

9. Agroforestry: Trees in Sustainable Agriculture

Shaik Aslam

Teaching Associate,
PJTSAU, Telangana, India.

**Keerthi Sai Ram Murali Krishna,
Shaik Abdul Khadar Basha**

Junior Research Fellow,
National Institute of Plant Health Management,
Telangana, India.

Abstract:

Agroforestry, the integration of trees into agricultural landscapes, offers a promising approach to address pressing global challenges such as food security, climate change mitigation, and rural livelihoods enhancement. Through a synthesis of existing literature and case studies, we highlight the multifunctional nature of agroforestry systems, which provide a wide range of ecological, economic, and social benefits. Agroforestry enhances soil fertility, biodiversity, and water management, while also increasing agricultural productivity, diversifying income sources, and promoting resilience to climate variability. However, agroforestry adoption faces several challenges, including land tenure insecurity, knowledge gaps, financial constraints, and policy barriers. Addressing these challenges requires collaborative efforts from governments, policymakers, researchers, and local communities to create enabling environments that support agroforestry adoption and scaling up. Looking ahead, agroforestry holds immense potential as a sustainable land management strategy, offering pathways towards climate-smart agriculture, ecosystem restoration, and inclusive rural development. By embracing the principles of agroforestry and investing in its promotion and implementation, we can unlock its transformative potential to build resilient and thriving landscapes for present and future generations.

Keywords:

soil fertility, biodiversity, and water management, climate variability, agroforestry, climate-smart agriculture,

9.1 Introduction:

Agroforestry, the artful integration of trees into agricultural landscapes, emerges as a beacon of promise amid the ever-evolving landscape of sustainable land management practices. Unlike its conventional counterparts, agroforestry stands as a testament to the intricate dance between trees, crops, livestock, and the environment (Kumar, 2011). Captivating odyssey to unveil the profound implications of agroforestry in shaping the destiny of agriculture while nurturing ecosystems of resilience and vitality.

Throughout the annals of human history, trees have stood as stalwart companions, bestowing upon civilizations sustenance, sanctuary, and sustenance. Yet, the advent of industrial agriculture and the relentless pursuit of monoculture paradigms relegated the arboreal realm to the shadows of neglect.

However, in an era rife with existential challenges such as climate flux, soil degradation, and food insecurity, the wisdom of entwining trees within the fabric of agricultural systems has resurfaced with resounding urgency.

At its essence, agroforestry embodies a holistic ethos that transcends the confines of conventional agriculture, weaving a tapestry of practices as diverse as the landscapes they adorn. From the rhythmic symphony of alley cropping to the verdant tranquility of silvopasture, agroforestry celebrates the intricacies of ecological, social, and economic harmony, tailored to the nuances of diverse terrains and communities.

It is a symphony where trees and crops perform in tandem, each note resonating with the promise of sustainable abundance. The verdant corridors of agroforestry, unraveling its multifaceted tapestry of ecological, agronomic, and socioeconomic hues.

From nurturing soils teeming with life to fostering biodiversity sanctuaries, agroforestry emerges as a testament to nature's resilience and humanity's ingenuity. It is a sanctuary where innovation and tradition converge, birthing landscapes of sustenance and prosperity.

As we navigate this enchanting labyrinth of agroforestry, let us heed the ancient wisdom that reverberates through the rustling leaves and fertile soils, reminding us of our sacred duty as stewards of the land.

Through collaboration and collective action, let us nurture the seeds of change, cultivating a future where agroforestry flourishes as a cornerstone of sustainable agriculture, nourishing both people and planet alike.

9.2 Agroforestry and Principles:

Agroforestry is defined as a land use system that involves the deliberate integration of trees and shrubs into agricultural and forestry practices to achieve environmental, economic, and social benefits.

At its core, agroforestry recognizes the intricate relationships between trees, crops, soil, water, and biodiversity, leveraging these synergies to create sustainable and resilient landscapes. In this section, we delve into the principles, types, and significance of agroforestry, shedding light on its diverse manifestations across different ecosystems worldwide.

The principles of agroforestry emphasize the multifunctionality of tree-crop interactions, the optimization of resource use efficiency, and the enhancement of overall system resilience (Sheppard *et al.*, 2020).

Unlike monoculture systems, which focus on maximizing the yield of a single crop, agroforestry systems harness the complementary relationships between trees and crops to achieve multiple objectives simultaneously.

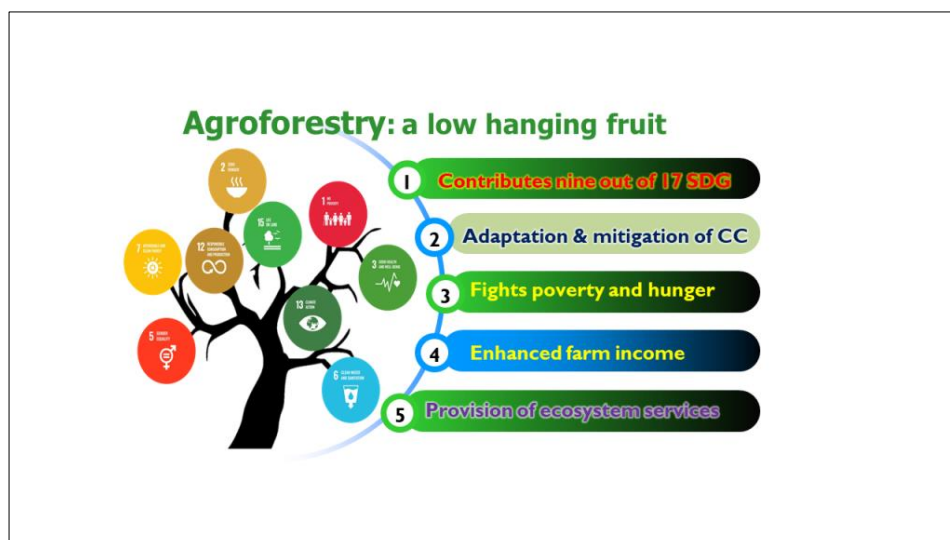


Figure 9.1: Agroforestry Systems and its benefits

9.2.1 Types of Agroforestry Systems:

- A. **Alley Cropping:** Involves planting rows of trees alongside rows of crops, providing shade, wind protection, and additional organic matter to the soil.
- B. **Silvo-pasture:** Integrates trees, forage, and livestock, offering shade, shelter, and fodder for animals while promoting soil health and biodiversity.
- C. **Windbreaks:** Rows of trees planted along field edges or boundaries to reduce wind erosion, protect crops, and create microclimatic conditions conducive to agriculture.
- D. **Forest Gardens:** Mimic natural forest ecosystems with layers of trees, shrubs, herbs, and vines, providing a diverse array of products while enhancing biodiversity and ecosystem services.
- E. **Agroforestry Parklands:** Traditional systems found in arid and semi-arid regions, where trees are interspersed with agricultural crops to maximize water use efficiency and soil fertility (Mahmud *et al.*, 2021).

9.2.2 Global Significance:

Agroforestry has deep historical roots and is practiced in various forms across different cultures and continents, from the terraced hillsides of Southeast Asia to the savannas of Africa and the temperate forests of North America.

It plays a crucial role in supporting the livelihoods of millions of smallholder farmers, especially in developing countries, where it contributes to food security, income generation, and resilience to climate variability.

Agroforestry also offers promising solutions to contemporary challenges such as climate change, deforestation, and land degradation, by sequestering carbon, restoring degraded lands, and enhancing ecosystem services.

9.3 Ecological Benefits of Agroforestry:

Agroforestry stands as a beacon of ecological stewardship, offering a multitude of benefits that reverberate through the intricate web of life on our planet. In this section, we delve deeper into the profound ecological advantages that agroforestry bestows upon landscapes, ecosystems, and biodiversity, illuminating its role as a cornerstone of sustainable land management practices.

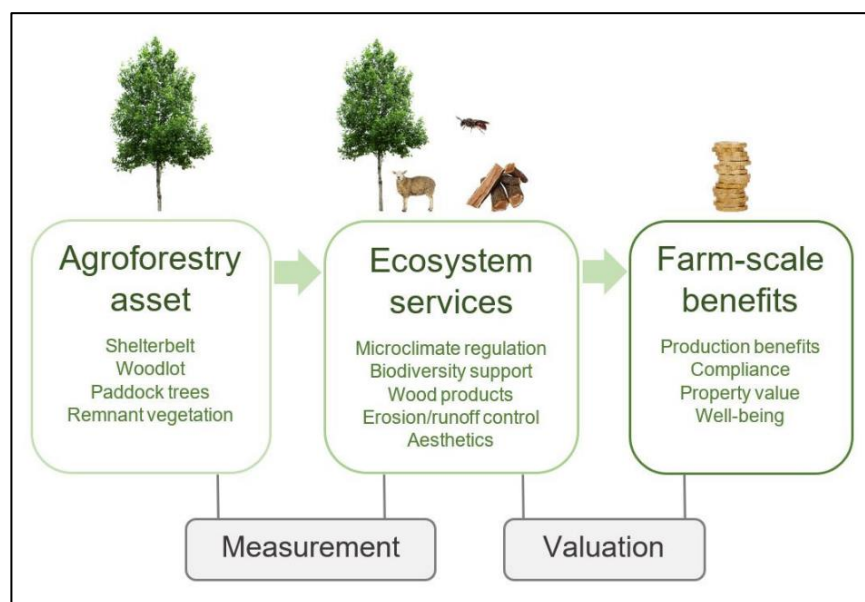


Figure 9.2: Ecological Benefits of Agroforestry

A. Soil Health Enhancement:

- Agroforestry systems serve as custodians of soil health, nurturing the very foundation upon which agricultural productivity rests.
- Through the deposition of leaf litter, root exudates, and organic residues, trees enrich the soil with essential nutrients, fostering a fertile environment for crop growth.
- The intricate network of tree roots enhances soil structure and stability, preventing erosion, promoting water infiltration, and mitigating the adverse impacts of extreme weather events.

B. Biodiversity Enrichment:

- Agroforestry landscapes teem with life, offering sanctuary to a diverse array of plant, animal, and microbial species.

- b. The diverse structure and composition of agroforestry systems create a mosaic of habitats, catering to the ecological needs of both native and cultivated species.
- c. By providing food, shelter, and breeding sites, agroforestry habitats support pollinators, natural enemies of pests, and other beneficial organisms essential for ecosystem resilience.

C. Climate Change Mitigation:

- a. Trees in agroforestry act as carbon sinks, sequestering atmospheric carbon dioxide through photosynthesis and storing it in biomass and soil organic matter.
- b. Agroforestry systems contribute to climate change mitigation by offsetting greenhouse gas emissions, reducing the carbon footprint of agricultural activities.
- c. The cooling effect of trees in agroforestry systems moderates local microclimates, mitigating temperature extremes and reducing the energy demand for cooling in adjacent areas.

D. Water Resource Management:

- a. Agroforestry plays a pivotal role in water conservation and management, optimizing the utilization of this precious resource (Jose, 2009).
- b. Tree roots enhance soil water holding capacity, reducing water runoff, erosion, and the risk of drought stress for crops.
- c. By intercepting rainfall and reducing surface runoff, agroforestry systems help recharge groundwater reserves and maintain hydrological balance in watersheds.

9.4 Agricultural Productivity and Resilience:

In the face of mounting challenges such as climate variability, soil degradation, and fluctuating market conditions, agroforestry emerges as a beacon of resilience, offering pathways to enhance agricultural productivity while bolstering the capacity of farming systems to withstand shocks and stresses. In this section, we explore how agroforestry practices contribute to increased yields, diversified production, and enhanced resilience in agricultural landscapes.

9.4.1 Enhanced Crop Yields through Tree-Crop Interactions:

Within the intricate tapestry of agroforestry, the interactions between trees and crops serve as catalysts for unlocking the full potential of agricultural productivity. In this section, we embark on a journey to explore the myriad ways in which tree-crop interactions synergize to elevate crop yields, optimize resource utilization, and foster sustainable agricultural systems.

A. Resource Utilization Optimization:

- a. Trees and crops within agroforestry systems engage in complementary resource utilization strategies, tapping into different soil layers, water sources, and nutrient pools to maximize productivity.

- b. Tree roots explore deeper soil horizons, accessing nutrients and water beyond the reach of crop roots, thereby expanding the overall resource capture and utilization capacity of the system.
- c. Crops benefit from the shade provided by trees, which reduces water stress, mitigates heat extremes, and extends the duration of photosynthesis, leading to improved growth, flowering, and fruiting.

B. Nutrient Cycling and Soil Fertility Enhancement:

- a. Tree species in agroforestry systems contribute to nutrient cycling and soil fertility through the deposition of leaf litter, root exudates, and biomass decomposition.
- b. The decomposition of tree litter releases organic matter and nutrients into the soil, enriching soil fertility and creating a nutrient-rich environment conducive to crop growth.
- c. Trees, particularly nitrogen-fixing species, enhance soil nitrogen availability, which stimulates crop growth, enhances protein synthesis, and improves overall crop quality and yield.

C. Pest and Disease Management:

- a. Agroforestry systems capitalize on natural pest and disease regulation mechanisms mediated by trees, which serve as hosts for beneficial insects, predators, and antagonistic microorganisms.
- b. The presence of trees in agroforestry landscapes disrupts pest and disease cycles by providing alternative hosts and habitat for natural enemies, reducing pest pressure on crops.
- c. Allelopathic compounds released by certain tree species suppress weed growth and competition, thereby reducing weed infestation and resource competition with crops, leading to higher yields.

D. Microclimate Modification and Stress Mitigation:

- a. Trees modulate the microclimate within agroforestry systems, creating a more favorable environment for crop growth by regulating temperature, humidity, and light intensity (Fahad *et al.*, 2022).
- b. Shade provided by trees reduces water stress and heat stress on crops, especially during periods of high temperatures and drought, resulting in improved photosynthetic efficiency and yield stability.
- c. Windbreaks formed by trees protect crops from wind damage and desiccation, maintaining optimal growing conditions and minimizing yield losses due to physical stress.

9.4.2 Diversification of Production within Agroforestry Systems:

In the rich tapestry of agroforestry, diversification emerges as a cornerstone principle, offering a myriad of benefits that transcend traditional agricultural paradigms.

In this section, we embark on a captivating exploration of how agroforestry fosters the diversification of production, enriching landscapes with a bounty of agricultural commodities while nurturing resilience and sustainability.

A. Multi-layered Productivity:

- a. Agroforestry systems embrace a multi-layered approach to production, where trees, crops, and sometimes livestock coexist harmoniously, each contributing to the overall productivity of the landscape.
- b. Trees offer a diverse array of products, including timber, fruits, nuts, fuelwood, fodder, and medicinal plants, providing farmers with multiple income streams and livelihood options.
- c. Through integrating different tree species with varying growth habits and phenological cycles, agroforestry systems optimize resource utilization and space, maximizing the overall productivity per unit area.

B. Crop-Livestock Integration:

- a. Agroforestry facilitates the integration of crops and livestock within the same land area, creating synergistic relationships that enhance productivity and sustainability.
- b. Trees provide shade, shelter, and fodder for livestock, reducing heat stress and supplementing their diet with nutritious forage, thereby improving livestock health and productivity.
- c. Livestock contribute to nutrient cycling and soil fertility through manure deposition, enriching the soil and promoting crop growth, while also providing additional income opportunities for farmers.

C. Economic Diversification and Resilience:

- a. Agroforestry diversifies income sources for farmers, reducing their reliance on a single crop or commodity and buffering them against market fluctuations and price volatility.
- b. The combination of tree products, cash crops, and livestock enterprises in agroforestry systems spreads risk and enhances economic resilience, ensuring stable incomes and livelihoods for farming households.
- c. Diversified agroforestry landscapes offer opportunities for value addition and niche market development, enabling farmers to capture higher returns and create added value from their produce.

D. Environmental and Social Benefits:

- a. The diversification of production within agroforestry systems promotes environmental sustainability by reducing monoculture pressures, conserving biodiversity, and enhancing ecosystem services.
- b. Agroforestry landscapes provide habitat and food resources for a wide range of plant and animal species, fostering biodiversity conservation and ecological resilience (Singh *et al.*, 2020).

- c. Through fostering social cohesion and community engagement, agroforestry contributes to the resilience of rural communities, empowering farmers to collectively manage and benefit from diverse and multifunctional landscapes.

9.4.3 Tree-Crop Interactions:

At the heart of agroforestry lies the intricate dance between trees and crops, where their symbiotic relationships pave the way for enhanced productivity, resilience, and sustainability. In this section, we delve deeper into the dynamic interactions between trees and crops within agroforestry systems, unraveling the multifaceted ways in which they synergize to optimize resource utilization, mitigate environmental stresses, and foster thriving agricultural landscapes.

A. Microclimate Regulation:

- a. Trees exert a profound influence on the microclimate within agroforestry systems, modulating temperature, humidity, and air movement to create optimal conditions for crop growth.
- b. The canopy of trees provides shade and shelter to crops, shielding them from excessive sunlight and reducing evapotranspiration rates, thereby conserving soil moisture and mitigating heat stress.
- c. Windbreaks formed by trees in agroforestry systems act as natural barriers, reducing wind speed and wind-induced damage to crops, especially in exposed areas.

B. Soil Health Enhancement:

- a. Tree roots play a pivotal role in improving soil structure, aeration, and fertility within agroforestry systems, creating a conducive environment for crop root development and nutrient uptake.
- b. Through processes such as nitrogen fixation and nutrient cycling, trees contribute to the enrichment of soil organic matter and the availability of essential nutrients for crop growth.
- c. Agroforestry systems exhibit greater soil stability and resistance to erosion, thanks to the anchoring effect of tree roots and the protective canopy cover they provide.

C. Nutrient Cycling and Recycling:

- a. Trees and crops engage in dynamic nutrient cycling processes within agroforestry systems, where organic matter and nutrients are exchanged and recycled between above-ground and below-ground components.
- b. Tree leaf litter and prunings serve as valuable sources of organic nutrients, providing a continuous supply of nitrogen, phosphorus, potassium, and other micronutrients to the soil.
- c. Root exudates from trees stimulate microbial activity in the rhizosphere, enhancing nutrient mineralization and uptake by crops, while also promoting beneficial soil microorganisms that aid in pest and disease control.

D. Pest and Disease Management:

- Agroforestry systems leverage the natural pest and disease regulation services provided by trees, which act as hosts for beneficial insects, predators, and parasites that help control crop pests.
- The presence of diverse tree species in agroforestry landscapes disrupts pest and disease cycles by creating ecological barriers and reducing the buildup of pest populations.
- Allelopathic compounds released by certain tree species inhibit the germination and growth of weeds, reducing competition for water, nutrients, and light with crops.

9.4.4 Risk Reduction and Adaptation:

- Agroforestry systems offer inherent resilience to climatic variability and extreme weather events, such as floods, droughts, and storms, due to their diversified and multifunctional nature.
- The presence of trees in agroforestry landscapes helps stabilize soils, reduce erosion, and mitigate the impacts of climate change on agricultural productivity.
- Agroforestry practices, such as alley cropping and windbreaks, provide natural buffers against environmental stresses, protecting crops and livelihoods in vulnerable areas.

9.5 Socioeconomic Impacts of Agroforestry:

In the intricate weave of agroforestry systems, the impacts ripple far beyond the boundaries of agricultural fields, reaching into the heart of communities and economies. In this section, we embark on an illuminating journey to uncover the multifaceted socioeconomic impacts of agroforestry, exploring how it transforms livelihoods, fosters resilience, and nurtures inclusive development.

A. Livelihood Diversification:

- Agroforestry offers diverse income opportunities for farmers, enhancing their resilience to economic shocks and market fluctuations.
- The integration of trees with crops and livestock provides farmers with multiple income streams throughout the year, reducing dependence on seasonal or single-source incomes.
- Tree products such as fruits, nuts, timber, and non-timber forest products (NTFPs) supplement household incomes, improving standards of living and enhancing financial security for farming families.

B. Access to Resources:

- Agroforestry enhances access to essential resources such as fuelwood, fodder, and medicinal plants, meeting household needs and reducing reliance on external sources.
- Trees in agroforestry systems provide renewable sources of biomass for cooking, heating, and construction, alleviating energy poverty and promoting sustainable resource management.

- Livestock in agroforestry landscapes benefit from access to shade, shelter, and nutritious fodder provided by trees, improving animal health and productivity.

C. Food Security and Nutrition:

- Agroforestry contributes to food security by diversifying agricultural production and increasing the availability of nutritious foods at the household level.
- The integration of fruits, vegetables, and nuts in agroforestry systems enhances dietary diversity, improving nutrition outcomes and reducing the risk of malnutrition (Mukhlis *et al.*, 2022).
- Agroforestry landscapes provide a continuous supply of food throughout the year, reducing seasonal food shortages and improving food access for vulnerable households.

D. Capacity Building and Empowerment:

- Agroforestry fosters knowledge exchange and capacity building within communities, empowering farmers with skills and resources to manage diverse and multifunctional landscapes.
- Training programs, farmer field schools, and extension services promote adoption of agroforestry practices, enhancing farmers' adaptive capacity and resilience to environmental changes.
- Through engaging farmers as active participants in decision-making processes and resource management, agroforestry strengthens social capital and fosters collective action for sustainable development.

E. Economic Development and Market Access:

Agroforestry generates employment opportunities along value chains, from tree nursery establishment and agroforestry management to processing, marketing, and trade of tree products. The sale of tree products such as timber, fruits, nuts, and medicinal plants creates economic value and stimulates local economies, generating income for rural communities. Agroforestry enterprises promote entrepreneurship and innovation, unlocking new markets and value-added opportunities for smallholder farmers and rural entrepreneurs.

9.6 Challenges in Promoting Agroforestry:

Despite its numerous benefits, agroforestry faces several challenges that hinder its widespread adoption and implementation. These challenges span economic, social, environmental, and institutional dimensions, posing barriers to the realization of agroforestry's full potential. Below are some of the key challenges:

- A. Land Tenure and Property Rights:** Insecure land tenure and unclear property rights can discourage farmers from investing in agroforestry, as they may lack assurance of long-term land access and control. Conflicts over land ownership, boundaries, and use rights can arise, especially in areas with overlapping land claims or competing land-use interests.

- B. Knowledge and Awareness Gaps:** Limited awareness and knowledge about agroforestry practices among farmers, extension agents, policymakers, and the general public can impede adoption and scaling up. Insufficient training, technical support, and extension services may hinder farmers' ability to implement and manage agroforestry systems effectively.
- C. Financial Constraints:** High upfront costs and long payback periods for tree planting and agroforestry establishment can deter farmers, especially smallholders, from investing in agroforestry. Limited access to credit, insurance, and other financial services further exacerbates financial barriers to agroforestry adoption and expansion.
- D. Market Access and Value Chains:** Limited market access, price volatility, and inadequate market infrastructure for tree products can undermine the economic viability of agroforestry enterprises. Weak market linkages, lack of value-added processing facilities, and quality standards may restrict farmers' ability to capture value from their agroforestry products.
- E. Policy and Institutional Constraints:** Inadequate policy frameworks, regulatory barriers, and institutional capacity constraints may hinder the integration of agroforestry into national agricultural development strategies and land-use planning. Policy inconsistency, conflicting regulations, and bureaucratic hurdles can impede the scaling up of agroforestry initiatives and hinder their long-term sustainability.
- F. Socio-cultural Factors:** Socio-cultural norms, traditions, and perceptions may influence farmers' attitudes towards tree planting and agroforestry, shaping their willingness to adopt these practices. Gender disparities in access to land, resources, and decision-making may exacerbate inequalities and limit women's participation in agroforestry activities.

Strategies to promote agroforestry adoption and overcome constraints may include:

- Strengthening land tenure systems and providing secure land rights for farmers.
- Increasing awareness and building capacity through extension services, farmer training programs, and participatory learning approaches.
- Improving market access and value chains for tree products through infrastructure development, market linkages, and price stabilization mechanisms.
- Formulating supportive policies, incentives, and regulations that promote agroforestry adoption and provide a conducive enabling environment.
- Mobilizing financial resources and developing innovative financing mechanisms, such as microcredit, subsidies, and payment for ecosystem services schemes.
- Fostering social inclusion and gender equity by promoting women's participation and leadership in agroforestry decision-making and implementation.

9.7 Future Prospects of Agroforestry:

As we look ahead to the future, agroforestry stands poised at the forefront of sustainable land management practices, offering a beacon of hope for addressing pressing environmental, social, and economic challenges. The future prospects of agroforestry are bright, driven by growing recognition of its multiple benefits and its potential to contribute to global sustainability goals. Here are some key future prospects for agroforestry:

A. Climate Change Mitigation and Adaptation:

Agroforestry holds immense potential for climate change mitigation through carbon sequestration, biodiversity conservation, and enhanced resilience to extreme weather events.

With increasing recognition of the role of forests and trees in climate change mitigation and adaptation, agroforestry is poised to play a central role in climate-smart agriculture strategies worldwide.

B. Sustainable Agriculture and Food Security:

Agroforestry offers a pathway towards sustainable intensification of agriculture, where productivity is enhanced while minimizing negative environmental impacts.

By diversifying agricultural production, enhancing soil fertility, and improving water management, agroforestry contributes to food security and nutrition outcomes, especially in the face of climate change and population growth.

C. Restoration of Degraded Lands and Ecosystems:

Agroforestry has the potential to restore degraded lands, rehabilitate ecosystems, and enhance biodiversity conservation through the integration of trees into agricultural landscapes.

With increasing emphasis on ecosystem restoration and nature-based solutions, agroforestry is gaining traction as a cost-effective and scalable approach for achieving multiple environmental and socioeconomic objectives.

D. Economic Development and Poverty Alleviation:

Agroforestry offers economic opportunities for smallholder farmers, rural communities, and marginalized groups through diversified income streams, value-added products, and market access.

With proper investment, supportive policies, and market linkages, agroforestry has the potential to generate employment, alleviate poverty, and promote inclusive economic growth in rural areas.

E. Resilient Landscapes and Sustainable Livelihoods:

Agroforestry enhances landscape resilience by promoting biodiversity, soil health, and water management, thereby reducing vulnerability to climate change, natural disasters, and market shocks. By fostering diversified and multifunctional landscapes, agroforestry contributes to sustainable livelihoods, social cohesion, and community resilience, especially in rural areas.

F. Innovation and Technological Advances:

Advances in agroforestry research, technology, and innovation hold promise for unlocking new opportunities and addressing existing challenges in agroforestry practice (Gupta *et al.*, 2020). Emerging technologies such as remote sensing, agroecological modeling, and participatory approaches offer tools for enhancing decision-making, monitoring, and scaling up agroforestry interventions.

9.8 Conclusion:

Agroforestry stands as a beacon of hope and opportunity in our quest for sustainable development, offering a holistic approach to land management that harmonizes the needs of people and the planet. Throughout this exploration, we have witnessed the myriad benefits of agroforestry, from enhancing agricultural productivity and biodiversity conservation to mitigating climate change and alleviating poverty. Agroforestry embodies the principles of resilience, diversity, and synergy, weaving together the intricate threads of ecology, economy, and society into vibrant landscapes of abundance and prosperity. As we reflect on the challenges and constraints facing agroforestry and envision its future prospects, it becomes clear that concerted action and collaboration are essential. Governments, policymakers, researchers, civil society organizations, and local communities must work together to overcome barriers, promote enabling policies, and invest in capacity building, research, and innovation. By fostering an enabling environment that incentivizes agroforestry adoption, values ecosystem services, and empowers farmers, we can unlock the transformative potential of agroforestry to build resilient and sustainable landscapes for future generations.

In the tapestry of agroforestry, each tree, each crop, and each farmer play a vital role in shaping a more equitable, prosperous, and resilient world. As we embrace the lessons of agroforestry and integrate its principles into our agricultural systems and landscapes, we sow the seeds of a brighter future, where harmony with nature, thriving livelihoods, and shared prosperity flourish. Let us continue to nurture and cultivate the promise of agroforestry, weaving together the threads of knowledge, innovation, and stewardship to create landscapes of abundance and well-being for all.

9.9 Reference:

1. Kumar, B. M. (2011). Quarter century of agroforestry research in Kerala: an overview. *Journal of Tropical Agriculture*, 49, 1-18.
2. Sheppard, J. P., Bohn Reckziegel, R., Borrass, L., Chirwa, P. W., Cuaranhua, C. J., Hassler, S. K., ... & Kahle, H. P. (2020). Agroforestry: an appropriate and sustainable response to a changing climate in Southern Africa. *Sustainability*, 12(17), 6796.
3. Mahmud, A. A., Raj, A., & Jhariya, M. K. (2021). Agroforestry systems in the tropics: A critical review. *Agricultural and Biological Research*, 37(1), 83-87.
4. Jose, S. (2009). Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry systems*, 76, 1-10.

5. Fahad, S., Chavan, S. B., Chichaghare, A. R., Uthappa, A. R., Kumar, M., Kakade, V., ... & Poczai, P. (2022). Agroforestry systems for soil health improvement and maintenance. *Sustainability*, 14(22), 14877.
6. Singh, V. K., Rathore, S. S., Singh, R. K., Upadhyay, P. K., & Shekhawat, K. (2020). Integrated farming system approach for enhanced farm productivity, climate resilience and doubling farmers' income. *The Indian Journal of Agricultural Sciences*, 90(8), 1378-1388.
7. Mukhlis, I., Rizaludin, M. S., & Hidayah, I. (2022). Understanding socio-economic and environmental impacts of agroforestry on rural communities. *Forests*, 13(4), 556.
8. Gupta, S. R., Dagar, J. C., & Teketay, D. (2020). Agroforestry for rehabilitation of degraded landscapes: achieving livelihood and environmental security. *Agroforestry for Degraded Landscapes: Recent Advances and Emerging Challenges-Vol. 1*, 23-68.