

EXPLORING DRIVERS OF CROP DIVERSIFICATION IN THE FARMING COMMUNITIES OF NORTHERN BANGLADESH

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ABSTRACT

This study examines the drivers of crop diversification among farming communities in northern Bangladesh, where rice mono-cropping has long been prevailed. Using focus group discussions and in-depth interviews across six districts, it explores the shift toward more diverse cropping patterns that include cereals, vegetables, legumes, and spices. Findings reveal that diversification is motivated by both internal and external factors. Internal drivers comprise farmers' knowledge, household consumption needs, risk perception, and profitability, while external influences include market access, peer learning, extension services, input availability, and institutional support. Adaptation to local environmental conditions and responses to climate variability shape farmers' decision-making processes. A transition from subsistence-based to market-oriented agriculture, supported by both individual agency and community networks, is observed. Despite these positive incentives, farmers continue to face challenges such as pest outbreaks, climate shocks, limited extension services, and insufficient soil testing facilities. To address these obstacles, farmers often rely on agricultural officers and input dealers for guidance and support. This study underscores the need for targeted, integrated interventions by government and local stakeholders to expand diversified farming systems, and promote sustainable production and consumption practices in alignment with national goals and Sustainable Development Goal 12.



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I. INTRODUCTION

1.1 Background

Crop diversification has become an increasingly central theme in agricultural and development discourse, particularly for developing economies such as Bangladesh. It is widely recognized as a key strategy for addressing food and nutrition security in the context of land scarcity. By enhancing food system resilience and strengthening farmers' adaptive capacity, diversification contributes to both household stability and national agricultural sustainability (Joshi, 2011; De & Chattopadhyay, 2010; Kumari et al., 2010; Singh, 2001). Beyond safeguarding food availability, it is also closely linked to broader socio-economic outcomes, including poverty alleviation, employment generation, economic growth, and the efficient utilization of scarce natural resources (Singh, 2001; Gunasena, 2000). These benefits are particularly significant for low-income farm households that allocate a large share of their incomes to staple foods such as cereals, pulses, and edible oils (De & Bodosa, 2014; Birthal et al., 2007).

Crop diversification is generally defined as the sequential or simultaneous cultivation of multiple crops on the same land across different agricultural seasons. Conceptually, it marks a transition in farming systems, moving from subsistence-oriented to commercial farming, from monocropping to multi-cropping, and from low-value staples to high-value crops (Mukherjee, 2012). This transition enables farmers to reduce vulnerability to income and yield shocks associated with dependence on a single crop, thereby creating viable pathways out of poverty traps (Deshpande et al., 2007). However, the trajectory and outcomes of diversification are not uniform. They are shaped by a complex interplay of factors, including relative crop profitability, technological advancements, agro-climatic variability, access to irrigation and infrastructure, and institutional support such as credit, risk-sharing mechanisms, and enabling policy environments (De & Chattopadhyay, 2010; Pingali, 2004; Pattanayak & Nayak, 2003). Shifts in consumer demand also accelerate diversification, as income growth and deeper market integration stimulate dietary transitions away from cereals toward more nutrient-dense and higher-value commodities such as fruits, vegetables, pulses, and oilseeds (Islam, 2015).

In Bangladesh, policy and programmatic interventions have played a crucial role in driving diversification. The Crop Diversification Programme (CDP) illustrates a national effort to promote the profitability and sustainability of non-cereal crops. Evidence suggests that investment in irrigation, fertilization, and weed management has enabled the successful cultivation of pulses such as mung beans and lentils, which in some cases outperform high-yielding varieties (HYVs) of rice and wheat in terms of returns (Shome, 2009). Likewise, HYVs of potatoes, beans, tomatoes, mustard, sunflower, and watermelons have shown impressive productivity under effective management, while traditional varieties of vegetables and fruits continue to demonstrate profitability despite the absence of HYVs (Hoque, 2000). In parallel, the expansion of agro-processing industries and the emergence of consumer-driven value chains have offered new opportunities for farmers to engage in diversified farming. Nahar et al (2024) confirm that the crop diversified households are more secure, or marginally food secure than those of less crop diversified households. These trends align with the broader imperatives of sustainable agriculture and are consistent with national and international priorities such as achieving Sustainable Development Goal 12 (SDG-12) on sustainable production and consumption by 2030 (Rahman et al., 2024).

Despite these advancements, significant challenges persist in achieving widespread diversification in Bangladesh. Structural barriers such as inadequate infrastructure, fragmented

market linkages, and insufficient incentives continue to constrain the adoption of diversified cropping systems (Nandi et al., 2024). These limitations highlight critical gaps in the prevailing policy and institutional frameworks, underscoring the need for integrated approaches that address both supply- and demand-side factors shaping diversification outcomes.

Northern Bangladesh offers a particularly insightful context for advancing understanding of these dynamics. Characterized by heterogeneous agro-ecological zones, variable market access, and diversified livelihood strategies, the region provides a unique setting to explore how structural conditions interact with farmers' agency in shaping diversification trajectories. Employing a multiple case study methodology, this research interrogates the complex decision-making processes of farmers and the influence of institutional actors in facilitating or constraining diversification. By interrogating these dimensions, the study aims to contribute nuanced policy- and practice-relevant knowledge to support the development of resilient, diversified farming systems that enhance rural livelihoods and align with sustainable development objectives.

II. MATERIALS AND METHODS

2.1 Study Areas

This study was carried out in six districts located in the northern region of Bangladesh, where an OCPPE-funded agricultural project was being implemented. From each district, one upazila was purposively selected to ensure representation of diverse agro-ecological and farming conditions. The selected upazilas were: Sadar in Chapai Nawabganj, Boraigram in Natore, Shibganj in Bogura, Birganj in Dinajpur, Ulipur in Kurigram, and Jaldhaka in Nilphamari. These sites represent key agricultural zones where crop diversification has gained increasing relevance. Data were collected through focus group discussions (FGDs) and in-depth interviews (IDIs) with different categories of stakeholders within farming communities.

2.2 Research Design

The study adopted a qualitative multiple case study design to capture both depth and diversity of perspectives on crop diversification. A total of 12 FGDs were conducted with groups of farmers to generate detailed narratives on their experiences, motivations, and practices of diversification. Additionally, 22 In-depth Interviews (IDIs) were carried out with stakeholders actively engaged in agricultural development, such as local agricultural officers, NGO representatives, and agricultural input suppliers. To complement these data, field observations were undertaken to document on-farm practices, management strategies, and community-level agricultural dynamics.

To strengthen the reliability and authenticity of the findings, data were collected through multiple sources. FGDs and IDIs were audio recorded with participants' consent, while detailed notes were simultaneously taken. Where relevant, photography and short video recordings were used to further document practices and interactions. All recordings were later transcribed verbatim, with speaker identities clearly indicated in line with the transcription standards defined by Tessier (2012). These transcripts served as a core source for qualitative analysis and were compiled into a transcript book for systematic examination.

Secondary data were also reviewed to provide contextual and comparative insights. Sources included published and unpublished reports, peer-reviewed journal articles, official documents

from the Department of Agricultural Extension (DAE), Agriculture Census records, and statistical datasets from the Bangladesh Bureau of Statistics (BBS).

2.3 Analytical Techniques

The primary objective of the analysis was to identify the key factors influencing farmers' decisions to adopt crop diversification in northern Bangladesh. To achieve this, the study employed Thematic Analysis (TA), a method widely applied in qualitative research for identifying, analyzing, and interpreting patterns within data (Braun & Clarke, 2006). While TA was initially introduced in the 1970s (Merton, 1975), it has since been refined into a systematic process involving six distinct phases: familiarization, coding, generating themes, reviewing themes, defining themes, and reporting.

For this study, a simplified three-phase model of TA, as outlined by Saunders et al. (2023), was applied within the multi-case study framework (Figure 1). In the first phase, researchers engaged in iterative reading of the transcripts and compiled case-level summaries in an Excel spreadsheet to ensure a comprehensive understanding of each study site. During the second phase, systematic coding was undertaken to identify recurrent issues, drivers, and challenges across participants and cases. In the final phase, codes were aggregated into thematic categories, enabling the identification of common drivers, motivations, and constraints influencing crop diversification. These themes provided the analytical foundation for comparative interpretation across cases and for highlighting regionally specific trends.

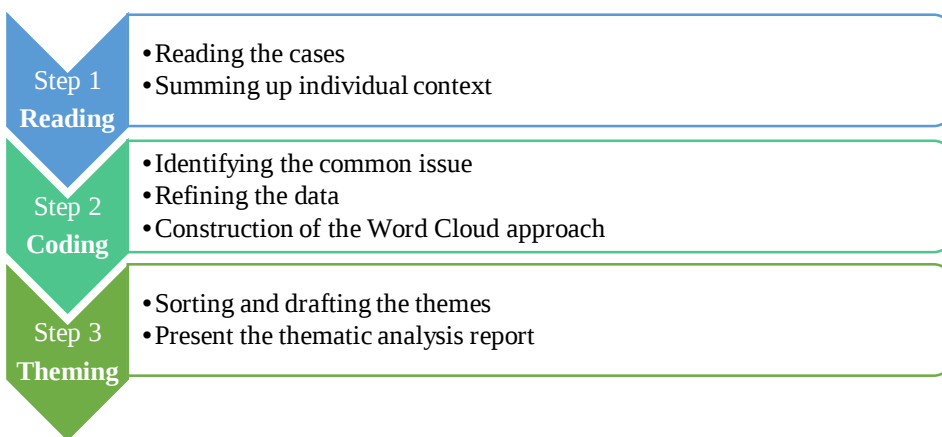


Figure 1: Steps in thematic analysis (TA) for multiple-case studies

Source: Adopted from Braun and Clarke (2006)

2.4 Drivers of Crop Diversification: Conceptual Framework

The drivers of crop diversification can be systematically explained through the Diffusion of Innovation (DOI) Theory, which describes how new ideas and practices spread within a social system (Rogers, 2003). According to the theory, adoption unfolds through five sequential stages: knowledge, persuasion, decision, implementation, and confirmation. In agriculture, these stages are strongly mediated by both internal factors (e.g., farmers' skills, risk perceptions, household

needs, and prior experience) and external factors (e.g., extension support, market access, peer influence, and climate conditions).

For smallholder farmers in Bangladesh, the process of adoption typically begins with exposure to new opportunities through knowledge channels, including agricultural extension services, NGOs, local input dealers, market networks, and peer farmers. This stage allows them to compare diversification prospects against the risks and returns of traditional monocropping systems. In the persuasion stage, farmers' attitudes are shaped by perceived attributes derived from internal and external factors. Internal considerations, such as household food security and prior experiences, intersect with external influences, such as demonstrations by progressive farmers, social acceptance, and the availability of markets and inputs.

At the decision stage, farmers determine whether to experiment with new crops, often adopting them on a limited scale to minimize potential losses. The implementation stage involves the practical cultivation and management of diversified crops, where farmers rely on accumulated knowledge, peer support, and institutional guidance. Finally, in the confirmation stage, outcomes such as profitability, resilience to climate shocks, and contributions to food security are assessed. Farmers then decide whether to continue, expand, or discontinue diversification.

This framework (Figure 5.1) underscores that the adoption of crop diversification in Bangladesh is not a discrete, one-time event but a dynamic and iterative process. It is continuously shaped by farmers' evolving perceptions, the demonstration of tangible benefits, community networks, and the effectiveness of institutional support systems. Ultimately, successful and sustained adoption depends on the alignment of economic incentives, agronomic suitability, and the enabling role of extension and market structures.

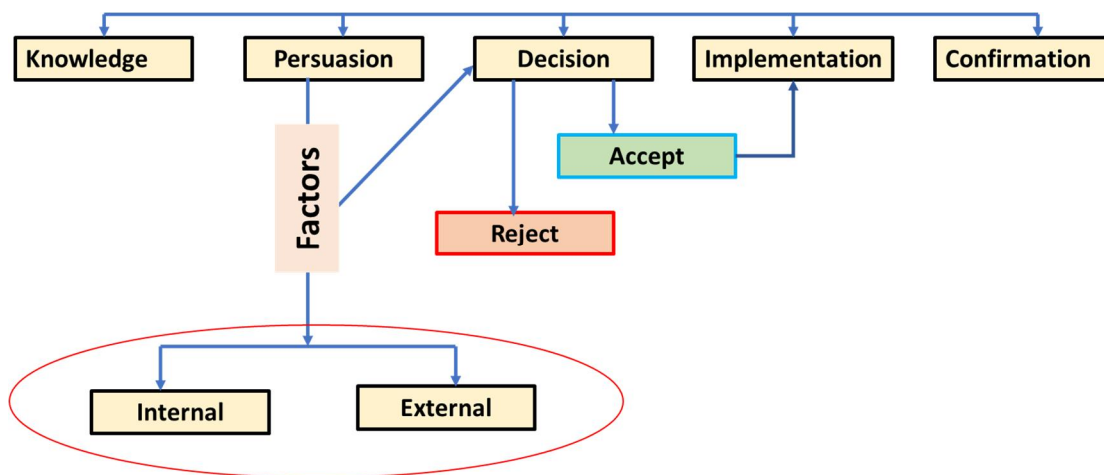


Figure 2: Process of crop diversification in connection with the diffusion of innovation theory

III. RESULTS AND DISCUSSION

3.1 Transition from Mono Cropping to Crop Diversification

Historically, Bangladesh's agriculture has been dominated by rice–rice monocropping, which secured food supply but created ecological and economic vulnerabilities. Challenges such as soil

fertility decline, groundwater depletion, pest outbreaks, and limited income opportunities have exposed the drawbacks of this system. Consequently, farmers and policymakers increasingly advocate crop diversification as a sustainable alternative. Cultivating vegetables, pulses, oilseeds, spices, and high-value horticultural crops enhances soil health, resource efficiency, dietary diversity, farm income, and resilience to climate shocks.

Evidence from Focus Group Discussions (FGDs) and in-depth interviews indicates that farming communities in the study areas have historically been reliant on single-crop or cereal-based systems, primarily rice. This dependence rendered them highly vulnerable to market fluctuations, climate variability, and gradual soil degradation. However, in recent years, a gradual but significant shift has taken place, particularly among smallholder farmers. Initially, farmer-driven diversification was limited and largely motivated by household consumption needs. Over time, this expanded to include more profitable, higher-value crops such as vegetables, spices, pulses, and fruits, reflecting a growing orientation toward income generation and livelihood security.

Participants frequently emphasized the influence of market exposure, agricultural extension services, and the role of peers or local leaders in encouraging this transition. The adoption of diverse cropping practices has enabled farmers to stabilize household income, optimize land use efficiency, and strengthen their capacity to cope with environmental and economic uncertainty. Importantly, this shift signals an incremental yet decisive movement from subsistence-oriented production toward market-oriented agriculture.

Table 1: Transition of crop diversification in Northern Bangladesh

Location	Crop cultivation before 2019	New crop cultivation after 2019
Sadar, Chapai Nawabganj	Aman, Boro, Potato, Lentil, Wheat,	Aus, Eggplant, Mustard, Wheat (new variety), Tomato, Onion, Garlic
Shibganj, Bogura	Aman, Aus, Boro, Radish, Onion, Potato, Garlic, Spinach, Coriander, Sweet gourd, Pointed gourd	Banana, Mustard, Fodder crop, Cabbage, Red cabbage, Cucumber, Cauliflower, Maize
Boraigram, Natore	Aman, Aus, Boro, Wheat, Garlic, Jute	Maize, Lentil, onion, Grass pea, Wheat (new variety)
Birganj, Dinajpur	Aman, Boro, Bean, Mustard, Ladies finger, Pointed gourd, Wheat	Maize, Potato, Black Gram, Wheat, Sesame
Ulipur, Kurigram	Aman Rice, Aus Rice, Black Gram, Betel leaf, Wheat	Maize, Pointed gourd
Jaldhaka, Nilphamari	Aman Rice, Boro Rice, Tobacco, Jute, Potato, Wheat	Aus Rice, Maize, Banana, Mug bean, Peanut, Onion, Black Gram, Wheat, Chili, Mustard

Source: Field survey, 2024

Empirical evidence further reinforces this trend. As illustrated in Table 1, all six study districts have introduced new crops since 2019, highlighting a consistent trajectory toward diversification. The decision to move away from rice monoculture appears to be shaped not only by structural drivers such as market access and institutional support but also by social influences, particularly inspiration drawn from family members, fellow farmers, and the demonstrated success of progressive or so-called “ideal” farmers within the community. This collective experience

underscores the importance of both individual agency and community-level dynamics in shaping agricultural transitions in rural Bangladesh.

Traditionally, farmers in northern Bangladesh relied on crops like Aman and Boro rice, which suited local conditions. The shift began when they recognized the potential of Rabi (dry season) crops such as potatoes, eggplants, black gram, onions, and garlic. One respondent from Chapai Nawabganj shared:

“Before 2019, I was growing Boro rice and lentils. After 2019, I started growing Aus rice, wheat, brinjal, black gram, onion, and garlic.” (CNS-IDIs, R4)

In Natore, farmers have introduced Aus rice, enabling a three-crop cycle on the same plot of land. A participant explained:

“By introducing a new variety of Aus, farmers can grow three crops on their land. After Aus, Aman rice can be easily cultivated. Currently, we are cultivating the BR-7 variety during the Aman season. The cropping pattern is Aus–Aman–Boro.” (NB-IDIs, R15)

FGDs from Natore, Bogura, Dinajpur, and Nilphamari revealed further diversification into leafy vegetables and Rabi crops. One participant noted:

“Potatoes and onions are grown side by side in the same field. After that, we cultivate maize or rice. We also grow vegetables like beans, turmeric, and eggplant in our yard garden. Since 2019, we have been cultivating Aus rice, which produces well.” (NJ-FGD10).

In the same way, one of the farmers reported that *“Previously, we cultivated crops like tobacco, paddy, and wheat. Now, we focus on paddy, maize, peanut, and banana.” (NJ-FGD7)*

Encouragingly, another farmer mentioned:

“I cultivated Indian spinach, red amaranth, and water spinach. We also cultivated wheat.” (NJ-FGD7)

This discussion clarified that farmers are diversifying in both crop types and cropping patterns. This shift optimizes land use, enhances resilience, improves profitability, and meets both subsistence and market demands.

3.2 Drivers of Crop Diversification: the practice

Crop diversification in northern Bangladesh is influenced by a combination of internal and external factors. Farmers' knowledge, experience, and risk perception shape their awareness of alternative crops and their willingness to adopt new practices. Household needs, including food security and labor requirements, drive decisions to diversify production. Profitability and production costs are key economic considerations, with farmers evaluating potential returns against investment and risk. Finally, access to inputs and markets determines the feasibility of cultivating and selling diversified crops, as timely availability of seeds, fertilizers, and reliable market channels reduces barriers and enhances adoption. Together, these factors create a dynamic environment influencing farmers' transition from mono-cropping to diversified cropping systems. All the identified factors as themes are presented in Table 2, and described separately

Table 2: Summary of the crop diversification with quotation

Theme	Definition	Code	Quotation	Bridging with Diffusion Theory
Internal factors				
Knowledge, experience and risk perception	Farmers' reflection on crop varieties, practices, and previous exposure Willingness or fear to try new crops due to uncertainty	Farm Weather Sense / Climate Wisdom Challenge lead adoption	<i>"We have good knowledge of the weather for suitable crop cultivation."</i> (NJ-FGD10). <i>"In our locality, we have grown lentil and wheat for a long time because the winter is prolonged here, and we got a good harvest"</i> (CNS IDS-R8) <i>"The water level was dropping, and shallow tube wells could no longer provide enough water during the later stages. As a result, I stopped cultivating Boro rice and focused on Rabi crops instead."</i> (NB-IDIs, R15). <i>Last season, we cultivated Jute and made twice the profit. Encouraged by that, we planted a lot of jute this time, but unfortunately, due to flood, all the jute were destroyed."</i> (KU-IDIs, R22)	• Awareness stage– farmer must first hear about new crops • Perceived benefits/risks– relative advantage, complexity, risk • Compatibility – meet family requirement in addition support additional income • Change agents – extension workers, NGOs act as disseminators of innovation
Household needs	Crop selection based on food, nutrition, household needs	Home consumption	<i>"We grow chili, onion, garlic, and ginger, only for household consumption."</i> (DB-FGD5)	• Social system – farmers rely on trusted peers before adopting new crops
Profitability and cost	Crop choices influenced by expected return, input requirements and profit	High return Optimum land use	<i>"Maize gives huge production, price is stable, so profit is also high though it is less laborious and cost effective. It needs less pesticides than other crops."</i> (NB-IDIs, R16) <i>"We use fallow land for growing black gram"</i> (DB-FGD-6)	• Barriers or catalyst– context can slow down or speed up the diffusion process
Access to input and market	Accessibility to market and crop	Distance, transport,	<i>"We have access to the Mahasthan Garh market, which serves as a major facility for us. From there, products are transported directly</i>	

Theme	Definition	Code	Quotation	Bridging with Diffusion Theory
Influence of peer farmers and input retailers	demand influencing choices	price fluctuation	<i>to Dhaka, providing us with excellent opportunities for trade.” (BS-IDIs, R12)</i>	
	Availability and affordability of seeds, fertilizer, and equipment	Quality seeds, timely fertilizer	<i>“The dealer told us this was a new variety and that everyone was growing it. Convincing me with this, I decided to give it a try and started growing it.” (NB-IDIs, R14).</i>	
Extension support (government and private sector)	Information from peers, neighbors, farmer groups, or NGOs	Informal (peer), Formal (NGOs, Govt.)	<i>“I saw one of my neighbors has planted Ginger under the Bottle Gourd shade, and Ginger is produced well. So, I thought, let’s attempt, and the outcome was wonderful.” (BS-IDIs, R12).</i>	
	Availability and effectiveness of training/advisory support	Govt, NGO, mobile advisory	<i>“In COVID time, we cultivated excessive vegetables which we shared with our relatives and neighbors.” (NJ-FGD9)</i> <i>“I started growing wheat because the agriculture officer recommended it, so I planted wheat. As for mustard, the agriculture office also suggested it, and that's why I decided to plant mustard.” (CNS-IDIs, R7)</i>	

3.3 Knowledge, Experience, and Risk Perception

Local knowledge and long-term farming experience play a central role in shaping crop diversification decisions. Farmers often rely on their deep understanding of weather patterns to select crops that align with prevailing environmental conditions. As one respondent noted,

“We have good knowledge of the weather for suitable crop cultivation” (NJ-FGD10). Another farmer explained,

“In our locality, we grow lentil and wheat for a long time because the winter prolongs here, and we get a good harvest” (CNS-IDS, R8).

These statements illustrate how farmers’ awareness of seasonal variations—such as extended cold periods—guides their crop choices and helps secure higher yields.

This experiential knowledge not only enables farmers to anticipate climatic challenges but also supports better planning around sowing and harvesting times, thereby reducing risks of crop failure. One respondent remarked,

“Due to the cold weather, my wheat and lentils are doing well” (CNS-IDIs, R8).

highlighting the direct benefits of favorable climate conditions on specific crops. Such adaptive capacity, developed through years of practice and observation, is especially valuable in regions like northern Bangladesh, where climate variability increasingly threatens smallholder livelihoods. In addition to climate knowledge, irrigation access strongly influences diversification choices. Crops such as maize and Boro rice demand significant amounts of water, posing difficulties in areas with limited irrigation infrastructure. As one farmer recounted,

“The water level was dropping, and shallow tube wells could no longer provide enough water during the later stages. As a result, people stopped cultivating Boro rice and focused on Rabi crops instead” (NB-IDIs, R15).

Conversely, improved irrigation facilities can expand diversification options. For example, another respondent observed,

“After gaining access to irrigation facilities, farmers are now focusing on Boro rice, potatoes, and various kinds of vegetables” (BS-IDIs, R13).

Taken together, these accounts underscore that farmers’ knowledge of climate trends and irrigation conditions shaped by long-term experience and changing resource availability-plays a decisive role in guiding crop diversification strategies.

3.4 Household Needs

Household dietary needs and preferences are a major driver of crop diversification, as farming decisions often extend beyond commercial considerations to meet family consumption requirements. Many smallholder farmers in Bangladesh select crops to ensure year-round food availability, reflecting a subsistence-oriented rationale for diversification. One respondent explained,

“When my family told me that they would need onion and garlic at home, I thought I could grow them in the field, so I decided to do it myself” (CNS-IDIs, R2).

Similarly, another participant noted,

“We harvest chili, onion, garlic, and ginger, but only for household consumption” (DB-FGD5), demonstrating how everyday food needs influence on-farm decisions.

Beyond staple consumption, household preferences also shape the variety of crops grown. Farmers often cultivate vegetables, spices, and fruits to diversify their diets and reduce reliance on markets, thereby ensuring food security and saving household income. This practice highlights the dual role of crop diversification in meeting nutritional needs while providing a buffer against market price fluctuations.

Importantly, women play a significant role in household-centered diversification. Their knowledge of nutrition, food preparation, and family needs directly informs crop choices. One respondent from Kurigram shared,

“My wife decided to cultivate pumpkin and pointed gourd together, and it was her idea” (KU-IDIs, R22),

reflecting women’s active involvement in strategic farm planning. Such contributions not only enhance dietary diversity but also strengthen women’s agency in agricultural decision-making.

Overall, household-level considerations, ranging from dietary requirements to women’s decision-making are central to shaping diversification strategies. These dynamics underscore that crop diversification is not merely an economic strategy but also a socially embedded practice that supports food security, nutrition, and sustainability at the family level.

3.5 Profitability & Cost

Farmers’ decisions regarding crop choice are strongly influenced by the cost of production, particularly for smallholders with limited financial resources. Selecting crops that require lower inputs allows farmers to minimize risk, enhance economic viability, and improve potential profits. As one respondent noted, “Banana cultivation is permanent, while other crops are temporary. Bananas are profitable because they require low production costs” (BS-IDIs, R10). Similarly, another farmer emphasized,

“The low cost of production is the main reason for the growing sweet potato. It requires minimal inputs, and there’s no need to spray chemicals on sweet potato plants. Additionally, producing sweet potatoes is not labor-intensive” (BS-FGD1).

Such accounts illustrate that affordability and ease of cultivation are key determinants of crop choice. Crops with low input requirements—both in terms of materials and labor—allow smallholders to optimize limited financial resources while maintaining food security and income stability. Maize, for instance, is valued for its high yield, stable market price, and comparatively low labor and pesticide requirements. As one respondent reported, “Maize gives huge production, price is stable, so profit is also high though it is less laborious and cost-effective. It needs less pesticides than other crops” (NB-IDIs, R16). Similarly, farmers make strategic use of otherwise underutilized land by cultivating low-cost crops such as black gram, as noted by another respondent,

“We use fallow land for growing black gram” (DB-FGD6).

These examples highlight that financial considerations are a major driver of diversification strategies. By choosing crops that are both low-cost and low-risk, farmers can sustain their livelihoods, balance labor demands, and capitalize on market opportunities, especially in regions

where access to credit and agricultural inputs is constrained. Consequently, economic feasibility and resource efficiency often underpin smallholders' on-farm decisions, shaping the overall pattern of crop diversification in Bangladesh.

3.6 Access to Inputs and Markets

Access to both input supplies and reliable markets is a critical driver of crop diversification among smallholder farmers. When farmers can readily obtain quality seeds, fertilizers, and other necessary inputs, they are more confident in experimenting with new crops. Similarly, access to domestic and international markets allows them to sell produce at competitive prices, meet consumer demand, and maximize profitability, which in turn incentivizes diversification. One farmer noted,

"We have access to the Mahasthan Garh market, which serves as a major facility for us. From there, products are transported directly to Dhaka, providing us with excellent trade opportunities" (BS-IDIs, R12).

Another observed,

"It is clear that we have 100% marketing facilities, which is also a factor in the successful production of crops" (BS-FGD2).

These accounts highlight that reliable market access reduces uncertainty regarding the sale of produce and provides farmers with confidence to diversify beyond subsistence crops.

Market incentives, particularly higher prices for certain crops, further encourage diversification. One respondent reported,

"Maize has huge production, the price is high, so the profit is also high. It is less laborious and cost-effective, and requires fewer pesticides than other crops" (NB-IDIs, R16).

Similarly, another farmer shared, "We started cultivating bananas after seeing others grow them. We realized that it is quite profitable. Last year,

"We cultivated a small amount, but this year we are growing more, and the profit will also be higher" (NJ-FGD7).

These examples demonstrate how perceived profitability, coupled with reliable market access, drives decisions to adopt diversified cropping systems.

In addition to market access, guidance from input dealers and observation of emerging trends influence farmers' crop choices. As one participant noted,

"The dealer told us this was a new variety and that everyone was growing it. Convincing me with this, I decided to give it a try and started growing it" (NB-IDIs, R14).

This highlights the role of information flow through supply chains and social networks, which complements market incentives and facilitates the adoption of profitable and diversified cropping practices.

Overall, these findings indicate that both input availability and strong market linkages are essential for promoting crop diversification. By reducing production risks and enhancing profitability, these factors create a conducive environment for farmers to experiment with and sustain diversified cropping systems, ultimately contributing to improved livelihoods and resilience in smallholder agricultural communities.

3.7 Influence of Peer Farmers and Input Retailers

Farmers' decisions to diversify crops or adopt innovative techniques are strongly shaped by social learning and local exemplars. Observation of successful practices by respected or "ideal" farmers often serves as a key motivator for experimentation. One respondent shared,

"I saw one of my neighbors had planted ginger under the bottle gourd shade, and the ginger grew well. So, I thought, let's give it a try—and the outcome was wonderful" (BS-IDIs, R12).

Another farmer highlighted the role of demonstration plots and peer guidance:

"I had a close friend who received a demo plot from the DAE. I learned about new techniques and crop varieties from him, and I also received suggestions. I took lentil seeds from him and got satisfactory results" (NB-IDIs, R18).

Similarly, a participant in a Focus Group Discussion observed,

"Mostly, people are influenced by the practices of ideal farmers. By following these farmers, they can observe, understand, and gradually adopt their methods" (BS-FGD2).

These accounts underscore that peer influence and observational learning are central mechanisms through which innovations spread within farming communities, particularly in smallholder contexts.

In addition to peer influence, input retailers and private sector actors play an increasingly significant role in shaping crop diversification decisions. Farmers often rely on dealers to access new seed varieties, fertilizers, and other agricultural inputs, as well as to receive guidance on their use. Recommendations from input retailers are typically informed by product availability, market demand, or promotional campaigns by seed and agrochemical companies. Due to their accessibility and regular contact with farmers, these actors can exert considerable influence. One respondent noted,

"The dealer told us this was a new variety and that everyone was growing it. Convincing me with this, I decided to give it a try and started growing it" (NB-IDIs, R14).

Such interactions illustrate the growing importance of informal extension systems, where private sector actors complement or even substitute for formal government advisory services. In areas with limited or inconsistent access to public extension officers, input retailers serve as critical conduits of knowledge, facilitating the introduction and adoption of innovative cropping practices. By combining peer observation with commercially mediated guidance, farmers are better able to navigate decisions around diversification, balancing risk, resource constraints, and potential profitability.

3.8 Extension Support (Government and private sector)

Government agricultural officers and private sector entities play a significant role in guiding and motivating farmers toward crop diversification. In many cases, Sub-Assistant Agricultural Officers (SAAOs) from the Department of Agricultural Extension (DAE) are the primary influencers. One respondent shared,

"I started growing wheat because the agriculture officer recommended it, so I planted wheat. As for mustard, the agriculture office also suggested it, and that's why I decided to plant mustard." (CNS-IDIs, R7).

Another respondent similarly noted,

“Agricultural officers advise us on which crops to cultivate. We had a meeting with them, where they recommended cultivating wheat, black gram, chili, and other crops.” (NJ-FGD7).

In fact, government-provided incentives are a key factor in motivating farmers to adopt new crops. These incentives often take the form of cash grants, free seed and fertilizer distribution, technical guidance, and access to training programs. For example, one farmer explained,

“I received help from the agriculture office. They enrolled me in a tomato project and provided seedlings, some fertilizers, and training.” (CNS-IDIs, R2).

Other farmers echoed similar experiences.

“The agriculture office provides different types of seeds of vegetables” (BS-IDIs, R11). “DAE is working on safe vegetables, and we are all involved in these activities.” (BS-FGD2).

“I cultivated a small amount of black gram that I received from the agriculture office. It grew well and now provides me with a year-round supply of pulses.” (DB-IDIs, R19).

The introduction of new crop varieties that are often higher-yielding, pest-resistant, or more climate-resilient further motivates farmers to diversify. A respondent explained,

“I got information about the lentil variety BARI-8 from the SAAO, who said it was better than the local variety. I also received seeds from BADC.” (NB-IDIs, R14).

The public institutions like Bangladesh Agricultural Research Institute (BARI) and Bangladesh Agricultural University (BAU), along with various non-governmental organizations (NGOs), have also played a vital role in promoting crop diversification. These organizations support rural farmers by enhancing food security, encouraging economic diversification, and promoting climate-resilient crops. As one farmer stated,

“The NGO provides us with seeds and fertilizer, which have inspired us to cultivate these new crops.” (NJ-FGD9).

BARI and BAU have long-standing involvement with farmers in the region. One respondent noted, “We started cultivating wheat again after visiting BARI and BAU.” (NJ-FGD9). Another added,

“A few years ago, I received mustard of the BARI variety”.

Another farmer reported,

“Over the last two years, I received BARI onion, chili, and black gram.” (NJ-FGD10).

In addition to public and research institutions, private input companies also play an influential role at the grassroots level. Company representatives regularly engage with farmers to offer product advice and crop recommendations. One respondent shared,

“Generally, we take agricultural inputs from the Syngenta company. So, they told me to try maize on my land.” (NB-IDIs, R16).

These combined efforts from government agencies, research institutions, NGOs, and private companies have contributed significantly to changing cropping patterns and encouraging crop diversification across northern Bangladesh.

profitably. Climatic Vulnerability: Exposure to extreme weather events, pests, and other climate-related risks that affect farmers' cropping decisions. The adoption of crop diversification is strongly shaped by social learning from peers, reinforced by extension services. Market access and climatic risks further influence farmers' decisions, though typically to a moderate extent.

3.10 Challenges of Crop Diversification

Introducing new crops into existing farming systems presents farmers with a range of challenges, which can hinder the successful adoption and sustainability of crop diversification. These challenges are multifaceted, encompassing agronomic, environmental, and institutional dimensions. Agronomic challenges include increased susceptibility of new crops to pests and diseases, vulnerability to weather-related events, and the need for specialized cultivation knowledge. Environmental and site-specific issues, such as river siltation, salinity, and poor soil fertility, further complicate crop management. Additionally, inadequate access to agricultural support services exacerbates these difficulties, limiting farmers' ability to respond effectively.

Crop-specific challenges, as reported by participating farmers, are summarized in Table 5.3. For example, pest attacks on maize and tomatoes were frequently reported. One farmer explained,

"In maize, I faced a Fall Armyworm attack during the growing stage" (NB-IDIs, R16), while another noted, "The tomato problem is the leaf bug/leaf curling. If I spray medicine for this, it will be fixed" (CNS-IDIs, R2).

Weather-related impacts also posed significant barriers. A farmer described,

"The maize plants fell down because of the storm and wind. Then we harvested them and did not get the desired yield" (NB-IDIs, R17).

Another observed,

"This year, the production of potatoes will be hampered because of the bad weather. The volatility of weather rots potatoes inside the soil in many areas" (BS-IDIs, R12).

Beyond crop-specific issues, farmers face broader structural challenges. River siltation caused by upstream excavation results in sand deposition on agricultural fields, reducing soil fertility and limiting crop growth. As one farmer reported,

"A big problem here is river siltation. The sand from the river occupies most of our cultivated land for a year" (NJ-FGD9).

Similarly, the lack of timely soil testing services undermines efficient nutrient management, leading to suboptimal yields. A respondent from Dinajpur explained,

"Two or three months ago, some people came to conduct a soil test, but the results have not been provided yet" (DB-IDIs, R19).

Salinity, particularly in coastal zones or poorly drained areas, poses another significant challenge. One farmer observed,

"Acidity in the land reduces production. Recently, the use of Doloson lime has helped decrease salinity and increase fertility" (NJ-FGD10).

Table 3: Problems faced by crop diversification reflected by the farmers

Area	Crop Name	Problems	Reflective statement
Chapai Nawabganj Sadar, Chapai Nawabganj	Lentil	Dying	<i>"I faced a problem with lentils. After a few days, some of them started dying, and I couldn't find any solution for it." (CNS-IDIs, R1)</i>
	Tomato	Leaf curling	<i>Respondent said that "The tomato problem is the leaf bug/leaf curling. If I spray medicine for this, it will be fixed." (CNS-IDIs, R2)</i>
	Wheat	Rat	<i>"Wheat has a big problem, which is rats. They cause a lot of damage to wheat. We sprinkle medicine and try to catch rats." (CNS-IDIs, R7)</i>
Shibganj, Bogura	Potato	Bad weather	<i>"This year, the production of potatoes will be hampered because of the bad weather. The volatility of weather rots potatoes inside the soil in many areas" (BS-IDIs, R12)</i>
	Ginger	Rotting	<i>"Sometimes, I face problems with ginger as it starts rotting. During such times, I have to spray fungicide." (BS-IDIs, R12)</i>
	Tomato	Leaf curling	<i>"I planted a Tomato and after a while, the leaves became curled and yellowed" (BS-IDIs, R11)</i>
Boraigram, Natore	Wheat	Wheat blast	<i>"Wheat blast appeared last year. All the spikes were affected and rotted, and the grains became sterile." (NB-IDIs, R14)</i>
	Aman	Brawn Plant Hopper	<i>"Late Aman is at high risk of attack by the Brawn Plant Hopper (BPH). Most of the crop lands were attacked by the Brawn Plant Hopper (BPH)." (NB-IDIs, R15)</i>
	Maize	The Fall Armyworm fell because of the storm and wind	<i>"In maize, I faced a Fall Armyworm attack during the growing stage" (NB-IDIs, R16). "The maize plants fell down because of the storm and wind. Then we harvested them and did not get the desired yield." (NB-IDIs, R17)</i>
Birganj, Dinajpur	Wheat	Rat	<i>"Rats caused a lot of damage to the wheat. Another problem is the lack of machines for threshing the wheat." (DB-IDIs19)</i>
Ulipur, Kurigram	Jute	Flood	<i>"Last season, we cultivated jute and made twice the profit. Encouraged by that, we planted a lot of jute this time, but unfortunately, due to the flood, all the jute was destroyed." (KU-IDIs, R22)</i>

Source: Field survey, 2024

Institutional constraints also play a critical role. Many farmers lack awareness of available agricultural support services, particularly those provided by Sub-Assistant Agricultural Officers (SAAOs). Limited engagement of these officers reduces farmers' access to technical advice and assistance. One respondent expressed frustration:

“The agriculture department provides support to select people. The SAAO never visits or addresses problems. Instead, they spend time in meetings and are seen at the market in the evening” (NJ-FGD10).

To mitigate these challenges, farmers employ various strategies, including seeking guidance from government organizations, local dealers, and retail shops, as well as adopting context-specific agronomic practices to mitigate risks. Addressing these challenges through targeted interventions, including improved extension services, timely soil testing, salinity management, and awareness campaigns, can strengthen agricultural systems and facilitate the successful adoption of diversified cropping practices.

3.11 Strategies for Promoting Crop Diversification

Effective strategies are essential for facilitating the adoption and long-term success of crop diversification. A combination of institutional support, knowledge dissemination, and community-based initiatives contributes to creating an enabling environment for farmers to adopt new crops. Government organizations, including the Department of Agricultural Extension (DAE), Bangladesh Agricultural Development Corporation (BADC), local dealers, and model farmers, play a central role in promoting diversified cropping systems.

Government organizations can reach farmers through structured programs, extension services, and targeted support mechanisms. One respondent highlighted,

“It can be done with the help of DAE, through field days and meetings with farmers” (BS-IDIs, R12),

emphasizing the importance of organized outreach. Exposure visits to regions practicing successful cultivation of specific crops serve as additional motivation and learning opportunities. As one farmer noted,

“Farmers can be motivated by organizing exposure visits. Once we visited Rangamati to observe ginger production” (BS-FGD2).

These interactions allow farmers to witness practical applications of crop management techniques, fostering confidence in adopting new practices.

Regular field visits, interactive discussions, and timely provision of inputs help build and maintain farmer trust. One participant stated,

“Regular visits and advice from BS would help increase production, along with the timely supply of seeds and fertilizers” (NJ-FGD10).

Workshops, field demonstrations, and hands-on training organized by government agencies provide farmers with guidance on selecting appropriate crop varieties, managing pests and diseases, and adapting to climatic challenges. A farmer shared,

“They prescribed a pesticide for my tomatoes, and it worked. I received many suggestions on crop production” (BS-IDIs, R11),

while another noted,

“They advised me on fungicide rotation for my crops, and it worked well” (BS-IDIs, R12).

Focus group discussions further revealed that training on pest control, such as the use of pheromone traps for insect management, was particularly helpful and recommended for continuation.

Model farmers act as critical community ambassadors for crop diversification, facilitating knowledge transfer within local farming networks. One respondent emphasized,

“Ideal farmers should be trained in every area. They will help disseminate technology, and farmers will easily adopt it” (NB-IDs, R18).

By sharing their experiences, demonstrating best practices, and mentoring neighboring farmers, model farmers help bridge the gap between formal agricultural programs and local farming communities.

In addition to structured programs and model farmers, continuous support through field visits, expert advice, and practical, hands-on training plays a pivotal role in enabling farmers to implement new techniques effectively. Strategies focusing on timely technical guidance, access to inputs, and capacity-building in areas such as pest control, disease management, and climate-resilient practices are critical to enhancing farmers' confidence and productivity. Collectively, these interventions not only promote the adoption of diversified crops but also contribute to strengthening the resilience and sustainability of agricultural systems.

V. CONCLUSIONS

Crop diversification in Northern Bangladesh represents a transformative shift in local agricultural systems, highlighting the adaptability and resilience of farmers in the region. Moving beyond traditional monocropping, farmers are increasingly adopting a diverse range of crops, resulting in multiple agronomic and socio-economic benefits. These include improved soil fertility, higher farm productivity, greater income stability, and enhanced resilience to climate-related risks.

The drivers of this transition are multifaceted, encompassing support from government agencies, private sector actors, peer influence, and evolving market demands. Institutional interventions, such as extension services, training programs, and model farmer initiatives, have played a critical role in facilitating knowledge transfer and motivating adoption. However, farmers continue to face significant challenges, including inadequate irrigation infrastructure, high production costs, and limited access to soil testing and extension services, which constrain the full potential of crop diversification.

Despite these obstacles, the adoption of diversified cropping systems has yielded tangible benefits, including improved food security, better nutritional outcomes, enhanced financial stability, and increased access to education and health services. Sustaining and expanding these gains requires coordinated strategic interventions by government agencies, NGOs, private sector actors, and research institutions. Strengthening input supply chains, enhancing knowledge dissemination, and improving market linkages are essential measures to support farmers in the broader adoption of diversified farming practices. In reality, crop diversification emerges as a critical pathway toward sustainable agriculture, rural development, and environmental stewardship in Northern Bangladesh. With continuous support through government programs, expert advice, and community-driven initiatives, farmers are better equipped to implement innovative practices, increase productivity, and ensure long-term agricultural sustainability and prosperity.

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Appendix:

IDIs = In-depth interviews	FGD = Focus Group Discussion
R = Respondent no.	SB = Shibganj, Bagura
CPNS = Chapai Nawabganj Sadar	BN = Boraigram, Natore
SB = Shibganj, Bagura	BGDP = Birganj, Dinajpur
BN = Boraigram, Natore	NLFR = Jaldhaka, Nilphamari
BGDP = Birganj, Dinajpur	BAU = Bangladesh Agricultural University
UPKG = Ulipur, Kurigram	BBS = Bangladesh Bureau of Statistics
DAE = Department of Agricultural Extension	SAAO = Sub Assistant Agriculture Officer
BADC = Bangladesh Agricultural Development Corporation	NGO = Nongovernmental organization
BARI = Bangladesh Agricultural Research Institute	