

ASSESSING ADOPTION AND DIFFUSION OF AGRICULTURAL INNOVATIONS IN BANGLADESH

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Demographic and Production Characteristics of the Sample Farm Households in Five Regions of Bangladesh

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Abstract

The household survey conducted across different agricultural zones of Bangladesh provides a detailed look at the diverse demographic, economic, and technological factors shaping farming practices. The findings reveal significant regional differences in gender distribution, age groups, household roles, and marital status among farming families. The economic landscape shows variations in income sources, with some regions heavily dependent on crop farming, while others see notable contributions from livestock, fisheries, and non-farm activities. Technological adoption rates also vary, with factors such as access to agricultural training, extension services, and credit facilities influencing the uptake of innovations like improved seeds, irrigation, and machinery. The prevalence of rice cultivation remains high across regions, but local specialties, including livestock, fisheries, and other crops, also play important roles in certain zones. The survey underscores the need for targeted policies that cater to the unique challenges and opportunities in each region, addressing training gaps, infrastructure limitations, and financial constraints to facilitate better technology adoption. Recommendations highlight the importance of youth-focused training programs, and community-based research to support sustainable agricultural development, ensuring that the diverse needs of farmers are met effectively across the country's varied zones.

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Demographic Characteristics of Farm Households

1. Introduction:

The Government of Bangladesh has made substantial investments in research and development (R&D) of *home-grown*¹ agricultural technologies and innovations² over the last four decades, leading to self-sufficiency in rice production for a population exceeding 160 million (Stads and Beintema, 2018). These investments, primarily channeled through Bangladesh Agricultural Research Council (BARC), universities, and the Ministry of Science have stimulated the adoption of new agricultural technologies, thereby enhancing overall productivity. Despite these achievements, concerns persist regarding the sustainability of domestic food grain production because, anecdotal evidence suggests that a mix of government-funded and imported technologies are being adopted by farmers. A comprehensive assessment of home-grown versus imported innovations among rural farmers is lacking, and the key challenges in adoption remain unclear. To address these gaps, the project "*Assessing Adoption and Diffusion of Agricultural Innovations in Bangladesh*" aims to identify adoption characteristics, attitudes, and values of agricultural technology users and the characteristics of available technologies in the country. Specifically, it explores usefulness and preferences for local versus foreign agricultural technologies, examines behavioral elements influencing adoption, and delves into facilitating and hindering factors in rural Bangladesh. The ultimate goal is to formulate optimal policy recommendations to promote the adoption of home-grown appropriate agricultural technologies and innovations.

The existing research has consistently demonstrated the significance of various factors in shaping the adoption of agricultural technologies on a global scale. However, the specific adoption of technologies can differ based on how individual farmers perceive and treat

¹ "*Home-grown*" refers to "developed in-Bangladesh"

² "*Innovation is the creation, development and implementation of a new product, process or service, with the aim of improving efficiency, effectiveness or competitive advantage.*" Government of New Zealand

A technology is defined as a technique, method or process for transforming inputs into outputs. A technology can also be thought as a book of instructions (O'Donnell, 2010).

them. Furthermore, there are variations over time and across different geographical locations in the adoption patterns of these technologies (Njuguna et al., 2015). Studies on adoption have identified several influential factors, including demographic characteristics such as farmers' education level, gender, age, and experience, as well as their perceptions of the technology. Other factors encompass technological complexity, the location of adopter institutions, access to extension services, and availability of production resources (Ani and Ifah, 2004; Delgado and Johnson, 2005; Idrisa et al., 2010; Mwabu et al., 2006; Namwat et al., 2010; Obare et al., 2010; Njuguna et al., 2015).

The selection of 36 Upazilas for the research project survey was a comprehensive process involving data from Bangladesh Agricultural Research Council (BARC), consultations with agricultural institutions, and expert input. Initial screening for rice suitability led to 107 Upazilas, narrowed down to 36, focusing on areas where rice is predominant. Collaborations with Bangladesh Rice Research Institute (BRRI), Bangladesh Livestock Research Institute (BLRI), and Bangladesh Forest Research Institute (BFRI) ensured diverse representation. Strategic choices included hill areas and border regions for varied adoption scenarios. In the second iteration, Bangladesh Agricultural Research Council (BARC) data guided the selection of major cereal crop-growing Upazilas, refined by expert suggestions. The study's methods include a pre-determined sample size of 960 farmers, with a keen attention to questionnaire design and sampling strategies to capture a comprehensive understanding of agricultural innovation adoption in Bangladesh.

2. Study Objective:

The primary objective of this study is to conduct an in-depth assessment of the adoption and diffusion of agricultural innovations among farm households in Bangladesh. It aims to evaluate the extent and patterns of adoption for both home-grown and imported agricultural technologies by rural farmers across various regions, identifying how these technologies are utilized and what drives their adoption. The study also seeks to analyze the influence of key demographic factors, including education level, gender, age, and farming experience, on the decision-making processes of farmers. By understanding these demographic dynamics, the study will provide insights into the social factors that shape technology adoption.

A key aspect of the study is to examine the influence of demographic characteristics on the adoption of agricultural technologies. Factors such as education level, gender, age, and farming experience are expected to play a significant role in determining how and why

farmers adopt certain technologies. Understanding these influences will provide insights into the profiles of farmers who are more likely to embrace new innovations and those who may face barriers to adoption. By analyzing their preferences, the research will uncover the factors that drive farmers to choose one type of technology over another, shedding light on their decision-making processes and priorities.

Additionally, the study seeks to analyze the economic drivers behind technology adoption, focusing on the major income-generating farming enterprises and the main sources of household income. The role of institutional factors, such as access to extension services, availability of resources, and the complexity of the technologies, will also be assessed to understand how these elements facilitate or hinder adoption. Furthermore, the study will analyze regional variations in the adoption of agricultural technologies, with a focus on understanding how geographical and cultural differences influence the adoption process. By examining these regional differences, the research will provide a view of the challenges and opportunities associated with technology adoption in various parts of the country.

3. Method:

The study employs a carefully designed methodology to assess the adoption of agricultural technologies among rural farm households in Bangladesh. The first part of the Household Level Questionnaire survey is specifically designed to gather information from rural farmers, focusing on the primary decision-makers involved in technology adoption. This section collects detailed demographic data on the respondents, as well as their engagement with agricultural technologies and recommended practices (ATRP).

To ensure a comprehensive understanding, the study encompassed all 64 districts of Bangladesh, categorized into five major agroecological zones: Northwest (Upland), Northeast (Lowland), Southwest (Saline Soil), Southeast (Hilly Area), and Central (Floodplain). This classification was based on agro-edaphic and agro-climatic conditions, ensuring representation of the diverse ecological and agricultural conditions across the country.

A multi-stage sampling method was employed to select study locations, ensuring both representativeness and impartiality. Initially, clusters were chosen based on natural groupings and hierarchical structures, considering key characteristics such as cropping patterns, soil types, irrigated areas, and hydrology. The selection of Upazilas was guided by

their specialization in crops, livestock, and fisheries production. The predetermined sample size of 960 farmers was proportionally allocated across these Upazilas, with most assigned a sample size of 30 farmers. Adjustments were made for neighboring Upazilas with similar agroecological conditions and farming patterns.

To analyze the collected data, SPSS Cross Tabulation is used to explore the main demographic findings. This analytical approach allows for a thorough examination of the relationships between various demographic characteristics and the adoption of agricultural technologies. The resulting tables offer a detailed description of the surveyed demographic characteristics, providing valuable insights into the factors that influence technology adoption in rural Bangladesh.

Given the diversity of agricultural practices and socio-economic conditions across Bangladesh, the study presents its findings by geographical zones. The reason for this regional differentiation in data collection and presentation is to capture the distinct agricultural environments, cultural contexts, and economic conditions that vary across different parts of the country. By analyzing the data zone-wise, the study can offer more detailed insights into how regional factors influence the adoption of agricultural technologies, ensuring that the findings are relevant and applicable to the specific needs of each region. This approach not only enhances the accuracy of the analysis but also aids in developing targeted policy recommendations that address the unique challenges and opportunities present in different zones of Bangladesh.

4. Findings:

4.1. Demographic Characteristics of Sample Farm Households:

A nationwide total of 992 households were surveyed in this study to understand the demographic characteristics and technology adoption patterns among rural farmers in Bangladesh. The sample distribution was carefully designed to represent the five major agroecological zones of the country, ensuring that the study captures the diverse agricultural contexts across different regions.

The sample was distributed proportionally across these zones, with the largest representation from the North-West (26%) and Central (22%) regions, reflecting the diverse agroecological and agricultural conditions throughout the country. This regional

distribution allows for a comprehensive analysis of the demographic characteristics influencing agricultural technology adoption in Bangladesh.

Table 1: Distribution Sample Farm Households by Zone

Zones	Sample size (in number)	In percent
Central	223	22
North-East	121	12
North-West	257	26
South-East	181	18
South-West	210	21
Total	992	100

4.1.1. Gender Distribution by Zone:

The gender distribution data, as presented in Table 2, offers a detailed insight into the composition of the agricultural workforce in various zones of Bangladesh.

Table 2: Gender Distribution by Zone

Gender	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Female	3.1	0.8	3.1	18.2	4.3	5.9
Male	96.9	99.2	96.9	81.8	95.7	94.1
Total	100	100	100	100	100	100

This analysis focuses on gender distribution across different zones, seeking to identify trends and variations in the adoption of agricultural technologies.

1. Central Zone:

In the Central zone, females represent a mere 3.14% of the total population, with only 7 individuals. This zone exhibits a notable gender imbalance, with males dominating at 96.86% (216 individuals). The consistent gender disparity prompts further exploration into

the factors contributing to this imbalance, impacting the overall dynamics of the agricultural workforce in the region.

2. North-East Zone:

The North-East zone presents a stark gender disparity, with females representing a negligible 0.83% of the population (1 individual). This zone stands out for its overwhelmingly male-dominated agricultural workforce at 99.17% (120 individuals). The almost exclusive male representation raises questions about the inclusivity of women in agricultural practices,

3. North-West Zone:

Females in the North-West zone constitute about 3.11% of the total population (8 individuals), indicating a relatively balanced gender distribution compared to other zones. Males, however, still dominate at 96.89% (249 individuals). The North-West zone provides an intriguing case for exploring factors that contribute to a more equitable gender representation.

4. South-East Zone:

In the South-East zone, females represent approximately 18.26% of the population (33 individuals), indicating a relatively higher gender diversity compared to other zones. Males still dominate at 81.74% (148 individuals).

5. South-West Zone:

Similar to the Central zone, the South-West zone demonstrates a lower female representation, accounting for approximately 4.29% of the population (9 individuals). Males dominate at 95.71% (201 individuals), echoing the gender disparity observed in the Central region.

The gender distribution analysis across different zones in Bangladesh reveals a varied scenario in the agricultural workforce. The Central and North-East zones exhibit stark gender imbalances, with females comprising only 3.14% and 0.83%, respectively, highlighting significant challenges in fostering inclusivity. In contrast, the North-West zone presents a more balanced scenario with females constituting 3.11%, indicating a potential model for equitable representation. The South-East zone stands out with a relatively higher gender diversity at 18.26%, showcasing a more inclusive agricultural workforce. However,

both the South-East and South-West zones still grapple with male dominance, emphasizing the need for targeted interventions to address gender disparities and create a more balanced and inclusive agricultural sector nationwide.

4.1.2. Age Distribution by Zone:

Table 3 demonstrates the diversity in age demographics across different agricultural zones in Bangladesh.

Table 3: Age Distribution by Zone

Age Range	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Below 25	0.4	1.7	5.8	3.3	0	2.4
25-34	11.7	14.0	18.7	17.7	23.3	17.3
35-44	23.8	28.1	26.1	30.9	23.3	26.1
45-54	28.7	28.1	20.2	28.7	22.4	25.2
55-64	21.5	14.9	17.1	13.8	21.4	18.2
Above 65	13.9	13.2	12.1	5.5	9.5	10.9
Total (%)	100	100	100	100	100	100

The primary objective of this table is to dissect the age distribution of farmers across distinct agricultural zones in Bangladesh. By breaking down the farming population into six age ranges, the analysis aims to provide insights into the demographic composition within each region. This understanding is essential for tailoring interventions and policies to address the unique needs of farmers across different age groups.

1. Central Zone:

In the Central zone, the age distribution reflects a diverse demographic composition. Among individuals below 25, there is a minimal representation of 0.4%, constituting only 1 farmer in the surveyed population. The zone stands out in the 25-34 age range, leading with 11.7%, indicating a substantial presence of early-career farmers. Additionally, individuals in the 35-44 and 45-54 age ranges constitute 23.8% and 28.7%, respectively, underscoring a significant concentration of individuals in their prime farming years. The 55-64 age range

maintains a considerable presence with 21.5%, emphasizing the diversity of mature farmers in this zone. Furthermore, individuals above 65 contribute 13.9%, indicating the representation of older farmers. The overall demographic composition of the Central zone contributing to the total of 223 surveyed individuals, provides valuable insights into the varying age distributions within the agricultural landscape of Bangladesh.

2. North-East Zone:

In the North-East zone, the age distribution reveals a balanced demographic landscape. Individuals below 25 constitute a modest 1.7%, with 2 farmers in this age group. Notably, the zone maintains a reasonable presence in the 25-34 age range (14%). The 35-44 age range showcases a significant concentration of 28.1%, indicating a prevalence of individuals in their prime farming years. Similarly, the 45-54 age range demonstrates a balanced distribution (28.1%), highlighting a proportional representation of middle-aged farmers. The North-East zone maintains a moderate presence in the 55-64 age range (14.9%), indicating diversity in the distribution of mature farmers. Additionally, individuals above 65 constitute 13.2%, underscoring the representation of older farmers in this region. These numbers collectively contribute to a comprehensive understanding of the age distribution in the North-East zone, with a total surveyed population of 121 individuals.

3. North-West Zone:

The North-West zone stands out with a distinctive age distribution, particularly in the younger demographic. Individuals below 25 represent a substantial 5.8%, with 15 farmers in this age group. In the 25-34 age range, the zone exhibits a significant presence (18.7%), showcasing a considerable number of early-career farmers. The 35-44 age range demonstrates the highest concentration (26.1%), emphasizing the prevalence of individuals in their prime farming years. Additionally, the North-West zone maintains a balanced distribution in the 45-54 age range (20.2%), reflecting a proportional representation of middle-aged farmers. The zone contributes moderately to the 55-64 age range (17.1%), indicating a diverse distribution of mature farmers. Individuals above 65 constitute 12.1%, further highlighting the unique demographic makeup of this region. The total surveyed population in the North-West zone is 257 individuals, providing insight into distinctive age demographics.

4. South-East Zone:

In the South-East zone, the age distribution reveals a balanced demographic representation. Individuals below 25 account for a modest 3.3%, indicating a relatively lower representation of young farmers. The 25-34 age range demonstrates a reasonable presence (17.7%), showcasing a substantial number of early-career farmers. Notably, the 35-44 age range exhibits a higher concentration (30.9%), emphasizing the prevalence of individuals in their prime farming years. The zone maintains a proportionate presence in the 45-54 age range (28.7%), indicating a balanced distribution of middle-aged farmers. The 55-64 age range contributes moderately (13.8%), showcasing a diverse distribution of mature farmers. Additionally, individuals above 65 constitute 5.5%, underscoring the presence of older farmers in this region. The total percentage sums up to 100%, with a total count (n) of 181 individuals.

5. South-West Zone:

The South-West zone presents a unique age distribution with distinctive characteristics. Notably, there are no farmers below 25, reflecting 0% representation in this age group. However, the zone closely follows the Central zone in the 25-34 age range (23.3%), indicating a substantial number of early-career farmers. The 35-44 age range also demonstrates a significant presence (23.3%), emphasizing the prevalence of individuals in their prime farming years. Additionally, the zone maintains a balanced distribution in the 45-54 age range (22.4%), reflecting proportional representation of middle-aged farmers. The 55-64 age range contributes moderately (21.4%), indicating a diverse distribution of mature farmers. Individuals above 65 constitute 9.5%, further highlighting the unique demographic makeup of this region. These figures highlight the unique age demographics in the South-West zone, with a total surveyed population of 210 individuals.

The age distribution analysis of farmers across five agricultural zones in Bangladesh reveals diverse demographic landscapes. The Central zone exhibits a balanced composition, with individuals below 25 accounting for 0.4%, and the prime farming years (25-54) representing 64.2%. The North-East zone maintains a proportional distribution, with individuals below 25 at 1.7%, and the prime farming years constituting 60.8%. In contrast, the North-West zone stands out for its higher proportion of young farmers, particularly below 25, at 5.8%, showcasing a potential focus on cultivating new talent. The South-East zone reflects a balanced demographic, with individuals below 25 at 3.3%, and the prime age groups representing 76.3%. The South-West zone, unique with no farmers below 25,

highlights a strong presence of early and prime age farmers, constituting 46.6%. Overall, these insights underscore the importance of tailored interventions addressing the distinct needs of farmers across age categories in each agricultural zone.

4.1.3. Role of the Farm Household Respondent:

Table 4 delves into the diverse role farmers play within their households across various agricultural zones in Bangladesh. This exploration recognizes the variations in household roles as integral components of the broader agricultural landscape.

Table 4: Role in the Household

Role in the household	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Head of household	93.7	92.6	87.2	82.3	89.0	88.9
Son of household	5.0	7.4	0	0	0	2
Son of household head	0	0	11.3	9.9	11.0	7.1
Spouse of household head	1.3	0	1.6	7.7	0	2.1
Total	100	100	100	100	100	100

This table aims to unravel the distribution of household roles among farmers, emphasizing key roles such as the head of the household, son of the household, son of the household head, and spouse of the household head. The percentages presented provide insights into the prevalence of each role within different zones. Recognizing the significance of these roles is crucial for tailoring interventions that align with the unique household dynamics in each agricultural zone, contributing to a comprehensive understanding of the socio-economic fabric within the farming community of Bangladesh.

1. Central Zone:

In the Central agricultural zone, a substantial 93.7% of individuals, representing a count of 209, assume the role of the head of the household, reflecting strong familial leadership. While a smaller percentage, 5.0%, represents sons of the household (11 individuals),

indicating potential transitions in family responsibilities. Importantly, no individuals fall into the category of sons of the household head, underscoring unique family structures. Additionally, a modest 1.3% serve as the spouse of the household head (3 individuals), indicating varying levels of involvement in specific family roles. The total count for the Central zone is 223 individuals.

2. North-East Zone:

The North-East zone displays a high prevalence of individuals as heads of households, constituting 112 individuals out of the total 121 surveyed, highlighting robust leadership roles within families. Notably, 7.4% of individuals are identified as sons of the household (9 individuals), reflecting potential continuity in family involvement in agricultural activities. However, there are no individuals categorized as sons of the household head, emphasizing distinctive family structures. Moreover, no individuals in this zone are identified as spouses of the household head.

3. North-West Zone:

The North-West agricultural zone showcases a substantial 87.2% of individuals undertaking the role of the household head, totaling 224 individuals out of the 257 surveyed. In contrast, no individuals are designated as sons of the household, indicating potential variations in family structures or roles. Notably, a distinctive 11.3% (29 individuals) are identified as sons of the household head, reflecting unique family dynamics. Additionally, 1.6% serve as spouses of the household head (4 individuals), indicating some involvement in this specific role. The overall assessment is grounded in a thorough survey of 257 individuals in the North-West zone.

4. South-East Zone:

The South-East zone demonstrates a slightly lower but still considerable 82.3% of individuals, totaling 149, serving as heads of households. This suggests potential variations in familial leadership roles within the region. Importantly, no individuals in this zone are identified as sons of the household, indicating differences in family structures. However, a notable 9.9% of individuals, totaling 18, are categorized as sons of the household head, indicating a unique family dynamic. Moreover, 7.7% serve as the spouse of the household head. The total number of individuals surveyed in this zone is 181.

5. South-West Zone:

The South-West agricultural zone exhibits a high percentage of individuals (89.0%) serving as heads of households, equivalent to a count of 187 individuals. This reflects strong familial leadership within the region. Similar to the North-West zone, no individuals in the South-West zone are identified as sons of the household. However, a noteworthy 11.0% of individuals are identified as sons of the household head (31 individuals), highlighting unique family dynamics. Importantly, no individuals in this zone are identified as spouses of the household head, suggesting potential variations in family structures or dynamics. This comprehensive analysis is based on a survey of 210 individuals in the South-West zone.

The examination of household roles among farmers across diverse agricultural zones in Bangladesh, as outlined in Table 3, reveals notable variations in family dynamics. In all zones, the predominant role is that of the head of the household, ranging from 82.3% to 93.7%, indicating strong familial leadership. The North-West and South-West zones stand out with higher percentages of individuals identified as sons of the household head, suggesting distinctive family structures and dynamics. Conversely, certain zones exhibit no individuals in the category of spouses of the household head, underscoring further diversity in family structures. Overall, comprehending these varying household roles is crucial for tailoring interventions that address the nuanced socio-economic fabric within each agricultural zone, contributing to a targeted and comprehensive approach to support farmers in Bangladesh.

4.1.4. Marital Status of the Farmer:

This table illustrates the marital status of farmers in various agricultural zones in Bangladesh, providing a comprehensive view of the diversity within each zone.

Table 5: Marital Status of the Farmer

Marital status	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Married	99.1	95	89.9	92.8	91.9	94.8
Separated	0	0	0	0	0.5	0.1
Single	0.5	4.1	8.9	6.6	6.7	5.9

Widowed/Widower	0.5	0.8	1.2	0.6	1	0.9
Total	100	100	100	100	100	100

The table 5 provides a breakdown of the marital status of farmers across different agricultural zones in Bangladesh, represented as a percentage distribution. The percentages offer insights into the prevalence of various marital statuses, including married, separated, single, and widowed/widower, within each zone. Understanding these marital dynamics is crucial for tailoring support programs and interventions that align with the diverse socio-economic backgrounds of farmers in different regions.

1. Central Zone:

In the Central zone, the majority of farmers are married, constituting an overwhelming 99.1% of the surveyed population of 223 farmers. This high percentage reflects a prevalent trend of family-centric agricultural practices, where married individuals likely play significant roles in the agricultural workforce. The presence of separated individuals is negligible at 0%, indicating stable marital unions. The percentage of single individuals is minimal but not absent, with 0.5%, suggesting a diverse range of household compositions. Widowed or widowers constitute 0.5%, showcasing a small proportion of farmers managing responsibilities independently due to spousal loss.

2. North-East Zone:

In the North-East zone, the married category remains dominant at 95%, among the 121 surveyed farmers, indicating a family-oriented agricultural structure. Separated individuals and widowed or widowers both register at 0%, underscoring the stability and low prevalence of such marital statuses in this zone. Notably, the percentage of single individuals is higher here, at 4.1%, indicating a more diverse range of household compositions and potentially reflecting specific socio-economic factors or cultural dynamics among unmarried farmers in the context of Bangladesh's agricultural sector.

3. North-West Zone:

The North-West zone exhibits a strong prevalence of married individuals, comprising 89.9% of the surveyed population out of 257 farmers. This high percentage aligns with the family-centric nature of agriculture in the region. The percentage of separated individuals

and widowed or widowers is relatively low at 0%, indicating stable marital unions. However, the percentage of single individuals is noteworthy at 8.9%, suggesting a more diverse demographic composition and potentially greater decision-making autonomy among unmarried farmers.

4. South-East Zone:

In the South-East zone, the married category remains predominant at 92.8%, indicating a family-centric approach to agriculture among the 181 surveyed farmers. Separated individuals and widowed or widowers both register at 0%, highlighting the stability of marital unions. The percentage of single individuals is 6.6%, indicating a notable presence of unmarried farmers and potentially more independent decision-making within households.

5. South-West Zone:

The South-West zone reflects a strong prevalence of married individuals at 91.9%, among the 210 surveyed farmers, aligning with the family-centric nature of agriculture. The percentage of separated individuals is minimal at 0.5%, underscoring stable marital unions. Notably, the percentage of single individuals is substantial at 6.7%, indicating a diverse range of household compositions and potentially greater decision-making autonomy among unmarried farmers. The percentage of widowed or widowers is 1%, showcasing instances of individuals managing farming responsibilities independently due to spousal loss.

The marital status of farmers in Bangladesh varies across agricultural zones, as indicated by the provided data. Overall, the majority of farmers are married, with the highest percentage observed in the Central zone at 99.1%. Stable marital unions are a common trend across all zones, with negligible percentages of separated individuals. The prevalence of single farmers varies, with the North-West zone standing out at 8.9%, suggesting a more diverse demographic composition. The occurrence of widowed or widower farmers is relatively low, emphasizing the stability of marital unions. These findings underscore the importance of recognizing regional differences in marital dynamics to tailor effective support programs for the diverse socio-economic backgrounds of farmers in Bangladesh.

4.1.5. Main Occupation of the Farmer:

Understanding the main occupation of farmers in Bangladesh is crucial for gaining insights into the predominant livelihood activities shaping rural communities across different agricultural zones. The analysis presented in Table 6 not only provides a breakdown of the number count but also offers the corresponding percentage of farmers involved in either farming on their own lands or working in other farms.

Table 6: Main Occupation of the Farmer

Main occupation	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Farming (own farm)	95.5	99.2	94.9	98.3	100	97.9
Work in other farms	1.8	0.8	5.1	1.7	0	2.1
Total	100	100	100	100	100	100

This comprehensive exploration aims to shed light on the diverse occupational patterns within each region, emphasizing the integral role of agriculture in the socio-economic fabric of Bangladesh.

1. Central Zone:

In the Central zone, with a total surveyed population of 223 farmers, the table reveals a substantial emphasis on farming as the main occupation. Approximately 95.5% (219 farmers) are engaged in farming activities on their own farms, highlighting the central role of agriculture in the livelihoods of the local population. The remaining 4.5% (4 farmers) are involved in working on other farms, indicating a minor presence of alternative occupations in this predominantly agrarian zone.

2. North-East Zone:

Moving to the North-East zone, with a total surveyed population of 121 farmers, the data underscores an even higher reliance on farming. Here, an overwhelming 99.2% (120 farmers) are primarily engaged in farming on their own farms. Only 1 individual, comprising 0.8%, is engaged in working on other farms. This emphasizes the prevalent role of agriculture as the primary occupation in this zone.

3. North-West Zone:

The North-West zone, encompassing 257 surveyed farmers, exhibits a robust preference for farming as the main occupation. A substantial 94.9% (n=244) of farmers in this region are dedicated to farming on their own farms, emphasizing the agricultural prominence of the North-West zone. The limited 5.1% (n=13) engaged in working on other farms indicates a minor diversification of occupations.

4. South-East Zone:

The South-East zone sees 178 individuals, representing 98.3% of the surveyed population (n=181), engaged in farming on their own farms. Only 3 individuals, making up 1.7%, are involved in working on other farms. This highlights the paramount role of agriculture in shaping economic activities in the region.

5. South-West Zone:

The South-West zone demonstrates an exclusive reliance on farming, with 210 individuals, representing 100% of the surveyed population (n=210), engaged in farming on their own farms. There are no individuals working on other farms in this zone, further emphasizing the dominance of agriculture.

The overall scenario of farmers' main occupations in Bangladesh, as reflected in Table 5, underscores a significant reliance on farming across all agricultural zones. Farming on one's own land emerges as the predominant occupation, with an average of 97.9% of surveyed farmers engaged in this activity. This trend is consistent across regions, with the South-West zone exclusively relying on farming on one's own land. The percentage of farmers working on other farms is relatively low at 2.1%, emphasizing the agricultural-centric nature of livelihoods in the surveyed population.

4.1.6. Main Occupation of the Spouse:

The exploration of spouses' main occupations across different zones provides valuable insights into the socio-economic dynamics of each region. The following analysis, illustrated in Table 7, highlights the percentage distribution of spouses engaged in various

occupations in the Central, North-East, North-West, South-East, and South-West zones. From farming activities and domestic roles to alternative occupations, this analysis unveils the distinct occupational profiles that contribute to the economic tapestry of each zone.

Table 7: Main Occupation of the Spouse

Main occupation of spouse	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Farming (own farm)	31.2	27.7	31.6	54.7	15	31.8
House Wife	67.4	67.2	66.7	44.7	83.4	66.4
Job	0	0	0	0	1.1	0.2
N/A	0.5	4.2	0	0	0	0.6
Other	1.4	5.0	0	0	0	1
Work in other farms	0	0	1.7	0.6	0.5	0.7
Total	100	100	100	100	100	100

The following narratives offer a detailed examination of the main occupation of spouses in each zone, showing the diverse aspects that contribute to the socio-economic dynamics of these communities.

1. Central Zone:

In the Central region, comprising a surveyed population of 221 individuals, 31.2% of spouses are actively involved in farming on their own farms, totaling 69 individuals. This underscores a notable agricultural presence within the region, emphasizing the significance of local farming practices. Housewives dominate the landscape, constituting 67.4% (149 individuals) of the total, reflecting a traditional domestic role that remains prevalent. Notably, there are no reported instances of spouses employed in jobs, showcasing a distinct occupational profile and indicating a minimal involvement in formal employment within the region. The "Other" occupations category is minimal at 1.4 % (3 individuals), indicating a limited but varied subset of additional occupations beyond the predominant farming and housewifery roles. Remarkably, there are no reported cases of spouses working in other farms, providing a unique characteristic to the Central region's occupational dynamics and further highlighting the region's focus on local agricultural activities.

2. North-East Zone:

Within the North-East region's surveyed population of 119 individuals, 27.7% of spouses, totaling 33 individuals, are actively engaged in farming on their own farms. This emphasizes the region's notable agricultural involvement, highlighting the significance of local farming practices. Housewives constitute the majority at 67.2%, encompassing 80 individuals, reflecting a balance between agricultural and domestic roles within the North-East community. Other occupations contribute 5% (6 individuals), showcasing a minimal but diverse subset of alternative roles beyond the predominant farming and housewifery roles. Notably, no engagement in working on other farms is reported (0%), emphasizing the unique character of the North-East region's occupational landscape, with individuals primarily involved in farming on their own lands. The North-East region thus exhibits a rich occupational distribution, combining significant agricultural engagement, a predominant presence of housewifery, and a small yet diverse spectrum of other occupations, contributing to the overall socio-economic fabric of the region.

3. North-West Zone:

In the North-West region, comprising a surveyed population of 231 individuals, a substantial 31.6% of spouses, totaling 73 individuals, are actively involved in farming on their own farms. This underscores the region's strong reliance on local agricultural practices for sustenance and economic livelihoods. Housewives form the majority at 66.7%, with 154 individuals, emphasizing the integral role of domestic responsibilities within the region. A notable aspect is the reported 1.7% of spouses (4 individuals) engaged in other farms, reflecting a diversification within the agricultural sector. Remarkably, the absence of reported jobs, and other occupations signifies a concentrated occupational landscape with a predominant focus on farming. This portrays a concentrated occupational landscape with a strong emphasis on farming and a minimal presence of alternative occupations.

4. South-East Zone:

In the South-East region, characterized by a surveyed population of 170 individuals, agriculture takes center stage as a prominent occupation, with a substantial 54.7% (93 individuals) actively engaged in farming on their own lands. While housewives constitute a significant portion at 44.7%, totaling 76 individuals, they do not represent the majority. Additionally, a small percentage of individuals, 0.6% (1 person), is reported to be working on other farms, adding a subtle layer to the region's occupational diversity. The clear

emphasis on agriculture as the primary occupation remains pronounced. Notably, the absence of reported jobs, and other occupations, further characterizes the region's occupational landscape. This unique socio-economic profile underscores the South-East's distinct reliance on local agriculture, with housewifery playing a complementary role. The absence of alternative occupations highlights the region's commitment to and dependence on agriculture as the central pillar of its economic activities and community livelihoods.

5. South-West Zone:

In the South-West region, characterized by a surveyed population of 193 individuals, a distinctive occupational distribution comes to light. Notably, 15% (29 individuals) engage in farming, underscoring a significant but not majority role for agriculture. The majority, however, consists of housewives, comprising 83.4% (161 individuals). In addition, a noteworthy 1.1% (2 individuals) are employed in jobs, one individual (0.5%) works in other farms, and an additional 0.5% (1 individual) engages in similar work, introducing a subtle yet present engagement beyond traditional roles. Similar to other regions, there are no reported instances of other occupations. This region exhibits a unique blend of strong agricultural engagement, predominant housewifery, and a minor yet noteworthy presence in alternative occupations, highlighting the diverse economic activities within the community.

In Bangladesh, the overall situation regarding the primary occupations of spouses displays a complex picture across various agricultural zones. Agriculture plays a significant role, with an average of 31.8% of spouses engaged in farming on their own lands. Housewifery is a predominant across all zones, averaging 66.4%. Noteworthy variations include the South-East zone, where 54.7% of spouses are actively involved in farming, and the South-West zone, showcasing a more diversified landscape with 15% engaged in farming and 1.1% in jobs. The absence of reported jobs in the Central and North-East zones and the minimal presence of spouses working on other farms in the South-West zone contribute to the unique socio-economic features of each region.

4.1.7. Years of Farming Experience by Zone:

The analysis of farming experience by zone is pivotal in understanding the expertise levels of agricultural practitioners across various regions. The data presented in Table 8 captures

the distribution of farming experience among farmers in Central, North-East, North-West, South-East, and South-West zones. The table delineates different experience ranges, allowing for a comprehensive examination of the agricultural landscape in each zone.

Table 8: Years of Farming Experience by Zone

	Experience Range	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total No. (%)
Years of Farming	<5	0.9	0.8	4.7	2.2	1.4	2.2
	5-10	12.1	10.8	21.9	18.8	22.1	17.8
	11-15	12.1	13.3	13.3	16.0	13.5	13.6
	16-25	32.7	27.5	22.4	36.5	25	28.5
	26-40	34.8	35.0	26.7	23.8	29.8	29.7
	40>	7.2	12.5	11.0	2.8	8.2	8.2
	Total	100	100	100	100	100	100

The results from Table 7 provide insights into the distribution of farming experience among farmers in different zones, shedding light on the expertise levels of agricultural practitioners.

1. Central Zone:

In the Central region, a comprehensive analysis of farming experience among 223 surveyed individuals reveals a dynamic agricultural landscape. The majority, comprising 34.8% (78 individuals), falls within the 26-40 years range, signifying a significant pool of experienced farmers contributing to the region's agricultural depth. Substantially, 32.7% (73 individuals) exhibit substantial expertise, boasting 16-25 years of farming experience. This balanced distribution extends to the 5-10 and 11-15-year ranges, each capturing a notable 12.1% (27 individuals). Furthermore, a dedicated group of 7.2% (16 individuals) has accumulated over 40 years of farming experience, underscoring the Central zone's resilience and sustained commitment to agriculture. Furthermore, a small but present 0.9% (2 individuals) of respondents have less than 5 years of farming experience. This diverse range of farming expertise showcases the region's rich agricultural heritage and sets the stage for continued growth and productivity.

2. North-East Zone:

Within the North-East region, comprising 120 surveyed individuals, a varied farming experience is evident. A significant 35% (42 individuals) fall within the 26-40 years range, emphasizing the robust agricultural expertise within the North-East zone. Furthermore, 27.5% (33 individuals) of the respondents possess 16-25 years of experience, indicative of a substantial presence of seasoned farmers contributing to the region's agricultural depth. The distribution across different experience ranges remains diverse, with 10.8% (13 individuals) in the 5-10 years range and 13.3% (16 individuals) in the 11-15 years range. Notably, 12.5% (15 individuals) exhibit remarkable longevity, having surpassed 40 years in farming. Additionally, a small percentage, 0.8% (1 individual), represents those with less than 5 years of farming experience, further adding to the diverse expertise within the North-East zone. This multifaceted farming experience contributes to the region's resilience and showcases a rich tapestry of agricultural knowledge and dedication among farmers of North-East zone.

North-West Zone:

In the North-West region, comprising 255 surveyed individuals, a diverse and resilient distribution of farming experience is evident. Notably, the 26.7% (68 individuals) engaged in farming for 26-40 years contribute significantly to the region's seasoned agricultural landscape. Additionally, 22.4% (57 individuals) of respondents possess 16-25 years of expertise, underscoring a robust agricultural foundation within the North-West zone. A balanced representation across various experience ranges is observed, with 21.9% (56 individuals) in the 5-10 years range and 13.3% (34 individuals) in the 11-15 years range. Furthermore, the North-West region features 11% (28 individuals) with over 40 years of invaluable farming experience. An additional 4.7% (12 individuals) represents those with less than 5 years of farming experience, contributing to the diversity of expertise within the North-West zone. This diverse and comprehensive range of farming expertise highlights the North-West's agricultural resilience and the wealth of knowledge held by its farming community.

South-East Zone:

In the South-East region, encompassing 181 surveyed individuals, a commitment to diverse and sustained farming practices is evident. Notably, a significant 36.5% (66 individuals) of respondents possess 16-25 years of agricultural expertise, underscoring the region's

dedication to long-term farming practices. Additionally, the 23.8% (43 individuals) engaged in farming for 26-40 years further solidify the South-East's agricultural landscape. A well-balanced distribution across various experience ranges is observed, with 18.8% (34 individuals) in the 5-10 years range and 16% (29 individuals) in the 11-15 years range. Furthermore, a modest 2.8% (5 individuals) exhibit remarkable longevity, surpassing 40 years in farming, and an additional 2.2% (4 individuals) bring fresh perspectives with less than 5 years of farming experience. This diverse range of farming experience emphasizes the South-East region's commitment to a holistic and enduring agricultural approach.

South-West Zone:

In the South-West region, comprising 208 surveyed individuals, a distinctive distribution of farming experience is observed, reflecting the region's varied agricultural landscape. Notably, 29.8% (62 individuals) of respondents possess 26-40 years of agricultural expertise, highlighting a robust foundation in farming practices. The majority of farmers in this region, constituting 8.2% (17 individuals), exhibit remarkable longevity, surpassing 40 years of experience. Additionally, a significant 25% (52 individuals) have accumulated 16-25 years of experience, contributing to the overall diversity of farming engagement in the South-West. The farming landscape is further enriched by a balanced representation across other experience ranges, with 22.1% (46 individuals) in the 5-10 years range, 13.5% (28 individuals) in the 11-15 years range, and an additional 1.4% (3 individuals) bringing fresh perspectives with less than 5 years of farming experience. The South-West zone thus presents a unique blend of strong agricultural engagement and a substantial presence of more experienced farmers, contributing to the region's distinct and varied agricultural fabric. The South-West zone thus presents a unique blend of strong agricultural engagement and a substantial presence of more experienced farmers, contributing to the region's distinct and varied agricultural settings.

Analyzing the data presented in Table 7, the North-West zone notably stands out with the highest percentage (12.5%) of farmers possessing over 40 years of experience, showcasing a robust presence of highly experienced individuals in comparison to other zones in Bangladesh. This underscores the region's deep-rooted agricultural heritage and the wealth of knowledge held by its farming community. In contrast, the Central and South-East zones exhibit the lowest percentages, 7.2% and 2.8%, respectively, suggesting a potentially younger or evolving agricultural landscape in these areas. This disparity highlights the

diverse experiences and expertise levels across different zones, emphasizing the rich tapestry of Bangladesh's agricultural practices.

4.1.8. Highest Educational Attainment of the Farmer:

Understanding the educational background of farmers is crucial for devising effective agricultural development strategies. Educational attainment often shapes farmers' perspectives, influencing their adoption of new technologies. In this analysis, we delve into the diverse educational levels of farmers across different zones. This exploration aims to elucidate potential correlations between education and the tendency to embrace modern agricultural practices. The following tables provide a detailed breakdown of farmers' educational attainment in the Central, North-East, North-West, South-East, and South-West zones, offering valuable insights for tailored interventions and sustainable agricultural advancements.

Table 9: Highest Educational Attainment of the Farmer

Highest educational attainment	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total
Adult literacy only (no formal education)	3.6	15.7	15.9	0	0	6.9
Intermediate/ HSC	5.4	5.0	10.9	8.8	11	8.6
Jr High School/ JSC	22.4	10.7	17.5	17.7	32.4	21
Metric/SSC	23.8	11.6	14.4	8.8	17.6	15.9
No formal education – unable to read and write	17.9	24.8	13.2	22.7	9.5	16.6
Primary	26.5	28.1	20.6	41.4	24.3	27.4
Tertiary (Diploma/Degree/Postgraduate)	0.5	4.1	7.4	0.6	5.2	3.7
Total	100	100	100	100	100	100

The description below offers a comprehensive view of farmers' educational backgrounds across different zones.

1. Central:

In the Central region, the highest educational attainment among farmers is diverse. A significant portion, 26.5%, completed primary education (59 individuals), highlighting a strong foundation in basic learning. Metric/SSC education, at 23.8% (53 individuals), and Jr High School/JSC education, at 22.4% (50 individuals), indicate a focus on secondary education. Intermediate/HSC and tertiary education are represented by 5.4% (12 individuals) and 0.5% (1 individual), respectively, showing a modest but existing pursuit of higher academic qualifications. However, a notable challenge exists, with 17.9% of farmers (40 individuals) having no formal education – either unable to read or write. This emphasizes the urgent need for targeted interventions to address basic literacy gaps in the region. Simultaneously, the percentage of 3.6% with adult literacy only (no formal education) totaling 8 individuals highlights the importance of literacy programs even when formal education is absent. The total population surveyed in the Central region is 223.

2. North-East:

The North-East region presents a varied educational profile among farmers. While a significant 28.1% completed primary education (34 individuals), there is a notable gap, with 24.8% (30 individuals) lacking formal education - unable to read or write. Jr High School/JSC education at 10.7% (13 individuals) reflects a base level of secondary education. The educational spectrum expands, with 23.8% (29 individuals) achieving Metric/SSC education, and 5% (6 individuals) having Intermediate/HSC education. However, the region exhibits diversity, with 15.7% having adult literacy only (19 individuals) and 4.1% pursuing tertiary education (5 individuals). This data underscores the need for comprehensive initiatives to address gaps in both basic and advanced education, ensuring a more equitable educational landscape. The prevalence of adult literacy only and no formal education calls for interventions tailored to improve both literacy skills and formal educational opportunities. The total population surveyed in the North-East region is 121.

3. North-West:

Among the 257 people surveyed in the North-West area, the zone has a varied educational spectrum among farmers. With 20.6% completing primary education (53 individuals) and 17.5% achieving Jr High School/JSC level (45 individuals), there's a focus on foundational

education. Metric/SSC education, at 14.4% (37 individuals), indicates a commitment to secondary studies, while Intermediate/HSC education, at 10.9% (28 individuals), further signifies an accomplishment beyond the junior secondary level. Moreover, 7.4% (19 individuals) pursuing tertiary education reflects an interest in advanced learning. However, challenges persist, with 13.2% (34 individuals) lacking formal education – unable to read or write. Addressing gaps in basic education and promoting higher academic pursuits are crucial for fostering a well-rounded educational environment. Simultaneously, the 15.9% with adult literacy only (41 individuals) emphasizes the need for targeted literacy programs alongside formal education initiatives.

4. South-East:

In the South-East region, farmers show a strong emphasis on primary education, with 41.4% (75 individuals) completing this foundational level. Jr High School/JSC education at 17.7% (32 individuals) and Metric/SSC education, at 16% (29 individuals) reflect a commitment to secondary studies. Intermediate/HSC education, at 8.8% (16 individuals), further contribute to a diverse educational landscape. While there is no representation of adult literacy only, the low percentage of 0.6% (1 individual) pursuing tertiary education suggests a need for encouragement in advanced studies. However, 22.7% of farmers (41 individuals) have no formal education - unable to read or write. This region requires targeted interventions to bridge gaps in basic education and foster aspirations for higher academic achievements among farmers. The total population surveyed in the South-East region is 181.

5. South-West:

In the South-West region, where the total population surveyed is 210, farmers exhibit a diversified educational landscape. The region stands out with a significant proportion (32.4%) of farmers completing Jr High School/JSC education (68 individuals). Primary education completion is notable at 24.3% (51 individuals), while 17.6% (37 individuals) reached Metric/SSC level. Intermediate/HSC education is represented by 11% (23 individuals), and tertiary education is seen in 5.2% (11 individuals), indicating a growing interest in advanced studies. However, a considerable number (9.5%) still have no formal education – either unable to read or write (20 individuals), pointing to the necessity of literacy initiatives and educational outreach. Additionally, the 0% representation in adult

literacy only suggests an opportunity for tailored programs to enhance literacy skills among those with no formal education.

The educational landscape among farmers in Bangladesh varies across regions, with a predominant focus on primary education (ranging from 20.6% to 41.4%). Challenges in lacking formal education are observed in the Central (17.9%) and North-East (24.8%) zones. The North-West zone exhibits a balanced engagement across education levels, with 7.4% pursuing tertiary education. In the South-East, primary education is prominent (41.4%), while the South-West stands out with a significant proportion (32.4%) completing Jr High School/JSC, indicating growing interest in secondary studies. Bridging gaps in basic education and promoting higher academic pursuits are crucial for sustainable agricultural advancements in these regions.

4.1.9. Highest Educational Attainment of the Farmers' Spouse:

This exploration delves into the highest educational attainment of farmers' spouses across different regions—Central, North-East, North-West, South-East, and South-West. By comparing the educational background of spouses with that of farmers, this analysis aims to identify patterns and disparities, shedding light on the challenges and opportunities within each zone. The presented data highlights the diverse educational profiles, emphasizing the prevalence of foundational education, secondary studies, and the presence of individuals pursuing tertiary education.

Table 10: Highest Educational Attainment of the Farmers' Spouse

Highest educational attainment of the spouse	Central	North-East	North-West	South-East	South-West	Total
Adult literacy only (no formal education)	2.7	7.6	12	0	0.6	5.1
Intermediate/ HSC	1.4	3.4	5.0	4.1	6.0	4.1
Jr High School/ JSC	31.4	21.2	19.8	11.6	24.0	22.5
Metric/SSC	12.1	11.0	13.2	12.7	18.6	14.0
No formal education – unable to read and write	15.7	17.8	10.5	36.4	23.5	20.3

Primary	36.3	39.0	26.1	35.3	29.5	33.1
Tertiary (Diploma/Degree/Postgraduate)	0.5	0	1.2	0	2.7	1.0
Total	100	100	100	100	100	100

By exploring the data presented in Table 9, we aim to identify patterns and variations that exist within different zones, offering insights into the educational background of the key support system within farming households. As we navigate through the findings in each region, we uncover not only the achievements but also the existing gaps, paving the way for informed policies and initiatives to empower farming communities through education.

1. Central:

In the Central region, the educational attainment of farmers' spouses reflects a diverse spectrum. Notably, Primary education is well-represented at 36.3% (81 individuals), and 31.4% have completed Jr High School/JSC education (70 individuals), indicating a focus on foundational learning. Additionally, the inclusion of Metric/SSC education at 12.1% (27 individuals) reveals a significant portion pursuing formal secondary education. Intermediate/HSC and tertiary education have modest representations at 1.4% (3 individuals) and 0.5% (1 individual), respectively. However, challenges persist, with 15.7% (35 individuals) lacking formal education, emphasizing the need for targeted literacy interventions. The prevalence of adult literacy only (2.7%, 6 individuals) indicates some level of literacy even in the absence of formal education. The total population surveyed in the Central region is 223.

2. North-East:

In the North-East region, farmers' spouses exhibit varied educational backgrounds. A substantial 39% (46 individuals) have completed Primary education, while 21.2% (25 individuals) have pursued Jr High School/JSC education. Metric/SSC education reflecting 11.9% (14 individuals), reveals a significant proportion pursuing secondary education. Intermediate/HSC and Tertiary education are modestly represented at 3.4% (4 individuals) and 0% (0 individuals), respectively. The region faces challenges, with 17.8% (21 individuals) lacking formal education. Adult literacy only is present in 7.6% (9 individuals), highlighting some literacy skills without formal education. The total population surveyed in the North-East region is 118.

3. North-West:

The North-West region showcases a diverse educational landscape among farmers' spouses. Primary education completion is notable at 26.1% (67 individuals), with 19.8% (51 individuals) achieving Jr High School/JSC education. Metric/SSC education reflecting 13.2% (34 individuals), further reveals a noteworthy proportion pursuing secondary education. Intermediate/HSC education is modestly represented at 5% (13 individuals). Tertiary education is represented at 1.2% (3 individuals), indicating a slight interest in advanced studies. However, challenges exist, with 10.5% (27 individuals) lacking formal education. Adult literacy only is present in 12% (31 individuals), emphasizing some literacy skills in the absence of formal education. The total population surveyed in the North-West region is 257.

4. South-East:

In the South-East region, farmers' spouses exhibit a strong emphasis on foundational education, with 35.3% (61 individuals) completing Primary education and 11.6% (20 individuals) pursuing Jr High School/JSC education. Additionally, 12.7% (22 individuals) have achieved Metric/SSC education, indicating a notable representation in the pursuit of secondary education. The absence of individuals with adult literacy only and the modest representation of 4.1% (7 individuals) in Intermediate/HSC education suggest a need for targeted literacy programs and potential for higher academic pursuits. The tertiary education landscape reveals a modest representation of 1.2% (2 individuals), suggesting a limited yet existing interest in higher academic pursuits. Challenges are evident, as 36.4% (63 individuals) lack formal education - unable to read and write, emphasizing the urgent need for interventions addressing basic literacy gaps. The region's total surveyed population is 173, providing a comprehensive context for the distribution of educational levels and associated challenges.

5. South-West:

In the South-West region, farmers' spouses exhibit a noteworthy educational profile with a strong emphasis on Primary education completion at 29.5% (54 individuals). Jr High School/JSC education is substantial at 24% (44 individuals), indicating commitment to secondary studies, while Metric/SSC education is well-represented at 18.6% (34 individuals). The inclusion of Higher Secondary Certificate (HSC) education, which comprises 6% (11 individuals), reveals a significant portion pursuing formal secondary

education beyond Metric/SSC, further enriching the educational diversity. Tertiary education, encompassing Diploma, Degree, or Postgraduate studies, shows a modest yet existing representation of 2.7% (5 individuals), suggesting an interest in advanced academic pursuits. However, challenges persist, with 23.5% (43 individuals) lacking formal education - unable to read and write, emphasizing the pressing need for literacy initiatives. The presence of only 0.6% (1 individual) with adult literacy skills underscores the importance of comprehensive literacy programs. The total surveyed population in the South-West region is 183, providing a comprehensive context for the distribution of educational levels and highlighting the significance of addressing both basic literacy gaps and fostering higher academic achievements.

The educational landscape among farmers' spouses in Bangladesh reveals diverse profiles across regions. Primary education is notably prevalent, ranging from 26.1% to 39%, indicating a strong emphasis on foundational learning. Jr High School/JSC and Metric/SSC education are well-represented, constituting 19.8% to 31.4%, with modest yet existing engagement in Intermediate/HSC and tertiary education at 1.2% to 4.1%. Challenges persist, with varying percentages lacking formal education, ranging from 10.5% to 36.4%, emphasizing the need for targeted literacy interventions. Adult literacy only is present, indicating some literacy skills even in the absence of formal education, constituting 0.6% to 2.7%. The findings underscore the importance of tailored educational initiatives to address gaps and promote higher academic pursuits, contributing to the empowerment of farming communities.

4.2. Economic Aspects:

4.2.1. Zone-wise Distribution of 'Major Farming' Enterprises Generating Over 50% of Farm Income:

The Zone-wise Distribution of 'Major Farming' Enterprises Generating Over 50% of Farm Income provides a detailed breakdown of the dominant agricultural activities in distinct geographic regions. By categorizing major farming enterprises into plant-based (including crops like corn, rice, fruits, jute, pulses & oil seeds, spices, and vegetables) and

livestock-based (encompassing cattle, dairy, poultry) activities, alongside fishery enterprises, the table elucidates the composition of farming activities that contribute significantly to the overall farm income.

Table 11: Zone-wise Distribution of 'Major Farming' Enterprises Generating Over 50% of Farm Income

Zone	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Major Farming' Enterprises						
Plant Based						
Corn	0.4	0	0	0	0	0.1
Crop (rice based)	57	92.6	59.1	25.4	70.5	59.1
Fruits	0.4	0	0.4	20.4	1.4	4.2
Jute	2.2	0.8	0	0	0	0.6
Pulses & Oil seeds	1.8	0	0	0	0.5	0.5
Spices	0	0	0	7.2	0	1.3
Vegetables	9	6.6	0.4	13.3	0.5	5.5
Livestock						
Cattle	17.5	0	9.7	16	11.9	11.9
Dairy	2.7	0	5.1	0.6	1.4	2.3
Poultry	0	0	0	0.6	0	0.1
Fish Species						
Fishery	9.0	0	25.3	16.6	13.8	14.5
Total	100	100	100	100	100	100

Table 11 provides breakdown that underscores the economic significance of specific crops, livestock, and fishery activities in each region, providing stakeholders with valuable insights for informed decision-making.

1. Central Zone:

In the Central zone, agriculture is marked by a diverse mix of major farming enterprises, with rice-based crop farming leading the way, involving 127 individuals and constituting 57% of major activities, emphasizing a significant focus on staple food production. Livestock, particularly cattle, plays a crucial role, with 39 individuals contributing 17.5%, reflecting a balanced farming approach. Corn cultivation is limited, involving only 1 individual, representing 0.4% of major farming activities, adding a diversity element. Jute

cultivation involves 5 individuals, contributing 2.2%. Pulses and oil seeds have a modest representation with 4 individuals, contributing 1.8%. Vegetable cultivation engages 20 individuals, contributing 9%, while fruit cultivation involves 1 individual, constituting 0.4%. Dairy activities involve 6 individuals, contributing 2.7%, and fishery activities engage 20 individuals, contributing 9% to major farming enterprises. The absence of spice cultivation and poultry farming is notable. With a total of 223 individuals surveyed, this provides a comprehensive insight into the distribution and significance of various farming practices in the Central region.

2. North-East Zone:

The North-East zone distinguishes itself with an overwhelming emphasis on rice-based crop farming, constituting a remarkable 92.6% (112 individuals) of major activities. This exclusive focus on rice production is evident in the absence of other major farming enterprises such as Corn, Fruits, Pulses & Oil seeds, Spices, Cattle, Dairy, and Poultry, each registering 0 individuals. However, there is a slight representation in Jute (0.8%, 1 individual) and Vegetables (6.6%, 8 individuals), diversifying the agricultural landscape. The survey of 121 individuals offers unique insights into the region's agricultural landscape, highlighting the dominance of rice cultivation while acknowledging the presence of Jute and Vegetables.

3. North-West Zone:

In the North-West zone, a diverse agricultural profile is evident, with rice-based crop farming involving 152 individuals and constituting 59.1% of major activities. Livestock farming, especially cattle and dairy, holds substantial economic significance, with 25 and 13 individuals contributing 25% and 5.1%, respectively. Fishery activities make a noteworthy contribution, with 65 individuals constituting 25.3% of major farming enterprises. Corn cultivation involves 0 individuals, while jute cultivation engages 1 individual, contributing 0.6%. Vegetable cultivation engages 1 individual, contributing 0.4%, and fruit cultivation involves 1 individual, constituting 0.4%. Pulses and oil seeds cultivation and Poultry farming is notably absent. With a total of 257 individuals surveyed, this reveals a strategic blend of crop cultivation, livestock rearing, and fishery, highlighting a well-rounded and economically sustainable approach in the North-West region.

4. South-East Zone:

Agriculture in the South-East zone is characterized by a significant contribution from rice-based crop farming, involving 46 individuals and constituting 25.4% of major activities. Fruit cultivation involves 37 individuals, constituting 20.4%. Vegetables and fishery activities play vital roles, with 24 and 30 individuals contributing 13.3% and 16.6%, respectively. Cattle farming is also a significant contributor, with 29 individuals constituting 16% of the total income. Corn, Jute and Pulses and oil seeds cultivation is absent. Spice cultivation involves 13 individuals, contributing 7.2%. Dairy activities involve 1 individual, contributing 0.6%, and poultry farming involves 1 individual, constituting 0.1%. With a total of 181 individuals surveyed, this showcases a balanced mix of crop cultivation, livestock rearing, and fishery, indicative of a diversified and resilient agricultural economy in the South-East region.

5. South-West Zone:

The South-West zone relies heavily on rice-based crops, with 148 individuals involved, contributing a substantial 70.5% of the total farm income. Livestock farming, particularly cattle, also plays a vital role, with 25 individuals contributing 11.9% of the income. Pulses and oil seeds have a minor representation with 1 individual, contributing 0.5%, while corn, jute and spice cultivation are entirely absent. Vegetable cultivation involves 1 individual, contributing 0.5%, and fruit cultivation involves 3 individuals, constituting 1.4%. Dairy activities involve 3 individuals, contributing 1.4%, and poultry farming is absent in the surveyed individuals. Fishery activities make a minor contribution, with 29 individuals constituting 13.8% of major farming enterprises. With a total of 210 individuals surveyed, this reveals the specialization in rice cultivation and a modest presence in livestock and fishery activities in the South-West.

The economic landscape across different zones in Bangladesh exhibits diverse patterns of major farming enterprises contributing over 50% to farm income. In the Central zone, a balanced mix of rice-based crops, livestock, and fishery activities prevails, showcasing a well-rounded approach, with rice-based crops contributing 57%. The North-East zone distinguishes itself with an overwhelming emphasis on rice cultivation, constituting a remarkable 92.6% of major activities. In the North-West zone, a strategic blend of crop cultivation, livestock rearing, and fishery is evident, with rice-based crops contributing 59.1%. The South-East region demonstrates a balanced mix of rice (25.4%), fruits (20.4%), vegetables (13.3%), and fishery (16.6%), highlighting a diversified and resilient agricultural

economy. In the South-West zone, rice cultivation dominates at 70.5%, accompanied by a modest presence in livestock (11.9%) and fishery (13.8%). The overall scenario underscores the strategic importance of different agricultural activities in shaping the economic dynamics of each region.

4.2.2. Regional Distribution of Main Income Sources by Crop:

Table 12 offers a comprehensive snapshot of the regional distribution of main income sources based on crops across the Central, North-East, North-West, South-East, and South-West Zones. This table elucidates the diverse agricultural economies present in each region, showcasing the prominence of specific crops and livestock that contribute significantly to the overall income. The percentages provided represent the proportional contribution of each main income source within its respective zone, offering valuable insights into regional specialization and the strategic balance between different agricultural activities.

Table 12: Regional Distribution of Main Income Sources by Crop

Main source (crop) of income	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total
Banana	0	0	0	0.6	0	0.1
Cattle	15.7	0	10.5	13.8	4.8	9.8
Corn	0.5	0	0	0	0.5	0.2
Crop (rice based)	59.6	96.7	59.5	32.6	76.7	62.8
Dairy	1.8	0	2.7	1.7	2.9	2
Fishery	6.3	0	17.1	16.0	12.4	11.4
Fruits	1.4	0	3.1	17.7	1	4.5
Jute	2.7	0.8	0	0	0	0.7
Poultry	0	0	0	0.6	0	0.1
Pulses & Oil seeds	1.8	0	0	0.6	0.5	0.6
Spices	0	0	0	7.7	0	1.4
Vegetables	10.3	2.5	7	8.8	1.4	6.4
Total	100	100	100	100	100	100

The subsequent analysis delves into the details of Table 11 to unravel the distinctive patterns shaping each zone's economic landscape and understand the pivotal role played by various crops in defining the agricultural identity of these regions.

1. Central Zone:

The Central Zone boasts a unique agricultural profile characterized by a balanced income distribution. The region's economic backbone lies in rice-based cultivation, representing 59.6% of the total income, supported by 127 enterprises. Cattle, plays a significant role, contributing 15.7% to the income structure, with a count of 39 cattle enterprises out of 223 surveyed. The region's economic backbone lies in rice-based cultivation, representing 59.6% of the total income, supported by 127 enterprises. Additionally, vegetables contribute substantially at 10.3%, with 20 dedicated enterprises. Moderately, fishery and dairy farming contribute 6.3% and 1.8%, respectively, with 20 fishery and 6 dairy enterprises. This diverse yet balanced income distribution underscores the region's resilience, showcasing a harmonious integration of livestock and crop cultivation enterprises.

2. North-East Zone:

The North-East Zone's agricultural landscape exhibits a notable concentration on rice-based crops, comprising an impressive 96.7% of the total income, with 112 enterprises dedicated to rice cultivation out of 117 surveyed farming enterprises. In contrast, the contribution of vegetables is modest, constituting 2.5% of the income and represented by 3 enterprises. This clear specialization in rice cultivation underscores the region's distinct agricultural focus. However, with only one enterprise engaged in jute cultivation, contributing 0.8% to the income, the limited diversification poses challenges for overall income stability. The heavy reliance on a single crop category, coupled with minimal representation of alternative crops like jute, renders the region more susceptible to market fluctuations or environmental uncertainties affecting rice production.

3. North-West Zone:

The North-West Zone stands out for its diversified income structure, showcasing a balanced approach to agriculture. A notable emphasis on rice-based crops is evident, constituting 59.5% of the total income, with 152 enterprises engaged in rice cultivation out of the 257 surveyed farming enterprises. Additionally, fishery plays a significant role, contributing 17.1% to the income, represented by 44 enterprises. Livestock, particularly cattle, also contributes substantially, accounting for 10.5% of the total income with 27 cattle-focused enterprises. Further diversification is observed through the contributions of vegetables and

fruits, constituting 7% and 3.1% of the income, respectively, and represented by 18 and 8 enterprises. This comprehensive engagement in both crop cultivation and animal husbandry suggests a well-rounded and balanced agricultural strategy in the North-West Zone. Such diversity not only enhances the resilience of the region's agricultural economy but also contributes to its overall sustainability by mitigating risks associated with reliance on a single income source.

4. South-East Zone:

The South-East Zone exhibits a diversified income profile, showcasing a robust agricultural economy with multiple sources of income. The most significant contribution comes from rice-based crops, constituting 32.6% of the income, with 59 dedicated enterprises. Fruits follow closely, contributing 17.7%, represented by 32 enterprises, while vegetables contribute 8.8% through 16 enterprises. Fishery plays a substantial role, contributing 16.0% to the income, represented by 29 enterprises. Livestock, particularly cattle, adds to the income structure, contributing 13.8% through 25 enterprises. Dairy makes a mere contribution of 1.7%, represented by 3 enterprises, and poultry contributes 0.6% through 1 enterprise. Specialized crops include spices, contributing 7.7% through 14 enterprises. Additionally, there are smaller contributions from Banana and Pulse and Oil Seed, represented by 1 enterprise, each making up 0.6% of the total income. Notably, Corn and Jute do not contribute to the income in this zone. This corrected hierarchy accurately reflects the diverse engagement of the South-East Zone in various agricultural activities while noting the absence of income from Corn and Jute.

5. South-West Zone:

The South-West Zone reveals a distinctive income distribution, heavily reliant on rice-based crops, constituting a substantial 76.7% of the total income across 161 enterprises. Fishery plays a significant role, contributing 12.4% to the income through 26 enterprises, while livestock, particularly cattle, contributes 4.8%, represented by 10 enterprises. Dairy farming and vegetables make moderate contributions at 2.9% (6 enterprises) and 1.4% (3 enterprises), respectively. Corn contributes 0.6%, represented by 1 enterprise, and fruits contribute 1%, represented by 2 enterprises. However, Banana, Fruits, Poultry, and Spices have no recorded contribution (0%) in the South-West Zone, signifying

their absence in the overall income structure. This concentration on staple crops and animal husbandry underscores the South-West Zone's specialized yet stable agricultural economy. The region's income structure reflects a strategic balance, with a focus on core agricultural activities contributing to both economic stability and sustainability.

The agricultural landscape in Bangladesh presents diverse economic profiles across its zones, with variations in the contribution of different crops to the overall income. In the Central Zone, rice-based cultivation is a significant source, constituting 59.6% of income, while livestock and vegetables contribute 15.7% and 10.3%, respectively. The North-East Zone heavily relies on rice, making up 96.7% of income, with minimal diversification. The North-West Zone adopts a balanced approach, with rice at 59.5%, fishery at 17.1%, and livestock at 10.5%. In the South-East Zone, income is diversified, with rice at 32.6%, fruits at 17.7%, vegetables at 8.8%, and fishery at 16.0%. The South-West Zone specializes in rice (76.7%) and fishery (12.4%), with moderate contributions from livestock and dairy. These percentages highlight the need for region-specific agricultural strategies to promote resilience and sustainable income sources.

4.2.3. Zone-wise Distribution of Second Major Farming Enterprises:

The Zone-wise Distribution of Second Major Farming Enterprises provides a comprehensive overview of the diverse agricultural practices beyond the primary source of income in each region. Analyzing the data from Central, North-East, North-West, South-East, and South-West Zones, the table provide details on the prevalence and variety of second major farming enterprises in different geographical areas. From staple crop cultivation to livestock enterprises and specialty crops, the findings highlight the unique agricultural landscapes in each zone, emphasizing the adaptability and resourcefulness of farming communities. This analysis aims to offer insights into the diverse nature of farming practices across various regions, contributing to a better understanding of the varied and region-specific agricultural practices in the surveyed areas.

Table 13: Zone-wise Distribution of Second Major Farming Enterprises

Zone	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
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Second Major Farming Enterprises	Agriculture and Plant-Based Enterprises					
Corn	9.5	3.3	0	0	4.8	3.6
Crop (rice based)	31.5	44.6	51.6	21.0	29.7	35.9
Fruits	1.8	0	2.4	14.9	1.0	4.0
Jute	5.9	16.5	0	4.4	5.7	5.4
Mustard	0	0	0	0	2.9	0.6
Onion	0.5	0	0	0	0	0.1
Peanut	0	0.8	0	0	0	0.1
Pulses & Oil seeds	6.8	1.6	10.7	0	13.9	7.4
Tobacco	1.4	0	0	0	0	0.3
Vegetables & Spices	25.2	20.7	25.8	21.6	15.3	22.0
Wheat	1.8	0.8	0	0	0	0.5
Livestock Enterprises						
Cattle	7.7	9.9	4.4	9.4	13.9	8.7
Dairy	4.1	0	0.8	12.7	4.3	4.4
Poultry	2.7	0.8	0.4	0.6	0.5	1.0
Fishery Enterprises						
Fishery	1.4	0.8	4.4	14.4	5.7	5.4
Other Income Sources						
Business	0	0	0	1.1	1.4	0.5
Job	0	0	0	0	1.0	2.0
Total	100	100	100	100	100	100

The following detailed breakdown provides insights into the specific crops and livestock enterprises that farmers in each zone actively pursue as their second major source of income, offering a holistic perspective on the multidimensional nature of farming practices in these distinct geographical regions.

1. Central Zone:

In the Central Zone, the distribution of second major farming enterprises reveals a diverse agricultural landscape. Crop cultivation encompasses various ventures, with notable percentages and counts. Corn cultivation engages 9.5% of farmers, representing 21 individuals, while rice-based crops involve a substantial 31.5%, with 70 farmers participating. Fruit cultivation, pursued by 1.8% of farmers (4 individuals), coexists with jute cultivation engaging 5.9% (13 farmers). Though mustard and peanut cultivation are absent, onion cultivation involves 0.5% (1 farmer). Pulses and oilseed cultivation attract 6.8% (15 farmers), whereas vegetable cultivation is prominent, engaging 25.2% (56 farmers). While not as prevalent as some other crops, wheat cultivation adds to the diverse

agricultural practices observed in the region by representing 1.8% (4 farmers) of the surveyed population. Livestock enterprises contribute significantly, with cattle farming involving 7.7% (17 farmers), dairy farming 4.1% (9 farmers), and poultry 2.7% (6 farmers). Fishery enterprises are noteworthy, engaging 1.4% (3 farmers), while other income sources like business and jobs show no engagement. This comprehensive overview emphasizes the richness and variety of agricultural pursuits within the Central Zone, reflecting the adaptability and resourcefulness of the farming community.)

2. North-East Zone:

The North-East Zone, consisting of 121 respondents, showcases a diverse agricultural landscape. The predominant activity is rice-based crop cultivation, involving 44.6% (54 individuals), highlighting the region's focus on staple crops. Livestock enterprises, particularly cattle farming, play a significant role, engaging 9.9% (12 individuals) of respondents. Jute cultivation is practiced by 16.5% (20 individuals), contributing to the regional agricultural diversity. Other activities, such as peanut farming and vegetable/spice cultivation, further enrich the farming practices, with respective percentages of 0.8% (1 individual) and 20.7% (25 individuals). Fishery enterprises are reported by 1.4% (1 individual), reflecting a limited but existing engagement in aquaculture. However, poultry farming and certain crops like corn have lower representation, with 0.8% (1 individual) and 3.3% (4 individuals) respectively. Vegetables and spices cultivation is remarkable, engaging 20.7% of respondents (25 individuals), while wheat cultivation has a minimal representation of 0.8% (1 individual). Dairy farming in the North-East Zone is not practiced by any respondents, signifying a complete absence of this particular farming enterprise among the 121 individuals surveyed. Mustard cultivation is not prevalent, and onion cultivation involves only 0.5% (1 individual). Pulses & oil seeds cultivation is reported by 1.6% (2 individuals), while tobacco cultivation is absent. The absence of fruit cultivation suggests that, in this specific region, respondents are not actively engaged in this particular farming enterprise as a second major source of income. Notably, other income sources like business and job-related activities are not present, highlighting a distinct focus on farming practices in the North-East Zone.

3. North-West Zone:

In the North-West Zone, consisting of 252 respondents, a diverse array of second major farming enterprises is evident. Rice-based crop cultivation stands out as the primary activity, with 51.6% (129 individuals) actively engaged, emphasizing the region's focus on staple crops. Livestock enterprises, particularly cattle farming, play a substantial role, involving 4.4% of respondents (11 individuals). Other activities, such as fruits (2.4%, 6 individual) and vegetable/spice cultivation (25.8%, 65 individuals), further enrich the farming practices. Pulses & Oil seeds cultivation, contribute significantly, with 10.7% of respondents (27 individuals), showcasing a regional emphasis on these specific crops and oilseed production. However, Fishery enterprises are reported by 4.4% of respondents (11 individuals), indicating a moderate engagement in aquaculture. In the livestock category, dairy farming is reported by 0.8% of respondents (2 individuals), and poultry farming constitutes 0.4% (1 individual). Other income sources, including business and job-related activities, contribute 0.5% (1 individual) and 0%, respectively, emphasizing a primary focus on diverse agricultural pursuits in the North-West Zone. In the North-West Zone, among the listed second major farming enterprises, Corn, Jute, Mustard, Onion, Peanut, Tobacco, and Wheat have zero representation, indicating that none of the respondents in this zone reported engaging in these specific farming activities as their second major source of income.

4. South-East Zone:

In the South-East Zone, encompassing 181 respondents, a diverse array of second major farming enterprises characterizes the agricultural practices. Rice-based crop cultivation is a dominant activity, engaging 21% of respondents (38 individuals), highlighting the region's reliance on staple crops. Livestock enterprises, particularly cattle farming, play a vital role, involving 9.4% of respondents (17 individuals). Notably, Vegetable & Spice cultivation contributes significantly, with 21.6% of respondents (39 individuals), showcasing a distinct regional emphasis on horticultural activities. Fruits (14.9%, 27 individuals) and Fishery enterprises (14.4%, 26 individuals) exhibit moderate participation, contributing to the overall diversity of farming practices. Corn cultivation has no representation in this zone. In the Livestock category, dairy farming is reported by 12.7% of respondents (23 individuals), emphasizing a notable presence in dairy activities. Poultry farming constitutes 0.6% (1 individual) of respondents, contributing to the overall livestock enterprises. Among the specific crops, Jute, Mustard, Onion, Peanut, Pulses & Oil seeds, Tobacco and Wheat have

zero representation, indicating that none of the respondents in this zone reported engaging in these specific farming activities as their second major source of income. Regarding income sources, business ventures contribute 1.1% (2 individuals), providing a minor diversification in income streams. Job-related activities, however, have no representation among the respondents in the South-East Zone.

5. South-west Zone:

In the South-West Zone, encompassing 209 respondents, a diverse spectrum of second major farming enterprises characterizes the agricultural landscape. Rice-based crop cultivation stands out prominently, engaging 29.7% of respondents (62 individuals), reflecting a significant focus on staple crops. Livestock enterprises, particularly cattle farming, play a substantial role, involving 13.9% of respondents (29 individuals). Vegetable & Spice cultivation contributes significantly, with 15.3% of respondents (32 individuals), showcasing a regional emphasis on horticultural activities. Fruits cultivation involves 2 respondents (1%), indicating a limited engagement in this particular enterprise. Fishery enterprises are reported by 5.7% of respondents (12 individuals), suggesting a moderate involvement in aquaculture. Notably, Pulses & Oil seeds cultivation involves 13.9% of respondents (29 individuals), emphasizing a considerable focus on these specific crops. Corn cultivation engages 4.8% of respondents (10 individuals), indicating a moderate presence. In the Livestock category, dairy farming is reported by 4.3% of respondents (9 individuals), while Poultry constitutes 0.5% (1 individual). Jute involves 5.7% (12 individuals), and Mustard comprises 2.9% (6 individuals) of respondents. Among the specific crops, Onion, Peanut, and Wheat have zero representation, indicating that none of the respondents in this zone reported engaging in these specific farming activities as their second major source of income. Tobacco cultivation also has no representation. Regarding income sources, business ventures contribute 1.4% (3 individuals), while job-related activities constitute 1% (2 individuals). This comprehensive overview highlights the diverse agricultural practices and income sources within the South-West Zone.

The zone-wise distribution of second major farming enterprises provides an illustration of agricultural practices across Central, North-East, North-West, South-East, and South-West Zones. Rice-based crop cultivation is predominant, representing 35.9% of total activities, emphasizing the significance of staple crops. Livestock enterprises, particularly cattle farming, contribute significantly, with an overall engagement of 8.7%. Vegetable and spice

cultivation showcase regional variations, ranging from 15.3% to 25.2%, highlighting diverse horticultural focuses. Notably, each zone displays unique characteristics; for instance, the North-East Zone emphasizes staple crops and lacks dairy farming, while the South-East Zone demonstrates notable dairy activities. Fishery enterprises vary moderately, from 4.4% to 14.4%, indicating regional disparities in aquaculture engagement. Some crops, such as corn and wheat, have varying degrees of representation, while others like jute and mustard show zone-specific cultivation preferences. Overall, the comprehensive overview underscores cross-cutting nature of farming practices, reflecting distinct regional emphases and the adaptability of farming communities.

4.3. Technological Aspects:

4.3.1. Farmers’ Knowledge of ATRP (Agricultural Technology and Research Programs):

In the ever-evolving landscape of agriculture, the integration of cutting-edge technologies and research programs is paramount for sustainable and efficient practices. Understanding the level of awareness and comprehension among farmers regarding Agricultural Technology and Research Programs (ATRP) is crucial for effective implementation and dissemination of advancements in the agricultural sector. This evaluation delves into the insights gained from a comprehensive survey conducted across different geographical zones, namely Central, North-East, North-West, South-East, and South-West. By examining the diverse knowledge levels revealed by farmers in each zone, we aim to identify key patterns, strengths, and potential areas for improvement in fostering awareness and understanding of ATRP.

Table 14: Farmers’ Knowledge of ATRP

Zone	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Level of Knowledge						
No knowledge at all	0.9	0.8	0	1.7	0	0.6
Quite knowledgeable (good knowledge)	3.1	20.7	24.1	22.1	41.4	22.3
Very knowledgeable (excellent knowledge)	19.7	10.7	0.4	32.6	5.7	13.0

Very little knowledge (fair knowledge)	76.2	67.8	75.5	43.6	52.9	64.1
Total	100	100	100	100	100	100

This analysis provides valuable perspectives to inform targeted educational efforts and interventions, contributing to the enhancement of agricultural practices on a regional scale.

1. Central Zone:

In the Central Zone, the survey reveals a diverse range of knowledge levels among farmers concerning Agricultural Technology and Research Programs (ATRP). Only 2 individuals (0.9%) claim to have no knowledge at all, while a notable 19.7% (44 individuals) demonstrate excellent knowledge. Additionally, 7 individuals (3.1%) are classified as quite knowledgeable (good knowledge), signifying a portion with a solid understanding of ATRP. However, the majority, comprising 76.2% (170 individuals), falls into the category of having very little knowledge. This highlights the need for targeted educational efforts in the region. The total number of surveyed individuals in the Central Zone is 223.

2. North-east Zone:

In the North-East Zone, the survey underscores a varied landscape of knowledge levels among farmers in relation to Agricultural Technology and Research Programs (ATRP). A minimal 0.8% (1 individual) claim to have no knowledge at all, while a substantial 20.7% (25 individuals) demonstrate good knowledge. However, a significant majority, accounting for 67.8% (82 individuals), falls into the category of having very little knowledge. Additionally, 10.7% (13 individuals) demonstrate very knowledgeable (excellent knowledge), suggesting a notable expertise among a portion of respondents. The total number of surveyed individuals in the North-East Zone is 121.

3. North-west Zone:

Impressively, in the north-west zone there are no individuals claiming to have no knowledge at all, indicating a baseline understanding in the region. A substantial 24.1% (62 individuals) are classified as quite knowledgeable (good knowledge), showcasing a noteworthy proportion with a solid understanding. However, only 0.4% (1 individual) demonstrates very knowledgeable (excellent knowledge), indicating a potential area for

improvement in expertise. The majority, comprising 75.5% (194 individuals), falls into the category of having very little knowledge (fair knowledge), suggesting a need for targeted educational efforts. The total number of surveyed individuals in the North-West Zone is 257, emphasizing both the strengths and areas for enhancement in awareness and understanding of agricultural technology and research programs in this region.

4. South-East Zone:

In the South-East Zone, a modest percentage of 1.7% (3 individuals) indicates having no knowledge at all, establishing a baseline awareness within the region. Notably, 22.1% (40 individuals) are classified as quite knowledgeable (good knowledge), reflecting a substantial portion with a solid understanding. Furthermore, 32.6% (59 individuals) demonstrate very knowledgeable (excellent knowledge), suggesting a notable level of expertise among a significant portion of respondents. However, a significant 43.6% (79 individuals) fall into the category of having very little knowledge (fair knowledge), emphasizing potential areas for improvement. The total number of surveyed individuals in the South-East Zone is 181.

5. South-west Zone:

Within the South-West Zone, there is a complete absence of respondents claiming no knowledge, indicating a foundational understanding within the region. A substantial 41.4% (87 individuals) are categorized as quite knowledgeable (good knowledge), underscoring a significant portion with a robust comprehension. Additionally, 5.7% (12 individuals) demonstrate a high level of expertise, falling into the very knowledgeable (excellent knowledge) category. Despite these strengths, a considerable 52.9% (111 individuals) indicate having very little knowledge (fair knowledge), suggesting potential avenues for improvement. The total number of surveyed individuals in the South-West Zone is 210, portraying awareness levels and areas for potential growth in understanding agricultural technology and research programs in this region.

The analysis of farmers' knowledge of Agricultural Technology and Research Programs (ATRP) across different zones provides a comprehensive view of awareness levels and potential areas for improvement. In the Central Zone, a substantial 76.2% of farmers have very little knowledge, signaling the need for targeted educational efforts. The North-East Zone shows a notable expertise among 10.7%, while 67.8% have limited knowledge. The

North-West Zone displays strengths with 24.1% having good knowledge, but 75.5% need increased awareness. In the South-East Zone, 32.6% exhibit excellent knowledge, yet 43.6% have limited understanding. The South-West Zone portrays a foundational understanding, but 52.9% need increased awareness. Overall, the analysis highlights diverse knowledge landscapes, emphasizing the importance of tailored interventions to enhance understanding and foster sustainable agricultural practices.

4.3.2. Domestic or Foreign Technology Usage by Farmers:

This table delves into the intricacies of technology utilization among farmers across distinct geographic zones, emphasizing the balance between domestic and foreign innovations. The presented data in Table 14 unveils regional disparities in technology preferences, offering an exploration of the Central, North-East, North-West, South-East, and South-West Zones.

Table 15: Domestic or Foreign Technology Usage by Farmers

Domestic or Foreign Technology	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Domestic Agricultural Technologies	81.2	76.0	92.6	81.2	66.2	80.2
Foreign Agricultural Technologies	18.8	24.0	7.4	18.8	33.8	19.8
Total	100	100	100	100	100	100

The presented data in Table 15 provides a comprehensive overview of the percentages of domestic and foreign technology usage by farmers in each zone, allowing for a detailed examination of regional disparities.

1. Central Zone:

In the Central Zone, the adoption of agricultural technologies reflects a significant reliance on domestic innovations, constituting 81.2% of the total, with 181 individuals employing these technologies. Foreign agricultural technologies account for 18.8%, representing 42 individuals. This suggests a predominant preference for locally developed solutions. The

total surveyed population in the Central Zone is 223, making up 80.2% of the overall sample.

2. North-East Zone:

In terms of technology adoption, the North-East Zone showcases a diverse landscape, with 76% (92 individuals) of farmers embracing domestic agricultural technologies, while 24% (29 individuals) opt for foreign alternatives. This approach is evident in the total surveyed population of 121 individuals, underscoring a balanced integration of both domestic and foreign innovations into the agricultural practices of North-East Zone farmers. This suggests a flexibility and openness to diverse technological solutions within the farming community in this region.

3. North-West Zone:

The North-West Zone stands out with a strong preference for domestic agricultural technologies, constituting 92.6% of the total, involving 237 individuals. In contrast, only 7.4% (20 individuals) adopt foreign technologies. This substantial disparity underscores a distinct inclination towards local innovations. The total surveyed population in the North-West Zone is 257, providing valuable insights into the technological preferences of the region.

4. South-East Zone:

Within the South-East Zone, 81.2% (147 individuals) of farmers prefer domestic agricultural technologies, while 18.8% (34 individuals) opt for foreign alternatives. The adoption pattern, aligned with the national average, suggests a harmonious integration of both domestic and foreign innovations into the agricultural practices of South-East Zone farmers, as indicated by the surveyed population of 181 individuals.

5. South-West Zone:

The technological landscape in the South-West Zone is distinctly characterized by a preference for domestic agricultural technologies, with 66.2% (139 individuals) of farmers leaning towards locally developed solutions. Concurrently, 33.8% (71 individuals) opt for

foreign alternatives, reflecting a broad outlook observed in the surveyed population of 210 individuals.

The examination of domestic and foreign technology usage among farmers across distinct geographic zones reveals intriguing patterns and preferences. Overall, there is a notable inclination toward domestic agricultural technologies, constituting 80.2% of the surveyed population. The Central Zone emphasizes a significant reliance on local innovations, with 81.2% adopting domestic technologies. The North-East Zone showcases a balanced integration of both domestic (76%) and foreign (24%) technologies, highlighting flexibility within the farming community. The North-West Zone stands out with a robust preference for domestic technologies, constituting 92.6% of the total. In the South-East Zone, 81.2% of farmers opt for domestic technologies, aligning with the national average. The South-West Zone exhibits a distinctive pattern, with 66.2% favoring domestic technologies and 33.8% embracing foreign alternatives.

4.3.3. Farmers' Training in Agricultural Technologies by Zone:

The adoption of agricultural technologies plays a pivotal role in enhancing productivity and sustainability in the agricultural sector. Recognizing the significance of empowering farmers with the necessary skills and knowledge, this study delves into the landscape of farmers' training in agricultural technologies across different zones. The focus is on understanding the extent to which farmers in the Central, North-East, North-West, South-East, and South-West zones have received formal training in agricultural technologies.

Table 16.1: Farmers' Training in Agricultural Technologies by Zone

Any training in agricultural technologies	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
No	82.5	81.5	79.4	64.3	70.4	75.7
Yes	17.5	18.5	20.6	35.8	29.6	24.3
Total	100	100	100	100	100	100

The provided data in Table 16.1 give an overview on the prevalence of training among farmers in each zone, distinguishing between those who have undergone formal training and those who have not.

1. Central Zone:

In the Central Zone, the majority of farmers, accounting for 82.5%, have not received formal training in agricultural technologies, while 17.5% have undergone such training. This translates to 184 farmers without training and 39 farmers with training, out of a total surveyed population of 223. Despite a predominant lack of formal training, the region represents a significant portion of the overall surveyed population, indicating the need for targeted interventions to enhance technological education among farmers.

2. North-East Zone:

The North-East Zone exhibits a similar trend, with 81.5% of farmers lacking formal training and 18.5% having received training in agricultural technologies. This distribution corresponds to 97 farmers without training and 22 farmers with training, out of a total surveyed population of 119. The balanced representation of both trained and untrained farmers suggests a dynamic landscape open to diverse approaches, highlighting opportunities for educational initiatives tailored to the region's specific needs.

3. North-West Zone:

In the North-West Zone, a notable 79.4% of farmers have not undergone formal training, while 20.6% have received such training. This equates to 197 farmers without training and 51 farmers with training, out of a total surveyed population of 248. The substantial preference for non-formal training aligns with the region's strong reliance on local agricultural practices, emphasizing the significance of understanding and supporting indigenous knowledge.

4. South-East Zone:

The South-East Zone presents a distinctive scenario, with 64.3% of farmers lacking training and 35.8% having received formal training in agricultural technologies. This translates to 115 farmers without training and 64 farmers with training, out of a total surveyed population of 179. The comparatively higher proportion of trained farmers suggests a

receptiveness to formal education, providing a foundation for targeted capacity-building programs to further enhance technological adoption in the region.

5. South-West Zone:

In the South-West Zone, 70.4% of farmers have not undergone formal training, while 29.6% have received such training. This distribution corresponds to 145 farmers without training and 61 farmers with training, out of a total surveyed population of 206. The region's leaning towards non-formal training indicates an opportunity for interventions that align with the existing preferences, fostering a balanced and effective integration of agricultural technologies.

The exploration of farmers' training in agricultural technologies across diverse zones underscores the prevailing trends and opportunities for targeted interventions. Overall, a significant majority of farmers, comprising 75.7% of the surveyed population, have not undergone formal training, emphasizing the need for comprehensive educational initiatives. In the Central and North-East Zones, 82.5% and 81.5% of farmers, respectively, lack formal training, suggesting a common trend of limited exposure to structured agricultural technology programs. The North-West Zone follows suit, with 79.4% of farmers preferring non-formal training, aligning with the region's reliance on indigenous practices. The South-East Zone presents a distinctive landscape, where 35.8% of farmers have received formal training, indicating a receptiveness to educational programs. Meanwhile, in the South-West Zone, 70.4% of farmers favor non-formal training, signaling an opportunity for interventions aligned with existing preferences. This comprehensive overview provides insights into the training disparities across zones, paving the way for targeted strategies to enhance farmers' technological education and foster sustainable agricultural practices.

4.3.4. Sources of Training in Agricultural Technologies for Farmers by Zone:

Agricultural development is intrinsically tied to the knowledge and skills of farmers, particularly in the adoption of modern technologies. Understanding the sources from which farmers acquire training is paramount for shaping effective policies and interventions in the agricultural sector. Table 16.2 delves into the various channels through which farmers

acquire training in agricultural technologies across distinct zones—Central, North-East, North-West, South-East, and South-West.

Table 16.2: Sources of Training in Agricultural Technologies for Farmers by Zone

If yes, then where did you get the training?	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Government Organization	84.6	81.8	78.4	95.3	73.8	83.1
Private Organization/NGO	15.4	18.2	21.6	4.7	26.2	16.9
Total	100	100	100	100	100	100

This analysis delves into the distribution of training, both from government organizations and private entities or non-governmental organizations (NGOs), across the Central, North-East, North-West, South-East, and South-West zones.

1. Central Zone:

In the Central Zone, the majority of farmers (84.6%) have received training in agricultural technologies from government organizations, reflecting a significant reliance on public sector initiatives. The remaining 15.4% acquired their training from private organizations or NGOs. Out of the total surveyed population of 39 farmers, 33 farmers received training from government organizations, and 6 farmers received training from private organizations or NGOs.

2. North-East Zone:

The North-East Zone exhibits a similar trend, with 81.8% of farmers acquiring training from government organizations. This emphasizes the region's reliance on state-backed initiatives in imparting agricultural knowledge. The 18.2% who received training from private organizations or NGOs represent a smaller but notable segment. Out of the total surveyed population of 22 farmers, 18 farmers received training from government organizations, and 4 farmers received training from private organizations or NGOs.

3. North-West Zone:

In the North-West Zone, 78.4% of farmers have received training from government organizations, underlining a substantial preference for public-sector initiatives. The remaining 21.6% who acquired training from private organizations or NGOs highlight the coexistence of diverse training sources. Out of the total surveyed population of 51 farmers, 40 farmers received training from government organizations, and 11 farmers received training from private organizations or NGOs.

4. South-East Zone:

The South-East Zone stands out with a significant 95.3% of farmers receiving training from government organizations, indicating a strong governmental presence in disseminating agricultural knowledge. The small but noteworthy 4.7% who obtained training from private organizations or NGOs suggest a potential for diversification in training sources. Out of the total surveyed population of 64 farmers, 61 farmers received training from government organizations, and 3 farmers received training from private organizations or NGOs.

5. South-West Zone:

In the South-West Zone, 73.8% of farmers have received training from government organizations, indicating a substantial reliance on public-sector programs. The remaining 26.2% who obtained training from private organizations or NGOs showcase a notable contribution from non-governmental sources. Out of the total surveyed population of 61 farmers, 45 farmers received training from government organizations, and 16 farmers received training from private organizations or NGOs.

The analysis of sources of training in agricultural technologies across diverse zones reveals distinct patterns in the reliance on government organizations and private entities or NGOs. Overall, a substantial percentage of farmers, averaging at 83.1%, have received training from government organizations, emphasizing the pivotal role of public-sector initiatives in imparting agricultural knowledge. The South-East Zone stands out with an overwhelming 95.3% of farmers acquiring training from government organizations, showcasing a strong governmental presence in disseminating agricultural knowledge. In contrast, private organizations or NGOs contribute to training in varying degrees across zones, ranging from 4.7% in the South-East to 26.2% in the South-West. This diversity in training sources highlights the need for a nuanced approach to policy-making and interventions, considering the regional variations in the agricultural landscape and the preferences of farmers.

Tailoring strategies to leverage both public and private sector contributions can optimize the effectiveness of training programs and foster sustainable agricultural practices.

4.4. Research and Development:

4.4.1. List of Public Research Organizations Developing Agricultural Technologies by Zone:

The exploration of public research organizations in different zones, as identified and reported by farmers, provides a comprehensive overview of the landscape of agricultural technology development in Bangladesh. This analysis delves into the distinct contributions of various institutions, including National Agricultural Research System (NARS) Institutes, universities, and government organizations, shedding light on the regional priorities recognized by the farming community. Each zone Central, North-East, North-West, South-East, and South-West reveals a unique pattern of emphasis on specific organizations, reflecting the diverse agricultural ecosystems and the varying roles played by these entities in shaping sustainable agricultural practices.

Table 17: List of Public Research Organizations Developing Agricultural Technologies by Zone Mentioned by Respondents

Zone	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Organization Name	NARS Institutes					
BIRRI	13.5	15.4	14.5	20.4	16.3	16.0
BARI	22.2	19.5	18.4	28.0	24.4	22.9
BFRI (Fisheries)	3.1	0.0	1.8	3.9	4.4	3.0
BFRI (Forestry)	0.4	0.4	4.1	3.7	2.1	0.4
BINA	11.7	12.9	12.6	20.2	13.4	14.1
BJRI	2.5	1.5	0.2	0.9	0.9	1.2
BLRI	4.4	2.9	2.0	3.2	4.1	3.5
BSRI	1.3	0.7	0.2	0.4	0.4	0.6
BTRI	2.4	1.5	0.0	0.0	0.4	0.8
SRDI	1.5	1.1	0.0	0.2	0.4	0.6

Universities						
BAU	16.0	22.1	25.8	10.1	11.6	16.1
SAU	15.2	17.6	21.1	8.0	10.0	13.6
BSMRAU	0.7	0.4	2.9	0.2	0.1	0.8
Government Organizations						
BADC	0.7	0.7	0.0	0.0	3.4	1.2
BSRTI	0.0	0.0	0.0	0.0	4.1	1.2
CDB	1.3	0.7	0.0	0.4	0.4	0.6
DAE	3.1	2.6	0.0	0.0	1.9	1.5
KGF	0.2	0.0	0.0	0.0	0.0	0.0
Total	100	100	100	100	100	100

This detailed analysis sheds light on regional variations, reflecting the diverse agricultural landscapes and priorities across the Central, North-East, North-West, South-East, and South-West zones.

1. Central Zone:

In the Central Zone, respondent farmers highlighted a diverse set of public research organizations contributing to agricultural technology development. Among these institutions, the Bangladesh Rice Research Institute (BRRI) plays a significant role, with 74 mentions, constituting 13.5% of responses. Following closely, the Bangladesh Agricultural Research Institute (BARI) emerges as another key contributor, with 122 mentions, representing 22.2% of the surveyed responses. In the realm of fisheries and forestry research, the Bangladesh Fisheries Research Institute (BFRI) is cited 17 times (3.1%), while the Bangladesh Forest Research Institute (BFRI) is mentioned 3 times (0.4%). The Bangladesh Institute of Nuclear Agriculture (BINA) stands out as a prominent player, garnering 64 mentions, accounting for 11.7% of responses. Institutions like the Bangladesh Jute Research Institute (BJRI), Bangladesh Livestock Research Institute (BLRI), and Bangladesh Sugarcane Research Institute (BSRI) contribute specialized expertise to the region. These organizations are mentioned 14 times (2.5%), 24 times (4.4%), and 7 times (1.3%), respectively, showcasing the diversity of agricultural research areas covered. The Bangladesh Tea Research Institute (BTRI) and Soil Resources Development Institute (SRDI) are also recognized, with BTRI earning 13 mentions (2.4%) and SRDI being mentioned 8 times (1.5%).

Additionally, the contributions of universities in the central zone are noteworthy, with Bangladesh Agricultural University (BAU) and Sher-e-Bangla Agricultural University

(SAU) accumulating 88 (16.0%) and 82 (15.2%) mentions, respectively. Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) makes a modest yet notable impact with 4 mentions (0.7%).

Government organizations, BADC is mentioned 4 times (0.7%), while DAE is cited 17 times (3.1%), indicating the integral role of government agencies in driving agricultural innovation and extension services. The Cotton Development Board (CDB) is acknowledged 7 times (1.3%), illustrating the attention given to crops beyond staple food grains. Additionally, Krishi Gobeshona Foundation (KGF) is mentioned once (0.2%), highlighting the collaborative efforts between the public and private sectors in driving agricultural innovation. However, it's worth noting that the Bangladesh Sericulture Research and Training Institute (BSRTI) was not mentioned by any farmers in the central zone, suggesting a specific focus or potential gap in sericulture-related agricultural technologies in this region.

2. North-East Zone:

The North-East zone of Bangladesh reflects a diverse landscape of public research organizations engaged in the development of agricultural technologies, as outlined by respondent farmers. Among the NARS (National Agricultural Research System) Institutes, the Bangladesh Rice Research Institute (BRRI) and the Bangladesh Agricultural Research Institute (BARI) play pivotal roles, with 42 mentions (15.4%) and 53 mentions (19.5%), respectively. In the domain of fisheries and forestry research, the Bangladesh Fisheries Research Institute (BFRI) is notably absent from mentions in the North-East zone, while the Bangladesh Forest Research Institute (BFRI) is referenced once (0.4%). This absence or minimal representation may suggest specific research focuses or potential areas for expansion in these sectors within the region. The Bangladesh Institute of Nuclear Agriculture (BINA) also emerges as a significant contributor, garnering 35 mentions (12.9%), highlighting its role in promoting nuclear techniques for agricultural improvement. In contrast, the Bangladesh Jute Research Institute (BJRI) and the Bangladesh Livestock Research Institute (BLRI) receive modest mentions, each accounting for 1.5% (4 counts) and 2.9% (8 counts), respectively. The Bangladesh Sugarcane Research Institute (BSRI) and Bangladesh Tea Research Institute (BTRI) receive modest mentions, accounting for 0.7% (2 counts) and 1.5% (4 counts), respectively, suggesting measured emphasis on sugarcane and tea-related research. The Soil Resources Development Institute

(SRDI) garners 1.1% of mentions (3 counts), underscoring its crucial role in soil resource management.

Additionally, universities such as Bangladesh Agricultural University (BAU) and Sher-e-Bangla Agricultural University (SAU) contribute substantially, with 60 mentions (22.1%) and 48 mentions (17.6%), respectively. Additionally, the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) receives a modest representation with 0.4% of mentions (1 count),

Within the government sector, the Bangladesh Agricultural Development Corporation (BADC) is mentioned twice (0.7%), while the Bangladesh Sericulture Research and Training Institute (BSRTI) and Krishi Gobeshona Foundation (KGF) do not receive any mentions in the North-East zone. The Cotton Development Board (CDB) is mentioned in the breakdown of government organizations, receiving modest mentions with a contribution of 0.7% (2 counts). The Department of Agricultural Extension (DAE) is acknowledged with 7 mentions (2.6%), underlining the role of government agencies in driving agricultural innovation and extension services in the North-East zone. This data suggests variations in the perceived importance or visibility of different agricultural research organizations within the region.

3. North-West Zone:

In the North-West zone of Bangladesh, as reported by farmers, several public research organizations have been acknowledged for their contributions to the agricultural sector, as detailed in Table 16. The Bangladesh Rice Research Institute (BRRI) and the Bangladesh Agricultural Research Institute (BARI) emerge as central figures, receiving mentions from farmers at rates of 14.5% (64 counts) and 18.4% (82 counts), respectively. The Bangladesh Institute of Nuclear Agriculture (BINA) is notably recognized by farmers, securing 12.6% of mentions (56 counts).

Universities, led by Bangladesh Agricultural University (BAU) and Sher-e-Bangla Agricultural University (SAU), are prominently mentioned, contributing 25.8% (115 counts) and 21.1% (94 counts), respectively. However, BSMRAU receives acknowledgment with a representation of a mere 2.9% (13 mentions).

According to farmers in the North-West zone of Bangladesh, the Bangladesh Agricultural Development Corporation (BADC), Bangladesh Sericulture Research and Training Institute (BSRTI), Cotton Development Board (CDB), Department of Agricultural Extension (DAE), and Krishi Gobeshona Foundation (KGF) did not receive mentions. This absence of recognition suggests varying levels of visibility or perceived relevance of these organizations in the agricultural practices and priorities reported by farmers in the region. Understanding these preferences and gaps in acknowledgment can guide policymakers and stakeholders in tailoring strategies to address specific needs and opportunities for sustainable agricultural development.

4. South-East Zone:

The detailed breakdown of public research organizations mentioned by farmers in the South-East zone offers valuable insights into the agricultural dynamics of the region. Notably, the Bangladesh Rice Research Institute (BRRI) and the Bangladesh Agricultural Research Institute (BARI) emerge as central players, securing 20.4% (95 mentions) and 28.0% (130 mentions) of total mentions, respectively. The Bangladesh Institute of Nuclear Agriculture (BINA) is acknowledged significantly, garnering 20.2% of mentions (94 counts). The Bangladesh Fisheries Research Institute (BFRI) plays a crucial role in fisheries research, with 3.9% of respondents (18 mentions) recognizing its contributions. Simultaneously, the Bangladesh Forest Research Institute (BFRI) is acknowledged for its forestry-related endeavors, securing 3.7% of mentions (19 mentions).

In the realm of specialized research, the Bangladesh Jute Research Institute (BJRI) and the Bangladesh Livestock Research Institute (BLRI) receive mentions from 0.9% (4 mentions) and 3.2% (15 mentions) of respondents, respectively. The Bangladesh Sugarcane Research Institute (BSRI) got limited recognition, with 0.4% (2 mentions). The data indicates that SRDI received one mention, constituting 0.2% of the responses while the Bangladesh Tea Research Institute (BTRI) did not receive any mentions in the South-East zone.

Additionally, academic institutions like Bangladesh Agricultural University (BAU) and Sher-e-Bangla Agricultural University (SAU) contribute substantially, with 10.1% (47 mentions) and 11.6% (68 mentions), respectively, serving as vital knowledge hubs. Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) is mentioned once, constituting 0.2% of the total mentions in the university category.

In the South-East zone of Bangladesh, farmers' responses indicate that certain government organizations, namely the Bangladesh Agricultural Development Corporation (BADC), Bangladesh Sericulture Research and Training Institute (BSRTI), Department of Agricultural Extension (DAE), and Krishi Gobeshona Foundation (KGF), did not receive any mentions in the survey. These organizations appear to have a limited presence or visibility in terms of contributions to agricultural technology development, as perceived by farmers in this specific region. However, the Cotton Development Board (CDB) received a modest mention from 0.4% of respondents (2 individuals), suggesting a slight recognition of its role in the agricultural landscape of the South-East zone.

5. South-West Zone:

In the South-West zone of Bangladesh, a diverse array of public research organizations, universities, and government bodies actively contributes to the development of agricultural technologies. The Bangladesh Rice Research Institute (BRRI) and Bangladesh Agricultural Research Institute (BARI) stand out with substantial mentions, holding key positions in agricultural research and technology advancement. BRRI, with a number count of 111 (16.3%), and BARI, with 166 mentions (24.4%), underscore their significant roles in shaping agricultural practices within the region. In the realm of fisheries and forestry research, the Bangladesh Fisheries Research Institute (BFRI) and the Bangladesh Forest Research Institute (BFRI) are recognized, with 30 mentions (4.4%) and 25 mentions (2.1%) respectively. Their contributions indicate a noteworthy focus on aquatic and forestry ecosystems, highlighting the region's commitment to diverse agricultural sectors. The Bangladesh Institute of Nuclear Agriculture (BINA) emerges as a key player, securing 91 mentions (13.4%) and reflecting the importance of nuclear techniques in agricultural improvement. BJRI, with 6 mentions (0.9%), signifies a certain focus on jute-related research, reflecting the importance of this crop in the South-West zone. BLRI, with 28 mentions (4.1%), indicate recognition in livestock research. The Bangladesh Sugarcane Research Institute (BSRI), Bangladesh Tea Research Institute (BTRI), and Soil Resources Development Institute (SRDI) each receive 3 mentions (0.4%), reflecting their distinct roles and modest emphasis in sugarcane, tea, and soil-related agricultural research within the region.

Furthermore, academic institutions such as Bangladesh Agricultural University (BAU) and Sher-e-Bangla Agricultural University (SAU) contribute significantly, amassing 79

mentions (11.6%) and 68 mentions (10.0%) respectively. Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) is mentioned once, representing 0.1% of the surveyed responses, suggesting a relatively minor emphasis on this university's contributions to agricultural technology adoption in the region.

Within the government sector, the Bangladesh Agricultural Development Corporation (BADC) and the Bangladesh Sericulture Research and Training Institute (BSRTI) receive notable mentions, with 23 mentions (3.4%) and 28 mentions (4.1%) respectively. The Cotton Development Board (CDB) is also acknowledged, albeit to a lesser extent, with 3 mentions (0.4%). The Department of Agricultural Extension (DAE) plays a role with 13 mentions (1.9%), emphasizing the significance of government agencies in driving agricultural innovation and extension services in the South-West zone. Notably, the Krishi Gobeshona Foundation (KGF) does not receive any mentions in this specific zone.

The detailed breakdown of public research organizations contributing to agricultural technologies, as reported by farmers across the Central, North-East, North-West, South-East, and South-West zones, provides valuable insights into the diverse agricultural landscapes and priorities within each region. In the Central Zone, institutions such as Bangladesh Agricultural Research Institute (BARI) at 22.9%, Bangladesh Rice Research Institute (BRRI) at 16.0%, and Sher-e-Bangla Agricultural University (SAU) at 15.2% play prominent roles, showcasing a broad spectrum of research areas. The North-East Zone demonstrates a reliance on NARS (National Agricultural Research System) Institutes and universities, with BRRI at 15.4%, BARI at 19.5%, Bangladesh Agricultural University (BAU) at 22.1%, and Sher-e-Bangla Agricultural University (SAU) at 17.6% standing out. The North-West Zone emphasizes the pivotal role of universities, particularly BAU at 25.8% and SAU at 21.1%, and major research institutes like BRRI at 14.5% and BARI at 18.4%. The South-East Zone highlights the significance of BRRI at 20.4%, BARI at 28.0%, and BINA at 20.2%, with a substantial emphasis on fisheries and forestry research through Bangladesh Fisheries Research Institute (BFRI) at 3.9% and Bangladesh Forest Research Institute (BFRI) at 3.7%. The South-West Zone stands out for the substantial contributions of BRRI at 16.3% and BARI at 24.4%, reflecting a diverse range of agricultural research areas, and notable roles played by Bangladesh Fisheries Research Institute (BFRI) at 4.4%, BINA at 13.4%, and various universities. Government organizations like the Bangladesh Agricultural Development Corporation (BADC) and the Bangladesh Sericulture Research

and Training Institute (BSRTI) receive varied levels of recognition across zones, underscoring the need for targeted interventions and collaborations to address regional priorities. Overall, this nuanced understanding of regional variations, informs policymakers and stakeholders, enabling tailored strategies for sustainable agricultural development in Bangladesh.

4.4.2. List of Private Organizations Developing Agricultural Technologies:

The provided tables offer a detailed breakdown of private organizations involved in agricultural technology development, presenting a zone-wise analysis of their contributions. The following sections delve into each zone, discussing the key players, their contributions, and the overall landscape of agricultural technology adoption in Central, North-East, North-West, South-East, and South-West zones of Bangladesh.

Table 18: List of Private Organizations Developing Agricultural Technologies Mentioned by Respondents

Zone	Central (%)	North-East (%)	North-West (%)	South-East (%)	South-West (%)	Total (%)
Organization Name	Agricultural Inputs and Products Supplier					
BRAC	24.8	24.1	24.5	23.4	17.9	22.5
ACI	18.5	18.2	22.8	23.4	18.1	20.2
Ispahani Agro Limited	9.6	9.5	9.8	5.2	8.8	8.7
Lal Teer	8.2	12.1	11.3	9.7	11.7	10.6
Partex Agro Limited	4.9	2.8	3.1	4.2	5.8	4.4
Win-All Hi-Tech Seed Co. Limited	0.8	0.9	1.7	0.8	1.8	1.3
Crop Health and Protection Organizations						
Bayer	7.5	9.8	5.5	9.0	13.9	9.3
Syngenta	14.2	15	17.6	21.4	17.5	17.2
Agricultural Research and Development Organizations						
Crop Science	7.5	3.5	0	0	0	1.9
GETCO Agro Technologies Limited.	3.4	3.5	3.2	2.6	3.5	3.3
High Chem	0.5	0.7	0.4	0.5	1.1	0.6
Total	100	100	100	100	100	100

The following sections provide a detailed breakdown of the contributions of private organizations in each zone, shedding light on their individual and collective impacts on the agricultural sector.

1. Central Zone:

In the Central Zone of Bangladesh, a substantial number of respondents, totaling 904, highlighted the significant presence of BRAC in agricultural technology development, constituting 24.8% of the total surveyed population in this zone. ACI also played a crucial role, with 813 respondents accounting for 18.5%. Ispahani Agro Limited emerges as a pivotal player in agricultural technology development with 350 respondents, constituting 9.6%. Its substantial presence underscores its influential role in shaping technological advancements. Lal Teer, with 428 respondents at 8.2%, significantly contributes to the diverse agricultural landscape, showcasing its widespread influence. Partex Agro Limited, represented by 176 respondents (4.9%), is a notable contributor, highlighting collaborative efforts among private organizations. Win-All Hi-Tech Seed Co. Limited, with 53 respondents (0.8%), adds diversity to the technological fabric. Bayer and Syngenta, major players in crop health and protection, wield considerable influence with 376 and 693 respondents, constituting 7.5% and 14.2%, respectively, contributing to a comprehensive approach. Organizations like Crop Science (75 respondents, 7.5%), GETCO Agro Technologies Limited (131 respondents, 3.4%), and High Chem (26 respondents, 0.5%), collectively enrich the Central Zone's agricultural research and development sphere.

2. North-East Zone:

In the North-East Zone of Bangladesh, the adoption of agricultural technologies is shaped by several prominent private organizations. BRAC, a leading entity, is represented by 111 respondents, accounting for 24.1% of the surveyed population. ACI closely follows with 84 respondents, constituting 18.2%, indicating a balanced influence in technology adoption. Ispahani Agro Limited, with 44 respondents (9.5%), and Lal Teer, with 56 respondents (12.1%), play significant roles in enriching the technological landscape. Their collaborative efforts underscore the importance of diversity and cooperation in addressing agricultural challenges in the North-East Zone. Partex Agro Limited, with 13 respondents (2.8%), and Win-All Hi-Tech Seed Co. Limited, with 4 respondents (0.9%), contribute to the overall

technological fabric, showcasing different opinions in the adoption of agricultural innovations.

In the realm of crop health and protection, Bayer and Syngenta, with 45 respondents (9.8%) and 69 respondents (15%), respectively, are key players influencing the agricultural practices in the North-East Zone. Their combined efforts reflect a comprehensive strategy in addressing crop management challenges.

Within the agricultural research and development sector, Crop Science and GETCO Agro Technologies Limited both with 16 respondents (3.5%), and High Chem, with 3 respondents (0.7%), contribute to the innovative landscape. Despite their smaller individual percentages, these organizations collectively contribute to the diverse and dynamic technological ecosystem in the North-East Zone. The total surveyed population in the North-East Zone is 461, and the collaboration among these private organizations highlights the complexity and diversity of the agricultural technology adoption process in the region.

3. North-West Zone:

In the North-West Zone of Bangladesh, the agricultural technology landscape is characterized by the influential presence of key private organizations. BRAC stands out as a major player with 239 respondents, constituting a significant 24.5% of the surveyed population. ACI follows closely with 223 respondents, representing 22.8% of the total surveyed population. Ispahani Agro Limited, with 96 respondents (9.8%), and Lal Teer, with 110 respondents (11.3%), contribute significantly to the technological ecosystem. Partex Agro Limited, with 30 respondents (3.1%), and Win-All Hi-Tech Seed Co. Limited, with 17 respondents (1.7%), add to the overall landscape by providing unique perspectives and solutions to agricultural practices.

In the realm of crop health and protection, Bayer and Syngenta play crucial roles with 54 respondents (5.5%) and 172 respondents (17.6%), respectively. Their collaborative influence reflects a comprehensive strategy in addressing crop management challenges specific to the North-West Zone.

Within the agricultural research and development sector, GETCO Agro Technologies Limited contributes with 31 respondents (3.2%), while High Chem is represented by 4 respondents (0.4%). Although their individual percentages may be smaller, collectively,

these organizations contribute to the diversity and innovation in agricultural technology adoption in the North-West Zone. In the North-West Zone, Crop Science is notably absent from the responses, indicating that there were no recorded respondents for this organization in the surveyed population. The total surveyed population in the North-West Zone is 976, showcasing a collaborative effort among major and minor contributors to foster innovation and address the unique challenges and opportunities in the agricultural sector.

4. South-East Zone:

The South-East Zone of Bangladesh exhibits a diverse and dynamic landscape in the adoption of agricultural technologies, driven by various private organizations. BRAC, with 154 respondents, contributes significantly, representing 23.4% of the surveyed population in the region. ACI closely follows with 154 respondents, constituting 23.4%, indicating a balanced influence in technology adoption. Ispahani Agro Limited, with 34 respondents (5.2%), and Lal Teer, with 64 respondents (9.7%), play important roles in enriching the technological ecosystem. Partex Agro Limited, with 28 respondents (4.2%), and Win-All Hi-Tech Seed Co. Limited, with 5 respondents (0.8%), contribute to the overall fabric of technological adoption, showcasing a varied approach.

In the category of crop health and protection, Bayer and Syngenta influence agricultural practices with 59 respondents (9%) and 141 respondents (21.4%), respectively. Their combined efforts reflect a comprehensive strategy in addressing crop management challenges unique to the South-East Zone.

Within the agricultural research and development sector, GETCO Agro Technologies Limited contributes with 17 respondents (2.6%), while High Chem is represented by 3 respondents (0.5%). Crop Science is not represented in the responses, indicating that there were no recorded respondents for this organization in the surveyed population. While the absence of Crop Science suggests limited involvement in this specific region, other key organizations collectively shape the agricultural technology landscape in the South-East Zone. The total surveyed population in the South-East Zone is 659, highlighting a collaborative effort among major and minor contributors to foster innovation and address the distinctive challenges and opportunities in the agricultural sector of this region.

5. South-West Zone:

In the South-West Zone of Bangladesh, BRAC, with 204 respondents, plays a pivotal role, constituting 17.9% of the surveyed population in the region. ACI closely follows with 206 respondents, representing 18.1%, indicating a balanced influence in technology adoption. Ispahani Agro Limited, with 100 respondents (8.8%), and Lal Teer, with 133 respondents (11.7%), contribute significantly to the technological ecosystem. Partex Agro Limited, with 66 respondents (5.8%), and Win-All Hi-Tech Seed Co. Limited, with 21 respondents (1.8%), add to the overall fabric of technological adoption.

In the category of crop health and protection, Bayer and Syngenta influence agricultural practices with 159 respondents (13.9%) and 199 respondents (17.5%), respectively. Their combined efforts reflect a comprehensive strategy in addressing crop management challenges unique to the South-West Zone.

Within the agricultural research and development sector, GETCO Agro Technologies Limited contributes with 40 respondents (3.5%), while High Chem is represented by 12 respondents (1.1%).

In the South-West Zone, similar to the other zones, Crop Science is not represented in the responses. The total surveyed population in the South-West Zone is 1140, showcasing a collaborative effort among major and minor contributors to foster innovation and address the distinctive challenges and opportunities in the agricultural sector of this region.

The comprehensive analysis of private organizations involved in agricultural technology development across the Central, North-East, North-West, South-East, and South-West zones of Bangladesh reveals a diverse landscape shaped by key players in each region. In the Central Zone, BRAC leads with 24.8%, followed by ACI at 18.5%, showcasing a diverse range of contributors such as Ispahani Agro Limited, Lal Teer, and Partex Agro Limited. The North-East Zone sees BRAC at 24.1% and ACI at 18.2% as major influencers, complemented by Ispahani Agro Limited, Lal Teer, and prominent crop health organizations Bayer and Syngenta. The North-West Zone is characterized by BRAC (24.5%) and ACI (22.8%) as major contributors, emphasizing Bayer, Syngenta, and GETCO Agro Technologies Limited in crop health and protection. The South-East Zone features BRAC (23.4%) and ACI (23.4%) as key players, with Bayer, Syngenta, and GETCO Agro Technologies Limited influencing agricultural practices. The South-West Zone showcases BRAC at 17.9% and ACI at 18.1%, with Bayer, Syngenta, and GETCO

Agro Technologies Limited contributing significantly. Overall, these percentages underscore the diverse and collaborative efforts of private organizations, shaping the intricate fabric of agricultural technology adoption across different regions in Bangladesh.

5. Conclusion:

The household survey conducted across Bangladesh's agroecological zones has revealed significant insights into the demographic, economic, and technological aspects of farming households. Key findings include notable variations in gender distribution, age profiles, and marital status among regions. The majority of respondents are engaged in farming as their primary occupation, underscoring the critical role of agriculture in their livelihoods. Economic conditions and income sources related to agriculture are central to the household economy. Additionally, there is a marked disparity in the adoption of agricultural technologies, with some areas showing higher adoption rates and others lagging behind due to various barriers.

These findings have substantial implications for agricultural policy formulation and program development. Policymakers need to develop region-specific policies that address the unique demographic and economic characteristics of each agroecological zone. For example, regions with a higher proportion of young farmers may benefit from targeted training programs and technological support to promote innovation and adoption. Gender-sensitive policies are also essential to promote the inclusion of women in agricultural development programs, ensuring equal access to resources and training. The disparity in technological adoption calls for suitable strategies to promote modern agricultural technologies, including targeted outreach, subsidies, and training initiatives that address regional needs.

Based on the survey findings, several recommendations emerge for future research and development initiatives. First, further research is needed to explore gender-specific barriers and opportunities in agriculture. Understanding the unique challenges faced by female farmers and identifying effective support mechanisms can inform policies aimed at promoting gender equality and empowering women in agriculture. Second, future studies should focus on addressing the specific barriers to technology adoption in regions that lag behind. This includes investigating factors such as infrastructure constraints, financial

limitations, and access to training, and developing tailored interventions to overcome these challenges.

Longitudinal research is also recommended to track changes in demographic, economic, and technological factors over time. Such studies can provide valuable insights into the evolving needs of farm households and help adjust policies and programs accordingly. Additionally, community-based research initiatives that actively involve local farmers can enhance the relevance and effectiveness of interventions. Engaging communities in identifying challenges and co-developing solutions can lead to more sustainable and impactful outcomes.

In conclusion, the study provides a comprehensive understanding of the demographic, economic, and technological landscape of farming households in Bangladesh. By employing these insights, policymakers and development practitioners can design and implement more effective strategies to support agricultural growth and improve the livelihoods of farmers across the country.

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