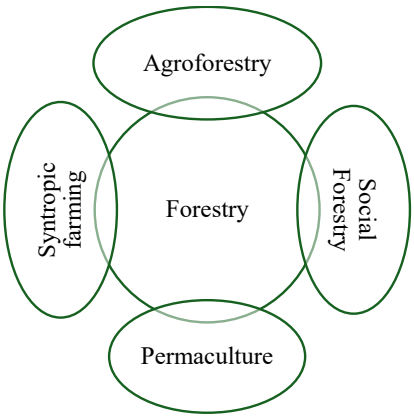
Forests, vital for habitats, spiritual connection, and resources, have suffered from deforestation due to agricultural and economic expansion. Since 1990, deforestation has significantly impacted global forests, with an estimated loss of 420 million ha and primary forests declining by over 80 million ha. Though agriculture and forestry occupy similar land areas, forestry receives considerably less focus on research, resources and manpower. New concepts like agroforestry, social forestry, permaculture and syntropic farming are emerging to address these challenges and promote sustainable land management practices.

Keywords: Agroforestry, Permaculture, Social forestry, Syntropic farming, Urban food forest

Forests have had a variety of roles over time, acting as habitats for numerous species, places of spiritual significance, and sources of valuable resources. Unfortunately, human expansion has resulted in deforestation in various areas, mainly due to agriculture and economic growth. Despite agriculture and forestry covering roughly the same amount of land globally (about 1.5 billion ha each), agriculture receives more attention. This is evident in the number of people working in agriculture, the resources dedicated to it, and the research facilities accessible in most nations. Surprisingly, only 7% of the world's forests are plantations, as reported by the UN's Food and Agriculture Organization (*FAO*), yet these plantations produce half of the world's timber. Despite a decrease in deforestation rates in recent years, a significant portion of forests has been lost. Since 1990, an estimated 420 million ha of forests have been transformed for other purposes, equal to a yearly loss of around 10 million ha between 2015 and 2020, a decrease from 16 million ha annually in the 1990s. Notably, primary forests worldwide have decreased by more than 80 million ha since 1990. Fortunately, there is a growing recognition of the environmental advantages that forests offer, prompting many regions to actively preserve them. The 20th century witnessed a surge in interest in tree planting and forest management, leading to the introduction of several new terminologies related to forestry. Agroforestry was one of the prominent terminologies that became popular and acted as a bridge between conventional agriculture and forestry. Today global area under agroforestry is estimated to be around 1.6 billion ha. It is seen as an effective method to enhance tree cover while promoting sustainable agriculture practices. During the 2014 World Congress on Agroforestry in Delhi, agroforestry was viewed as a means of achieving 33% tree coverage in India. Since 2014, emerging tree-based production systems have received more prominence in India for their sustainable approach and ability to counteract the enervating effect of climate change on natural resources.

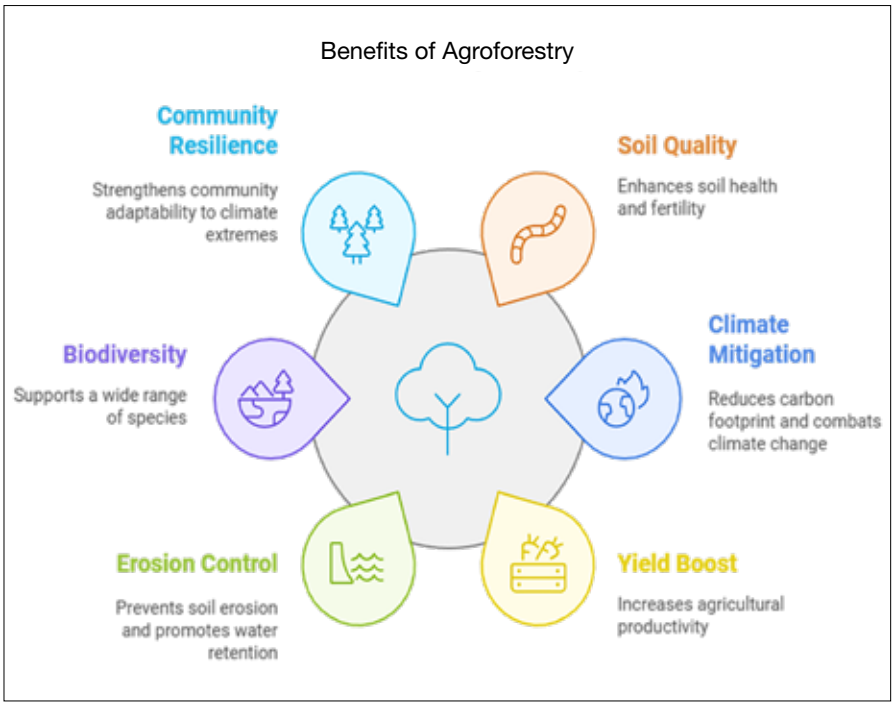


Agroforestry related land use systems

Agroforestry

Agroforestry, introduced in 1977, involves combining trees, crops and/or livestock within the same management unit. These integrated systems offer ecological and economic benefits compared to monoculture practices. This approach aligns with Sustainable Development Goals (*SDG*) and is globally recognized for its economic benefits to farmers. Agroforestry has evolved from a traditional practice to a valued approach to sustainable land management in the 21st century.

The world community has acknowledged agroforestry's



potential to address global issues such as climate change, food security, and biodiversity loss.

Several programmes are attempting to promote agroforestry practices such as the United Nations Decade on Ecosystem Restoration, which aims to rehabilitate damaged habitats, mostly through agroforestry. Agroforestry is key for achieving the SDGs, which include diversifying farmers' income sources (*SDG* 1), improving food security (*SDG* 2), improving health and well-being (*SDG* 3), empowering women (*SDG* 5), ensuring clean water and sanitation (*SDG* 6), providing clean energy (*SDG* 7), contributing to sustainable urban development (*SDG* 11), mitigating climate change (*SDG* 13), and promoting biodiversity (*SDG* 15).

The Green Climate Fund (GCF) promotes agroforestry initiatives to reduce greenhouse gas emissions and improve climate resilience. Reducing emissions from deforestation and forest degradation in developing countries (REDD+) urges countries to use agroforestry to help prevent deforestation and forest degradation. The Forests, Trees, and Agroforestry Partnership (FTAP) strives to maximize the benefits of agroforestry for sustainable development. International organizations like the World Agroforestry Centre, The Center for International Forestry Research (CIFOR), The Association for Temperate Agroforestry (AFTA), The European Agroforestry Federation (EURAF), Indian Council of Agricultural Research (ICAR) and World Wide Fund for Nature (WWF) advance agroforestry through research, capacity building, and advocacy.

India has recently made tremendous progress in promoting agroforestry through a variety of initiatives. The National Agroforestry Policy 2014 seeks to integrate tree production with agriculture, whilst the Sub-Mission on Agroforestry promotes tree planting on fields.

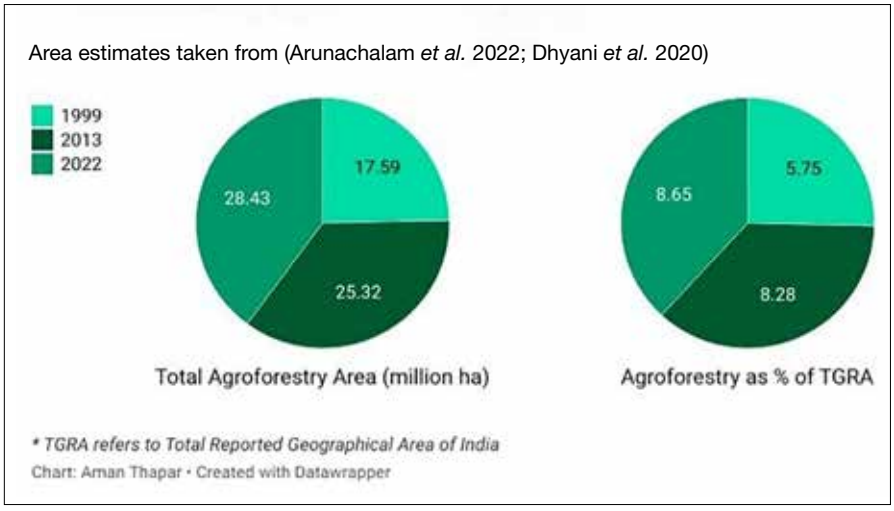
The Greening India's Wastelands with Agroforestry (GROW) initiative introduced by NITI Ayog employs geographic information system (GIS) technology to identify viable agroforestry regions, whereas Rashtriya Krishi Vikas Yojana's (RKVY) agroforestry Component focuses on increasing the availability of high-quality planting materials.

Furthermore, the "*Har Medh Par Ped*" project promotes tree planting on every farmland, and capacity-building measures are underway to support research and extension services. These programmes jointly aim to increase agricultural output, improve soil health, reduce climate change, and give farmers additional income sources, linking agroforestry as a cornerstone of India's sustainable agriculture strategy.

With the popularization of agroforestry on a global scale, the initiatives related to agroforestry, such as "community forestry" and "farm forestry," have also gained popularity alongside relatively newer land use systems such as "urban forestry," "permaculture," and "syntropic farming.

Social forestry (Forestry of the People, by the People and for the People)

Social forestry, a term coined by J.C. Westoby, plays a crucial role in addressing rural needs. It involves using trees or tree planting to achieve social goals, benefiting local residents, especially the economically disadvantaged. Think of it as a "tree growing by the people, for the people." Unlike traditional



Estimated area under Agroforestry in India

forest management, social forestry considers the requirements of local communities alongside external interests.

This approach promotes sustainable forest utilization and management, particularly among communities living near forests. It serves as a powerful tool to combat deforestation, encourage conservation, empower communities and enhance livelihoods through collaborative efforts. In India, initiatives like *Nagar Van Yojana*, *School Nursery Yojana*, Compensatory Afforestation Fund Management and Planning Authority (CAMPA), National Afforestation Programme (NAP) and Green India Mission (GIM) exemplify conservation, reforestation and grassroots movements led by the people.

Community forestry: Community forestry involves planting trees on communal lands with local participation to improve living standards while protecting the environment, contrasting with profit-driven forest management. In Uttarakhand, 12,167 Van Panchayats manage 7,32,688 ha of forests, incorporated under Section 28(2) of the Indian Forest Act, 1927 (FSI, ISFR: 2019). Globally successful projects in countries like the Philippines, India, Nepal, and Brazil empower local communities to manage forests sustainably, benefiting both people's livelihoods and the environment.

Farm forestry: It emerged in the late 1970s as a way to encourage farmers in states like Gujarat, Uttar Pradesh, Karnataka, and West Bengal to plant trees on their land. This practice integrates tree cultivation into farming, offering a range of benefits. These include timber production, biodiversity preservation and sustainable resource management.

On the other hand, community forestry involves villagers collectively managing forests. By working together, they enhance community involvement and livelihoods.

Urban forestry (Cultivating green cities): It involves planting trees in cities for aesthetics, environmental benefits, and recreation. Some exciting projects, like Urban Food Forests, specifically focus on food production in megacities of developing countries. The approach revolves around managing trees within community ecosystems to enhance the urban environment through thoughtful planting and maintenance.

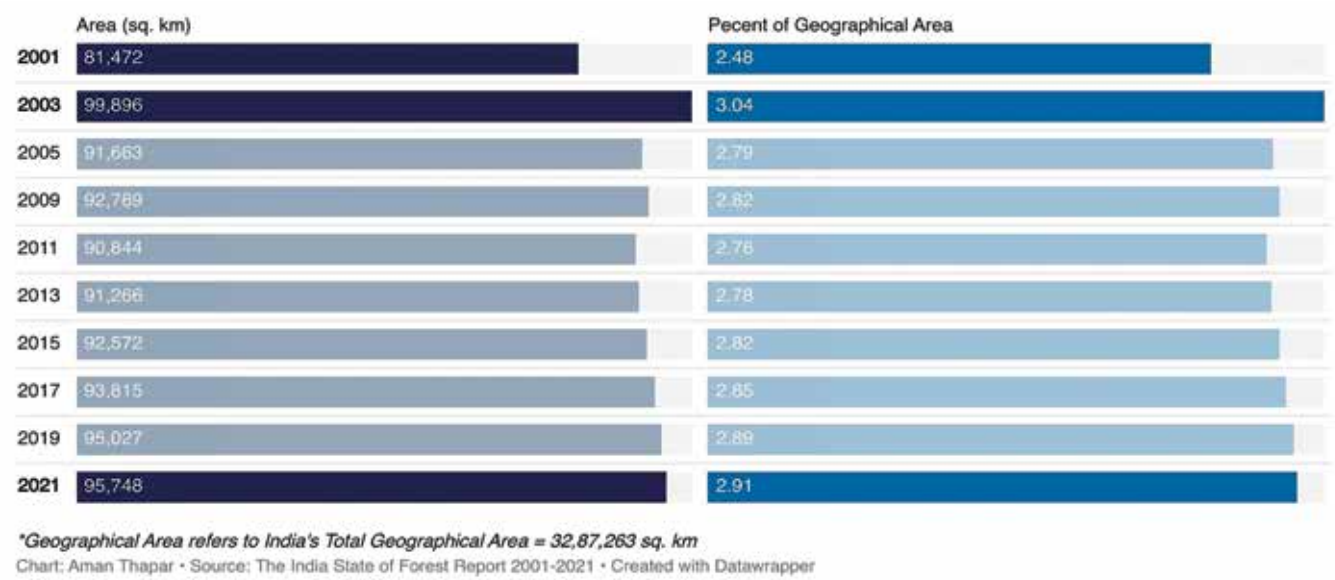
Urban food forests are sustainable systems that cleverly combine various layers of fruit trees, nut trees, and edible plants. These green havens provide fresh produce while supporting biodiversity and essential services like urban cooling. By strategically planting edible plants, they establish self-sustaining ecosystems. According to Clark & Nicholas, 2013, these urban forests address critical issues:

- ***Food insecurity***: By offering fresh produce.
- ***Education***: Providing learning opportunities.
- ***Sustainable living***: Promoting eco-friendly practices.

However, urban tree growth faces challenges due to limited space and poor soil quality. Socially, insufficient funding and the need for community-based tree care training are key concerns. Notable initiatives in Singapore and India champion urban forestry, showcasing diverse plant species and expanding green spaces through tree planting efforts. For instance, Singapore's Urban Forest project features a delightful variety of plant life, while India established an Urban Forestry Wing in Hyderabad back in 1986 to increase greenery by planting different tree varieties.

Permaculture (Designing sustainable land-use systems)

Permaculture, a term coined by Mollison and Holmgren in 1981, involves intentionally designing and maintaining agriculturally productive ecosystems that mimic natural diversity, stability, and resilience. It's a holistic approach to ecological and sustainable living, integrating plants, animals, people, buildings and communities. Key



Tree Cover Trend 2001-2021

principles include earth care, people care and fair share. The following are commonly used permaculture techniques:

Technique	Description
Observation	Learn from nature's patterns.
Terroir	Adapt practices to your specific location.
Layers & Guilds	Create diverse ecosystems for increased productivity.
Agroforestry	Integrate trees and crops for mutual benefit (a core permaculture technique).
Natural Building & Resource Conservation	Use natural materials and minimize waste.
Conservation of Effort	Let nature work for you whenever possible.

Permaculture is practised worldwide, with examples in countries like Sweden, the United States and India where indigenous communities have been using sustainable agricultural techniques for thousands of years (Mclennon *et al.*, 2021). Individuals like Peter Fernandes (Permaculture designer and organic farmer based in Assagao, Goa, India), Narsanna Koppula (Permaculture pioneer in India) and Shagun Singh (Founder of Geeli Mitti Farms, Uttrakhand) have successfully applied permaculture principles in their farming practices, promoting biodiversity, adopting sustainable methods and creating resilient ecosystems.

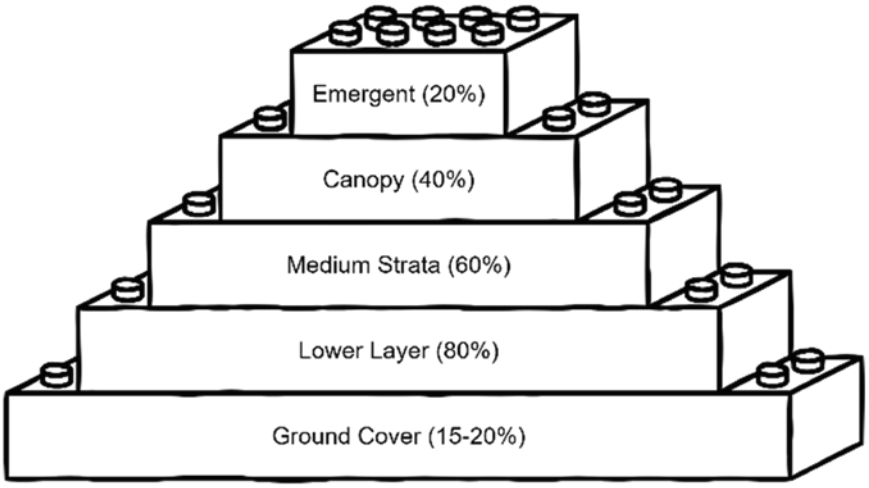
Syntropic farming

Syntropic farming, as taught by Ernst Götsch, enables farmers to understand natural regeneration and apply it in agriculture. This approach mimics nature, emphasizing the accumulation of life's energy to enhance diversity and complexity, much like a forest ecosystem. Previously known by terms such as Successional Agroforestry, Dynamic Agroforestry and Analog Regenerative Agroforestry, Syntropic farming has now emerged as the preferred name.

The key principles of this approach include syntropy (a term for nutritional interdependence), ecological succession and strata distribution. In practice, it involves maintaining continuous soil cover, promoting biomass production, strategically distributing plants and ensuring synchronized growth. The objectives are to achieve independence from irrigation and external inputs, increase productivity, restore soil and plant health, and empower farmers by freeing them from technological limitations.

Within a plantation, plant placement is determined both horizontally and vertically. Each species occupies a specific layer based on its natural habitat. Different layers have recommended occupation ratios to optimize sunlight absorption, with plant crowns acting as efficient solar panels.

Plantation Strata Hierarchy



Hierarchy of strata categories and occupancy rates in syntropic farming

CONCLUSION

Diverse forestry practices are essential for sustainable land management and ecosystem resilience. The transition from traditional to modern land use practices, such as agroforestry, community forestry, farm forestry, urban forestry, permaculture, and syntropic farming, is key for achieving food security, enhancing livelihoods, and meeting sustainable development goals. These practices not only provide fuel, fodder, timber, and raw materials to industries but also contribute to environmental benefits by boosting biodiversity, climate change mitigation, sequestering carbon, and preserving soil fertility. Globally, the adoption of diverse land use systems is increasing with each passing year. In India, there has been a positive trend of increased tree cover and area under agroforestry over the last decade or two.

Promoting, prioritizing, and utilizing the potential of agroforestry and related land use systems to achieve a more resilient and sustainable future is critical, particularly in developing nations. Investing in research, capacity building, and policy assistance will allow agroforestry to reach its full potential in addressing global concerns and promoting a sustainable future. As global, governmental, and commercial organizations are progressively prioritizing these practices, their role in promoting resilient and sustainable future becomes ever clearer, as is evident in India.

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