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Enhancing Food Productivity through Intensive Agroforestry Cropping for Sustainable Soil Practices – A Review

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Abstract

Adoption of sustainable agriculture through agroforestry systems presents a viable solution to address declining soil fertility, land degradation, and food insecurity in Bangladesh. This review focuses on intensive agroforestry systems characterized by high density, multispecies cropping and their potential to improve crop yield, restore soil health, and enhance ecosystem services. Agroforestry practices such as homestead gardening, multi-storey cropping, orchard based systems, and boundary plantations contribute to nutrient cycling, biodiversity conservation, and climate resilience. However, widespread use of chemical fertilizers continues to degrade soil quality and diminish productivity. Integrating organic and bio fertilizers within an integrated nutrient management (INM) framework offers a sustainable alternative that improves soil structure, increases nutrient availability, and supports long term agricultural productivity. The review also emphasizes the importance of policy interventions to promote balanced fertilizer use, incentivize sustainable practices, and enhance extension services. Furthermore, regionally informed strategies and insights from global models can guide the effective adoption of agroforestry in Bangladesh. This review highlights intensive agroforestry and diversified fertilizer management as practical pathways to achieving sustainable food production, ecological balance, and rural livelihood improvement.

Keywords: *Agroforestry, Intensive Cropping, Fertilizer Types, Food Production, Soil Health*

Introduction

The current global food crisis highlights the urgent need for sustainable development strategies that enhance food production and ensure food security particularly in densely populated countries like Bangladesh (Talucder et al., 2024). Rising demand for food, however, has accelerated soil degradation and environmental decline, posing significant threats to long term agricultural productivity (Ray & Ray, 2011). Bangladesh, with a population exceeding 165 million and a land area of only 147,570 km², has among the world's lowest per capita availability of arable (0.06 ha) and forest land (0.02 ha) (Hasan et al., 2013; BBS, 2019). Furthermore, 21.8% of the population lives in poverty, with over 87% of the poor residing in rural areas where livelihoods are heavily reliant on tree and cropbased farming systems (Islam et al., 2015). Land degradation presents a major threat to sustainable food systems. Each year, more than 23,000 hectares of cultivable land are lost to infrastructure expansion, urban sprawl, and rural settlement growth extremely affecting smallholder farmers and intensifying pressure on remaining agricultural land (Hasan et al., 2013). Between 1989 and 2020, the share of arable land fell from 73.4% to 61.5% (Ahsan et al., 2023), and projections suggest that rapid urbanization and industrial growth could result in an annual loss of approximately 69,000 hectares of farmland (Khan, 2023). These trends exacerbate land scarcity and threaten Bangladesh's capacity to meet the growing demand for food and nutrition.

Soil, a finite and non-renewable resource crucial to food production, is increasingly being depleted due to unsustainable land management practices. Healthy soils are essential for poverty alleviation and food security, as they enhance crop yields and reduce vulnerability to pests and diseases (FAO, 2017; Hou et al., 2020). Over the past five decades, global food production has declined by 11.9–13.4% due to soil degradation (Jie et al., 2002). In South Asia, including Bangladesh, soil degradation is particularly severe 140 million hectares of land are impacted by groundwater depletion, erosion, waterlogging, and nutrient loss (Jahan & Gurung, 2017), resulting in an estimated annual GDP loss of 2% (USD 10 billion) due to land degradation (Niino, 2011). The situation is especially dire in south eastern Bangladesh, where land degradation is compounded by steep topography (Chowdhury et al., 2023). However, the Green Revolution initially boosted yields through high yield crop varieties, intensive tillage, and chemical inputs, these practices have also led to long term soil fatigue and nutrient depletion.

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Continuous monoculture and input intensive methods have rendered 74.2% of Bangladesh's soils deficient in key nutrients, undermining productivity and climate resilience (Sharna et al., 2022; Barbier & Hochard, 2018).
Agroforestry integrating trees with crops and/or livestock on the same land unit offers a promising and sustainable alternative. It has been recognized for enhancing livelihoods, improving climate resilience, and supporting food and nutritional security (Islam et al., 2013). Research by Allen et al. (2004) and Mukhlis et al. (2022) has shown that agroforestry can rehabilitate degraded land and enhance ecosystem services by improving the physical, chemical, and biological properties of soil through mechanisms such as litter deposition and root activity. Nevertheless, much of the existing research focuses primarily on biophysical outcomes, with limited attention to the socioeconomic dimensions of agroforestry particularly within the Bangladeshi context (Atangana et al., 2013).
Recently, orchard based systems particularly in districts like Dinajpur have gained popularity due to their economic returns and potential to enhance soil health. However, many of these orchards lack integrated management practices, such as intensive understory cropping, that could maximize land use efficiency. Sustainable orchard management through multispecies understory cropping and improved nutrient practices could significantly enhance productivity, stabilize income, and rehabilitate soil health for smallholder farmers.
This review aims to fill the knowledge gap surrounding sustainable, orchard based agroforestry systems in north western Bangladesh. Specifically, it evaluates the potential of intensive understory cropping to improve soil health, examines current fertilizer management practices, and proposes sustainable strategies to enhance productivity within agroforestry frameworks. Addressing these factors is essential for improving the long term sustainability of agroforestry, ensuring food security, promoting ecological restoration, and supporting resilient rural livelihoods.

Food Production Patterns in Bangladesh

Bangladesh's fertile soils and favourable agro climatic conditions support the production of over 70 million tonnes of agricultural output annually, with more than 70% of the country's land area devoted to agricultural use (BIDA, 2021). The primary crops cultivated include rice, jute, wheat, potatoes, fruits, vegetables, legumes, and oilseeds. Among these, rice is the most dominant, occupying approximately 71% of the total cultivated land and contributing 59% to the overall crop value. Potatoes follow as the second most valuable crop, accounting for 9.5% of total crop value (Barois et al., 2024). Moreover, in the livestock and aquaculture sectors, fish and crayfish dominate animal production, comprising 73% of total output, with aquaculture alone contributing 68% of fish production. Goat farming ranks second in meat production value at around 6% (FAO, 2023a). The agriculture sector including crops, fisheries, and forestry employs approximately 40.6% of the labor force aged 15 and older. Smallholder farmers represent the backbone of the agricultural economy, with about 12 million farms supporting 60 million people and producing roughly 60% of the nation's food. The average farm size is just 0.24 hectares, and most households engage in integrated farming systems that combine rice cultivation with one to two additional crops and livestock rearing (Barois et al., 2024).

Status of Food Security in Bangladesh

Bangladesh has made measurable progress in food and nutrition security over recent years. The prevalence of moderate and severe food insecurity declined slightly from an average of 32.2% during 2014–2016 to 31% in 2020–2022, even as food insecurity increased significantly across South Asia, rising from 27.6% to 41.3% during the same period (Barois et al., 2024). Despite this progress, the country remains heavily reliant on food imports to meet the nutritional needs of its growing population. As of 2015, food imports constituted approximately 17% of total merchandise imports, whereas food exports accounted for just 3%, underscoring a considerable trade imbalance (World Bank, 2015). This reliance on traditional, subsistence based agriculture limits opportunities for commercialisation and poses risks to long term food sovereignty. These challenges highlight the urgent need for sustainable, resource efficient agricultural practices that can reduce import dependence and bolster national food security.

Soil Fertility and Soil Health Status in Bangladesh

To sustain crop productivity, farmers in Bangladesh have increasingly depended on chemical fertilisers urea alone accounting for approximately 75% of total fertiliser use (Shil et al., 2016). However, this intensive use of synthetic inputs has contributed to declining soil quality. Organic matter levels in most agricultural soils remain critically low, with values below the recommended 1.5%, and saw a 5–36% decline between 1967 and 1995. Furthermore, recent assessments indicate that nearly 47% of farmers misuse fertilisers, which not only compromises soil health but also poses environmental and human health risks (Barois et al., 2024).Therefore, soil fertility remains poor across much of the country, with the exception of a few Agro Ecological Zones (AEZs 10, 12, 13, and parts of 11), which exhibit comparatively better conditions. This widespread degradation necessitates immediate and strategic intervention. Promoting sustainable land management practices such as the use of organic and biofertilisers, crop rotation, and ecologically integrated approaches like intensive agroforestry can help restore soil fertility, enhance soil structure, and reduce dependence on synthetic inputs. Strengthening farmer awareness, along with institutional and policy support, will be essential for ensuring long term soil health and agricultural sustainability (Barois et al., 2024).

Contributions of Agroforestry Practices to Soil Health Improvement

Agroforestry has emerged as a vital land use strategy in many developing countries, including Bangladesh, offering smallholder farmers a means to enhance ecological resilience, farm productivity, and biodiversity. By integrating trees with crops, agroforestry systems play a critical role in preventing soil degradation while simultaneously boosting agricultural yields. These systems enrich soil organic matter, increase soil carbon content, and improve the availability and cycling of key nutrients such as nitrogen (N), phosphorus (P), and potassium (K) (Islam et al., 2024). As such, agroforestry offers a promising and sustainable pathway for restoring soil fertility and supporting broader environmental conservation efforts.

Traditional or extensive agroforestry systems have long been practiced across diverse ecological zones in Bangladesh. As noted by Nair (1990), these systems are well adapted to the rural livelihood needs and local environmental conditions of the country. Practices such as homestead gardening, boundary planting, alley cropping, and silvopasture have developed organically, shaped by local variations in soil type, rainfall, topography, and socioeconomic context. According to Islam et al. (2024), these low input systems provide multiple ecosystem services, including food, fodder, fuelwood, and timber, while enhancing climate resilience and conserving natural resources at the community level. In contrast, intensive agroforestry systems are designed to optimise land productivity by employing multistory canopy structures and increasing both tree and crop density. These systems often incorporate fast growing, multifunctional species such as *Grevillea robusta* and are structured to promote vertical layering, year round output, and ecological synergy (Keerthika et al., 2024). Unlike traditional systems that emphasize subsistence and minimal management, intensive agroforestry is driven by goals of yield maximisation, ecological sustainability, and revenue diversification, often employing precision agriculture and "smart" farming techniques (Leakey, 1999). This approach is particularly relevant for land scarce countries like Bangladesh, where efficient land use is paramount.

Despite its advantages, the adoption of intensive agroforestry remains limited in Bangladesh, particularly concerning its long term impact on soil health under the country's subtropical monsoon climate. However, ecosystem services such as enhanced biodiversity, regulated soil moisture, and biomass recycling suggest that even low input intensive systems can deliver significant environmental benefits. Expanding research and field implementation of these systems could unlock their full potential in sustainable land management and agricultural productivity enhancement.

Table 1: Key differences between traditional and intensive agroforestry systems

Futures	**Traditional Agroforestry systems**	**Intensive agroforestry systems**
Input level	Low to moderate	High
Purpose	Farmer food security, income and ecological balance	Industrial production such as tea and cocoa
Management	Traditional	Precision or smart practice
Scale	subsistence	Commercial
Output	Moderately diversified	Highly diversified
Examples	Homestead, cropland, silvopasture, alley cropping etc.	Fodder bank, tea garden, bioenergy, timber, food chain processing etc.

Trends and Challenges of Agroforestry in Bangladesh

Agroforestry has deep historical roots in rural Bangladesh, particularly within smallholder and homestead systems. Traditionally, these practices have supported household food security, biodiversity conservation, and cultural continuity while providing essential resources such as fuel, timber, and supplementary income (Ahsan & Begum, 2023). Common forms such as boundary planting and scattered tree cultivation within croplands continue to enhance local climate resilience and diversify livelihoods (Hanif et al., 2018). Studies on agroforestry have received growing attention from the government and development partners as a viable strategy to meet socioeconomic and environmental objectives. Nevertheless, most institutional efforts and policy initiatives have focused on promoting conventional agroforestry models, with limited emphasis on research, extension, or promotion of intensive approaches. Although there is considerable potential for diverse, site specific systems across agroecological zones including the Chittagong Hill Tracts, floodplains, and coastal regions systematic adoption of high density, intercropped agroforestry remains limited (Bari et al., 2024). Several structural challenges constrain the widespread adoption of intensive agroforestry in Bangladesh. These include the absence of integrated policy frameworks and scientific validation tailored to the complex, multispecies nature of such systems. Extension services are often inadequate, limiting farmers' access to high quality planting materials, technical support, and training. Furthermore, weak market linkages, poor knowledge dissemination mechanisms, and insufficient farmer engagement hinder the replication of successful models. A critical gap also persists in interdisciplinary research that integrates ecological, agronomic, and socioeconomic dimensions particularly studies involving long term soil monitoring. Addressing these gaps is essential for advancing a nuanced understanding of how intensive agroforestry systems affect soil fertility, resource use efficiency, and rural livelihoods, thereby enabling the development of scalable and sustainable land use strategies.

Role of Intensive Agroforestry Systems in Food Security and Sustainability

Intensive agroforestry systems significantly contribute to food security and sustainable agriculture by promoting dynamic interactions among crops, trees, and soil organisms. As Bhaduri et al. (2017) note, these interactions enhance biological, chemical, and physical soil processes, leading to increased agricultural productivity and improved soil health. Trees incorporated into farmland contribute organic matter through leaf litter and root biomass, stimulating soil organic carbon (SOC) accumulation. Higher SOC levels, in turn, improve microbial activity, enhance soil structure, and increase water holding capacity all vital attributes for long term agricultural sustainability. One of the hallmark features of agroforestry is the use of nitrogen fixing leguminous tree species, which naturally enrich the soil and reduce dependence on synthetic fertilisers (Sileshi et al., 2014). Additionally, the deep rooted nature of many agroforestry species facilitates a process known as "nutrient pumping," whereby nutrients are absorbed from subsoil layers and redistributed to the surface through litter fall and root turnover (Garrity & Lefroy, 1994). This nutrient recycling enhances topsoil fertility and promotes higher crop yields over time.

Agroforestry also confers significant physical protection to the soil. Tree canopies reduce the erosive impact of rainfall, while their extensive root systems help stabilise soil, thereby mitigating erosion an especially critical service in Bangladesh's flood and cyclone prone regions (Zuazo & Pleguezuelo, 2009). Furthermore, shaded microclimates created by tree cover help moderate soil temperature, retain moisture, and foster beneficial microbial communities such as mycorrhizal fungi, which facilitate nutrient mineralisation and suppress soil pathogens (Sileshi et al., 2014). This intensive system indicate that root density and biomass turnover are high thereby improve the ecological functions significantly. The synergy between woody perennials and annual crops not only rejuvenates degraded soils and reduces chemical input requirements but also builds resilient agroecosystems. In the context of Bangladesh, such systems represent a vital pathway for enhancing food security, improving soil sustainability, and supporting climate adaptation.

Table 2: Comparative impact of cropping systems on key sustainability parameters

Parameters	**Mono cropping**	**Traditional Agroforestry**	**Intensive Agroforestry**
Soil fertility	Decline over time	Regulators	Significantly improves
Carbon sequestration	Minimal(0.51 t c/ha/yr)	Moderate (2.4 t c/ha/yr)	High (48 t C/ha/yr)
Biodiversity conservation	Very low	Medium	High
Climate resilience	Poor (vulnerable)	Moderate	High
Water retention	Low	Moderate	High
Overall Sustainability	Low	Medium to high	Very high

Yield Productivity Index under Different Cropping Systems

The comparative analysis of yield productivity indices across cropping systems reveals distinct differences in agricultural efficiency and sustainability. Among the systems, monocropping consistently demonstrates the lowest productivity index. This underperformance is primarily due to its inherent limitations dependence on a single crop species per season leads to rapid nutrient depletion, increased vulnerability to pest infestations, and accelerated soil degradation. Such systems also lack ecological redundancy, making them highly susceptible to climatic and market shocks. Traditional agroforestry systems show marginal improvements in productivity over monocropping. These systems involve limited integration of trees with crops, contributing to modest gains in soil health, biodiversity, and microclimate regulation. However, their productivity remains suboptimal due to low species diversity, inadequate spatial design, and limited management intensity. While they provide subsistence benefits and ecological services, their potential to enhance output is constrained by their extensive, low input nature. Comparatively, intensive agroforestry systems achieve the highest yield productivity index. These systems strategically combine high density, multispecies planting arrangements that utilise vertical stratification and complementarity among species to maximise land use efficiency. Through mechanisms such as nutrient cycling, nitrogen fixation, and organic matter enrichment, intensive agroforestry significantly enhances soil fertility and resilience. It also supports year round production and greater economic returns through diversified outputs, including food, fodder, timber, and biomass. The superiority of intensive agroforestry in yield productivity underscores its potential as a climate adaptive, resource efficient, and sustainable agricultural model. This is particularly relevant for densely populated, resource constrained regions such as Bangladesh, where land scarcity, soil degradation, and food insecurity are persistent challenges. By integrating ecological principles with modern agronomic practices, intensive agroforestry can play a transformative role in ensuring long term productivity and rural livelihood resilience.

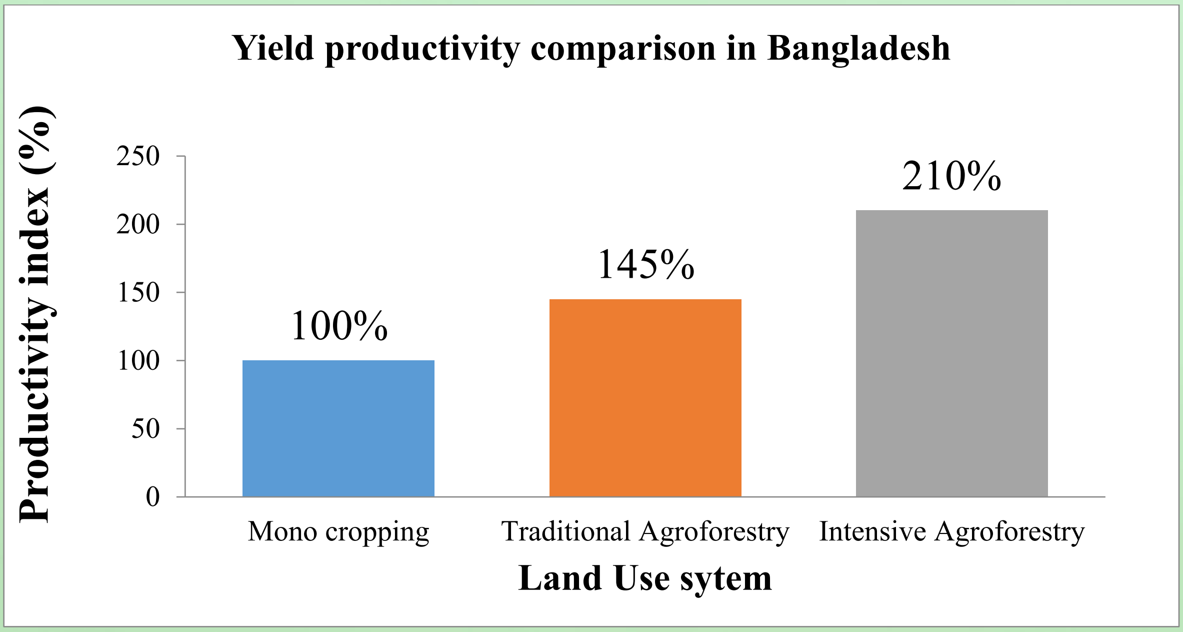

Figure 1: Yield Productivity index under different cropping systems
Source: (Islam, K.K., et al. 2024)

Food Production Potential under Different Cropping Systems

Intensive agroforestry systems have demonstrated significant potential for enhancing food production in Bangladesh, particularly among smallholder farmers operating on limited land resources. By integrating multiple crop species with perennial trees in spatially and temporally optimized arrangements, these systems consistently outperform conventional monoculture practices in terms of productivity per unit area (Rahman et al., 2015). Strategic pairings such as banana with vegetables or mango with pulses enable efficient vertical stratification and staggered harvesting cycles, thereby ensuring dietary diversity and more effective land use (Awasthi, 2018).

The synergistic relationships between trees and crops in intensive agroforestry systems result in higher aggregate caloric and protein yields compared to monocropping or traditional agroforestry (Mulugeta, 2014). These systems offer a year round food supply, mitigate seasonal food shortages, and enhance resilience to climate induced stresses such as droughts and floods. Moreover, the incorporation of fruit bearing and nitrogen fixing leguminous trees contributes to improved household nutrition while also generating supplementary income through the sale of marketable produce. Economic evaluations indicate that intensive agroforestry can deliver greater long term returns on investment than conventional cropping systems, despite moderately higher initial establishment costs (Van et al., 2016). Benefits such as enhanced soil fertility, reduced dependency on synthetic fertilisers, diversified income streams, and climate adaptability collectively contribute to the economic viability and sustainability of these systems. Their effectiveness is particularly evident in ecologically sensitive regions such as the coastal belts and the Chittagong Hill Tracts where they contribute to landscape rehabilitation and sustainable livelihoods (Saha et al., 2022).

The integration of sustainable management techniques including mulching, composting, and integrated pest management (IPM) further amplifies the productivity and ecological value of intensive agroforestry. These practices thrive in diverse cropping environments, reinforcing system resilience while reducing input costs and environmental risks. In the context of Bangladesh's land constraints and environmental challenges, intensive agroforestry presents a scalable and sustainable **model** for food security, soil restoration, and agricultural intensification.

Table 3: Food Production Potential under Different Cropping Systems

System type	Production output	Source
Mono cropping	Single crop	Islam et al 2021
Traditional Agroforestry	Tree, crops, fruits, fuel wood	Rasul and Thapa, 2006
Intensive agroforestry	Homestead Gardening, Integrated Mangrove Aquaculture	Ahmed et al 2018

Conceptual Framework of Intensive Agroforestry Systems

Agroforestry is increasingly recognised as a sustainable land use approach that synergistically integrates trees and shrubs with crops and/or livestock to form ecologically resilient and economically productive landscapes (Dahal et al., 2025; Tennakoon & Tharindi, 2025). These multifunctional systems promote biodiversity, enhance soil fertility, support water conservation, and strengthen climate resilience attributes that are particularly valuable in regions vulnerable to environmental degradation and food insecurity. Agroforestry systems display considerable structural and functional diversity, ranging from simple boundary plantations and scattered onfarm trees to more complex multistory home gardens and alley cropping configurations. In tropical regions, especially South and Southeast Asia, home garden agroforestry systems are a widely adopted traditional model. These systems are typically arranged around homesteads, incorporating a variety of perennial trees, shrubs, herbaceous crops, and sometimes livestock in a vertically stratified and spatially integrated manner (Kumar, 2015).

In Bangladesh, traditional agroforestry practices such as mixed cropping, farmhouse gardening, and homestead forestry are deeply embedded in rural culture and livelihoods. These systems have long contributed to food, fuel, and fodder security while maintaining ecological balance. Contemporary efforts now aim to intensify and modernise these practices by incorporating scientific design, improved species selection, and enhanced management techniques to optimise land productivity, improve soil health, and ensure agricultural sustainability.

At the core of intensive agroforestry systems lies the principle of soil health regeneration, which is fundamental to the sustainability and productivity of any agricultural system. Soil health is governed by the dynamic interaction of physical, chemical, and biological components (Rajput et al., 2024). Key indicators include the availability of essential nutrients nitrogen (N), phosphorus (P), and potassium (K) as well as pH stability, microbial biomass, resistance to erosion, and soil organic carbon (SOC). Maintaining and enhancing these indicators are critical not only for sustaining yields but also for safeguarding broader ecosystem services that underpin food security. Sal forest regions indicate that intensive agroforestry practices can significantly improve soil fertility parameters. These improvements are visually represented in Figure 4, which highlights trends in SOC build up, nutrient availability, and other soil quality markers following the adoption of intensive agroforestry interventions.

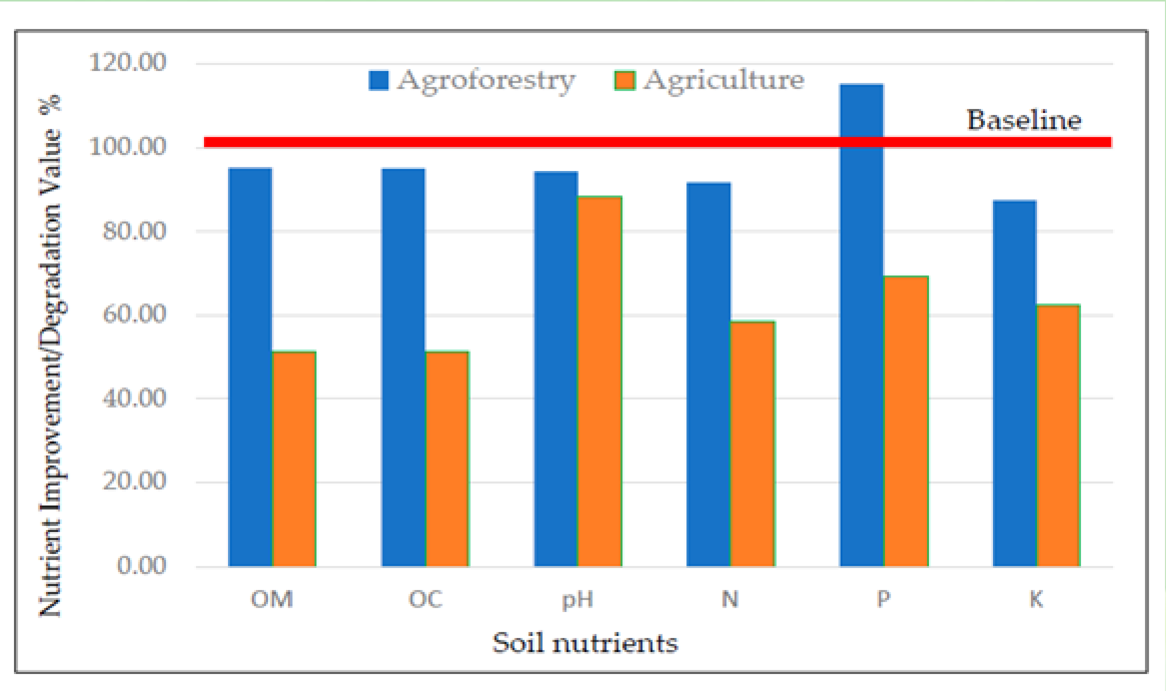

Figure 2: Role of Agroforestry for soil Improvement
Source: Islam, K.K., et al. (2024)

Intensive agroforestry systems contribute to soil enhancement through several ecological mechanisms. These include the deposition of organic matter via litter fall, biological nitrogen fixation through leguminous tree species, stimulation of soil microbial activity, and improved water retention capacity (Kaur et al., 2023). Together, these processes foster long term soil fertility, reduce vulnerability to erosion, and build resilient agro ecosystems supporting the broader transition toward sustainable and climate adaptive farming systems.

Model Success Stories and Adoption of Intensive Agroforestry Systems

Bangladesh has numerous successful agroforestry projects that have demonstrated the viability and benefits of intensive agroforestry systems (Rahman et al., 2011). In the northern districts of Rangpur and Dinajpur, farmer led innovations that integrate fruit trees with vegetables and legumes have notably enhanced both crop yields and soil stability (Chaki et al., 2023). Such combinations like maize intercropped with lentil improve nutrient cycling and reinforce soil structure, particularly in regions prone to both drought and flooding. In coastal regions such as Khulna and Barisal, mixed cropping models have been implemented that combine rice and leafy vegetables with saline tolerant trees, including mangrove species (Rahman et al., 2021). These models address soil salinity issues while enhancing food production and providing environmental services like saline intrusion control. These climate resilient strategies contribute to land rehabilitation and increased food security in ecologically vulnerable coastal areas. Similarly, in the Chittagong Hill Tracts, agroforestry combinations involving bamboo, banana, and turmeric in multistrata arrangements have yielded significant ecological and economic returns (Hossain et al., 2020). These systems well suited to steep, erosion prone terrain have reduced soil loss, enhanced land stability, and raised household incomes. Notably, these models are accessible to smallholder and indigenous communities, offering low input yet high impact solutions

Regional Background and adaptation strategies

Replicable models from neighbouring countries offer strategic insights. For instance, India’s Greening India Programme has promoted drip irrigation alongside high density agroforestry (Kumar et al., 2023), while community managed agroforestry in Nepal has bolstered food security and soil retention on steep slopes (Maharjan et al., 2024). These examples underscore the importance of community engagement, cooperative marketing, and topography sensitive practices like contour planting, which could be adapted to Bangladesh’s context. Modern technologies are increasingly instrumental in supporting agroforestry optimisation. The use of remote sensing, GIS based monitoring, and systems modelling allows for spatial analysis of soil variability, prediction of yields, and tracking of land use changes (Nuwarapaksha & Udumann, 2025; Toromade & Chiekezie, 2024). These tools promote evidencebased planning and strengthen the evaluation of agroforestry interventions.

Limitations and Prospects for Adoption

Several barriers hinder the widespread adoption of intensive agroforestry systems in Bangladesh, despite their promising potential. A primary limitation is the continued dependence on chemical fertilizers. When not properly integrated with biologically active systems, synthetic inputs can disrupt natural nutrient cycling and degrade soil health (Nair et al., 1999). Over application, especially when inconsistent with agroecological principles, may undermine the nutrient recycling mechanisms essential for long term sustainability. Another major challenge is the high labor intensity required for managing these systems. Unlike monoculture farming, high density and multispecies agroforestry setups demand more time, specialized skills, and technical knowledge (Raj et al., 2022). Poorly designed systems can also lead to interspecies competition for sunlight, water, and nutrients, reducing overall productivity (Ong et al., 2007). As noted by Sima and Shemelis (2025), nutrient management remains a technical obstacle, particularly in regions with limited resources and variable soil conditions. Moreover, smallholder and subsistence farmers may be reluctant to adopt agroforestry practices due to the delayed economic returns, which do not align with their immediate income needs (Rahman et al., 2017). Despite these constraints, promising strategies are emerging to overcome them. Integrated Nutrient Management (INM), which blends organic fertilizers, biofertilizers, and limited chemical inputs, has shown to significantly enhance soil health while reducing dependence on synthetic products (Prakash et al., 2024). INM approaches have been particularly effective in increasing soil organic carbon, improving pH levels, and enhancing nutrient availability in mountainous and resource scarce areas. Furthermore, agroforestry practices such as orchards, boundary plantings, homestead gardens, and multistory systems offer a range of additional ecological benefits. These include improved microclimate regulation, enhanced carbon sequestration, and greater biodiversity preservation (Kumar, 2016). Such benefits reinforce agroforestry’s value as a tool for sustainable land use planning. To facilitate wider adoption, targeted extension services and farmer education programs are critical. Additionally, policy support is essential. The formal recognition of agroforestry within national land use frameworks could improve institutional backing and resource allocation, accelerating the transition toward large scale implementation.

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Research Gaps and Future Directions

Although agroforestry is gaining recognition in Bangladesh, long term studies assessing its impacts on soil health, agricultural productivity, and ecosystem services remain insufficient. Most existing research is either short term or fragmented, which limits comprehensive understanding especially in the context of socioeconomic and climatic variability.To ensure meaningful adoption, future efforts must integrate regional knowledge with global scientific advancements. Lessons from countries with similar agroecological conditions should be tailored to local realities, fostering systems that enhance both livelihood security and environmental resilience. A systems based approach is vital to embed agroforestry within broader development agendas targeting poverty reduction, climate adaptation, and food security. However, key research priorities include quantifying the biophysical and economic trade offs of various agroforestry models, creating decision support tools for species and system selection, and using spatial technologies like GIS and remote sensing to inform land use planning. Moreover, policy frameworks must institutionalize agroforestry within national strategies for climate resilience and sustainable agriculture. With adequate policy backing, research investment, and extension infrastructure, agroforestry in Bangladesh has the potential to evolve from a soil rehabilitation technique into a driver of sustainable development and equitable rural transformation.

Conclusion

This review highlights the transformative potential of intensive agroforestry systems in enhancing Bangladesh's food security, soil health, and climate resilience. By integrating trees with crops in strategic and ecologically sensitive ways, these systems offer a viable alternative to conventional monoculture farming, particularly in land constrained and environmentally vulnerable regions. Case studies at both national and regional levels illustrate that well designed agroforestry systems can enhance biodiversity, boost soil fertility, and increase overall agricultural output. Nevertheless, challenges such as labor intensity, insufficient technical support, and the lack of long term studies continue to hamper broader adoption. Looking ahead, scaling up agroforestry will require a coordinated approach that blends scientific innovation, farmer education, supportive policy frameworks, and modern technological tools. Only through such an integrated effort can agroforestry fulfil its promise as a cornerstone of sustainable agriculture and rural development in Bangladesh.

Novelty of the Present Review

This review uniquely focuses on high density, multispecies agroforestry systems, distinguishing them from traditional models by highlighting their enhanced ecological and agronomic functions. It explicitly explores the link between soil health improvement and tangible food production benefits for smallholder farmers. Grounded in evidence from the Bangladeshi context, the review addresses a critical gap in localized assessments of intensive agroforestry. It underscores agroforestry as a comprehensive, systems based strategy that integrates agroecological principles with food security and climate resilience, offering a pathway toward sustainable rural livelihoods.

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