Agroforestry Practices and Livelihood Outcomes: Evidence from Sub-Division Darazinda, District Dera Ismail Khan

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Abstract

Agroforestry, the deliberate integration of trees with agricultural crops, represents a sustainable land-use strategy that strengthens rural livelihoods and ecological resilience. By expanding tree cover and meeting rising timber and fuelwood needs, it provides both economic and environmental benefits. Diversifying farm income, improving ecosystem services, and enhancing climate adaptability further highlight its value. This study investigates the current status of agroforestry and its socioeconomic effects on farmers in Sub-Division Darazinda, District Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. Results indicate that about 20-30 % of local farmers engage in agroforestry—primarily through Agri-Silviculture and boundary planting—motivated by financial returns and environmental considerations. Predominant species such as Eucalyptus camaldulensis (roughly 40-60 % of trees) and Dalbergia sissoo (5-15 %) generate annual earnings of Rs. 60,000-100000 per hectare. Additional income, estimated at Rs. 5,000-15,000 per hectare, is derived from non-timber products such as fodder from Acacia nilotica. Overall, agroforestry in Darazinda emerges as a practical pathway to sustainable development, advancing both livelihood security and climate goals. Nevertheless, its wider adoption is hindered by policy shortcomings, market constraints, technical limitations, and socioeconomic challenges.

Keywords

Agroforestry, Livelihood, Socioeconomic Impact, Climate Resilience, Darazinda

1. Introduction

Agroforestry—the deliberate integration of trees with agricultural crops and/or livestock on the same parcel of land—is widely recognized as a sustainable and multifunctional land-use strategy that can enhance livelihoods while improving ecological resilience. In today's context of global warming, rapid decline in land productivity, and rising environmental threats, agroforestry stands out as a key approach for preserving natural resources and ensuring socio-economic sustainability. It is widely regarded as one of the most effective strategies for supporting social, economic, and ecological balance. For smallholder farmers, integrating trees with crops or livestock reduces dependence on monoculture, buffers against crop failure, and can improve household nutrition through fruit and fodder production [1].

In Pakistan, where agriculture employs over 40 percent of the labor force and remains a major contributor to the national economy, agroforestry provides a pathway to address food insecurity, land degradation, and the growing impacts of climate change. In an age of global overpopulation, agroforestry offers an innovative approach to protect agricultural sustainability, create livelihood opportunities, deliver ecological advantages, and enhance household food security. National initiatives, including the National Forest Policy 2015, underscore the government's commitment to expanding forest and tree cover, while programs such as the Billion Tree Tsunami have further highlighted agroforestry's role in climate-change adaptation and landscape restoration [2].

Agroforestry has been practiced since ancient times and remains widespread today. Systems that incorporate both native and introduced tree species demonstrate how sustainability, regulation, habitat provision, and other ecological functions can be simultaneously harnessed. This review highlights the capacity of agroforestry to generate diverse socioeconomic benefits, including food, fuelwood, fodder, fiber, timber, non-timber forest products, and supplementary income. Environmentally, agroforestry helps prevent soil erosion, supports bioenergy production, enhances carbon sequestration, diversifies agricultural landscapes, promotes sustainable land management, aids in natural pest control, and provides vital habitats for global biodiversity. Khyber Pakhtunkhwa (KP), with its mix of arid and semi-arid zones, offers significant potential for agroforestry adoption. Agroforestry can mitigate these stresses by diversifying farm income, supplying timber and fuelwood, improving soil fertility, and sequestering carbon [3]. Species such as *Eucalyptus camaldulensis* and *Dalbergia sissoo* are commonly used in Pakistan for boundary planting and agri-silviculture, providing both marketable wood products and ecosystem services [4]. Nevertheless, adoption remains uneven due to policy gaps, limited extension services, and market constraints [5]. Given these circumstances, reliable, location-specific data are essential to guide planners and practitioners [6]. Within KP, Sub-Division Darazinda of District Dera Ismail Khan typifies the challenges of semi-arid agriculture: annual rainfall averages only 200-300 mm and soils are

predominantly sandy-loam, making farming systems vulnerable to water scarcity, erosion, and climatic variability. as well as challenges in water management for tree-crop systems in semi-arid regions [7].

This study therefore focuses on (i) documenting current agroforestry practices in Sub-Division Darazinda, (ii) evaluating their socioeconomic impacts on farmers' livelihoods, and (iii) identifying key barriers and opportunities for wider adoption. By linking field observations with national and international research, the study aims to inform strategies that strengthen rural livelihoods and environmental resilience in Pakistan's semi-arid landscapes [8].

Study Objective

- To assess the role of agroforestry in improving the livelihoods of farmers in Sub-Division Darazinda, District Dera Ismail Khan
- To identify the main constraints and potential opportunities for the expansion of agroforestry in the region.

2. Literature Review

Agroforestry delivers notable environmental advantages worldwide, including carbon capture, biodiversity protection, and drought resilience. Global assessments estimate that such systems can sequester roughly 0.2-0.4 Mg C ha^{-1} yr^{-1}, supporting its potential for climate-change mitigation in fragile settings like Darazinda's semi-arid landscape [9].

Evidence from South Asia shows that supportive policies are pivotal for scaling up agroforestry. India's National Agroforestry Policy illustrates how clear regulations, market connections, and financial incentives can accelerate adoption—lessons that remain highly relevant where local policy gaps still hinder progress [10].

Studies in Punjab confirm that approaches such as agri-silviculture and boundary planting fit well with existing cropping practices and use land efficiently. Farmers often favor fast-growing species like *Eucalyptus camaldulensis* for their market value, though water demand and ecological concerns persist [11].

Research from India shows that poplar-based agri-silviculture can generate two to three times the income of traditional monocropping, particularly when supported by farmer cooperatives and contract farming that improve market access and limit middlemen exploitation—strategies that could be replicated in Dera Ismail Khan [12].

In Pakistan's Punjab province, integrating trees with crops has been shown to raise household income, create jobs, and improve land productivity, illustrating agroforestry's contribution to rural development and livelihood diversification in water-stressed regions [13].

Agroforestry also plays a vital role in climate adaptation for semi-arid zones by improving soil stability, enhancing water retention, and providing protective shade and windbreaks, all of which are critical in areas with low rainfall and sandy soils [14].

A broader meta-analysis across low- and middle-income countries concludes that agroforestry boosts farm productivity, strengthens ecosystem services, and supports human well-being, reinforcing its value for climate-vulnerable rural communities [15].

Despite these benefits, restrictive tree-harvest rules, weak institutional support, and limited financial incentives still constrain adoption in Pakistan. Simplified permit procedures and targeted subsidies could help farmers in Darazinda expand tree planting [16].

Finally, participatory models developed in India and Pakistan demonstrate that community-driven planning, training, and capacity building can significantly raise adoption rates, especially among marginalized groups, offering a promising approach for the Dera Ismail Khan region [17].

3. Materials and Methods

This study employs a qualitative research design centered on a systematic review and synthesis of secondary data, chosen because primary, site-specific data for agroforestry in Sub-Division Darazinda (District Dera Ismail Khan) are scarce. The methodology aligns with the study's objectives by integrating regional and national agroforestry information with comparative global literature to produce an analysis suited to the Darazinda context. The process includes data collection, source selection, data analysis, and recognition of limitations to ensure transparency and research rigor.

3.1 Study Area

Sub-Division Darazinda lies in the western part of District Dera Ismail Khan (DI Khan), Khyber Pakhtunkhwa (KPK), near the border with South Waziristan. It is a rugged, semi-arid zone characterized by hilly terrain and piedmont plains. The area experiences a hot desert (BWh) climate under the Köppen-Geiger classification, with annual rainfall typically between 200-350 mm, very hot summers often exceeding 45 °C, and mild winters ranging from 5-12 °C. Soils are predominantly sandy-loam with scattered gravelly patches and are prone to wind erosion [17].

Agriculture and forests from production Takht-e-Suleiman is the backbone of Darazinda's economy, with most residents engaged in smallholder mixed farming on landholdings averaging 2-4 ha. Major crops include wheat, chickpea,

and fodder grasses, while vegetable cultivation is limited by erratic rainfall and scarce irrigation. Livestock—especially goats, sheep, and cattle—complements cropping systems, though fodder shortages remain a persistent challenge. The agriculture of Darazinda, a region in Dera Ismail Khan district, is part of the broader agricultural landscape of Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. Agriculture here is mostly subsistence level and depends on rainfall, spate irrigation (rod kohi), and also on canal irrigation from Chashma Right Bank Canal and its branches. The district including Darazinda produces a variety of crops such as chickpeas, moong, wheat, jowar, guarseed, cotton, sugarcane, rice, bajra, barley, maize, mustard, rapeseed, sesame, and vegetables like coriander, peas, okra, tomato, cauliflower, potato, onion, turnip, carrot, cabbage, spinach, and radish. Chilghoza (pine nuts) and various medicinal plants are also found in the subtropical vegetation of the Darazinda region. The area is known for its special crops like chickpeas and moong beans, and is a producer of vegetables and fruits including citrus, mango. The district contributes significantly to the production of gram, moong, cotton, mango, and especially dates with notable varieties like Dhakki dates, famous for their quality. Farming here still uses traditional subsistence methods with potential for modernization and commercial vegetable and fruit production near irrigated areas. The presence of cereal crops, fruits, fodder plants, and subtropical flora underscore the region's diverse agricultural base. Darazinda itself has been studied for its weed flora and fodder plants as part of its agricultural ecosystem. The diversity of crops and vegetation in Darazinda reflects its agro-ecological significance within Dera Ismail Khan district [18].

Socioeconomically, the sub-division faces low literacy levels (around 40-50 % rural illiteracy), limited healthcare, and poor market infrastructure. These factors slow the uptake of innovative land-use strategies. Yet Darazinda's semi-arid environment and dependence on agriculture make agroforestry an attractive option to diversify income, enhance climate resilience, and supply timber, fuelwood, and fodder.

Existing agroforestry mainly takes the form of agri-silviculture and boundary planting, practiced by an estimated 25-35 % of farmers. Common tree species include *Eucalyptus camaldulensis* (about 60-70 % of planted trees), *Dalbergia sissoo* (10-15 %), and *Acacia nilotica*, all valued for their adaptability and market demand. These systems provide timber and non-timber products, reduce reliance on mono-cropping, and help combat soil degradation and wind erosion. However, adoption remains constrained by policy gaps, weak market linkages, limited extension services, and inadequate supplies of quality planting material.

3.2 Data Collection

Because primary field data specific to Darazinda are limited, this study relies on secondary data drawn from diverse, credible sources:

- Academic Literature: Peer-reviewed articles and books on agroforestry in Pakistan—particularly KPK and Punjab—and in comparable semi-arid regions worldwide. Databases such as Google Scholar, PubMed, and ResearchGate were used with search terms like *"agroforestry Dera Ismail Khan," "Darazinda agriculture," "agri-silviculture livelihoods,"* and *"climate resilience agroforestry."*

- Government & NGO Reports: Publications from the Food and Agriculture Organization (FAO), (8), Pakistan's Ministry of National Food Security & Research, Khyber Pakhtunkhwa Forest Department, and international agencies like CIFOR-ICRAF [19] National Forest Policy documents and agricultural census reports provided key background data.

- Regional Studies: Research from nearby DI Khan tehsils and similar semi-arid districts of Punjab and KPK was used to extrapolate insights. For example, studies such as Climate Seed's agroforestry assessments for Punjab informed adoption rates and economic impacts.

- Global Literature: Comparative evidence from India, sub-Saharan Africa, and other dryland regions offered additional perspectives on environmental services and policy frameworks, including foundational works. A total of approximately 25 high-quality sources—most published between 2014 and 2023—were reviewed to ensure relevance to current agro ecological and socioeconomic conditions. Older foundational sources were included when necessary to explain key agroforestry concepts.

3.3 Source Selection and Screening

A two-stage screening process ensured that only relevant, methodologically sound sources were incorporated:

- Initial Screening: Titles and abstracts were checked to identify studies addressing agroforestry practices, livelihood outcomes, or adoption barriers in Pakistan (especially KPK and Punjab) or similar dryland settings. Sources lacking empirical evidence or focusing exclusively on industrial forestry were excluded.

- Full-Text Review: Selected studies were examined in detail to extract data on tree species, system types, socioeconomic impacts (income, employment), environmental effects (e.g., carbon sequestration), and constraints (policy, markets). Studies using robust methodologies, such as field surveys or econometric analyses, were prioritized.

Because Darazinda-specific data are limited, a proxy approach was used, incorporating findings from agroecologically similar districts in southern KPK and Punjab. Extrapolations were cross-checked with national agricultural surveys and FAO reports to validate their applicability to Darazinda's conditions.

3.4 Data Analysis

Data were analyzed thematically to address the study's objectives using a qualitative synthesis approach. The analysis was organized around three major themes:

- Agroforestry Systems: Identification of the main agroforestry practices in Darazinda—such as agri-silviculture and boundary planting—along with commonly planted species and estimated adoption levels. Regional literature was compiled to approximate the dominance of key trees like Eucalyptus camaldulensis and Dalbergia sissoo and to highlight their ecological roles.

- Livelihood Outcomes: Evaluation of socioeconomic benefits including income diversification, employment generation, household food security, and climate-resilience contributions. Quantitative figures (e.g., farm-gate returns from timber species) were integrated with qualitative insights, such as farmer perceptions reported in comparable semi-arid districts, to create a holistic understanding [20].

- Constraints and Opportunities: Assessment of major barriers—policy gaps, market limitations, and technical challenges—as well as potential solutions such as carbon-credit schemes, farmer training, and improved extension services. Comparative lessons were drawn from successful agroforestry initiatives in Pakistan and neighboring regions of India.

Thematic coding was done manually. For example, income statistics were grouped under "economic impacts," while information on soil conservation and micro-climate regulation was categorized under "environmental benefits." Cross-checking between sources helped maintain consistency, and discrepancies in adoption estimates were noted as study limitations.

3.5 Limitations

Several limitations were recognized to ensure transparency:

- Absence of Primary Data: Because no detailed field surveys exist for Darazinda, the analysis depended on secondary information and extrapolation from similar semi-arid districts, which may reduce precision.

- Information Gaps: Limited quantitative figures on tree density, total land under agroforestry, or gender-specific impacts constrained the depth of analysis [21].

- Temporal Variability: Some earlier studies may not fully reflect recent policy changes or shifts in farmer practices, although more recent publications were prioritized.

- Generalization Risks: Applying findings from Punjab or other provinces to Darazinda may overlook site-specific soil conditions, cultural preferences, or market dynamics.

To minimize these issues, data were triangulated from multiple credible sources, the most up-to-date literature was emphasized, and sections requiring extrapolation were clearly identified. Future research should include primary field surveys in Darazinda to validate and refine these results.

3.6 Ethical Considerations

As this investigation relies entirely on secondary data, no direct ethical concerns—such as human-subject participation—were involved. Proper citation of all data sources was maintained to avoid plagiarism, and the analysis was conducted impartially without favoring any particular agroforestry practice or policy stance [22].

4. Results

This chapter consolidates secondary data to assess the current status of agroforestry, its livelihood impacts, and key constraints in Sub-Division Darazinda, District Dera Ismail Khan. Because few studies focus exclusively on Darazinda, the analysis draws on findings from other semi-arid areas of Khyber Pakhtunkhwa and nearby provinces with similar ecological and socioeconomic conditions. Results are organized into three parts: agroforestry status, socioeconomic impacts, and adoption constraints.

4.1 Agroforestry Status in Darazinda

Agroforestry practices in Darazinda mirror those found across Pakistan's semi-arid belt, shaped by sandy soils, limited rainfall, and market dynamics. The principal systems are:

- Agri-silviculture

The dominant practice integrates trees with annual crops such as wheat, maize, and chickpea. *Eucalyptus camaldulensis* (sufaida) and *Dalbergia sissoo* (shisham) are most common, chosen for rapid growth and durable timber. Regional evidence shows more than 80 % of agroforestry farmers favor *Eucalyptus*, which can be harvested within 6-8 years, while *Dalbergia sissoo* is valued for long-lasting furniture wood despite slower maturation [23].

- Boundary Planting

Farmers plant trees along field edges and irrigation channels to conserve crop space while gaining fuelwood and fodder. Species such as *Acacia nilotica* (kikar) and *Morus alba* (mulberry) dominate. Comparable districts report boundary planting on about 15-20 % of agroforestry land, a pattern likely in Darazinda where smallholdings average 2-5 ha.

- Silvopastoral Systems

Less common because cropping predominates, but some households grow fodder species like *Acacia nilotica* and *Leucaena leucocephala* to support small goat and cattle herds. Regional data indicate these systems cover under 5 % of agroforestry land in similar semi-arid zones

Table 1 shows the results of agroforestry adoption across Darazinda is moderate, with roughly 20-30 % of farmers engaged in at least one agroforestry system. *Eucalyptus* accounts for about 70-80 % of planted trees, followed by *Dalbergia sissoo* (10-15 %) and other species such as *Populus deltoides* and *Acacia nilotica* (5-10 %). Tree density in agri-silviculture systems is estimated at 50-100 trees ha^{-1} and in boundary planting at 10-20 trees ha^{-1}.

Table 1. Summary of Agroforestry Systems in Sub-Division Darazinda

Agroforestry System	Dominant Species	Estimated Prevalence	Main Economic Impacts	Key Environmental Benefits
Agri-silviculture	*Eucalyptus camaldulensis*, *Dalbergia sissoo*	≈83 %	Timber income Rs 60000-100,000 ha^{-1}; fuelwood Rs 10,000-20,000 ha^{-1}	Soil-organic matter +0.5-1 %, carbon sequestration 0.21-0.29 Mg C ha^{-1} yr^{-1}
Boundary Planting	*Acacia nilotica*, *Morus alba*	15-20 %	Fodder Rs 5,000-15,000 ha^{-1}; fuelwood sales	Erosion control, micro-climate moderation
Silvopastoral	*Acacia nilotica*, *Leucaena leucocephala*	<5 %	Livestock fodder and small cash income	Biodiversity support, soil stabilization

4.2 Socioeconomic Impacts

4.2.1 Economic Benefits

Agroforestry provides multiple income streams—timber, fuelwood, fodder, and occasional fruit—reducing dependence on single-crop markets. Regional studies suggest *Eucalyptus* plantations yield Rs 60000-100,000 ha^{-1} over 6-8 years, with fuelwood adding Rs 5000-15000 ha^{-1} annually. Acacia fodder contributes roughly Rs 5,000-15,000 ha^{-1} for livestock keepers. Agroforestry also generates seasonal employment for nursery work, tree planting, and timber processing, helping curb rural-to-urban migration.

4.2.2 Social Benefits

Fruit species (e.g., mango, citrus) where adopted improve household nutrition and food security. Fodder trees sustain livestock, indirectly boosting dairy production and strengthening community resilience through shared resources like communal woodlots or fodder banks.

4.2.3 Environmental and Resilience Benefits

Tree integration improves soil fertility (adding 0.5-1 % organic matter annually), reduces erosion, and enhances water retention—critical for drought-prone Darazinda. Carbon sequestration is estimated at 0.21-0.29 Mg C ha^{-1} yr^{-1}, roughly equivalent to 0.8-1.1 Mg CO_2 ha^{-1} yr^{-1}, creating potential for carbon-credit projects. Biodiversity increases, supporting pollinators and beneficial soil organisms [24].

4.3 Constraints

Despite clear benefits, adoption faces multiple barriers:

- Policy Gaps: Absence of a Darazinda-specific agroforestry framework and complex timber-harvest rules discourage participation.

- Market Access: Limited buyer networks and high transport costs (Rs 5,000-10,000 per timber load) reduce profits, forcing reliance on middlemen.

- Technical Barriers: Scarce certified saplings and understaffed extension services leave knowledge gaps about optimal tree-crop arrangements.

- Socioeconomic Factors: Small landholdings (2-5 ha), low literacy rates, and gender inequities restrict participation and benefits.

5. Discussion

The results demonstrate agroforestry's strong potential to enhance livelihoods and ecosystem services in Darazinda, echoing findings from other semi-arid regions of Pakistan and South Asia.

5.1 Economic Benefits

Integrating *Eucalyptus* and *Dalbergia sissoo* with staple crops offers diversified and relatively stable income compared with monoculture farming. The estimated Rs 100,000-200,000 ha^{-1} timber return parallels gains reported in Indian poplar systems, but profitability is dampened by weak market linkages and bureaucratic harvest regulations. Strengthening buyer agreements and simplifying permit processes could raise farmer earnings and employment opportunities [25].

5.2 Environmental and Social Impacts

Agroforestry mitigates soil degradation, enhances carbon storage, and improves micro-climates, aligning with global studies on carbon sequestration in tropical agroforestry. Socially, it supports food security and community cooperation, although gender disparities and low literacy hinder equal access to training and decision-making.

5.3 Challenges and Opportunities

Key challenges—policy voids, market constraints, technical gaps, and socioeconomic limitations—mirror those faced in other developing regions. Policy reforms modeled on successful Indian and provincial initiatives, coupled with carbon-credit incentives, could stimulate broader adoption. Expanding extension services and promoting species diversification beyond *Eucalyptus* would further strengthen system resilience.

5.4 Future Directions

Recommended actions include:

- Drafting a localized agroforestry policy with subsidies and simplified harvest rules,
- Developing timber industry buy-back programs,
- Expanding public-private extension services targeting women and low-literacy farmers,
- Conducting primary field research on tree density, adoption rates, and gendered impacts.

6. Conclusions

Agroforestry in Sub-Division Darazinda offers a practical path toward sustainable rural development. Approximately 30-40 % of farmers practice some form of tree-crop integration, dominated by *Eucalyptus camaldulensis* and *Dalbergia sissoo*. These systems generate higher and more stable income than sole cropping, provide employment, and enhance resilience to drought through soil improvement and carbon sequestration.

Yet, growth is hampered by weak policy support, restricted markets, technical shortcomings, and socioeconomic challenges such as small landholdings and low literacy. Targeted interventions—local policy reforms, stronger market linkages, improved extension services, and community-based approaches—are essential to scale up adoption. Diversifying species to include fruit and fodder trees will improve food security and reduce ecological concerns tied to *Eucalyptus* monoculture. By addressing these barriers, agroforestry can become a cornerstone of sustainable livelihoods and climate adaptation in Darazinda, aligning with Pakistan's broader environmental and development goals.

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