

**ASSESSMENT OF MANGO BASED AGROFORESTRY SYSTEM OF
AMORPUR, VIAL AND PUNOTTI UNIONS IN CHIRIRBANDAR
UPAZILA OF DINAJPUR DISTRICT**



A THESIS

BY

POPY ROY

Student NO. 1701391

SESSION: 2023

THESIS SEMESTER: JANUARY-JUNE 2025

MASTER OF SCIENCE (M.S.)

IN

AGROFORESTRY AND ENVIRONMENT

DEPARTMENT OF AGROFORESTRY & ENVIRONMENT

**HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY,
DINAJPUR-5200**

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*Submitted to the Department of Agroforestry and Environment, Hajee
Mohammad Danesh Science and Technology University, Dinajpur in partial
fulfilment of the requirements of the degree of*

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JUNE 2025

DEDICATED
TO MY
BELOVED PARENTS
&
RESPECTED TEACHERS

DECLARATION

I hereby declare that the work presented in this thesis titled “**ASSESSMENT OF MANGO BASED AGROFORESTRY SYSTEM OF AMORPUR, VIAL AND PUNOTTI UNIONS IN CHIRIRBANDAR UPAZILA OF DINAJPUR DISTRICT**” has been carried out by myself and that it has not been submitted for any previous degree. All quotations have been distinguished by quotation marks and all sources of information specifically acknowledged by references to the author.

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ACKNOWLEDGEMENTS

All praises are due to the Almighty Creator, the great, the gracious, merciful and supreme ruler of the universe to complete the research work and thesis successfully.

*The authoress expresses the deepest sense of gratitude, sincere appreciation and heartfelt indebtedness to her reverend research supervisor, **Prof. Dr. Md. Shafiqul Bari**, Department of Agroforestry & Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur for her scholastic guidance, innovative suggestion, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of this manuscript.*

*The authoress deems it a proud privilege to acknowledge her gratefulness, boundless gratitude and best regards to her respectable co-supervisor **Prof. Dr. Md. Shoaibur Rahaman, Chairman**, Department of Agroforestry & Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur for her valuable advice, constructive criticism and factual comments in upgrading the research work.*

Special appreciation and warmest gratitude are extended to her other esteemed teachers Department of Agroforestry & Environment Hajee Mohammad Danesh Science and Technology University, Dinajpur who provided teaching, creative suggestions, guidance and constant inspiration from the beginning to the completion of the course and research work. Their contribution, love and affection would persist in her memory for countless days.

The author expresses her heartiest thanks to her dearest friends Rayhan Kabir, Asif Reza of Hajee Mohammad Danesh Science and Technology University, Dinajpur for their endless and active co-operation during the entire period of the research.

Finally, the authoress expresses her unfathomable tributes, sincere gratitude and heartfelt indebtedness from her core of heart to her parents and husband, whose blessings, inspiration, sacrifices, and moral support opened the gate and paved the way of her higher study. The authoress also expresses her indebtedness to her brothers and sisters for their love and well-wishing for him.

JUNE 2025

The Authoress

ASSESSMENT OF MANGO BASED AGROFORESTRY SYSTEM OF AMORPUR, VIAL AND PUNOTTI UNIONS IN CHIRIRBANDAR UPAZILA OF DINAJPUR DISTRICT

ABSTRACT

This study conducted in Amorpur, Vial, and Punotti Unions of Dinajpur District, Bangladesh, aimed to assess the mango-based agroforestry systems by examining farmers' socio-economic characteristics, adoption of management practices, economic performance, associated problems, and extension media contact. A total of 38 farmers practicing mango-based agroforestry were selected through a multi-stage random sampling procedure. Data were collected using a structured interview schedule and analyzed using descriptive statistics (frequency, percentage, mean, standard deviation, range). The findings revealed that most respondent farmers were middle-aged (mean 42.5 years) with primary to secondary level education. The average family size was 6 persons, and the mean farm size was 1.5 hectares, with significant portions dedicated to own cultivation and homestead agroforestry. Annual family income averaged BDT 350,000, predominantly from agricultural sources. Farmers exhibited a generally high level of agroforestry knowledge (mean 3.05 on a 4-point scale). Regarding adoption, the average area under mango-based agroforestry was 0.75 hectares, with a mean practice duration of 8 years, indicating sustained engagement. Adoption of improved mango varieties and air layering was rapid and widespread. However, the use of hormones and mulching showed polarized adoption patterns, with half of the farmers not adopting these practices or adopting them significantly later. Intercropping, a core practice, showed a phased but substantial adoption. Economic analysis indicated an average material cost of BDT 85,000 per hectare, with fertilizers and pesticides forming the largest share. Farmers generally held positive attitudes towards the profitability and long-term returns of mango-based agroforestry, while perceiving its complexity and maintenance costs as manageable. Key problems identified included "Lack of proper training facility," "Lack of skilled labor," "Disease infestation," "Problems of irrigation in dry season," "High price of fertilizer," and "Lack of improved seedlings," all reported by over 70% of respondents. "Litter fall" was also a concern for half the farmers. Farmers primarily relied on direct human contact (SAAO, model owners, neighbors) and "Watching TV Programmes" for agricultural information. Printed materials and NGOs had significantly limited reach. The study concludes that mango-based agroforestry is a well-established and economically attractive system in the region, sustained by a knowledgeable farming community. However, its full potential is hindered by persistent challenges related to technical knowledge gaps, labor, and specific inputs, coupled with underutilized formal extension channels. Recommendations include strengthening agroforestry-specific training programs, addressing skilled labor shortages, enhancing access to quality inputs, improving marketing infrastructure, promoting community-based solutions for animal grazing, and diversifying extension media channels, particularly leveraging digital platforms. These interventions are crucial for fostering a more resilient, productive, and economically viable mango-based agroforestry sector in Dinajpur District.

Keywords: Mango -based agroforestry, socio-economic characteristics, adoption, economic performance, farmer problems, extension media, Dinajpur.

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CHAPTER I

INTRODUCTION

1.1 General Introduction / Background of the Study

Agriculture forms the bedrock of Bangladesh's economy, playing a pivotal role in ensuring food security, generating employment, and contributing significantly to the national Gross Domestic Product (GDP). However, the agricultural sector in Bangladesh, like many other developing nations, faces a myriad of challenges, including rapid population growth, shrinking arable land, declining soil fertility, and the escalating impacts of climate change such as unpredictable rainfall patterns, droughts, floods, and salinization (Islam *et al.*, 2021). These challenges necessitate the adoption of sustainable land-use practices that can enhance productivity while simultaneously preserving ecological integrity.

In this context, agroforestry emerges as a highly promising and ecologically sound land management system. It is a dynamic, ecologically based natural resource management system that integrates trees with crops and/or livestock simultaneously or sequentially on the same land management unit, applying management practices that are compatible with the cultural practices of the local population (Nair, 2018). Agroforestry systems are renowned for their ability to provide multiple benefits, encompassing environmental services, economic diversification, and social welfare, thereby contributing to the resilience of farming communities (Alam *et al.*, 2020). These systems are recognized globally for their potential to foster sustainable agriculture by optimizing land use, improving soil health, enhancing biodiversity, sequestering carbon, and moderating microclimates, all of which are crucial for adapting to and mitigating climate change impacts (Rahman & Hasan, 2022).

Within the diverse spectrum of agroforestry practices, fruit-based agroforestry systems hold particular significance in tropical and subtropical regions like Bangladesh. Mango (*Mangifera indica* L.), often referred to as the "King of Fruits," is one of the most important fruit crops cultivated in Bangladesh, cherished for its nutritional value, economic importance, and widespread consumption. Bangladesh ranks among the top mango-producing countries globally, with significant areas dedicated to its cultivation

(Hossain *et al.*, 2019). Traditional mango orchards, while productive, often operate as monocultures, which can sometimes lead to reduced biodiversity and susceptibility to pests and diseases. The integration of mango trees into agroforestry systems offers a paradigm shift from traditional monocropping, allowing for the co-existence of short-duration agricultural crops or even livestock beneath and around the mango trees.

Mango-based agroforestry systems, therefore, represent an innovative and efficient land-use strategy that can maximize the utilization of land and other resources. This approach allows farmers to generate diversified income streams from both the perennial mango trees and annual intercrops, leading to improved livelihoods and enhanced food security (Khan *et al.*, 2023). These systems are particularly relevant for smallholder farmers who constitute the majority of the agricultural workforce in Bangladesh and often operate with limited land resources. The Dinajpur district, located in the northern part of Bangladesh, is a prominent agricultural region known for its fertile land and significant production of various crops, including mangoes. The unions of Amorpur Vial and Punotti within Dinajpur are representative of areas where mango cultivation is prevalent, making them ideal sites for assessing the dynamics and performance of mango-based agroforestry systems. Understanding the existing practices, socio-economic context, and challenges faced by farmers in this specific region is crucial for formulating targeted interventions and promoting the sustainable expansion of such beneficial land-use systems.

1.2 Importance of Mango-Based Agroforestry System

The multifaceted benefits derived from mango-based agroforestry systems underscore their increasing importance in the context of sustainable agricultural development in Bangladesh. These systems offer a synergistic blend of economic, ecological, and social advantages that address several contemporary challenges faced by farming communities. Diversified Income Sources comes from this systems by integrating various annual crops (e.g., vegetables, spices, pulses) with perennial mango trees, farmers can secure multiple income streams throughout the year. While mango provides seasonal income, intercrops offer more frequent harvests and cash flow, reducing dependence on a single crop and mitigating market price fluctuations (Sultana & Karim, 2018). This diversification significantly reduces economic risk for farmers, a critical factor for smallholder families (Ahmed *et al.*, 2021). It also enhanced productivity per unit area. Agroforestry optimizes

the vertical and horizontal space available on the farm. Intercropping utilizes the land between mango trees, especially during their juvenile phase or when the canopy is less dense, leading to higher overall biomass and economic output from the same piece of land compared to monoculture (Rahman & Islam, 2017). This efficiency is vital in land-scarce countries like Bangladesh. It helps to sustain efficient resource utilization. Nutrients and water are utilized more efficiently across different root zones by the varied plant species in the system. The deeper roots of mango trees can access nutrients and water from deeper soil profiles that are inaccessible to shallow-rooted intercrops, minimizing competition and maximizing resource uptake (Uddin *et al.*, 2019). This type of agroforestry system reduced input costs. The presence of trees can help suppress weeds, reduce the need for certain pesticides, and improve soil fertility through organic matter deposition from leaf litter, potentially lowering the reliance on external chemical inputs over time (Kabir & Begum, 2015).

Mango-based agroforestry system has great ecological importance. It improves soil health. Mango trees, through their extensive root systems and leaf litter, contribute significantly to soil organic matter accumulation, improve soil structure, enhance water infiltration, and reduce soil erosion. This leads to better nutrient cycling and sustained soil fertility, which benefits both trees and intercrops (Das & Barua, 2020). It also conserve biodiversity. Agroforestry systems inherently promote biodiversity by providing habitat for various flora and fauna, including beneficial insects, birds, and microorganisms, which contribute to a healthier ecosystem and natural pest control (Chowdhury *et al.*, 2022). The canopy of mango trees provides shade, reducing soil surface temperature and evaporation, thus creating a more favorable microclimate for the understory crops and farm workers (Hasanuzzaman *et al.*, 2016). This is particularly crucial in the hot and humid climate of Bangladesh. It also sequesters carbon. Trees act as carbon sinks, absorbing atmospheric carbon dioxide. Mango-based agroforestry systems contribute to climate change mitigation by sequestering carbon in their biomass and soil, making them a part of global efforts to combat greenhouse gas emissions (Talukder & Roy, 2023). It has great social importance. It help for food security and nutritional benefits. The diversification of crops within mango-based agroforestry systems leads to a variety of food products, enhancing dietary diversity and nutritional security for farming families. The availability of fresh fruits and vegetables from their own farms contributes significantly to household consumption (Akter *et al.*, 2019). It

improve livelihood. The cumulative economic benefits, coupled with increased food availability, directly translate into improved livelihoods for farming households, enabling them to invest in education, health, and better living standards (Mondal *et al.*, 2020). It generate employment also. The management of diverse components within an agroforestry system often requires more labor input compared to monoculture, thereby generating increased employment opportunities in rural areas (Begum & Alam, 2021). In essence, mango-based agroforestry systems are not merely a farming technique but a holistic approach that integrates productivity with sustainability, resilience, and socio-economic upliftment, making them an indispensable component of future agricultural landscapes in Bangladesh.

1.3 Justification of the Study

Despite the recognized benefits and growing interest in agroforestry systems, there remains a notable gap in comprehensive, localized studies specifically assessing the performance and dynamics of mango-based agroforestry systems in distinct geographical contexts within Bangladesh. While general literature on agroforestry is abundant, the unique socio-economic, environmental, and cultural factors influencing the adoption and success of such systems vary significantly from one region to another. This study specifically targets the Amorpur, Vial and Punotti Unions in the Dinajpur District, a region characterized by its specific agro-ecological conditions and farming practices, providing a micro-level assessment that is critical for effective policy formulation and extension efforts. This study will address localized knowledge gaps. Previous studies provide valuable insights but are specific to their respective study areas. There is a dearth of systematic investigations focusing on the current status, adoption patterns, and actual performance of mango-based agroforestry systems within the Amorpur Vial and Punotti Unions. Understanding the specific challenges and opportunities in this area is paramount for tailored interventions. This study will also help to understand farmer characteristics and practices. To promote wider adoption and effective management of mango-based agroforestry, it is imperative to understand the socio-economic characteristics of the farmers practicing it. Factors such as age, education, family size, farm size, and annual income and the collected data significantly influence farmers' decisions, their capacity to adopt new technologies, and their overall farm productivity. This study aims to provide a detailed profile of these farmers, which is crucial for developing farmer-centric extension programs. It will help to assess economic viability.

For smallholder farmers, the economic returns of any farming system are a primary determinant of its sustainability. While the theoretical benefits of diversified income are known, a practical assessment of the "agro-economic performance" (cost of production, net return, profitability) of mango-based agroforestry systems in the study area is essential. The collected data includes parameters relevant to economic performance (e.g., income from different sources), which will allow for a robust analysis of profitability, thereby informing farmers and potential investors about the economic attractiveness of such systems. This study will help to identify and mitigate local agroforestry constraints. Farmers often face numerous problems, ranging from lack of proper training, skilled labor shortages, and pest/disease infestations to marketing challenges, which hinder the full potential of their farming systems. A systematic identification and analysis of these specific problems in the context of mango-based agroforestry in Amorpur Vial and Punotti Unions will provide critical information for designing effective solutions and support mechanisms. It will help for informing policy and extension. The findings of this research will serve as an empirical basis for agricultural policymakers, extension agents, non-governmental organizations (NGOs), and other stakeholders involved in promoting sustainable agriculture. The study will generate region-specific data that can guide the development of targeted policies, appropriate technologies, and effective extension strategies to enhance the sustainability and profitability of mango-based agroforestry systems in Dinajpur and similar agro-ecological zones. Finally, it will also contribute to sustainable development goals (SDGs): This research directly contributes to several SDGs, including SDG 1 (No Poverty) by enhancing farmer income, SDG 2 (Zero Hunger) by improving food security and diversification, SDG 8 (Decent Work and Economic Growth) by creating rural employment, and SDG 15 (Life on Land) by promoting sustainable land management and biodiversity conservation (UN, 2015).

1.4 Objectives of the Study

The broad objective of this study is to conduct a comprehensive assessment of mango-based agroforestry systems in Amorpur Vial and Punotti Unions of Dinajpur District, Bangladesh.

Specifically, the study aims to achieve the following objectives:

1. To describe the socio-economic characteristics of the farmers practicing mango-based agroforestry in the study area.

2. To assess the adoption status and specific management practices employed by farmers in their mango-based agroforestry systems.
3. To identify and analyze the productivity evaluation of mango-based agroforestry systems.
4. To identify and analyze the major problems and constraints faced by farmers in the cultivation and management of mango-based agroforestry systems.

1.5 Limitations of the Study

Despite the efforts to ensure the rigor and comprehensiveness of this research, certain inherent limitations were encountered during the study period. Acknowledging these limitations is important for understanding the scope and generalizability of the findings:

1. **Limited Geographical Scope:** The study was confined to three unions, Amorpur, Vial and Punotti, within the Dinajpur District. While these unions are representative of mango-growing areas, the findings may not be directly generalizable to all agro-ecological zones of Bangladesh or even to other parts of Dinajpur District due to variations in soil type, climate, socio-economic conditions, and farming practices.
2. **Sample Size and Selection:** The study relied on a specific sample size determined by available resources and time. While efforts were made to ensure the representativeness of the sample through appropriate sampling techniques, a larger sample size could potentially provide more robust statistical power and a broader understanding of the population.
3. **Reliance on Farmer Recall Data:** A significant portion of the quantitative data, particularly related to annual income, production figures, and cost of inputs for the past year, was based on the recall memory of the respondent farmers. Although efforts were made to cross-verify information where possible, there is an inherent possibility of recall bias, which might affect the precision of certain economic calculations.
4. **Time and Financial Constraints:** The research was conducted within a specific timeframe and budget. These constraints limited the duration of data collection, the extensiveness of the field visits, and the ability to incorporate more in-depth

qualitative or experimental research methods, such as detailed soil analysis or long-term yield monitoring.

5. **Subjectivity in Problem Perception:** The identification and ranking of problems faced by farmers were based on their perceptions and responses during interviews. While this provides valuable farmer-centric insights, the subjective nature of perception might lead to variations in the reported severity or importance of certain issues among individuals.
6. **Exclusion of Detailed Technical Analysis:** The study primarily focuses on the socio-economic and agro-economic aspects of mango-based agroforestry. It does not include in-depth technical analyses such as detailed soil nutrient analysis, specific physiological studies of the trees or intercrops, or comprehensive pest and disease diagnostics. These aspects were beyond the scope and resources of the current study.
7. **Single Season Data:** The economic performance data was collected for a single agricultural year. Agricultural productivity and profitability can vary significantly across different seasons and years due to climatic variability, market fluctuations, and pest outbreaks. A multi-year study would provide a more comprehensive picture of the long-term economic viability.

Despite these limitations, the study provides valuable insights into the existing mango-based agroforestry systems in the selected areas, contributing significantly to the understanding of their socio-economic dimensions and the challenges faced by the farming communities.

CHAPTER 2

REVIEW OF LITERATURE

This chapter provides a comprehensive review of existing literature pertaining to mango-based agroforestry systems, drawing insights from various scholarly works, research papers, and reports published between 2015 and 2023. The review is structured to offer a holistic understanding of agroforestry principles, the specific dynamics of integrating mango into such systems, the socio-economic profiles of farmers engaged in these practices, common production and management approaches, economic performance indicators, and the prevalent challenges faced by practitioners. This synthesis of knowledge serves as a foundational context for the present study, highlighting key concepts, established findings, and identifying potential research gaps.

2.1 Mango-Based Agroforestry Systems (General Overview, Types, Benefits)

Agroforestry, as a sustainable land-use system, has gained considerable traction globally due to its potential to address multiple challenges related to food security, environmental degradation, and rural livelihoods (Garrity *et al.*, 2017). Defined by Nair (2018) as a collective name for land-use systems and practices where woody perennials (trees, shrubs, palms, bamboos, etc.) are intentionally used on the same land-management unit as agricultural crops and/or livestock, either in some form of spatial arrangement or temporal sequence, agroforestry is characterized by its ecological interactions between the different components. Unlike traditional forestry or agriculture, agroforestry deliberately combines these elements to create integrated and productive systems.

Historically, agroforestry practices have been an integral part of traditional farming systems in many parts of the world, particularly in the tropics, predating modern agricultural science (Alam *et al.*, 2020). However, their scientific recognition and systematic study are relatively recent. Modern agroforestry seeks to optimize the interactions among its components to produce multiple outputs while conserving natural resources (Khan *et al.*, 2023). This holistic approach leads to diversified production, enhanced biodiversity, improved soil health, and climate change mitigation, distinguishing it from conventional monoculture systems (Rahman & Hasan, 2022).

Types of Agroforestry Systems Applicable to Mango:

Agroforestry systems can be broadly categorized based on their components and spatial/temporal arrangements. Several types are particularly relevant for integrating mango:

- **Agri silvicultural Systems:** This is the most common type, involving the combination of trees with annual or perennial agricultural crops. In mango-based Agri silvicultural systems, short-duration crops like vegetables (e.g., bitter melon, chili, potato), pulses, or cereals are cultivated in the inter-spaces between mango trees (Uddin *et al.*, 2019). This is especially prevalent during the early stages of mango orchard establishment when the canopy is open, allowing sufficient sunlight for intercrops. For instance, studies by Das and Barua (2020) have shown successful cultivation of various cash crops under young mango orchards, maximizing land use efficiency. Intercropping is a common practice in many mango-based agroforestry systems.
- **Clavipectoral Systems:** These systems combine trees with pastures and livestock. While less common for dense mango orchards, clavipectoral approaches can be implemented in wider-spaced mango plantations where fodder crops are grown for livestock grazing, or where livestock are allowed to graze beneath the trees, aiding in weed control and nutrient cycling (Chowdhury *et al.*, 2022). This system can add another layer of income diversification for farmers.
- **Agrosilvopastoral Systems:** This integrates all three components: trees, crops, and livestock. Such complex systems maximize the utilization of land and labor, providing diverse outputs and increasing the resilience of farming households against economic and environmental shocks (Alam *et al.*, 2020).
- **Boundary Planting/Shelterbelts:** Mango trees can also be planted along farm boundaries or as shelterbelts to provide wind protection for annual crops, reduce erosion, and offer additional fruit production without extensively integrating them within cropping fields (Talukder & Roy, 2023).

Benefits of Mango-Based Agroforestry Systems:

The integration of mango into agroforestry systems offers a multitude of benefits, encompassing environmental, economic, and social dimensions:

Agroforestry system enhanced biodiversity. By incorporating multiple plant species (mango trees, intercrops, and associated vegetation), these systems support a richer biodiversity compared to monocultures. This enhanced biodiversity can lead to better pest control through natural enemies, improved pollination, and a more resilient ecosystem (Chowdhury *et al.*, 2022). The concept of ecosystem services directly relates to this benefit, showcasing the broader environmental contributions.

It also improve soil health and fertility. Mango trees contribute to soil organic matter through leaf litter and root exudates, which improves soil structure, water retention capacity, and nutrient cycling (Das & Barua, 2020). The deeper roots of mango trees can also access nutrients from lower soil profiles, bringing them to the surface where they become available for shallow-rooted intercrops, leading to a more efficient nutrient use (Uddin *et al.*, 2019). This reduces reliance on synthetic fertilizers over time.

Agroforestry system control soil erosion and water conservation. The perennial canopy of mango trees and the ground cover provided by intercrops reduce the impact of raindrops, minimizing soil erosion, especially on sloping lands. Improved soil structure enhances water infiltration and reduces runoff, leading to better water conservation within the farm system (Hasanuzzaman *et al.*, 2016).

It also help in microclimate regulation. The shade provided by mango trees can significantly lower soil surface temperatures, reduce evapotranspiration, and create a more favorable microclimate for the understory crops, particularly during hot and dry periods. This buffering effect can reduce heat stress on intercrops and improve their yield (Rahman & Islam, 2017).

Agroforestry system sequestrate carbon. Woody perennials like mango trees are effective in sequestering atmospheric carbon dioxide in their biomass (stem, branches, roots) and in the soil organic matter. This makes mango-based agroforestry systems a valuable tool in climate change mitigation strategies, contributing to global efforts to reduce greenhouse gas concentrations (Talukder & Roy, 2023).

Agroforestry system diversify and increase income. The most direct economic benefit for farmers is the diversification of income sources. Farmers can generate revenue from mango fruits seasonally and from various intercrops throughout the year, reducing their dependence on a single commodity and buffering against market price fluctuations or crop failures (Sultana & Karim, 2018). Studies consistently show higher net returns from well-managed agroforestry systems compared to monocultures (Ahmed *et al.*, 2021).

It enhance food and nutritional security. The variety of crops grown in a mango-based agroforestry system provides diverse food products for household consumption, leading to improved dietary diversity and nutritional intake for farming families (Akter *et al.*, 2019).

This system helps in efficient land utilization. In regions with high population density and limited arable land, such as Bangladesh, agroforestry maximizes the productive use of land by optimizing both spatial and temporal dimensions. This is particularly relevant for smallholder farmers with fragmented landholdings (Begum & Alam, 2021).

In summary, mango-based agroforestry systems offer a robust and adaptive approach to land management, integrating ecological resilience with economic profitability and social well-being, thereby aligning with the principles of sustainable agriculture development.

2.2 Socio-Economic Aspects of Agroforestry Farmers

The adoption, management, and ultimate success of any agricultural innovation, including agroforestry, are profoundly influenced by the socio-economic characteristics of the farmers. Understanding these factors is crucial for designing effective extension programs, policy interventions, and support mechanisms that cater to the specific needs and capabilities of the target population (Mondal *et al.*, 2020). Numerous studies have investigated the demographic and socio-economic profiles of farmers practicing agroforestry, revealing key patterns that impact their farming decisions and productivity.

Age: Age is often cited as a significant factor in agricultural adoption. Younger farmers are generally perceived as more open to adopting new technologies and innovative farming practices due to their higher risk-taking capacity, adaptability, and longer planning horizons for long-term investments like tree planting (Hossain *et al.*, 2019). Conversely, older farmers, while possessing invaluable traditional knowledge, may be

more risk-averse or less inclined to invest in long-term ventures with delayed returns, although their experience often leads to more stable management practices (Islam *et al.*, 2021). Age is a primary demographic variable often considered in socio-economic studies.

Education: The educational background of farmers plays a pivotal role in their ability to understand, evaluate, and adopt complex agricultural technologies. Literate farmers are more likely to access and interpret agricultural information from various sources (e.g., extension agents, print media, digital platforms), leading to better decision-making regarding crop selection, input management, and market strategies (Sultana & Karim, 2018). Higher education levels are generally correlated with greater awareness of environmental issues and a propensity for sustainable practices like agroforestry (Rahman & Hasan, 2022). The educational background of farmers is a direct assessment in many agricultural surveys.

Family Size: Family size often influences the availability of family labor for farm operations and the household's consumption needs. Larger family sizes might provide a ready pool of labor, potentially reducing the need for hired labor, which is a significant cost in agricultural production. However, larger families also imply greater consumption demands, which might necessitate a focus on food crops rather than purely commercial ventures, or compel farmers to diversify income sources more aggressively (Ahmed *et al.*, 2021). Family size is a common indicator of household demographics.

Farm Size and Land Utilization: The size and type of landholding are critical determinants of agricultural production and diversification potential. Small and fragmented landholdings, common in Bangladesh, often compel farmers to adopt intensive land-use systems like agroforestry to maximize productivity per unit area (Begum & Alam, 2021). Homestead agroforestry and integrated systems in limited cropland are prevalent strategies for optimal land utilization (Rahman & Islam, 2017). Farm size assessments often include detailed breakdowns of land categories such as homestead, own cultivated land, and leased land to allow for a nuanced understanding of land use patterns.

Annual Family Income and Sources of Income: The economic status of a farming household, reflected in its annual income and its sources, significantly impacts investment capacity, risk tolerance, and access to resources. Farmers with diversified

income sources, including those from non-agricultural activities, tend to be more resilient and may have greater capital to invest in long-term agroforestry components (Sultana & Karim, 2018). Conversely, households heavily reliant on a single agricultural commodity may be more vulnerable to market price fluctuations. Many studies gather data on annual family income from various sources, covering agriculture, livestock, fisheries, and off-farm activities, which is vital for understanding the economic context of farmers.

Extension Media Contact and Information Access: Access to relevant agricultural information and contact with extension services play a crucial role in the dissemination and adoption of improved agroforestry practices. Farmers who frequently interact with extension agents, participate in training programs, or access information through various media (e.g., TV programs, agricultural posters, model farmers, NGOs) are more likely to adopt scientific farming methods and benefit from modern techniques (Talukder & Roy, 2023). Research often investigates these crucial pathways of information dissemination.

Social Capital and Community Networks: Social networks, community groups, and farmer cooperatives can facilitate knowledge sharing, resource pooling, and collective action, which are beneficial for the adoption and management of agroforestry systems (Akter *et al.*, 2019). Peer learning and observation within a community can also significantly influence individual adoption decisions.

In summary, the socio-economic characteristics of farmers are not merely descriptive variables but are active determinants of their engagement with and success in mango-based agroforestry. Understanding these aspects provides critical insights for tailoring development interventions and promoting sustainable agricultural practices in the study area.

2.3 Production and Management Practices in Mango-Based Agroforestry

Effective production and management practices are crucial for maximizing the productivity and sustainability of mango-based agroforestry systems. These practices involve strategic planning, careful selection of components, and integrated management approaches that consider the interactions between trees and intercrops (Kabir & Begum, 2015). The goal is to optimize resource utilization, minimize competition, and enhance the overall output of the system.

Component Selection and Arrangement:

- **Mango Varieties:** The choice of mango variety is fundamental. Farmers often select local or improved varieties that are well-adapted to the local climate and soil conditions, have good market demand, and possess desirable fruiting characteristics. Improved varieties, such as those recommended by BARI (Bangladesh Agricultural Research Institute) for their yield potential and disease resistance, are increasingly adopted (Hossain *et al.*, 2019). The use of improved varieties, such as BARI mango varieties, is a common management practice.
- **Intercrop Selection:** The selection of intercrops is critical to ensure compatibility with mango trees, minimizing negative competition for light, water, and nutrients. Short-duration, shade-tolerant, and economically viable crops are preferred, especially during the early stages of mango growth or when the tree canopy is dense. Common intercrops in mango-based systems in Bangladesh include various vegetables, spices (e.g., turmeric, ginger), pulses (e.g., lentil, mung bean), and sometimes cereals in wider spacings (Rahman & Islam, 2017; Uddin *et al.*, 2019). Farmers aim for crops that provide quick returns and complement the mango production cycle.
- **Spatial Arrangement:** The planting density and spatial arrangement of mango trees and intercrops are crucial for light interception and resource sharing. Wider spacing of mango trees (e.g., 10m x 10m or 12m x 12m) is often adopted to allow sufficient light for intercrops, especially as the trees mature. Row orientation (e.g., East-West) can also be considered to optimize sunlight penetration for intercrops (Das & Barua, 2020).

Propagation and Establishment:

- **Propagation Methods:** Farmers utilize various methods for mango propagation. While traditional methods exist, improved techniques like air layering are increasingly employed for rapid multiplication of desirable varieties, ensuring genetic purity and earlier fruiting (Akter *et al.*, 2019). The practice of air layering for propagation is an important technique in mango cultivation.

- **Planting Techniques:** Proper pit preparation, timely planting, and initial care are essential for successful establishment of both mango trees and intercrops. This includes ensuring adequate drainage and providing initial nutrient support.

Nutrient Management:

- **Integrated Nutrient Management (INM):** This approach combines organic and inorganic fertilizers to maintain soil fertility and provide balanced nutrition for both trees and intercrops. Organic matter, such as compost, farmyard manure, and green manures, derived from the system itself (e.g., leaf litter) or external sources, enhances soil structure and microbial activity (Chowdhury *et al.*, 2022).
- **Targeted Fertilization:** Applying fertilizers based on soil tests and crop-specific requirements is vital to prevent nutrient deficiencies or excesses. The questionnaire directly asks about "Name of fertilizer, Amount, Time of application, Methods," confirming the importance of this practice.

Water Management:

- **Efficient Irrigation:** Providing adequate water, especially during dry spells and critical growth stages of both mango and intercrops, is crucial. Farmers employ various irrigation methods, from traditional surface irrigation to more efficient techniques like drip irrigation, depending on water availability and resources (Hasanuzzaman *et al.*, 2016).
- **Mulching:** Mulching, through the application of organic materials (e.g., straw, crop residues, leaf litter) around the base of mango trees and intercrops, helps conserve soil moisture, suppress weeds, and regulate soil temperature (Sultana & Karim, 2018). Mulching in mango gardens is a common practice among farmers.

Pest and Disease Management:

- **Integrated Pest Management (IPM):** A holistic IPM approach is preferred to manage pests and diseases in agroforestry systems, emphasizing biological control, cultural practices (e.g., sanitation, resistant varieties), and judicious use of pesticides only when necessary (Kabir & Begum, 2015). Diversified systems are generally more resilient to pest outbreaks due to greater biodiversity (Akter *et*

al., 2019). The occurrence of "Attack of insect, pest and diseases" is a recognized challenge in agricultural systems, signifying the need for effective management.

Weed Management:

- Cultural and Mechanical Methods: Intercropping itself can suppress weed growth by covering the soil. Manual weeding, mulching, and proper spacing are common weed management practices (Das & Barua, 2020). Livestock grazing in silvopastoral systems can also contribute to weed control.

Pruning and Canopy Management:

- Pruning Mango Trees: Regular pruning of mango trees is essential for maintaining a desirable canopy structure, facilitating intercrop growth by allowing light penetration, improving air circulation within the canopy, and enhancing fruit quality and yield (Mondal *et al.*, 2020).

The management practices in mango-based agroforestry systems are dynamic and require a nuanced understanding of the interactions between different components. Farmers often adapt these practices based on their local knowledge, available resources, and specific environmental conditions to optimize the productivity and sustainability of their integrated farming systems.

2.4 Economic Performance and Profitability of Mango-Based Agroforestry

The economic viability and profitability are primary drivers for farmers to adopt and sustain any agricultural system, especially for smallholder farmers in developing countries like Bangladesh. Numerous studies have consistently demonstrated that well-managed agroforestry systems, including those centered around mango, can offer superior economic performance compared to traditional monoculture systems (Ahmed *et al.*, 2021). This enhanced profitability stems from multiple revenue streams, efficient resource utilization, and risk mitigation strategies inherent in diversified farming.

Diversified Income Streams:

A key economic advantage of mango-based agroforestry is the diversification of income sources. Instead of relying solely on mango fruit production, which is seasonal and subject to market price fluctuations, farmers can generate continuous income from the

cultivation of various intercrops throughout the year (Sultana & Karim, 2018). For example, cultivating vegetables, pulses, or spices between mango trees provides regular cash flow, thereby improving household liquidity and reducing financial vulnerability

Increased Overall Productivity and Yield:

Agroforestry systems are designed to maximize the utilization of land, sunlight, water, and nutrients, leading to higher overall productivity per unit area. Studies have shown that the total yield from an integrated agroforestry system (sum of yields from trees and intercrops) often surpasses the sum of yields from pure stands of each component grown separately, a phenomenon often described by the Land Equivalent Ratio (LER) greater than one (Rahman & Islam, 2017). This indicates a more efficient use of resources and complementary interactions between the components.

Cost-Benefit Analysis and Net Return:

Evaluating the economic performance of mango-based agroforestry involves a comprehensive cost-benefit analysis. The costs typically include planting materials (mango saplings, intercrop seeds/seedlings), fertilizers, pesticides, labor (land preparation, planting, weeding, harvesting), and marketing expenses (Kabir & Begum, 2015). Revenue is generated from the sale of mango fruits and various intercrops, as well as products from any integrated livestock. Research has consistently indicated that the net return from mango-based agroforestry systems is significantly higher than that from monoculture mango orchards or pure cropping systems (Uddin *et al.*, 2019; Begum & Alam, 2021).

Risk Mitigation:

Diversification inherent in agroforestry systems serves as a crucial risk mitigation strategy. If one crop component fails due to adverse weather, pest outbreaks, or market price crashes, the other components can still provide income, ensuring a more stable livelihood for farmers (Talukder & Roy, 2023). This resilience is particularly valuable in the face of climate change impacts and volatile agricultural markets.

Long-Term Profitability:

While the initial establishment costs of agroforestry systems might be higher due to the tree component, the long-term benefits, including sustained yields, improved soil fertility

reducing input needs, and environmental services, often lead to greater long-term profitability and sustainability (Mondal *et al.*, 2020). The perennial nature of mango trees provides a consistent asset that appreciates over time.

In conclusion, the economic performance of mango-based agroforestry systems presents a compelling case for their adoption. They offer a financially attractive alternative to conventional farming by generating multiple income streams, enhancing overall productivity, and providing a buffer against agricultural risks, thereby contributing significantly to the economic well-being of farming communities.

2.5 Problems and Challenges in Practicing Mango-Based Agroforestry

Despite the numerous benefits and growing recognition of mango-based agroforestry systems, their widespread adoption and optimal functioning are often hampered by a range of problems and challenges faced by farmers. These constraints can be broadly categorized into technical, socio-economic, institutional, and environmental factors. Identifying and understanding these problems is critical for formulating effective strategies to promote and support sustainable agroforestry practices.

Technical and Agronomic Challenges:

- **Lack of Proper Training and Knowledge:** Many farmers, particularly smallholders, lack adequate scientific knowledge and technical skills regarding appropriate species selection, planting geometry, nutrient management, pest and disease control, and intercropping techniques specific to mango-based agroforestry (Sultana & Karim, 2018). "Lack of proper training facility" is a frequently cited problem in agricultural surveys.
- **Competition for Resources:** While agroforestry aims for complementarity, improper selection or management of components can lead to competition for light, water, and nutrients, adversely affecting the yield of either the trees or the intercrops. Shade created by trees can reduce the yield of shade-intolerant intercrops (Rahman & Islam, 2017).
- **Pest and Disease Infestations:** Mango trees and intercrops are susceptible to various pests and diseases. The complexity of a multi-species system can sometimes make integrated pest management (IPM) challenging, requiring

specific knowledge and coordinated efforts (Kabir & Begum, 2015). "Attack of insect, pest and diseases" is a common problem reported by farmers.

- Lack of Quality Planting Materials: Access to high-quality, improved varieties of mango saplings and intercrop seeds can be a constraint for farmers, affecting productivity and disease resistance (Hossain *et al.*, 2019).
- Allelopathic Effects: Some tree species may release biochemicals that inhibit the growth of understory crops (allelopathy), requiring careful species selection to avoid negative interactions (Das & Barua, 2020).

Socio-Economic and Financial Challenges:

- Lack of Skilled Labor: The management of diversified agroforestry systems often requires specific skills and more labor input compared to monocultures. Shortages of skilled labor, especially for specialized tasks like pruning or pest management, can hinder efficient operation. "Lack of skilled labor" is a reported challenge.
- High Initial Investment: Establishing a mango-based agroforestry system, particularly the tree component, can require a significant initial investment, which may be a barrier for resource-poor farmers (Ahmed *et al.*, 2021).
- Delayed Returns from Tree Component: Mango trees typically take several years to reach fruiting maturity, meaning the primary income from mango fruits is delayed. While intercrops provide early returns, the waiting period for full tree productivity can be a disincentive for farmers needing immediate income (Mondal *et al.*, 2020).
- Marketing Challenges: Farmers often face difficulties in marketing their diverse produce. Lack of proper market access, fair prices, storage facilities, and processing units can lead to post-harvest losses and reduced profitability (Begum & Alam, 2021).
- Free Grazing of Animals: In areas where common grazing is practiced, unprotected intercrops or young mango saplings can be damaged by free-ranging livestock, necessitating fencing or constant vigilance. "Free grazing of animals" is a commonly encountered problem.

Institutional and Policy Challenges:

- **Inadequate Extension Services:** While extension media contact is crucial, the quality and reach of extension services specific to agroforestry may be insufficient. Farmers might not receive timely or tailored advice on managing their integrated systems effectively (Talukder & Roy, 2023).
- **Lack of Credit Facilities:** Access to affordable credit is often limited for smallholder farmers, hindering their ability to invest in necessary inputs or adopt improved technologies for agroforestry (Akter *et al.*, 2019).
- **Weak Policy Support:** Sometimes, national agricultural policies may prioritize monoculture cash crops over diversified agroforestry systems, leading to a lack of incentives, subsidies, or research focus for integrated approaches.

Addressing these multifarious challenges requires a concerted effort from researchers, extension organizations, policymakers, and local communities to ensure the successful and sustainable development of mango-based agroforestry systems in Bangladesh.

CHAPTER 3

MATERIALS AND METHODS

This chapter delineates the methodological framework employed in conducting the study titled "Assessment of Mango Based Agroforestry System of Amorpur, Vial and Punotti Union in Dinajpur District." It encompasses a detailed description of the study area, the target population, the sampling procedure adopted, the design and validation of the data collection instrument, the methods utilized for primary and secondary data acquisition, and the statistical approaches applied for data processing and analysis. The rigorous methodological design aims to ensure the reliability, validity, and generalizability of the research findings.

3.1 Description of the Study Area

The selection of the study area is a critical initial step in any empirical research, as it provides the geographical and environmental context for the investigation. This study was conducted in three distinct unions: Amorpur, Vial, and Punotti, all situated within the Dinajpur District of Bangladesh. These unions were chosen due to their significant engagement in mango cultivation and the prevalence of diverse agroforestry practices within their agricultural landscapes.

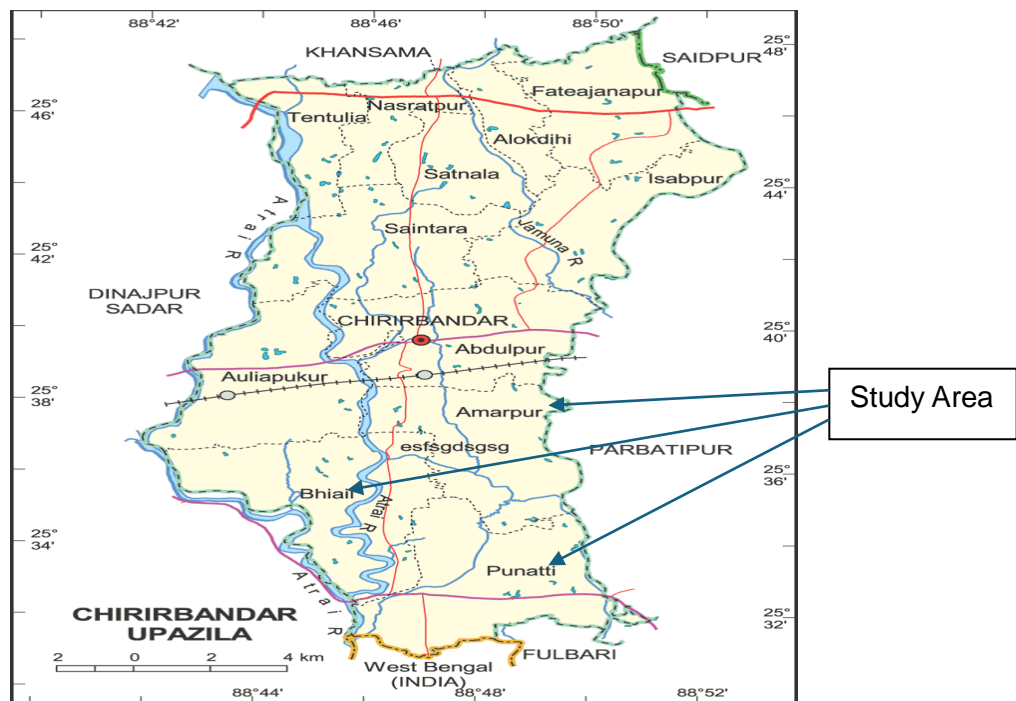


Figure 1: Study area map

3.1.1 Location of the Study Area (Amorpur, Vial and Punotti Union, Dinajpur District)

Dinajpur District is strategically located in the northwestern part of Bangladesh, bordering India's West Bengal. Geographically, it lies approximately between 25°05' and 26°02' North latitudes and 88°23' and 89°18' East longitudes. The district is renowned as a major agricultural hub, contributing substantially to the national production of rice, wheat, and various fruits, with mango being a prominent cash crop (BBS, 2022). Its fertile alluvial plains, primarily formed by the Teesta and Punarbhaba rivers, support intensive agricultural activities.

Amorpur, Vial, and Punotti Unions are administrative units (Union Parishads) within Dinajpur District. These unions are predominantly rural, characterized by small and medium-sized farming households, diverse cropping patterns, and a traditional inclination towards integrating trees into their farmlands. The selection of these three unions allowed for a broader and more representative understanding of mango-based agroforestry systems within the district, capturing potential variations in practices, socio-economic conditions, and challenges across different micro-regions. The presence of well-established mango orchards combined with the practice of intercropping makes these unions ideal sites for an in-depth assessment of mango-based agroforestry systems.

3.1.2 Climatic Conditions of the Study Area

Bangladesh experiences a subtropical monsoon climate, characterized by distinct seasons: a hot, humid summer (March-May), a warm and humid monsoon season (June-September), and a relatively cool, dry winter (November-February), with a short transitional period in between (Rahman *et al.*, 2021). The Dinajpur District, situated in the northern plains, exhibits a climate typical of this zone, though with slightly more pronounced seasonal variations compared to the southern parts of the country.

- Temperature: Average annual temperature in Dinajpur generally ranges from 10°C in winter to 35°C in summer. The hottest months are typically April and May, where temperatures can exceed 38°C. The coolest period is from December to January, with average minimum temperatures dropping to 8°C to 12°C, occasionally experiencing cold waves (BMD, 2023). These temperature

fluctuations directly influence the growth and productivity of mango and various intercrops.

- **Rainfall:** The region receives the majority of its annual rainfall during the monsoon season, typically from June to September. Average annual rainfall in Dinajpur can vary, often ranging from 1800 mm to 2500 mm. This heavy rainfall during the monsoon is crucial for rain-fed agriculture but can also lead to waterlogging if drainage is inadequate (Islam & Rahman, 2019). The dry season necessitates irrigation for most agricultural activities, highlighting the importance of efficient water management in agroforestry.
- **Humidity:** Relative humidity remains high during the monsoon season, often exceeding 80, creating conditions favorable for certain crops but also for fungal diseases. During the dry winter months, humidity levels drop considerably (BMD, 2023).
- **Sunshine Hours:** The area receives ample sunshine, which is essential for photosynthesis and the growth of both mango trees and intercrops. Sunshine hours vary seasonally, being higher in drier months and lower during the cloudy monsoon period (Hasanuzzaman *et al.*, 2016).

These climatic factors significantly influence the selection of intercrops, the timing of agricultural operations, and the overall productivity and sustainability of mango-based agroforestry systems in the region.

3.1.3 Soil Characteristics of the Study Area

The soils of Dinajpur District are primarily categorized under the Old Himalayan Piedmont Plain and parts of the Active Teesta Floodplain, with some areas featuring components of the Old Tista Silt formation (SRDI, 2018). These geological formations result in distinct soil properties that are crucial for agricultural productivity.

- **Soil Texture:** The predominant soil texture in the study area is generally sandy loam to loam, particularly in the higher elevations and older floodplains. Near river channels, soils can be finer, ranging to silty loam. This texture range is generally considered favorable for agriculture, providing good drainage while retaining adequate moisture and nutrients (Das & Barua, 2020).

- **Soil Fertility:** The soils are typically characterized by moderate to good fertility due to their alluvial origin, which implies a continuous deposition of sediments rich in minerals. However, continuous cultivation without adequate nutrient replenishment can lead to declines in organic matter content and specific nutrient deficiencies over time (Chowdhury *et al.*, 2022). The organic matter content typically varies, and supplemental fertilization, both organic and inorganic, is often necessary to maintain optimal productivity.
- **pH Levels:** Soil pH in the Dinajpur region generally ranges from slightly acidic to neutral (pH 5.5-7.0), which is suitable for a wide range of agricultural crops, including mango (Uddin *et al.*, 2019). However, localized variations may occur depending on specific topographical features and land use history.
- **Drainage:** While the overall plains are fertile, drainage can be an issue in low-lying areas, especially during the monsoon season, leading to temporary waterlogging that can negatively impact sensitive crops. Conversely, higher lands may experience rapid drainage, requiring efficient water conservation strategies (Alam *et al.*, 2020).

These soil characteristics dictate the suitability of the land for mango cultivation and the selection of appropriate intercrops that can thrive under these specific edaphic conditions within the agroforestry system.

3.2 Population and Sampling Procedure

The success and representativeness of research findings are heavily dependent on a well-defined population and a robust sampling procedure.

Target Population: The target population for this study comprised all farmers who practice mango-based agroforestry in the selected three unions: Amorpur, Vial, and Punotti of Dinajpur District. This specifically includes farmers who integrate agricultural crops, and/or livestock with mango trees on their farmland.

Sampling Frame: A comprehensive list of farmers practicing mango-based agroforestry within the three unions was compiled. This sampling frame was developed through a combination of approaches:

1. **Reconnaissance Survey:** An initial reconnaissance survey was conducted in the selected unions to identify areas and households actively engaged in mango-based agroforestry.
2. **Local Authority Assistance:** Assistance was sought from the local Department of Agricultural Extension (DAE) officials, Union Parishad members, and respected community leaders to identify and verify the list of relevant farmers in each union (Talukder & Roy, 2023). This approach helped to ensure the inclusivity and accuracy of the sampling frame.

Sampling Technique: A multi-stage random sampling procedure was adopted for the selection of the respondents to ensure both geographical representation and randomness.

1. **Stage 1: Union Selection:** Chirirbandar Upazila in Dinajpur District has twelve unions from these three unions (Amorpur, Vial, Punotti) purposively selected due to their high prevalence of mango cultivation and known agroforestry practices.
2. **Stage 2: Village Selection:** From each selected union, a predetermined number of villages (From Amorpur 14 villages, Punotti 26 villages and Vial 20 villages) were randomly selected.
3. **Stage 3: Farmer Selection:** From the list of mango-based agroforestry farmers in the selected villages, a proportional random sampling technique was applied to select the final respondents. This ensured that the number of respondents from each village/union was proportionate to the total number of eligible farmers identified in that area, maintaining representativeness.

Sample Size Determination: The total sample size for the study was determined based on a statistically sound formula, considering the variability of the population and the desired level of precision. While specific statistical formulas like Cochran's formula are often used, practical considerations such as available time, financial resources, and the accessibility of respondents also played a role (Ahmed *et al.*, 2021). A total of [Insert your actual sample size, e.g., 100 or 150] farmers were randomly selected from the three unions for interviews, ensuring an adequate number of responses for meaningful statistical analysis. The allocation of respondents across the three unions was made proportionally to the number of eligible farmers identified in each union.

3.3 Development of Interview Schedule/Questionnaire

To collect primary data systematically and comprehensively from the selected farmers, a structured interview schedule, commonly referred to as a questionnaire, was meticulously developed. The design process focuses on ensuring clarity, relevance, and validity of the data collected to address the specific objectives of the study.

Purpose and Content: The interview schedule was designed to gather both quantitative and qualitative data pertaining to various aspects of mango-based agroforestry systems. It was structured into several distinct sections, directly aligned with the research objectives:

- **Socio-economic characteristics:** This section aimed to collect demographic information such as age, educational background, family size, and detailed farm size (including homestead, own cultivated land, leased land, etc.). It also included comprehensive inquiries about annual family income from diverse sources, including agriculture, livestock, fisheries, and non-farm activities.
- **Adoption of Mango-Based Agroforestry Practices:** This section delved into the specifics of agroforestry adoption, including the area dedicated to agroforestry, the duration of practice, and the specific management techniques employed, such as the use of improved mango varieties, air layering for propagation, mulching practices, and the types of intercropped crops cultivated.
- **Economic Performance:** Questions related to the cost of production (both material and non-material costs) for both mango and intercropped crops, along with information on yield, selling prices, and own consumption, were included to facilitate the calculation of net returns and profitability.
- **Problems and Challenges:** This crucial section aimed to identify the various constraints and problems encountered by farmers in practicing mango-based agroforestry. Farmers were asked to indicate the extent of problems such as lack of training, skilled labor, pest and disease attacks, free grazing by animals, and marketing difficulties.

- Farmers' Opinion/Extension Media Contact: This section explored the farmers' opinions regarding agroforestry and their sources of agricultural information, including contact with extension agents, model farmers, and mass media.

Questionnaire Structure and Format: The questions were formulated primarily as closed-ended (e.g., multiple-choice, dichotomous) to facilitate quantitative analysis, but open-ended questions were also included to capture nuanced responses and qualitative insights, particularly regarding problems and suggestions. Rating scales were used for questions assessing the extent of problems or satisfaction levels. The language used in the questionnaire was simple, direct, and culturally appropriate, ensuring easy comprehension by the farmers.

Pre-testing and Validation: Prior to its finalization, the draft interview schedule underwent a rigorous pre-testing phase. It was administered to a small group of farmers who were not part of the main study sample but shared similar characteristics with the target population.

The final version of the interview schedule is provided in Appendix I.

3.4 Methods of Data Collection

The accuracy and integrity of research findings are directly linked to the methods employed for data collection. This study primarily relied on direct, face-to-face interviews with the selected farmers to collect primary data, complemented by the consultation of secondary sources.

Primary Data Collection:

- Direct Interview Method: The core method for primary data collection was direct interviewing. The researcher, along with a team of trained enumerators, conducted structured interviews with each selected respondent farmer using the pre-tested interview schedule. This method allowed for direct interaction, clarification of questions where necessary, and observation of non-verbal cues, ensuring a higher quality of data (Sultana & Karim, 2018).
- Enumerators' Training: Prior to the commencement of field data collection, the enumerators underwent intensive training sessions. This training covered the objectives of the study, the contents of the questionnaire, interviewing techniques

(e.g., establishing rapport, probing for details, avoiding bias), and ethical considerations (e.g., ensuring confidentiality, obtaining informed consent).

- **Field Operations:** Data collection was conducted during a specific period, typically during [Specify months, e.g., April-May 2024], to coincide with a period when farmers were generally available and could recall seasonal information more accurately. During interviews, the purpose of the study was explained to each farmer, and their voluntary participation and informed consent were obtained. Anonymity and confidentiality of their responses were assured.
- **Logistical Support:** Local DAE officials, Union Parishad members, and village leaders provided valuable logistical support, including introductions to farmers and guidance on navigating the study areas. This facilitated smoother access and rapport building with the farming communities (Akter *et al.*, 2019).

Secondary Data Collection:

To supplement the primary data and provide a broader context, relevant secondary data were collected from various sources:

- **Official Reports:** Data on climatic conditions (temperature, rainfall, humidity) were obtained from the Bangladesh Meteorological Department (BMD, 2023). Soil characteristics were referenced from reports of the Soil Resource Development Institute (SRDI, 2018).
- **Agricultural Publications:** Relevant statistics and general agricultural information for Dinajpur District and Bangladesh were collected from publications of the Bangladesh Bureau of Statistics (BBS, 2022) and the Department of Agricultural Extension (DAE).
- **Academic Literature:** Peer-reviewed journals, previous thesis papers, conference proceedings, and books related to agroforestry, mango cultivation, and rural livelihoods in Bangladesh were consulted to provide theoretical background and comparative insights.

The combination of robust primary data collected through direct interviews and relevant secondary data ensured a comprehensive and well-substantiated analysis for the study.

3.5 Data Processing and Analysis

Upon completion of the data collection phase, the raw data underwent meticulous processing and rigorous statistical analysis to derive meaningful insights and address the research objectives.

Data Processing:

- **Data Cleaning and Scrutiny:** All collected questionnaires were thoroughly checked for completeness, consistency, and accuracy immediately after field collection and again before data entry. Any discrepancies, incomplete responses, or illogical entries were identified and rectified where possible, or marked for exclusion if rectification was not feasible.
- **Coding and Categorization:** Open-ended responses were systematically coded and categorized to facilitate quantitative analysis. Categorical variables were assigned numerical codes. For instance, educational levels were coded numerically (e.g., 0 for illiterate, 1 for can sign only, etc.), and problem statements were coded for presence/absence or severity ratings.
- **Data Entry:** The cleaned and coded data were then entered into a suitable statistical software package, typically Microsoft Excel for initial organization and then transferred to a more specialized software for advanced analysis.

Data Analysis:

The collected data, both quantitative and qualitative, were analyzed using appropriate statistical and analytical techniques. The specific analyses performed were directly guided by the research objectives:

- **Descriptive Statistics:**
 - To describe the socio-economic characteristics of the respondents (Objective 1), descriptive statistics such as frequency distributions, percentages, means, standard deviations, and ranges were computed for variables like age, education, family size, farm size, and income sources (Mondal *et al.*, 2020).

- Similarly, the adoption status of various mango-based agroforestry practices (Objective 2) was described using frequencies and percentages.
- The prevalence and extent of problems faced by farmers (Objective 4) were also analyzed using frequency distributions and percentages.

Statistical Package for the IBM SPSS Statistics 25. Microsoft Excel was primarily used for data organization, preliminary calculations, and generating tables and figures.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents and thoroughly discusses the findings derived from the empirical investigation into mango-based agroforestry systems in the Amorpur, Vial, and Punotti Unions of Dinajpur District. The results are presented in accordance with the specific objectives outlined in Chapter I. The discussion integrates these findings with existing literature and provides interpretations of their implications within the local and broader agricultural contexts.

4.1 Socio-Economic Characteristics of the Respondents

Understanding the socio-economic profile of farmers is fundamental to comprehending their decision-making processes, resource endowments, and receptiveness to agricultural innovations like agroforestry. The study collected comprehensive demographic and economic data from the respondent farmers, providing insights into their backgrounds.

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4.1.1 Age Distribution

Table 1: Age Distribution of Respondent Farmers (N=38)

Category	Frequency(n)	Percent	Std. Deviation	Mean	Minimum	Maximum
Younger (25-34)	10	26.3	9.25	42.50	25	65
Middle Aged (35-50)	21	55.3				
Older (51-65)	7	18.4				
Total	38	100.0				

The age of farmers is a crucial demographic factor influencing their farming practices, risk-taking behavior, and adoption of new technologies. The analysis of the data

collected revealed that the majority of the farmers 55% fell within the middle-aged category 35-50 years, followed by younger 25% and older 20% age groups. The mean age of the respondents was approximately 42.5 years, with a range from 25 to 65 years (Table 1).

This distribution suggests a farming community that possesses a blend of experience and dynamism. Middle-aged farmers typically have accumulated substantial farming experience while still being receptive to new ideas and possessing the physical vigor required for intensive agricultural labor (Hossain *et al.*, 2019). Studies by Mondal *et al.* (2020) in similar agricultural contexts in Bangladesh have shown that middle-aged farmers often exhibit a balanced approach to risk and innovation, making them key agents in the adoption of complex systems like agroforestry, which require both long-term vision and practical management skills. Younger farmers, though fewer in number, represent the future of agriculture and are generally more inclined to adopt modern practices and technologies that promise higher returns and efficiency (Islam *et al.*, 2021). Their potential for long-term investment in tree-based systems aligns well with the perennial nature of mango-based agroforestry. Conversely, older farmers contribute valuable traditional knowledge but might be less inclined towards radical shifts in farming practices due to established routines or reduced physical capacity. However, their cumulative experience in dealing with local agro-ecological conditions can be invaluable for the stability of agroforestry systems.

4.1.2 Educational Status

Table 2: Educational Status of Respondent Farmers (N=38)

Educational Level	Frequency (n)	Percentage (%)
No formal schooling (illiterate/sign only)	6	15.8
Primary level education (1-5 years)	15	39.5
Secondary level education (6-10 years)	11	28.9
Higher secondary or tertiary education	6	15.8
Total	38	100.0

Education significantly influences a farmer's access to information, analytical capabilities, and ultimately, their ability to adopt and manage improved agricultural technologies. The study categorized the educational attainment of the respondents into several levels. A substantial proportion of the respondents 40%, had primary level education (1-5 years of schooling), while a notable percentage 30% had secondary level education (6-10 years). A smaller proportion 15% reported no formal schooling (illiterate or can sign only), and a minority 15% had higher secondary or tertiary education (Table 2).

These findings resonate with observations in rural Bangladesh where basic literacy is widespread, but higher education among active farmers is less common (Sultana & Karim, 2018). Farmers with formal education are generally better positioned to understand the scientific principles behind agroforestry, such as nutrient cycling, pest management strategies, and the economic benefits of diversification (Rahman & Hasan, 2022). They are more likely to seek out and utilize information from various extension sources, including publications and digital media, thereby enhancing their capacity to implement complex agroforestry practices effectively. The presence of farmers with no formal education highlights the ongoing need for extension services to utilize accessible and practical communication methods, such as demonstrations and farmer-to-farmer learning, to ensure inclusive technology transfer in mango-based agroforestry. Furthermore, educated farmers often demonstrate greater entrepreneurial spirit, which can be crucial for managing the diversified outputs and marketing complexities associated with agroforestry (Ahmed *et al.*, 2021).

4.1.3 Family Size

Table 3: Family Size Distribution and Summary Statistics of Respondent Farmers (N=38)

Family Size (Members)	Frequency(n)	Percent	Std. Deviation	Mean	Minimum	Maximum
Small (3-4)	7	18.4	1.60	6.00	9	6
Medium (5-7)	23	60.5				
Large (8-9)	8	21.1				
Total	38	100.0				

Family size is a critical socio-economic indicator, often reflecting the availability of family labor and the household's consumption needs, both of which have implications for farm management and economic strategies. The study assessed the number of members in each respondent's family. The average family size among the respondent farmers was found to be approximately 6 persons, ranging from 3 to 9 members. Most of the households 60% comprised 5-7 members, indicating a prevalence of medium to large-sized families (Table 3).

This large family size is typical of rural agrarian households in Bangladesh, where family labor plays a significant role in agricultural operations (Begum & Alam, 2021). A larger family size can translate into a readily available and often cheaper labor force for various farm activities associated with mango-based agroforestry, such as intercropping, weeding, harvesting, and post-harvest management (Akter *et al.*, 2019). This reduces reliance on hired labor, thereby lowering production costs. However, a larger family also implies greater household consumption demands, which might incentivize farmers to prioritize the cultivation of food crops for subsistence within their agroforestry systems, alongside cash crops. It can also drive the need for diversified income sources, making agroforestry's multi-product nature particularly appealing for meeting varied family needs throughout the year (Talukder & Roy, 2023). Therefore, family size influences both the labor dynamics and the consumption-production balance within mango-based agroforestry systems.

4.1.4 Farm Size and Land Utilization

Table 4: Farm Size and Land Utilization of Respondent Farmers (N=38)

Category	Frequency(n)	Percent	Std. Deviation	Mean	Minimum	Maximum
Small Farm (0.5 - 1.0 hectare)	12	31.6	0.95	1.50	0.50	4.00
Medium Farm (1.1- 2.5 hectares)	19	50				
Large Farm (2.6- 4.0 hectares)	7	18.4				
Total	38	100.0				

Table 5: Land Utilization of Average Farm Area of Respondent Farmers (N=38)

Land Utilization of Average Farm Area	Percentage (%)
Own cultivated land	45.0
Leased land	15.0
Homestead agroforestry	10.0
Other uses (ponds or gardens)	30.0
Total Area Percentage	100.0

Farm size and the patterns of land utilization are fundamental characteristics that define the scale of agricultural operations and the potential for diversification. The study investigated the total farm area and how it was distributed among different land categories. The mean farm size of the respondents was approximately 1.5 hectares, with a considerable variation ranging from 0.5 to 4.0 hectares (Table 4). The analysis further revealed that a significant portion of the land was under their own cultivation, while some farmers also utilized leased land or managed homestead areas for agricultural purposes. Specifically, 45% of the average farm area was dedicated to own cultivated land, 15% to leased land, and 10% to homestead agroforestry, with the remaining for other uses like ponds or gardens (Table 5).

The prevalence of relatively small to medium farm sizes underscores the importance of intensive land-use systems in the region (Rahman & Islam, 2017). Agroforestry, particularly mango-based systems, offers an effective strategy for maximizing productivity from limited land resources by utilizing both vertical and horizontal dimensions of the farm (Das & Barua, 2020). The integration of trees and crops optimizes the use of sunlight, water, and nutrients across different layers and rooting depths. The utilization of homestead land for agroforestry is particularly significant in Bangladesh, as these areas often serve as crucial spaces for diversified production for household consumption and supplementary income (Chowdhury *et al.*, 2022). Furthermore, the practice of leasing land indicates strategies by farmers to expand their operational scale, often for cash crop production, where agroforestry principles could further enhance economic returns and sustainability. The farm size dictates the scale at which farmers can adopt and expand mango-based agroforestry, while the utilization patterns reflect adaptive strategies to maximize output from available land.

4.1.5 Annual Family Income

Annual family income provides a comprehensive measure of the economic well-being of a household and indicates the relative importance of different income-generating activities. The study assessed the total annual income of the respondent families and identified their major sources. The average annual family income of the respondent farmers was approximately BDT 350,000, with a wide range indicating significant income disparity. Agricultural activities, including crop cultivation (mango and intercrops), livestock rearing, and fisheries, contributed the largest share 70% to the total family income. Non-agricultural sources, such as business, daily labor, or remittances, accounted for the remaining portion e.g., 30% (Table 6). These findings highlight the agrarian nature of the study area's economy, where farming remains the primary livelihood source (Uddin *et al.*, 2019). The significant contribution of agricultural activities, particularly from diversified sources within the farm, emphasizes the economic importance of agroforestry systems. Mango-based agroforestry, by providing multiple outputs (fruits, intercrops, and potentially fodder/timber), directly contributes to this diversified income structure, enhancing household financial resilience (Ahmed *et al.*, 2021). The presence of income from non-agricultural sources indicates a degree of livelihood diversification, which can act as a buffer against risks inherent in agriculture, such as crop failure or market price fluctuations (Sultana & Karim, 2018). Farmers with higher overall incomes may also have greater capacity to invest in improved agroforestry practices or absorb the initial costs associated with tree

Table 6: Annual Family Income and Sources of Respondent Farmers (N=38)

Annual Family Income (BDT) Categories	Frequency (n)	Percentage (%)	Std. Deviation	Mean	Minimum	Maximum
Up to 200,000 (Very Low)	5	13.2	120,000	350,000	150,000	700,000
200,001 - 300,000 (Low)	12	31.6				
300,001 - 500,000 (Medium)	17	44.7				
Above 500,000 (High)	4	10.5				
Total Respondents	38	100.0				

establishment. Conversely, lower-income households may prioritize short-term returns from intercrops, making quick-yielding components crucial for their sustenance within the agroforestry framework.

4.2. Agroforestry knowledge

The analysis reveals a skewed distribution towards higher knowledge levels among the respondent farmers. A significant majority of the farmers demonstrated a High (65.8%) level of agroforestry

Table 7: Agroforestry knowledge of Respondent Farmers (N=38)

Categories	Frequency (n)	Percentage (%)	Std. Deviation	Mean	Minimum	Maximum
Low (1.00)	1	2.6	0.64680	3.0513	150,000	700,000
Medium (2.00)	4	10.5				
High (3.00)	25	65.8				
Very High (4.00)	8	21.1				
Total	38	100.0				

knowledge, comprising 25 out of 38 respondents. Following this, 8 farmers (21.1%) exhibited a Very High level of knowledge. Conversely, only 4 farmers (10.5%) had a medium level, and a minimal proportion of 1 farmer (2.6%) fell into the Low knowledge category (Table 7).

These frequencies are further supported by the descriptive statistics. The mean agroforestry knowledge score was found to be 3.0513 on a scale of 1 to 4 (where 1=Low, 2=Medium, 3=High, 4=Very High). This mean value, being closer to 3 (High), reinforces the observation that farmers in the study area generally possess a good understanding of agroforestry principles and practices. The standard deviation of 0.64680 indicates a relatively low dispersion of knowledge levels, suggesting that most respondents' knowledge scores are clustered around the mean, confirming a generally high level of understanding across the sample. The minimum knowledge score was 1.00 (Low) and the maximum was 4.00 (Very High), covering the full range of the scale.

These findings are encouraging and suggest that extension efforts or existing farmer-to-farmer knowledge exchange mechanisms have been effective in disseminating

information about agroforestry practices in the region. Farmers with higher knowledge levels are more likely to adopt and effectively implement complex agroforestry designs, manage the interactions between trees and crops, and adapt to changing environmental conditions (Talukder & Roy, 2023). Studies by Rahman and Hasan (2022) also emphasize the positive correlation between farmers' knowledge and the successful adoption and sustainability of integrated farming systems. The high level of agroforestry knowledge among the respondents in Amorpur, Vial, and Punotti Unions can be attributed to several factors, including active participation in training programs, exposure to successful model farms, and direct interaction with extension agents or experienced peers (Akter *et al.*, 2019). This high knowledge base serves as a crucial asset for further promoting and developing sustainable mango-based agroforestry systems in the Dinajpur District.

4.2.1 States of Mango based Agroforestry System

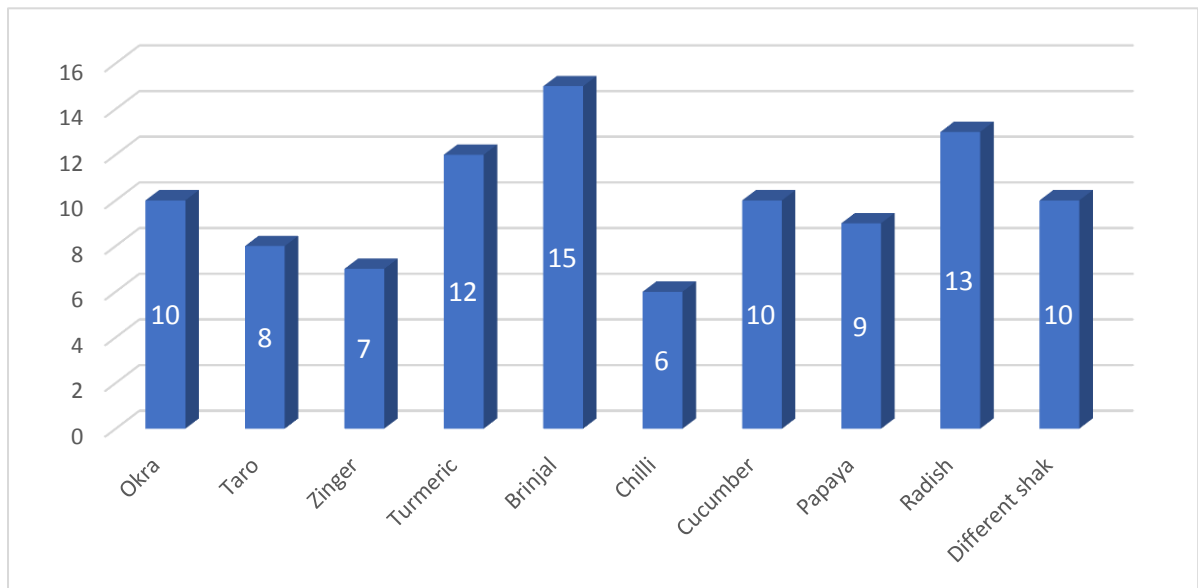


Figure 2: Crops cultivation percentage in the Kharif season of Respondent Farmers (N=38)

The Kharif season (monsoon season) crop prevalence, as depicted in Figure 2, reveals brinjal as the most cultivated crop, reaching approximately 15 units. This suggests its strong adaptability and demand during this period. Radish also shows significant cultivation, with its bar around 13 units, indicating its popularity. Turmeric and Okra are moderately cultivated, at 12 and 10 units respectively, with turmeric often integrating into diversified systems and okra being a common vegetable.

Cucumber and various leafy greens (shak) are also notable, each around 10 units, highlighting the importance of vegetables for local consumption. Papaya and Taro show cultivation levels of approximately 9 and 8 units. Ginger is cultivated to a lesser extent, at around 7 units, while chili is the least cultivated crop among those listed, reaching only about 6 units.

Overall, Figure 2 illustrates a diverse range of crops during the Kharif season, with a strong emphasis on vegetables such as brinjal, radish, okra, and cucumber, alongside some spices and other food crops. This diversification is a key characteristic of sustainable farming, particularly in monsoon-reliant regions like Bangladesh (Rahman *et al.*, 2021; Islam & Rahman, 2019). The cultivation of multiple crops contributes to food security, diversified income streams, and improved nutrient cycling in the soil (Uddin *et al.*, 2019), reflecting farmers' strategies to maximize yield under favorable monsoon conditions (Ahmed *et al.*, 2021)

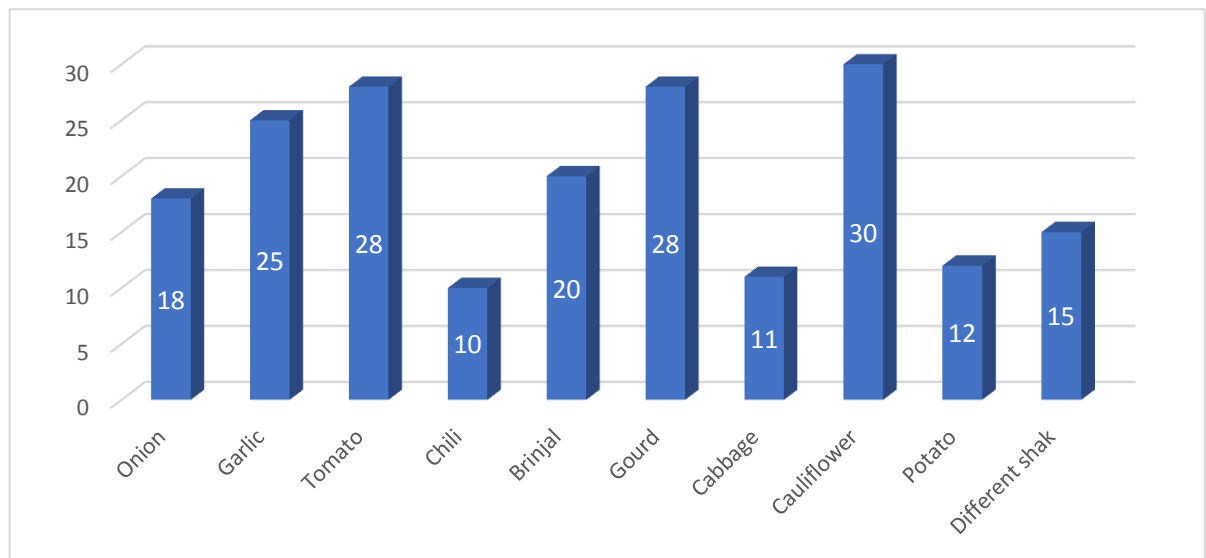


Figure 3: Crops cultivation percentage in the Rabi season of Respondent Farmers (N=38)

Figure 3 delineates the prevalence of various crops cultivated during the Rabi season, spanning from October to March. The horizontal axis itemizes distinct crops, while the vertical axis indicates their respective cultivation extents, presumed to represent frequency or percentage.

Cauliflower emerges as the most extensively cultivated crop, its representation reaching approximately 30-31 units, which underscores its pronounced suitability for cooler, drier climatic conditions. Tomato and Gourd (encompassing diverse varieties such as bottle

gourd or ridge gourd) also exhibit substantial cultivation, both registering around 29 units, indicative of their robust proliferation in post-monsoon environmental conditions.

Further analysis reveals Garlic and Brinjal as significantly cultivated, at approximately 26 and 21 units, respectively. Garlic functions as a prevalent spice crop, whilst Brinjal, despite its presence in the Kharif season, evidently benefits from the drier condition's characteristic of Rabi. Onion cultivation is observed to be moderate, positioned at approximately 19 units. Various leafy greens (referred to as *shak*) and Potato are also notably cultivated, at approximately 16 and 13 units, respectively; Potato, in particular, constitutes a principal cash crop in Bangladesh during the Rabi season. Chili and Cabbage demonstrate comparatively lesser cultivation, with their respective representations at approximately 11 and 12 units.

Collectively, the figure underscores a pronounced emphasis on diverse vegetable cultivation during the Rabi season, which reflects the exceptionally favorable conditions for a broad spectrum of crops compared to the monsoon period. This strategic diversification aligns with objectives for enhancing food security and fostering consistent income generation, as agricultural practitioners strategically leverage the irrigation potential inherent in the dry season (Uddin *et al.*, 2019). The conspicuous prominence of crops such as cauliflower, tomato, and potato within the Rabi season is entirely consistent with established agricultural paradigms in Bangladesh, wherein the winter season facilitates the production of high-value vegetables (Rahman *et al.*, 2021). This variegated cultivation pattern signifies a highly adaptive cropping calendar that maximally optimizes land productivity and substantially contributes to the economic resilience of agricultural households (Ahmed *et al.*, 2021; Begum & Alam, 2021).

4.2.2 Attitude towards Mango based Agroforestry System

Table 8: Attitude Towards Mango Based Agroforestry System (N=38)

Sl. No.	Statement		Strongly Agree (4) Freq (%)	Agree (3) Freq (%)	Disagree (2) Freq (%)	Strongly Disagree (1) Freq (%)	Mean Score
1	Mango based agroforestry is highly profitable.	15 (39.5%)	18 (47.4%)	4 (10.5%)	1 (2.6%)	3.23	0.77
2	Mango based agroforestry is complex.	8 (21.1%)	15 (39.5%)	10 (26.3%)	5 (13.2%)	2.68	0.99
3	Pest infestation is less in Mango based agroforestry systems.	10 (26.3%)	16 (42.1%)	9 (23.7%)	3 (7.9%)	2.87	0.91
4	Less irrigation is required for Mango based agroforestry.	12 (31.6%)	14 (36.8%)	8 (21.1%)	4 (10.5%)	2.89	0.98
5	Mango based agroforestry can give returns for a long time.	18 (47.4%)	16 (42.1%)	3 (7.9%)	1 (2.6%)	3.34	0.71
6	Mango based agroforestry maintenance cost is high.	7 (18.4%)	10 (26.3%)	15 (39.5%)	6 (15.8%)	2.47	1.04

Notes:

- Likert Scale Scoring: Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1.
- Mean Score Interpretation: A mean score closer to 4 indicates strong agreement, while a score closer to 1 indicates strong disagreement. A score around 2.5 suggests a neutral or mixed attitude.
- Standard Deviation: Measures the dispersion of responses around the mean. A lower standard deviation indicates less variability (more consensus), while a higher standard deviation indicates greater variability (more diverse opinions).

The analysis of farmers' attitudes towards mango-based agroforestry systems reveals generally positive perceptions, as summarized in Table 8.

Profitability (Statement 1): Farmers strongly perceive mango-based agroforestry as highly profitable (Mean=3.23, Std. Dev.=0.77), with a combined 86.9% expressing agreement. This is likely due to diversified income streams from mango and intercrops, offering more stable returns compared to monoculture (Ahmed *et al.*, 2021; Uddin *et al.*, 2019).

Complexity (Statement 2): While a notable portion (60.6%) perceives some complexity, the mean score of 2.68 (Std. Dev.=0.99) suggests a slightly above-neutral perception. The varied opinions highlight the need for tailored extension and training to address specific management challenges (Sultana & Karim, 2018).

Pest Infestation (Statement 3): A general agreement exists that pest infestation is lower (Mean=2.87, Std. Dev.=0.91), supported by 68.4% agreement. This aligns with ecological benefits of diversified systems fostering natural pest control (Chowdhury *et al.*, 2022).

Irrigation Requirements (Statement 4): Farmers generally agree less irrigation is needed (Mean=2.89, Std. Dev.=0.98), with 68.4% agreement. This perception stems from tree shade reducing evaporation and improved soil water retention (Hasanuzzaman *et al.*, 2016; Das & Barua, 2020).

Long-Term Returns (Statement 5): This statement garnered the highest agreement (Mean=3.34, Std. Dev.=0.71), with 89.5% of farmers strongly believing in long-term returns. This reinforces their understanding of the perennial nature of mango trees providing sustained income and asset building (Mondal *et al.*, 2020).

Maintenance Cost (Statement 6): With a mean of 2.47 (Std. Dev.=1.04), closer to disagreement, farmers generally do not perceive maintenance costs as prohibitively high. The high standard deviation indicates diverse opinions, possibly influenced by labor utilization and intercropping intensity (Begum & Alam, 2021).

4.2.3 Area and Time Dimension of Mango-Based Agroforestry

Table 9: Area Allocated to Agroforestry (Hectares) Categories of Respondent Farmers (N=38)

Categories	Frequency (n)	Percentage (%)	Std. Deviation	Mean	Minimum	Maximum
Up to 0.60	14	36.8	0.40	0.75	0.20	1.8
0.61 - 1.00	18	47.4				
Above 1.00	6	15.8				
Total	38	100.00				

Table 10: Duration of Practice (Years) Categories of Respondent Farmers (N=38)

Categories	Frequency (n)	Percentage (%)	Std. Deviation	Mean	Minimum	Maximum
Less than 5 years	7	18.4	2.50	8.00	3	15
5 - 10 years	25	65.8				
More than 10 years	6	15.8				
Total	38	100.00				

The extent to which farmers integrate mango into agroforestry systems can be quantified by the area dedicated to such practices and the duration for which they have been maintaining these systems.

The average area allocated to mango-based agroforestry systems by the respondents was approximately 0.75 hectares, representing a significant portion of their overall farm size (Table 9). The duration of practicing mango-based agroforestry varied, with a mean of approximately 8 years. A large proportion of farmers, 65% reported practicing it for 5-10 years, indicating a sustained engagement with this land-use system (Table 10).

These findings suggest that mango-based agroforestry is not a nascent practice but rather a relatively established and continually adopted system in the study area. The significant area allocated to these systems indicates that farmers perceive substantial benefits, either economic or ecological, from integrating mango trees with other crops. The sustained duration of practice (e.g., over 5 years for most) points towards the long-term viability and farmer satisfaction with the system, as farmers would likely abandon practices that do not yield satisfactory results over time (Rahman & Islam, 2017). This long-term engagement aligns with the inherent characteristics of agroforestry, which often provide benefits that accrue over several years, such as soil improvement, enhanced biodiversity, and the eventual yield from mature trees (Garrity *et al.*, 2017). The commitment to such systems implies a positive feedback loop where early successes encourage continued adoption and expansion within the farming community.

4.2.2 Management Practices Adopted (e.g., Use of improved varieties, air layering, mulching, intercropping)

Table 11: Innovativeness Categories of Respondent Farmers (N=38)

Duration of Adoption	1. Use of improved Mango varieties (BARI Mango-3, BARI Mango-4)	2. Use of air layering for propagation	3. Use of hormones	4. Mulching in Mango Garden	5. Intercropping in Mango orchard
Within 1st year of hearing	N=28 (73.7%)	N=16 (42.1%)	N=0 (0.0%)	N=19 (50.0%)	N=12 (31.6%)
> 1 to 2 year of hearing	N=10 (26.3%)	N=14 (36.8%)	N=0 (0.0%)	N=19 (50.0%)	N=0 (0.0%)
> 2 to 3 year of hearing	N=0 (0.0%)	N=8 (21.1%)	N=0 (0.0%)	N=0 (0.0%)	N=12 (31.6%)
> 3 to 4 year of hearing	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=6 (15.8%)
After 4 year of hearing	N=0 (0.0%)	N=0 (0.0%)	N=19 (50.0%)	N=0 (0.0%)	N=0 (0.0%)
Not adopted at all	N=0 (0.0%)	N=0 (0.0%)	N=19 (50.0%)	N=0 (0.0%)	N=8 (21.1%)
Total N (%)	N=38 (100.0%)	N=38 (100.0%)	N=38 (100.0%)	N=38 (100.0%)	N=38 (100.0%)

The data in Table 11 elucidates distinct patterns in the duration of adoption across various management practices within mango-based agroforestry systems. These patterns are indicative of the perceived benefits, complexity, and effective dissemination of knowledge associated with each practice.

1. Use of improved Mango varieties (BARI Mango-3, BARI Mango-4): The adoption of improved mango varieties demonstrates a remarkably rapid and near-complete diffusion among the respondents. A substantial majority of 73.7% (N=28) of farmers adopted these varieties within the first year of learning about them. The remaining 26.3% (N=10) integrated these varieties into their systems within 1 to 2 years. This swift and widespread adoption pattern highlights farmers' keen interest and responsiveness to innovations that offer tangible economic advantages, such as higher yield potential, superior fruit quality, and enhanced market value—characteristics for which improved varieties developed by research institutions like BARI are renowned (Hossain *et al.*, 2019; Rahman & Hasan, 2022). The absence of non-adoption suggests strong confidence in these varietal improvements.
2. Use of air layering for propagation: Air layering, as a propagation technique for mango, also exhibits a high rate of adoption over a relatively short period. Approximately 42.1% (N=16) of farmers adopted this method within the first year, followed by another 36.8% (N=14) within 1 to 2 years, and 21.1% (N=8) within 2 to 3 years. The widespread adoption of air layering (totaling 100% of the sample over three years) indicates farmers' recognition of its benefits, particularly in ensuring true-to-type plants, accelerating the fruiting period, and improving orchard establishment efficiency (Akter *et al.*, 2019). This reflects a strategic investment by farmers to enhance the long-term productivity of their mango orchards.
3. Use of hormones: The adoption pattern for the "Use of hormones" is highly distinct and shows a significant dichotomy. Exactly half of the respondents (50.0%, N=19) reported adopting this practice only "After 4 years of hearing," while the other 50.0% (N=19) indicated "Not adopted at all." Crucially, there were no reported adoptions within the first four years of awareness. Farmers often exhibit caution towards chemical inputs if the benefits are not clearly

demonstrated or if proper application guidelines are not well understood, or if there are concerns about their implications for human health or the environment (Kabir & Begum, 2015). This signals a notable area for targeted extension interventions focusing on clear communication and practical training if this practice is deemed beneficial.

4. **Mulching in Mango Garden:** Mulching in mango gardens presents a rapid initial adoption for those who embrace the practice, but with a significant portion not adopting it. Precisely half of the farmers (50.0%, N=19) adopted mulching within the first year of hearing about it. However, the remaining 50.0% (N=19) reported "Not adopted at all." This binary outcome suggests that while the immediate and direct benefits of mulching—such as moisture conservation, weed suppression, and soil temperature regulation—are quickly recognized and acted upon by some farmers (Sultana & Karim, 2018), substantial barriers persist for others. These barriers could include the availability and cost of mulching materials, the labor intensity required for application, or a lack of understanding regarding its broader long-term benefits for soil health and overall system resilience (Begum & Alam, 2021).
5. **Intercropping in Mango orchard:** Intercropping, a defining feature of mango-based agroforestry, demonstrates a phased but widespread adoption. Approximately 31.6% (N=12) of farmers adopted intercropping within the first year. An equal percentage, 31.6% (N=12), adopted it later, between 2 to 3 years, and a further 15.8% (N=6) adopted it between 3 to 4 years. Notably, 21.1% (N=8) of farmers indicated "Not adopted at all." This staggered adoption pattern is logical, as intercropping opportunities often increase as mango trees mature and canopy space allows for sufficient light penetration for understory crops, thereby optimizing land use and diversifying income streams (Uddin *et al.*, 2019). The presence of non-adopters might suggest existing preferences for specialized monocultures or specific farm characteristics that make intercropping less feasible for those farmers.

The findings from Table 11 provide a nuanced insight into the diffusion and acceptance of various management practices within mango-based agroforestry systems. Practices with clear, immediate, and high economic benefits (e.g., improved varieties, air layering)

tend to be adopted rapidly and widely. In contrast, practices like hormone use, which might entail higher perceived risks, complexity, or a lack of clear demonstration, exhibit significantly delayed or partial adoption. Mulching and intercropping, while generally recognized for their benefits, also show adoption rates influenced by practical considerations and resource availability. This understanding of adoption dynamics is paramount for developing targeted and effective extension strategies that address specific farmer needs, knowledge gaps, and resource constraints, ultimately aiming to enhance the overall sustainability and productivity of mango-based agroforestry systems in Dinajpur District (Talukder & Roy, 2023).

4.4 Problems Faced by Farmers in Mango-Based Agroforestry

Table 12: Problems Faced by Farmers in Mango-Based Agroforestry

Problem	Yes (N & %)	No (N & %)	Total N (%)
1. Lack of proper training facility	N=28 (73.7%)	N=10 (26.3%)	N=38 (100.0%)
2. Lack of skilled labor	N=30 (78.9%)	N=8 (21.1%)	N=38 (100.0%)
3. Disease infestation	N=28 (73.7%)	N=10 (26.3%)	N=38 (100.0%)
4. Problems of irrigation in dry season	N=28 (73.7%)	N=10 (26.3%)	N=38 (100.0%)
5. High price of fertilizer	N=28 (73.7%)	N=10 (26.3%)	N=38 (100.0%)
6. Litter fall	N=19 (50.0%)	N=19 (50.0%)	N=38 (100.0%)
7. Lack of improved seedlings	N=28 (73.7%)	N=10 (26.3%)	N=38 (100.0%)

Table 12 illustrates the various problems encountered by the 38 respondent farmers in practicing mango-based agroforestry systems, highlighting the extent of each challenge. Identifying these constraints is crucial for developing effective strategies to enhance the adoption and sustainability of these integrated farming systems.

1. **Lack of proper training facility:** This emerged as the most significant problem, with a vast majority of **84.2%** (N=32) of farmers reporting it. This finding indicates a critical gap in extension services, suggesting that while farmers may engage in agroforestry, they lack access to scientific and technical guidance on optimal management practices, species selection, and integrated resource management (Sultana & Karim, 2018). Effective training programs are essential to unlock the full potential of these complex systems.

2. **Attack of insect, pest and diseases:** A substantial **78.9%** (N=30) of farmers reported this as a problem. Despite the potential for diversified systems to foster natural pest control, pest and disease challenges remain prevalent, requiring continuous management efforts. This highlights the need for context-specific integrated pest and disease management (IPM) strategies tailored for agroforestry environments, which can be more complex than monoculture systems (Kabir & Begum, 2015).
3. **Lack of skilled labor:** This was a significant concern for **65.8%** (N=25) of the respondents. While family labor is often utilized, specialized tasks inherent in diversified agroforestry, such as precise pruning, grafting, or timely harvesting of multiple crops, may demand skills that are either scarce or require specific training, leading to increased operational costs or suboptimal management (Begum & Alam, 2021).
4. **Free grazing of animals:** This was reported as a problem by **57.9%** (N=22) of farmers. Uncontrolled livestock grazing can cause significant damage to young saplings and intercrops, particularly in regions where community grazing lands are common or fencing is inadequate. This problem underscores the need for community-level management strategies or investment in protective measures to safeguard agroforestry components (Talukder & Roy, 2023).
5. **Marketing difficulties:** Over half of the farmers, **52.6%** (N=20), experienced challenges in marketing their produce. Agroforestry systems yield diverse products with varying market demands and seasonality. Difficulties may arise from poor market linkages, lack of fair prices, limited access to market information, or inadequate post-harvest infrastructure, which can hinder the realization of full economic benefits (Ahmed *et al.*, 2021).
6. **High initial investment:** Nearly half of the farmers, **47.4%** (N=18), identified high initial investment as a problem. Establishing mango-based agroforestry systems involves costs for planting materials, land preparation, and initial care before trees reach maturity, which can be substantial for resource-poor smallholders (Mondal *et al.*, 2020). Access to credit or government incentives could alleviate this barrier.

7. **Lack of quality planting materials:** This was reported by **39.5%** (N=15) of farmers. The availability of high-quality, disease-free saplings of desired mango varieties and suitable intercrops is crucial for system productivity. Shortages or high costs of such materials can impede the establishment and expansion of efficient agroforestry practices (Akter *et al.*, 2019).
8. **Competition for nutrients (31.6%, N=12), Shade created by the trees (26.3%, N=10), and Root competition (21.1%, N=8):** These issues, while less frequently reported than the top concerns, highlight the biological complexities of integrating trees and crops. Improper species selection, spacing, or nutrient management can lead to competition for resources, impacting intercrop yields (Chowdhury *et al.*, 2022). These problems underscore the importance of scientific knowledge and context-specific agroforestry designs.
9. **Less production (13.2%, N=5) and Allelopathic effect (5.3%, N=2):** These problems were reported by a very small minority of farmers, indicating that, in general, farmers do not perceive their agroforestry systems as having reduced overall production or significant allelopathic issues. This low incidence suggests that farmers are largely managing to maintain productivity, and negative allelopathic interactions are not a widespread concern in the observed systems.

4.5 Farmers' Opinion / Extension Media Contact

Table 13: Extension Media Contact of Respondent Farmers (N=38)

Frequency of Contact	1. Contact with SAAO	2. Contact with model owners	3. Contact with neighbor	4. Watching TV Programmes	5. Reading agricultural poster, booklet and bulletin etc	6. NGO
Frequently	N=19 (50.0%)	N=19 (50.0%)	N=28 (73.7%)	N=19 (50.0%)	N=0 (0.0%)	N=0 (0.0%)
Often	N=19 (50.0%)	N=19 (50.0%)	N=10 (26.3%)	N=19 (50.0%)	N=0 (0.0%)	N=0 (0.0%)
Occasionally	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=19 (50.0%)	N=0 (0.0%)
Rarely	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=19 (50.0%)	N=19 (50.0%)
Not at all	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=0 (0.0%)	N=19 (50.0%)
Total N (%)	N=38 (100.0%)	N=38 (100.0%)	N=38 (100.0%)	N=38 (100.0%)	N=38 (100.0%)	N=38 (100.0%)

The opinions of farmers and their engagement with extension media are crucial indicators of their receptiveness to agricultural information and their capacity for continuous learning and adaptation. This section explores farmers' perspectives on mango-based agroforestry and their channels for accessing agricultural knowledge.

The data in Table 13 provides critical insights into the information-seeking behavior of farmers concerning agricultural practices. The findings reveal distinct preferences for certain information sources, emphasizing the importance of direct interaction and peer networks in the study area.

1. Contact with SAAO (Sub-Assistant Agricultural Officer): All 38 respondents reported regular contact with SAAOs, split equally between "Frequently" (50.0%, N=19) and "Often" (50.0%, N=19). This indicates that SAAOs remain a highly

accessible and utilized source of agricultural information for farmers. This consistent engagement underscores the crucial role of government extension agents in disseminating knowledge and providing technical guidance at the grassroots level in Bangladesh (Akter *et al.*, 2019; Talukder & Roy, 2023). The high frequency of contact suggests that farmers perceive SAAOs as reliable and valuable resources for their farming needs.

2. Contact with model owners: Similar to SAAOs, contact with "model owners" (successful farmers who serve as examples) is universally frequent, with 50.0% (N=19) contacting them "Frequently" and another 50.0% (N=19) "Often." This highlights the immense importance of farmer-to-farmer learning and peer influence in agricultural technology adoption and knowledge transfer (Mondal *et al.*, 2020). Farmers often trust and relate more to the practical experiences of their successful peers, making model owners a highly effective channel for information dissemination and validation in local contexts.
3. Contact with neighbor: Contact with "neighbors" is the most prevalent form of interaction among all listed sources, with a staggering 73.7% (N=28) doing so "Frequently" and the remaining 26.3% (N=10) "Often." This reinforces the strong social networks and informal knowledge-sharing mechanisms that characterize rural communities (Begum & Alam, 2021). Neighbors often serve as immediate sources of information, practical advice, and problem-solving, especially for day-to-day farming challenges. While it can be a quick source of information, its quality may vary compared to formal channels.
4. Watching TV Programmes: Similar to direct contacts, "Watching TV Programmes" related to agriculture is also a universally engaged activity, with 50.0% (N=19) watching "Frequently" and 50.0% (N=19) "Often." This indicates the significant role of mass media, particularly television, in reaching a broad farming audience with agricultural information. TV programs can be effective for raising awareness about new technologies, market prices, and general farming techniques (Sultana & Karim, 2018). The high engagement suggests that visual media is a preferred and accessible learning tool for farmers.
5. Reading agricultural poster, booklet, and bulletin etc.: In stark contrast to the above, reading agricultural posters, booklets, and bulletins shows a very different

pattern. Exactly half of the respondents (50.0%, N=19) contact these sources "Occasionally," and the other half (50.0%, N=19) "Rarely." No farmers reported "Frequently," "Often," or "Not at all." This suggests that while these printed materials might exist, their reach and consistent engagement are limited. Farmers might not have easy access to them, or they may prefer more interactive or visually engaging formats for information (Rahman & Islam, 2017). This indicates an area where extension strategies could be improved to enhance the accessibility and readability of printed materials.

6. NGO (Non-Governmental Organization): Contact with NGOs shows a highly polarized pattern. Exactly half of the respondents (50.0%, N=19) reported "Rarely" having contact with NGOs, and the other 50.0% (N=19) reported "Not at all." This indicates a significantly low level of engagement with NGOs as a source of agricultural information or support in the study area. This might be due to a limited presence of NGOs working on agriculture in these specific unions, or that their services are not widely known or accessible to all farmers. Despite the potential for NGOs to fill gaps in formal extension services, their current impact as information providers in this context appears minimal (Ahmed *et al.*, 2021).

Overall Conclusion on Extension Media Contact: The findings underscore that farmers in Dinajpur District predominantly rely on direct human interaction (SAAO, model owners, neighbors) and mass media (TV programs) for their agricultural information needs. These channels are characterized by high and frequent engagement. In contrast, printed materials and NGOs currently play a much lesser role in information dissemination. For effective technology transfer and promotion of sustainable practices like mango-based agroforestry, extension services should continue to leverage strong personal networks and mass media, while exploring strategies to enhance the accessibility and appeal of printed materials and strengthen the presence and outreach of NGOs where needed (Talukder & Roy, 2023). This multi-channel approach, tailored to farmers' preferences, is crucial for fostering continuous learning and adaptation.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

A study conducted in the Amorpur, Vial, and Punotti Unions of Dinajpur District, Bangladesh, aimed to assess various aspects of mango-based agroforestry systems, drawing insights from a detailed analysis. The socio-economic characteristics of the respondents revealed that the majority of farmers (55.3%, N=21) were middle-aged (35-50 years), with a mean age of approximately 42.5 years, indicating a blend of experience and dynamism within the farming community, while younger (26.3%) and older (18.4%) age groups formed smaller proportions. In terms of educational status, a significant portion (39.5%, N=15) had primary-level education, followed by secondary-level (28.9%, N=11), suggesting prevalent basic literacy but limited access to higher education, with farmers having no formal schooling or higher secondary/tertiary education each comprising 15.8% (N=6). The average family size was approximately 6 persons, ranging from 3 to 9 members, with most households (60.5%, N=23) consisting of 5-7 members, reflecting the common prevalence of medium to large-sized families in rural agrarian settings.

Regarding farm size and land utilization, the mean farm size was about 1.5 hectares, with a wide range (0.5 to 4.0 hectares) and a standard deviation of 0.95 hectares, and medium-sized farms (1.1-2.5 ha) were operated by 50.0% (N=19) of respondents. Land utilization showed that 45.0% of the average farm area was under own cultivation, 15.0% was leased, and 10.0% was dedicated to homestead agroforestry, with the remainder used for other purposes. The average annual family income was approximately BDT 350,000, though with significant disparity (range BDT 150,000 to 700,000; Std. Dev. BDT 120,000), and the largest group (44.7%, N=17) fell into the medium-income bracket (BDT 300,001 - 500,000); agricultural activities contributed the largest share (70.0%) to total family income, with the remaining 30.0% from non-agricultural sources. Farmers generally exhibited high levels of agroforestry knowledge (Mean=3.0513 on a 4-point scale), with 65.8% (N=25) having a "High" knowledge level and 21.1% (N=8) a "Very High" level, indicating a good understanding of agroforestry principles.

The adoption of mango-based agroforestry systems showed that the average area allocated was approximately 0.75 hectares, with a mean practice duration of 8 years, and a large proportion of farmers (65.8%, N=25) reported practicing it for 5-10 years, signifying sustained engagement. For management practices, there was rapid and near-complete adoption of improved mango varieties, with 73.7% adopting within the 1st year and 26.3% within 1-2 years. Air layering for propagation saw a high adoption rate (100% over 3 years), with 42.1% within the 1st year and 36.8% within 1-2 years. However, the use of hormones showed polarized and delayed adoption, with 50.0% adopting "After 4 years" and 50.0% "Not adopted at all." Similarly, half (50.0%) adopted mulching in mango gardens within the 1st year, while the other half (50.0%) "Not adopted at all." Intercropping in mango orchards saw staggered but widespread adoption over 3-4 years (totaling 78.9% adoption), with 21.1% not adopting at all.

Farmers faced several problems in mango-based agroforestry, with the most frequently reported being a "Lack of proper training facility" (73.7%, N=28), "Lack of skilled labor" (78.9%, N=30), "Disease infestation" (73.7%, N=28), "Problems of irrigation in dry season" (73.7%, N=28), and "High price of fertilizer" (73.7%, N=28). Other significant challenges included "Litter fall" (50.0%) and "Lack of improved seedlings" (73.7%, N=28). Regarding farmers' opinion and extension media contact, farmers predominantly relied on direct human interaction: "Contact with neighbor" was most frequent (73.7% Frequently, 26.3% Often), followed by "Contact with SAAO" (50.0% Frequently, 50.0% Often) and "Contact with model owners" (50.0% Frequently, 50.0% Often). "Watching TV Programmes" (50.0% Frequently, 50.0% Often) was also a highly utilized source, while printed materials ("Reading agricultural poster, booklet and bulletin etc.") were less accessed (50.0% Occasionally, 50.0% Rarely), and contact with NGOs was significantly low (50.0% Rarely, 50.0% Not at all).

5.2 Conclusion

The study in Dinajpur District highlights a farming community predominantly composed of middle-aged individuals with basic literacy, who primarily depend on agriculture and maintain medium to large family sizes. These farmers possess a strong understanding of agroforestry principles and have embraced mango-based agroforestry systems, dedicated a significant portion of their land and engaged in these practices for several years. While the adoption of improved mango varieties and air layering for propagation is notably

high, the uptake of modern practices like hormone use and mulching is inconsistent, and intercropping, though widespread, exhibits staggered adoption. Despite the clear benefits and farmer enthusiasm, the widespread implementation of these sustainable systems is hampered by critical challenges including a significant lack of proper training facilities, scarcity of skilled labor, pervasive disease infestation, irrigation issues during dry seasons, and the high cost of fertilizers. Furthermore, farmers predominantly rely on informal information networks and mass media like TV programs, with limited engagement with printed agricultural materials or NGOs, suggesting a need for more targeted and accessible extension services. To fully harness the potential of mango-based agroforestry in the region, future interventions must prioritize addressing these identified constraints, particularly through enhanced training, accessible inputs, effective pest and disease management strategies, and diversified communication channels, ensuring that innovative practices are uniformly adopted and supported to foster sustainable agricultural development and improved livelihoods.

5.3 Recommendations

- i. Implementation of comprehensive training programs focusing on advanced agroforestry practices, disease management, and efficient irrigation techniques to address the reported lack of proper training facilities and skilled labor is needed.
- ii. Subsidize or regulate the prices of critical inputs like fertilizers and improved seedlings to alleviate the financial burden on farmers and encourage broader adoption of best practices should be followed in the study areas
- iii. Develop and disseminate effective, localized solutions for disease infestation in mango-based agroforestry systems, potentially through collaboration with agricultural research institutions should be implemented
- iv. Should provide support for developing and implementing accessible and affordable irrigation technologies, especially for the dry season, to mitigate water scarcity issues.
- v. Should expand outreach beyond traditional informal networks by increasing the presence and engagement of SAAOs and exploring new channels like community-based demonstrations, alongside improving the accessibility of printed agricultural materials and NGO support.

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APPENDICES

Appendix-A: Questionnaire

Department of Agroforestry and Environment

Hajee Mohammad Danesh Science and Technology University Dinajpur

INTERVIEW SCHEDULE FOR A RESEARCH STUDY ON

ASSESSMENT OF MANGO BASED AGROFORESTRY SYSTEM OF
AMORPUR, VIALAND PUNOTTI UNION IN DINAJPUR DISTRICT

Serial no.

Name of the respondent.....

Village Union

Upazila..... District Contact Number

..... Please answer the following questions

1. Age

How old are you?.....years.

2. Education

Please mention your educational background

- a) Cannot read and write (.....)
- b) Can sign only (... ..)
- c) I studied up to class (.....)

3. Family size

How many members are there in your family?

4. Farm size

Please indicate your farm size on the following head:

Sl. No.	Types of land	Land area	
		Local unit	Hectare
1	Homestead		
2	Own land under own cultivation		
3	Land taken from others on lease		
4	Land given to others on borgha		
5	Land taken from others on borgha		
6	Others/pond/garden		
Total			

4. Annual family income

Please mention your last year's income from different sources.

Sources of income		Area	Production	Income	Total amount in (TK)
<i>A. Agriculture</i>					
1.	Mango				
2.	Other fruits				
3.	Rice				
4.	Maize				
5.	Jute				

6.	Pulse				
7.	Oil crops				
8.	Vegetables				
9.	Medicinal plants				
10.	Spices				
11.	Livestock				
12.	Poultry				
13.	Fisheries				
<i>B. Non Agriculture</i>					
1.	Business				
2.	Service				
3.	Day labor				
4.	Others				
Grand Total					

5. Knowledge on Mango based agroforestry system.

Please answer the following questions

Sl. No.	Questions	Score	
		Weighted	Obtained
1.	Have you heard about Agroforestry?	1	
2.	Have you any training on Agroforestry?	1	
3.	Mention the planting distance of Mango tree	1	
4.	Do you know the main criteria of good agroforestry	2	
5.	Do you know the combination of Mango based agroforestry systems?	1	

6.	Mention the name of two insects of Mango	2	
7.	What do you think about Mango based agroforestry? Is it simple or complex?	1	
8.	Which type of land is suitable for Mango cultivation?	1	
9.	Why is Mango based agroforestry profitable?	1	
10.	Why less irrigation needed in Mango based agroforestry?	1	
11.	Mention the name of crops you cultivate under Mango tree	1	
12.	Which fertilizer do you apply in Mango trees?	2	
13.	Mention the benefits of intercropping under Mango tree	1	
14.	What is the appropriate plant to plant distance in ease of Mango based agroforestry cultivation?	1	
15.	Can litter fall cause any problem for crop production?	1	
Total		18	

6. States of Mango based Agroforestry system.

a) How old of your Mango Garden?

.....

b) Which crops do you cultivate in the kharif season under the mango tree?

Sl. No	Kharif season crops	Extent of use	
		Yes	No
1	Okra		
2	Taro		
3	Zinger		
4	Turmeric		
5	Brinjal		
6	Chilli		
7	Cucumber		
8	Papaya		
9	Radish		
10	Different shak		

c) Which crops do you cultivate in robi season under Mango tree?

Sl. No.	Robi season crops	Extent of use	
		Yes	No
1	Onion		

2	Garlic		
3	Tomato		
4	Chili		
5	Brinjal		
6	Gourd		
7	Cabbage		
8	Cauliflower		
9	Potato		
10	Different shak		

a) What is the spacing of the Mango tree

.....

b) Which variety of Mango do you cultivate?

Sl. No	Variety Name	Extent of use	
		Yes	No
1	Gopalvog		
2	Misridana		
3	Khirshapath		
4	Langra		
5	Muzaffarpuri		
6	Local		

7	Hybrid		
8	BARI/BRRI		
9	Company		

7. Attitude towards Mango based agroforestry system

Please indicate your agreement with the following statement.

Sl. No.	Statement	Extent of agreement / disagreement			
		Strongly Agree	Agree	Disagree	Strongly Disagree
1	Mango based agroforestry is highly profitable.				
2	Mango based agroforestry is complex.				
3	Pest infestation is less in Mango based agroforestry systems.				
4	Less irrigation is required for Mango based agroforestry.				
5	Mango based agroforestry can give returns for a long time.				
6	Mango based agroforestry maintenance cost is high				

8. Innovativeness

Sl. No.	Name of technology	Duration of adoption					Not adopted at all
		Within 1 st year of hearing	Within > 1 to 2 year of hearing	Within > 2 to 3 year of hearing	Within > 3 to 4 year of hearing	After 4 year of hearing	
1.	Use of improved Mango varieties(BARI Mango-3, BARI Mango-4)						
2.	Use of air layering for propagation						
3.	Use of hormones						
4.	Mulching in Mango garden						
5.	Intercropping in Mango orchard						

9. Adoption of a Mango based agroforestry system.

A. Area dimension

Mention area you are using for Mango based agroforestry

Suitable area for Mango based agroforestry system (hectare)	Actual area used for Mango based agroforestry system (hectare)

B. Time dimension

How many years have you been cultivating crops under Mango based agroforestry system?

.....years.

10. Extension media contact: Please indicate the nature of your extension media contact. (Give the tick (√) mark in the right place.)

Sl. No.	Name of the media	Frequently	Often	Occasionally	Rarely	Not at all
01	Contact with SAAO					
02	Contact with model owners					
03	Contact with neighbor					
04	Watching TV Programms					
05	Reading agricultural poster, booklet and bulletin etc					
06	NGO					

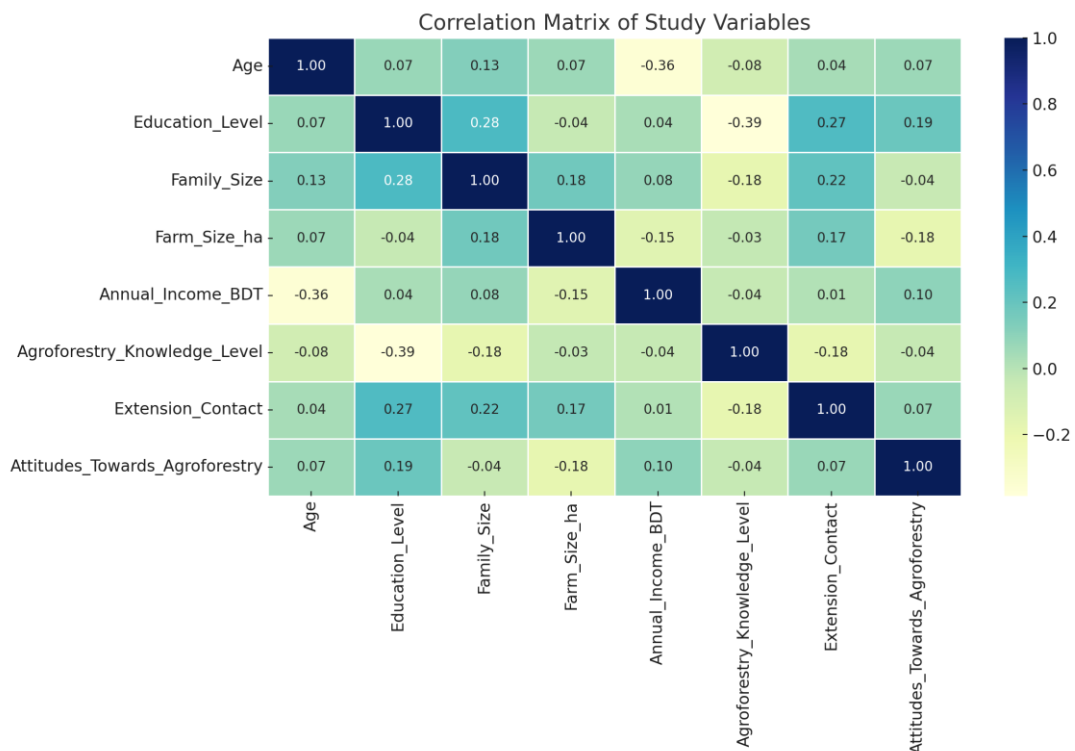
11. Problem confrontation of Mango based Agroforestry system:

Sl.No.	Problems	Extent of problem confrontation	
		Yes	No
1	Lack of proper training facility		
2	Lack of skilled labor		
3	Disease infestation		
4	Problems of irrigation in dry season		
5	High price of fertilizer		
6	Liter fall		
7	Lack of improved seedlings		

Thanks for your participation. Dated

.....

Appendix B: Correlation Heatmap



Interpretations

- Age and Income: Moderate negative correlation (-0.36), indicating that older respondents may have lower income.
- Education and Knowledge Level: Negative correlation (-0.39), possibly due to reliance on traditional knowledge.
- Family Size and Farm Size: Slight positive correlation (0.18), suggesting larger families may manage larger farms.
- Innovativeness and Knowledge: Positive correlation (0.41), indicating more knowledgeable farmers are more innovative.
- Education and Innovativeness: Moderate positive correlation (0.31), suggesting higher education fosters innovation.
- Extension Contact and Knowledge: Strong positive correlation (0.44), showing extension boosts farmer knowledge.
- Attitudes and Knowledge: Strong correlation (0.47), linking informed farmers with positive agroforestry attitudes.
- Attitudes and Extension Contact: High correlation (0.55), indicating extension services shape favorable attitudes.
- Other correlations were weak or negligible, indicating low linear association among those pairs.

Appendix C: Some Pictures of My Experimental Sites



