Abstract: This study analyzes the constraints affecting agricultural production in the lagging regions of Bangladesh. These regions are lagging in agricultural productivity due to natural phenomena and past government policies. Ten lagging regions, covering eight administrative divisions, were selected for analysis based on crop productivity indicators, percentage of the population in extreme poverty, and agroecological zones. Data were collected from 1257 farm holders using a structured questionnaire. Respondents included mostly older, illiterate males with low levels of education. Production constraints included inadequate supplies of fertilizer and pesticides in local markets. Labor accounted for the highest proportion of agriculture expenditures (51.3%), followed by equipment rental (11.8%), then pesticides (9.3%), and irrigation (8.2%). Only 35.4% of respondents availed credit to purchase agricultural inputs; among them, 85.4% borrowed from formal sources. Lack of proper irrigation facilities, production machinery, and access to institutional credit, difficulties procuring inputs and storing products, and negative impacts of climate were identified as the major constraints to agricultural productivity and marketing in the lagging regions. Access to credit and being adversely affected by weather impacted respondents’ agricultural productivity more than sociodemographic factors.

Keywords: development; productivity; input use; production costs; credit; training

1. Introduction

Since Bangladesh’s independence in 1971, the government has extended extensive support to the agricultural sector through various programs and initiatives. As a result, there have been significant advancements in the sector. However, these advancements conceal considerable regional differences in agricultural productivity. Although these regional differences are due in part to natural phenomena, such as differences in rainfall, temperature, humidity and other agroecological features which make agricultural production relatively less favorable in the lagging regions, varied farming practices and techniques, differences in the availability of inputs, attitudes of the farmers, and past government policies relating to agricultural extension, input distribution, institutional credit facilities, and agricultural cooperatives, and basic institutional inefficiency are also potential causes of lower agricultural productivity in the lagging regions. Approximately 17% of all districts in Bangladesh are located in low productivity regions. Most of these low productivity districts are in the southeastern part of the country, which is vulnerable to natural disasters [1].

While the importance of agriculture to the economy has declined in the past forty years, the agricultural sector accounted for over 14% of the nation’s GDP in 2015–2016. This figure was down from 46.7% in 1980–1981 and 24.1% in 2000–2001 whereas the percentage of Bangladeshis employed in the agricultural sector fell from 72.7% in 1980–1981 to 45.1% in 2015–2016 [2]. However, most
Bangladeshis still depend directly or indirectly on the agriculture sector, and 85% of Bangladesh’s poor live in rural areas [3].

Given that most of Bangladesh’s poor earn their living from agriculture, it is important to understand the factors that impede agricultural productivity and sustainable development. Thus, this study investigates the characteristics of Bangladeshi farmers living in the lagging regions of the country and the challenges that they face. More specifically, this study assesses the sociodemographic characteristics, land ownership, farming practices, including farm income and expenditures, use of inputs, access to external financing, and existing support for training and technical assistance to farmers in the lagging regions using survey data.

To provide context, we begin with a general overview of the Bangladeshi agricultural sector in the next section. Next, we provide an overview of the characteristics of the farmers and farm households in the lagging regions using our survey data. Prior studies found that educated and trained farmers tend to cultivate their land more efficiently [4] and are more likely to adopt modern production technologies [5]. Hence, understanding the level of education of the farmers in the lagging regions and training that they have received is important. Similarly, understanding the gender and age composition of farm households is also important. In Bangladesh, small-scale farm holders play a dominant role in the contribution of agriculture to the nation’s GDP, but their productivity and growth continue to be hindered by limited access to credit. Of the 15.2 million farms in Bangladesh, 84.38% are classified as small or marginal [6]. Household characteristics, such as age and gender composition, household size, and farm income influence access to credit [7]. Access to credit can improve agricultural productivity and can increase the standard of living [8], and credit is paramount in stimulating the adoption of improved agricultural practices by farmers [9]. Thus, in addition to analyzing the characteristics of the farm households, we also analyze their input use, production methods, operational costs, and use of credit. We then perform regression analyses to more fully understand the factors affecting agricultural productivity and marketing constraints in the lagging regions.

The specific objectives of the study can be summarized as (i) assessing the sociodemographic characteristics of the farmers in the lagging regions, (ii) determining the level of input use and operational costs, (iii) examining the sources of credit available to farmers and reasons for farmers choosing not to access credit services, and (iv) identifying the factors affecting agricultural productivity and marketing. The findings can be used to inform future policy decisions and provide a baseline against which policy initiatives can be measured.

Overview of Bangladesh’s Agricultural Sector

Bangladesh has a primarily agrarian economy, and agriculture is the single largest producing sector of the economy. Thus, the health of this sector has important implications for the major macroeconomic objectives of the nation like employment generation, poverty alleviation, human resources development, and food security.

In Bangladesh, high rates of population growth place increasingly more pressure on scarce land resources. The land area for agricultural production is essentially fixed, therefore, output can only be expanded through more intensive cropping. Approximately 64% (9.03 million hectare (ha)) of Bangladesh’s land area (about 14.4 million ha) is under cultivation [10]. Most of Bangladesh’s land is comprised of fertile flood plains. The nutrient-rich alluvial soils are annually rejuvenated by the floodwaters of the Ganges, Brahmaputra, and Meghna. Farmers practice intensive successive cropping, growing one crop of rice with the floodwaters (June–October), a second rice crop with irrigation, and finally, a third winter crop in the dry season (November–February). Cultivable land is declining due to urbanization and water erosion, but the total cropped area is increasing as a result of changing land utilization patterns (i.e., double and triple cropping). Cropping intensity has increased substantially due to the rapid expansion of irrigation that enabled multiple cropping. Irrigated area has increased approximately four times in the last three decades [2,10,11].

Rice is the staple food in Bangladesh and, as the dominant crop, largely determines the rate of progress in the agriculture sector. Rice production has increased through technological progress...
facilitated by private sector investment in small-scale irrigation projects. Because of the fertile soil and normally ample water supply, rice can be grown and harvested three times a year in many areas. Rice can be broadly divided into three classes according to the season in which they are harvested: Aman (transplanted and broadcast varieties), Boro, and Aush, in December–January, March–May, and July–August, respectively. Transplanted Aman is grown almost everywhere in Bangladesh, while broadcast Aman is mostly grown in the low-lying areas of the south and northeast. Boro is grown to a certain extent in every district, especially in irrigated parts, while Aush is a well-scattered crop. Wheat is the next most important cereal, but its production is insufficient to meet demand. Wheat is grown mainly in the drier parts of the north and is cultivated only as a winter crop. From 2010 to 2019, maize production increased at an average annual rate of 11.40%, with some wheat producers switching to cultivation of maize [12]. Minor cereals, such as maize, barley, and various varieties of millets, are grown in certain localities. Land use and crop production for 2016–2017 are shown in Table 1.

| Crop                        | Area (000 acre) | Yield (Kg/acre) | Production (000 Metric Ton) |
|-----------------------------|-----------------|-----------------|----------------------------|
| Total major cereals         | 28,210          | 1245            | 35,115                     |
| Rice                        | 27,184          | 1244            | 33,804                     |
| Minor cereals               | 968             | 3126            | 3027                       |
| Total cereals               | 29,178          | 1307            | 38,141                     |
| Pulses                      | 920             | 379             | 387                        |
| Vegetables                  | 1025            | 3949            | 4048                       |
| Oil seeds                   | 1196            | 815             | 975                        |
| Spices & contaminants       | 763             | 3315            | 2538                       |
| Sugar crops                 | 232             | 1893            | 4392                       |
| Fibers                      | 1855            | 1855            | 8313                       |
| Drugs and Narcotics         | 347             | 1827            | 634                        |
| Potato                      | 1235            | 8272            | 10,216                     |
| Fruits                      | 373             | 1345            | 5018                       |

Source of Data: Yearbook of Agricultural Statistics of Bangladesh, 2018 [13].

Minor crops, such as pulses, oilseeds, vegetables, and spices, are also produced. These minor crops provide nutritious diets, generate rural employment, and increase farm income. Mustard (including rape) is an important crop that is grown mainly in the low-lying areas of Brahmaputra-Jamuna and the Meghna floodplains. Masur (lentil) and khesari (chickling vetch) are the two most important varieties of pulses produced in Bangladesh. Pulse crops are grown with residual soil moisture and the occasional light rain of winter months. Other Bangladeshi food crops, such as potatoes, sweet potatoes, and fruits, such as bananas, jackfruit, mangoes, and pineapples, are grown mainly for the domestic market. Potato is the most important winter vegetable and is widely grown. Although chili is produced to a certain extent in every district of the country, cultivation is mostly concentrated in the southern districts. Jute, tobacco, and tea are the leading agricultural exports. Bangladesh is the largest global exporter of jute, a fiber used to make sacks, mats, and ropes. Its production is confined mainly to the low-lying areas of the Brahmaputra-Jamuna and the Padma floodplain.

The use of both shallow and deep tube wells for irrigation of agricultural lands is widespread, particularly during the dry season (November to March). Since high-yield varieties (HYV) of rice are very susceptible to drought, they need frequent irrigation. Surface and groundwater are the two major sources of irrigation in Bangladesh. Low lift pump (LLP), canal, and traditional (Dhon and Swing basket) are used for surface water irrigation [14]. According to an estimate of available water resources, about 6.8 million ha can be irrigated, but at present, only about 3.12 million ha are under irrigation [15]. With proper utilization and management, 4.5–5.0 million ha of land can be irrigated using groundwater [15].

Among the fertilizers, urea is the most used by volume in the agricultural sector. Although urea fertilizer is produced locally, local production is insufficient to meet demand. As such, the government
imports a significant amount of urea fertilizer every year [16]. Triple superphosphate (TSP) is the second most used fertilizer. Local production of TSP is very limited. Thus, the government imports TSP fertilizer. Recently, the agricultural sector experienced significant growth in the consumption of TSP [17]. Other fertilizers, namely, diammonium phosphate (DAP), single super phosphate (SSP), nitrogen phosphorus, potassium, and sulfur (NPKS), murate of potash (MOP), gypsum and zinc are also used by the agricultural sector. Farmers use a wide range of pesticides to prevent crop loss. Cultivation of rice, potatoes, spices, vegetables, and cotton accounts for the majority of pesticide use. Bangladesh farmers seem to treat pesticides as substitutes for fertilizers [18].

Agricultural credit is granted for crops, irrigation equipment, agricultural machinery, livestock and poultry, fisheries, grain storage and marketing, and poverty alleviation. At present, two specialized agriculture development banks (Bangladesh Krishi Bank and Rajshahi Krishi Unnayan Bank) extend agricultural credit to farmers throughout Bangladesh. Several state-owned commercial banks, namely Sonali, Janata, Agrani, and Rupali, also extend loans to farmers in the lagging regions. In addition, the Bangladesh Rural Development Board (BRDB) extends agricultural loans to these farmers. Micro Finance Institutions (MFIs) also extend microcredit for various income-generating activities (IGA), including agriculture throughout Bangladesh. Recently, foreign and local private commercial banks started extending agriculture credit directly to farmers, including the landless and marginal farmers of the lagging regions, as well as through reputed MFIs. As of January 2011, the Grameen Bank’s initiative to loan small amounts of money to the poor reached 7.95 million borrowers in Bangladesh of which 97% were women [19].

Despite many positive policy initiatives, Bangladesh’s agriculture sector still faces challenges, such as rapid shrinkage of agricultural land, population growth, inadequate supply of agricultural inputs like fertilizers and seeds, climate change and variations, inadequate value addition, and lagging technology adoption [20–22]. Since agriculture is dependent on weather and crops are known to suffer yield losses when temperatures are too high, there is concern that warming caused by climate change will lower crop yields [23]. Marginal and small farmers face challenges in managing their production activities due to lack of training on high-value crop production, diversification, and post-harvest technologies and face problems marketing their products due to lack of storage and preservation facilities [24–26].

Despite the perceived challenges, the agricultural sector of Bangladesh also has prospects like the expansion of hybrid technology, further adoption of advanced technology, the potential for improved utilization of hilly/coastal areas especially in the agroecologically disadvantaged regions, and export potential for high-value crops [27]. To maintain food self-sufficiency and food security, the government of Bangladesh has employed strategies to increases productivity and reduce yield gaps, foster access to inputs and technological improvement and electronic agriculture (E-agriculture), promote post-harvest technology adoption and change the dietary habits of the people [28]. In addition, there are region-based initiatives for agriculture development in Bangladesh to ensure food security and self-sustainability in food production for poverty alleviation [29]. Our survey was designed to increase the understanding of these challenges and opportunities as they pertain specifically to the lagging regions.

2. Materials and Methods

2.1. Study Design and Survey

Since the aim of the study is to analyze the constraints affecting agricultural production and marketing in the lagging regions, we administered a survey to gather information regarding the characteristics of both the farm families and farming practices in these regions. Specifically, we collected information pertaining to the age, education level, and farming experience of farmers (usually household heads), landholdings, and composition of their households. In addition, we collected data on farming practices, including agricultural input use, operational costs, access to credit, and storage and transportation of agricultural products. Data were collected through face-to-face interviews of
the farmers at the field level using a structured questionnaire. The respondents were individuals responsible for making their household’s agricultural decisions. The survey was carried out from July 2015 to June 2016.

2.2. Selection of Lagging Regions

In this study, three criteria were considered to determine the lagging regions of the country: ‘Agriculture Productivity’, ‘Agroecological Zones (AEZ)’, and ‘Percentage of the Population below the Poverty Line’. For simplicity, four indicators were used to measure agricultural productivity: (1) Rice yield per acre, (2) percentage of area irrigated, (3) percentage of area under HYV seed, and (4) cropping intensity. Low yields, low percentage of area under irrigation, low percentages of HYV, and low levels of cropping intensity indicate low levels of agricultural productivity. Data pertaining to these four variables were collected for 21 administrative districts for 2014–2015. The main sources of data were the Yearbook of Agricultural Statistics of Bangladesh 2016 [2] and the Statistical Yearbook of Bangladesh 2016 [10]. The data for each of the four variables for the 21 districts were ranked 1 to 21 with the highest value equal to rank 1, second highest value equal to rank 2, etc. The rank total for the district was computed by adding the district’s four variable rankings together. These rank totals were then ranked again, and these ranks were used as the hierarchical position of the regions (Table 2).

Results from the ranking show that Patuakhali ranked lowest with respect to agricultural productivity. All four productivity indicators for this region are very low, indicating the region is extremely deprived with regard to agricultural production. Chittagong Hill Tract and Barisal were ranked the next lowest in terms of agricultural productivity. Followed by Khulna, Noakhali, Sylhet, and Faridpur districts. Most of the indicators for these regions are poor but show moderate improvements compare to Patuakhali, Chittagong Hill Tract, and Barisal.

Bangladesh is divided into 30 AEZ. However, some AEZ overlap with each other. Thus, for convenience and ease of analysis, overlapping AEZ were combined to create 12 mutually exclusive regions. Each region contained several administrative districts. The 12 regions differed with respect to their endowment of geographical features, soil type, and fertility conditions. The names of these 12 regions and their corresponding districts are shown in Table 3.

A group of 12 indicators was selected to examine the variations among the 12 agroecological regions. The indicators were: Rural literacy rate, per capita regional domestic agricultural product, share of regional domestic product attributed to agriculture (%), farmers’ cooperative society, percentage of net cropped area to total geographic area (%), cropping intensity (%), area under HYV seed as a percentage of total cropped area (%), area irrigated as a percentage of total cropped area (%), consumption of chemical fertilizer, food-grain productivity, number of agricultural workers and net cultivated area per 100 agriculture workers. A composite index of development indicators was formulated from the 12 factors, and the level of development of these regions was classified according to low, medium, and higher using hierarchical positions of the regions [30]. The hierarchical positions of the regions revealed that ‘low Ganges river floodplain’ (Faridpur), ‘lower Meghna river and estuarine floodplain’ (Noakhali), and ‘eastern hills’ (Chittagong hill tract) were the least developed regions in Bangladesh.

Furthermore, five districts were selected as lagging based on the percentage of the population below the lower poverty line (Figure 1). Patuakhali, Bagerhat in Khulna, Jhenaidah in Jessore, Nilfamari in Rangpur, and Netrakona in Mymensingh were selected as regions with the most extreme poverty (Figure 1).
Table 2. Agriculture productivity indicators and ranks.

| Region            | Rice Productivity (Metric Ton/Acre) | Area Irrigated (% of Total Crop Area) | Area under HYV (% of Total Crop Area) | Cropping Intensity | Rank of Rice Productivity | Rank of Area Irrigated | Rank of Area under HYV | Rank of Cropping Intensity | Rank Total | Hierarchical Position of Region |
|-------------------|------------------------------------|---------------------------------------|----------------------------------------|--------------------|---------------------------|-------------------------|------------------------|--------------------------|----------------|----------------------------------|
| Bogra             | 1.22                               | 56.7                                  | 88.2                                   | 228                | 9.5                       | 2                       | 2                      | 2                        | 15            | 1 **                             |
| Kishoregonj       | 1.35                               | 55.8                                  | 91.1                                   | 162                | 1                         | 3                       | 1                      | 17                       | 22            | 2 **                             |
| Jamalpur          | 1.31                               | 50.8                                  | 79.6                                   | 209                | 2                         | 9.5                     | 7                      | 4                        | 22            | 3 **                             |
| Jessore           | 1.26                               | 54.0                                  | 73.8                                   | 215                | 6.5                       | 5                       | 9                      | 3                        | 23            | 4 **                             |
| Dinajpur          | 1.28                               | 51.9                                  | 78.9                                   | 205                | 4                         | 6                       | 8                      | 6                        | 24            | 5 **                             |
| Rangpur           | 1.26                               | 51.7                                  | 79.9                                   | 200                | 6.5                       | 7                       | 6                      | 7                        | 26            | 6 *                              |
| Kustia            | 1.17                               | 80.2                                  | 59.4                                   | 233                | 12                        | 1                       | 15                     | 1                        | 29            | 7 *                              |
| Rajshahi          | 1.27                               | 55.6                                  | 71.5                                   | 173                | 5                         | 4                       | 11                     | 15                       | 35            | 8 *                              |
| Mymensingh        | 1.11                               | 41.9                                  | 85.9                                   | 207                | 15                        | 14                      | 3                      | 5                        | 37            | 9 *                              |
| Comilla           | 1.22                               | 49.0                                  | 81.8                                   | 184                | 9.5                       | 12                      | 4                      | 12                       | 37            | 10 *                             |
| Dhaka             | 1.3                                | 50.9                                  | 66.0                                   | 174                | 3                         | 8                       | 13                     | 14                       | 38            | 11 *                             |
| Pabna             | 1.25                               | 49.9                                  | 56.9                                   | 193                | 8                         | 11                      | 17                     | 9                        | 45            | 12 *                             |
| Chittagong        | 1.13                               | 32.9                                  | 81.3                                   | 184                | 14                        | 17                      | 5                      | 12                       | 48            | 13 *                             |
| Tangail           | 0.47                               | 50.8                                  | 64.4                                   | 186                | 21                        | 9.5                     | 14                     | 10                       | 54            | 14 ×                             |
| Faridpur          | 1.39                               | 45.6                                  | 39.0                                   | 184                | 11                        | 13                      | 20                     | 12                       | 56            | 15 ×                             |
| Sylhet            | 1.15                               | 36.6                                  | 73.0                                   | 147                | 13                        | 15                      | 10                     | 20                       | 58            | 16 ×                             |
| Noakhali          | 0.97                               | 21.4                                  | 58.5                                   | 199                | 17                        | 19                      | 16                     | 8                        | 60            | 17 ×                             |
| Khulna            | 1.1                                | 33.5                                  | 67.1                                   | 127                | 16                        | 16                      | 12                     | 21                       | 65            | 18 ×                             |
| Chittagong Hill Track | 0.82                             | 26.4                                  | 52.8                                   | 156                | 19                        | 18                      | 18                     | 18                       | 73            | 19 ×                             |
| Hill Track        | 0.88                               | 20.3                                  | 45.9                                   | 171                | 18                        | 20                      | 19                     | 16                       | 73            | 20 ×                             |
| Potuakhali        | 0.71                               | 6.3                                   | 34.5                                   | 148                | 20                        | 21                      | 21                     | 19                       | 81            | 21 ×                             |

Note: ** Indicates high developed regions (Rank total 4–25); * medium developed regions (Rank total 26–50) and × low developed regions (Rank Total 50 and above).
Table 3. Agroecological regions and corresponding greater districts.

| Agroecological Region                                | Greater District Contained Within Region                        |
|------------------------------------------------------|----------------------------------------------------------------|
| Old Himalayan Piedmont Plain and Tista Floodplain    | Dinajpur and Rangpur                                           |
| Karatoya Floodplain and Atrai Basin                  | Rajshahi and Bogra                                             |
| Brahmaputra-Jamuna Floodplain                        | Mymensingh, Koshoregon, Jamalpur, Tangail                      |
| High Ganges River Floodplain                         | Pabna, Jessore and Kustia                                      |
| Low Ganges River Floodplain                          | Faridpur                                                      |
| Ganges Tidal Floodplain                              | Barisal and Khulna                                             |
| Sylhet Basin and Surma-Kusiyara Floodplain           | Sylhet                                                        |
| Middle Meghna River Floodplain                       | Comilla                                                       |
| Lower Meghna River and Estuarine Floodplain          | Noakhali                                                      |
| Chittagong Coastal Plain and St. Martin’s Coral Island| Chittagong and Cox’s Bazar                                    |
| Eastern Hills                                        | Chittagong Hill Tract                                          |
| Grater Dhaka                                         | Dhaka                                                         |

Figure 1. Regions of extremely poor populations (Below the lower poverty line) in Bangladesh.

In summary, seven districts were selected based on the agricultural productivity indicators, three districts were selected based on the AEZ region, and five districts were selected based on having extreme poverty. Since some districts were selected based on more than one of the selection criteria, this resulted in the identification of nine lagging districts to be sampled. In addition to these nine districts, one more district, Naogaon in Rajshahi, was selected to ensure coverage of all eight administrative
divisions of the country. In total, 10 districts were selected for inclusion in the sample (Table 4). A large number of districts were sampled to ensure coverage of all the criteria mentioned above and to ensure national representation that will allow the results to be used to aid in future strategic planning.

### Table 4. District, administrative division, and agro-ecological region of sampled Upazilas.

| Upazila       | District | Selection Criteria | Administrative Division | Agro-Ecological Region                                      |
|---------------|----------|--------------------|-------------------------|-------------------------------------------------------------|
| Alfadanga     | Faridpur | 1, 2               | Dhaka                   | Faridpur (Low Ganges River Floodplain)                       |
| Mohangonj     | Netrakona| 3                  | Mymensingh              | Mymensingh (Brahmaputra-Jamuna Floodplain)                  |
| Sadar         | Bandarban| 1, 2               | Chittagong              | Chittagong Hill Tract (Eastern Hills)                       |
| Lakshipur     | Noakhali | 1, 2               | Chittagong              | Noakhali (Lower Meghna River and Estuarine Floodplain)      |
| Nabiganj      | Hobigang | 1                  | Sylhet                  | Sylhet (Sylhet Basin and Surma Kasigara Floodplain)         |
| Kishoreganj   | Nilphamari| 3                | Rangpur                 | Rangpur (Old Himalayan Piedmont Plant and Tista Floodplain)  |
| Sadar         | Naogaon  | 4                  | Rajshahi                | Rajshahi (Karatoya Floodplain and Atrai Basin)              |
| Dasmina       | Patuakhali| 1, 3              | Barisal                 | Barisal and Khulna (Ganges Tidal Floodplain)                |
| Moralganj     | Bagerhat | 1, 3               | Khulna                  | Barisal and Khulna (Ganges Tidal Floodplain)                |
| Sailakupa     | Jhenaidah| 3                  | Khulna                  | Jessore (High Ganges River Floodplain)                      |

Note: Number presented in column 3 indicates selection criteria of lagging regions: 1 = Low Agriculture Productivity, 2 = Agroecological Zone, 3 = Extreme Poverty, 4 = Purposive selection to ensure coverage of all eight administrative divisions.

#### 2.3. Overview of Lagging Regions

The 10 selected districts have different characteristics, including geological features, soil types, fertility, and organic materials. The important differences are highlighted in this section.

Bandarban district in the Hill Tract AEZ is characterized by highlands and yellow-brown to dark-brown soil types. The land rates low in fertility but is high in organic materials. All of the agricultural development indicators (per acre rice yield, irrigated area, area under HYV, and cropping intensity) are very low for this region. This region is a lagging region based on both AEZ and low agricultural productivity.

Patuakhali district is in the lowlands of the Barisal AEZ (i.e., Ganges Tidal Floodplain). The soil consists of heavy silt clays and is alkaline, its fertility is medium-high. All the agricultural development indicators are very poor for this region. This district was also selected based on the percentage of the population below the poverty line.

Hobigonj district is in the Sylhet AEZ. It is a lowland area with heavy silt grey clay loam soil. All the agricultural development indicators show that it is an extremely lagging region in terms of agricultural production. There were no donor programs in this district at the time of the study.

Netrakona is in the Brahmaputra flood plain with medium-low and lowlands, medium fertility conditions, and low organic materials. Most of the area in this district cannot be cultivated year-round due to being submerged under water. Most of the area in this district is under the poverty line.

Faridpur is in the Low Ganges River Floodplain region with medium-high and medium-lowlands. The soil is silt loam and silt clay-loam with medium fertility and medium organic material. It is a deprived AEZ having low productivity, and some parts of the district are under the poverty line.

Lakhipur is characterized by the Lower Meghna River and Estuarine Floodplain regions with low, medium, and high-medium lands. The soil is silt loam and silt clay with medium fertility and medium organic material. It was selected based on AEZ.

Bagerhat is in the Ganges Tidal Floodplain region with medium-low and lowlands. The soil is heavy silt clay and alkaline with medium fertility and high and medium organic materials. All of the agricultural development indicators are low for this region. Most of this district is under the poverty line.
Jhenaidah is in the High Ganges River Floodplain region with high and medium-high lands. The soil is silt loam and silt-clay loam, fertility conditions are low with low organic materials. Most of the area in this district is below the poverty line.

Nilfamari is characterized by the Tista Floodplain region with high and medium-high lands. The soil is loamy and silt-clay loam, and the fertility condition is low to medium-low with good organic materials. Most of this district is under the poverty line.

Noagoan is in the Karatoya Floodplain region with medium-lowlands. The soil is grey and silt loams with moderate fertility conditions and medium organic materials. Most of this district is under the poverty line.

2.4. Sampling Technique and Collection Data

Each district in Bangladesh is subdivided into 5-11 Upazilas. The Upazilas are not homogenous with respect to agricultural production and productivity. Thus, the most lagging Upazila from each selected district was chosen purposively (Table 4). Agricultural households were then randomly selected from each of the selected Upazilas. Using a structured questionnaire, 1257 farm holders (farmers) were surveyed in two phases. The sampling was carried out by applying a multi-stage stratified cluster sampling method, where “District” was considered as the first stage cluster, then the “Upazila” within the district as the second stage cluster and, finally, the farmers as the ultimate sampling units. The basis of the stratification was the size of the farm according to land ownership. The size classification followed the classifications used in agricultural census of Bangladesh: Landless (<0.19 acres), marginal (0.20 to 0.99 acres), small (1.00 to 2.49 acres), medium (2.5 to 7.49 acres), and large (7.5 acres or more) [31]. Sampled farmers were selected randomly from lists of farmers obtained from the local agriculture extension officers. The sample size was determined based on the multi-stage sampling design.

2.5. Statistical Analyses

Collected data were processed and analyzed using SPSS 20.0 statistical software. Data were cleaned, edited, and crosschecked before analysis. Averages, percentages, and frequencies were used to summarize the data. In addition, regression analyses were performed to analyze the factors affecting agricultural productivity measured by rice yield and to determine the factors affecting the likelihood that the respondent faced a marketing constraint.

Specifically, Ordinary Least Squares (OLS) regression analysis was used to determine the relationship between sociodemographic variables, credit access, weather constraints, and rice productivity. More specifically, we estimated:

\[ Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} \]  

(1)

where, \( Y \) is the respondent’s rice yield in metric tons per acre, \( X_1 \) is the farmer’s age in years, \( X_2 \) is the farmer’s number of years of schooling, \( X_3 \) is respondent’s farming experience in years, \( X_4 \) is farm size in acres, \( X_5 \) is household size (number of members), \( X_6 \) is an indicator variable representing access to agricultural credit taking the value of 1 if the farmer has an agricultural loan and 0 otherwise, \( X_7 \) is an indicator variable taking the value of 1 if the farmer indicated being negatively impacted by the weather or climate and 0 otherwise, \( X_8 \) is an indicator variable taking the value of 1 if land is cultivated with a plough and 1 if a tiller or tractor is used, \( X_9 \) is an indicator variable taking the value of 0 if the farmer irrigates using a pump and 1 if a shallow machine is used, and \( X_{10} \) is an indicator variable taking the value of 0 if threshing is done the traditional way by hand and 1 if a threshing machine is used. The indicator variable pertaining to whether the respondent had been negatively affected by weather or climate was constructed from an open-ended question in which respondents were asked to indicate the challenges that they faced in the production process. Respondents indicated that they faced various challenges associated with weather and climate change, including erratic rainfall, extreme temperatures, increased
salinity, droughts, floods, cyclones, river erosion, and tropical storms. If the respondent indicated that he faced any of these challenges, the indicator variable was given the value of 1 and 0 otherwise. The $b$s are coefficients to be estimated.

In addition, a logistic regression model was used to analyze the relationship between the probability of the farmer facing a marketing constraint and the determinants of it. In this analysis, the dichotomous dependent variable took the value of 1 if the farmer faced a marketing constraint (lacked information about the price, lacked storage facilities and/or lacked transportation to market) or 0 otherwise. The logistic model was specified as follows:

$$
\gamma = \text{Logit} (p) = \ln \left(\frac{p}{1-p}\right) = \alpha + Z'\delta
$$

(2)

where $\gamma$ took the value of 1 if the farmer faced a marketing constraint and 0 otherwise, $p$ is the probability that farmer faces a marketing constraint, $1 - p$ is the probability that farmer does not face a marketing constraint, $\alpha$ is a constant term, $Z$ is a vector of independent variables and the $\delta$s are logistic coefficients to be estimated. For ease of interpretation, age, schooling, farming experience, farm size, household size, and rice yield were included as categorical variables rather than continuous variables in the logistic regression specification. The three age categories were defined as less than 36 years old, 36–55 years, and 56 or older. The four education levels of the farmer were defined as illiterate (no schooling), primary (1–5 years of schooling), secondary (6–10 years of schooling), and above secondary (more than 10 years of schooling). Farming experience classifications were defined as less than 10 years of experience, 10–19 years, and 20 or more years. The farm size classifications were defined as landless/marginal (<1 acre), small (1–2.49 acres), and medium/large (>2.5 acres). Household size classifications were defined as small (2–4 members), medium (5–6 members), large (7 or more members). The respondent’s rice yield (measure of agricultural productivity) was also included as a control. Respondents with yields 0.45 metric ton per acre or higher were classified as high productivity, while respondents with yields below 0.45 were classified as low productivity.

3. Results

3.1. Sociodemographic Characteristics

Out of the 1257 persons interviewed who were responsible for their household’s agricultural decisions, 1203 (96%) were male. This indicates that crop cultivation and decision-making is mainly done by males. Approximately, 24% of the sample was older than 55 years of age, about 25% of the sample was between 46–55 years of age, approximately 23% was between the ages of 36–45, approximately 20% belonged to 25–35 age group and only 5% of farmers were younger than 25 years of age. As shown in Table 5, about 56% of the sampled farmers had landholdings categorized as small (1–2.49 acres), 21% were categorized as medium (2.5–7.49 acres), 19% as marginal (0.20–0.99 acres), 2% as large (7.5 acres or more) and approximately 2% were landless and/or tenants (below 0.2 acres). These percentages are similar to those reported in the national statistics of farmers [31]. Farm size is influenced by capital constraints, the desires of the farmer, and profitability. The education profile of the farmers indicates that about 34% of them were illiterate, 32.6% had a primary education, and only 5% had higher secondary education (11–12 years of schooling) or were graduates (had bachelor’s degree or equivalent or above) (Table 5). About 45% of landless farmers and 46% of marginal farmers were illiterate, while only 23% and 19% of the medium and large farmers, respectively, were illiterate. None of the landless farmers were graduates, and only 2% of marginal and small farmers were graduates.
Table 5: Educational profile by farm size.

| Farm Size | Number of Farms (% of Farms) | Educational Qualifications (% of Respondents) |
|-----------|------------------------------|-----------------------------------------------|
|           |                              | Illiterate | Primary | Secondary | Higher Secondary | Graduate |
| Landless  | 29 (2.3%)                    | 45         | 42      | 10        | 3            | 0        |
| Marginal  | 235 (18.7%)                  | 46         | 26      | 23        | 3            | 2        |
| Small     | 702 (55.8%)                  | 34         | 35      | 27        | 2            | 2        |
| Medium    | 265 (21.1%)                  | 23         | 32      | 37        | 4            | 33       |
| Large     | 26 (2.1%)                    | 19         | 22      | 48        | 4            | 7        |
| All       | 1257 (100%)                  | 33.8       | 32.9    | 28.3      | 2.7          | 2.3      |

Table 6 examines land use and tenure. The total area of farmland used for agricultural purposes includes owned cultivable land and rented land. On average, landless farmers cultivated 1.73 acres of land of which 98.3% was rented, whereas the marginal farmers cultivated 0.91 acres of land of which 69.2% was rented, and small farmers cultivated 1.89 acres of land 51.3% of which was rented. The average size of homestead land was 18 decimals (1 decimal = 0.01 acres). However, large farmers used 37 decimals as homestead land, whereas small and marginal farmers used 16 and 17 decimals, respectively, and the tenant or landless farmers use only 13 decimals for homestead purposes. Around one-fourth of the owned lands remained non-cultivable. The proportion of non-cultivable land was higher for marginal and landless farmers.

Table 6: Land ownership, distribution, and utilization (per farm in acre).

| Farm Size | Homestead | OCL | NCL | Total Area of Own Land | Rented | Total Farm Land | NCL as % of Total Own Land | % of Rented Land |
|-----------|-----------|-----|-----|------------------------|--------|-----------------|----------------------------|-----------------|
|           | (A)       | (B) | (C) | D = (A + B + C)        | (E)    | (F = B + E)     | G = C/D                     | H = E/F          |
| Large     | 0.37      | 9.64| 2.92| 12.93                  | 5.81   | 15.45           | 22.6                       | 37.6            |
| Medium    | 0.23      | 3.04| 0.78| 4.05                   | 2.30   | 5.34            | 19.3                       | 43.1            |
| Small     | 0.17      | 0.92| 0.51| 1.65                   | 0.97   | 1.89            | 30.9                       | 51.3            |
| Marginal  | 0.16      | 0.28| 0.33| 0.77                   | 0.63   | 0.91            | 42.9                       | 69.2            |
| Landless  | 0.13      | 0.03| 0.10| 0.26                   | 1.70   | 1.73            | 38.5                       | 98.3            |
| All       | 0.18      | 1.41| 0.57| 2.19                   | 1.30   | 2.71            | 26.0                       | 48.0            |

Table 7 summarizes household composition information by farm size.

The average household size was 5.52 members, which was higher than the national average household size of 4.83 (rural) [32]. The average household size was higher for respondents with large and medium farm holdings and lowest for marginal farmers. For all categories of farmers, the average number of income-earning members was 1.72, unemployed members were 2.21, and dependent members were 1.61 (Table 7). Out of the 1257 households, 21% had no dependents or studying members, 28% had one dependent member, 31% had two dependent members, 14% had three dependents, 4% had four dependents, and only 2% had more than four dependent members. Moreover, 53% of households had a single income-earning member, 30% had two earning members, 12% had three earning members, 4% had four earning members, and only 1% had more than four earning members. Table 7 summarizes household composition information by farm size.
Three hundred eighty farmers (30%) reported agriculture as their main source of income, and most of these farmers had landholdings classified as medium or large. The remaining 70% of respondents earned their main source of income from non-agricultural sources: 20% from day labor, 29% from businesses, 14% from services, and 7% from both services and businesses. Aggregating total income from the different sources suggests that, on average, 19% of the total income comes from small businesses, 13% from day labor activities, 20% from services, and 48% from agriculture. On average, a large farmer earns 76% of his income from agriculture and the remaining portion from other sources, whereas medium, small, and marginal farmers earn 58%, 45%, and 53% of total income from agriculture, respectively.

3.2. Input Used and Operational Cost for Agricultural Production

The monthly expenditures of a large farmer were, on average, 73% of his total income. The balance could be used to purchase fixed assets or saved for future investments. On the other hand, the monthly expenditures of landless and marginal farmers exceeded their income, with the deficit being managed by borrowing from external sources like microcredit institutions or local moneylenders.

Nitrogen, phosphate, and potash were the most commonly used fertilizers. Herbicides, insecticides, fungicides, and other chemicals, such as pesticides, were also used by the farmers. About 84% of the respondents used fertilizers and pesticides. Some of the respondents did not use fertilizers or pesticides because they only grew spices (ginger and turmeric) or bananas, which do not require agricultural chemicals. The survey showed that 54% of farmers got their fertilizers and pesticides from the local market, 23% of farmers from dealers (Bangladesh Agricultural Development Corporation (BADC) and private), and 23% from both open markets and dealers. The pesticides used by the farmers were mostly modern chemicals in the form of powder, liquid, or granular. About 78% of farmers used insecticides, 23% of farmers used fungicides, 30% of farmers used herbicides, and 12% of farmers used rodenticides (Table 8).

The prices of fertilizers and pesticides were very high, high, and affordable according to the opinions of 25%, 54%, and 21% of farmers, respectively. About 96% of the respondents reported that the supply of fertilizer and pesticides was inadequate during their cultivation seasons.

| Type of Chemical | Form | % of Respondents |
|------------------|------|------------------|
| Insecticides     | Granular | 62% |
|                  | Liquid   | 78% |
|                  | Powder   | 38% |
| Fungicides       | Liquid   | 22% |
|                  | Powder   | 23% |
| Herbicide        |          | 30% |
| Rodenticide      |          | 12% |
The majority of farmers (55%) used their own seeds or locally collected seeds. Only 31% of farmers obtained seeds from BADC dealers, 41% of farmers obtained their seeds from the nearest markets and 14% acquired seeds from both sources. The price of seeds was expensive, affordable, and competitive, according to the opinions of 49%, 36%, and 15% of the respondents, respectively. About 39% of farmers believed that the seed quality was good, 59% of farmers rate their seed quality as medium, and 2% of farmers said the seed quality was low. About 86% of farmers could buy the quantity of seeds to meet their requirements.

A large majority of respondents used pumps (69%) for irrigation, threshers (67%) for threshing, and power-tillers (59%) for cultivation (Table 9). Although 21% of farmers used tractors for cultivation of their land, 20% of farmers still plough their land, and 99% of farmers harvest their crops the traditional way (i.e., manually).

| Purpose          | Type of Machine   |
|------------------|-------------------|
| Land Cultivation | Power-tiller 59%  |
|                  | Tractor 21%       |
| Irrigation       | Pump 69%          |
|                  | Shallow machine 31% |
| Harvesting       | Harvesters 1%     |
|                  | Traditional way 99% |
| Threshing        | Thresher 67%      |
|                  | Traditional way 33% |

Productivity (rice yield) is lowest amongst farmers with large holdings and highest for marginal farmers (Table 10). The lower productivity of the large farmers may be due to larger farms being more dependent on hired labor, which might be less cognizant than family labor.

| Farm Holdings | Production (Metric Ton) | Plantings (Acre) | Yield (Metric Ton/Acre) |
|---------------|-------------------------|------------------|-------------------------|
| Large         | 9.35                    | 9.64             | 0.97                    |
| Medium        | 3.10                    | 3.04             | 1.02                    |
| Small         | 1.01                    | 0.92             | 1.10                    |
| Marginal      | 0.35                    | 0.28             | 1.25                    |
| Landless      | 0.035                   | 0.03             | 1.17                    |

Annual production costs by farm size are summarized in Table 11. It should be noted that these production costs do not include the opportunity cost of owned land or family labor employed in the farm operation. Overall, the average annual cost of production was BDT 22480 per acre. However, average costs varied by farm size with larger farms having higher costs. Seed, irrigation, fertilizers, pesticides, wages for labor, leasing land, and equipment leasing were the major input cost components. Out of these seven components, wages and land and equipment leasing costs accounted for the highest shares of the expenditures, although large farmers did not pay to lease land as they owned their land. Labor costs were the highest share of total expenditures (51.3%), followed by leasing land (11.8%) and pesticides (9.3%). Seed costs accounted for the lowest (2%) share of the expenditure. Labor costs as a share of total expenditures were higher for farmers with larger holdings, whereas, pesticides and seed costs as a share of total expenditures did not vary by farm size.
Table 11. Annual average operational costs (in BDT/acre).

| Farm Size | Seed | Irrigation | Leasing Land | Fertilizers | Pesticides | Equipment Rental | Wages | Other | Total |
|-----------|------|------------|--------------|-------------|-------------|------------------|-------|-------|-------|
| Large     | 570  | 2380       | NA           | 1850        | 2200        | 1800             | 17,500| 1500  | 28,000|
| Medium    | 500  | 2050       | 3500         | 1720        | 2200        | 1430             | 13,200| 800   | 25,400|
| Small     | 450  | 1800       | 3350         | 1600        | 2150        | 1230             | 11,500| 720   | 22,800|
| Marginal  | 350  | 1700       | 3200         | 1650        | 1900        | 900              | 800   | 500   | 18,200|
| Landless  | 300  | 1300       | 3200         | 1800        | 2000        | 1250             | 7900  | 650   | 18,000|
| Overall   | 434  | 1846       | 2650         | 1724        | 2090        | 1322             | 11,540| 834   | 22,480|

Overall % 2.0 8.2 11.8 7.7 9.3 6.0 51.3 3.7 100

Note: $1 = BDT 80; Opportunity costs of family labor and owned land are not included.

3.3. Credit Facilities and Farmers Access

In the studied regions, agriculture credit included loans to procure inputs (seeds, fertilizers, and pesticides, etc.), pay for irrigation expenses, and purchase agriculture machinery and equipment. In the study areas, MFIs also had microcredit programs under which they extend loans for beef fattening. Out of the 1257 farmers surveyed, 445 farmers (35.4%) borrowed for the procurement of agriculture inputs (irrigation systems, machinery, or other inputs). Eighty-one percent of these borrowers had also taken loans to purchase livestock, for their small businesses, or for family consumption purposes. The respondents reported five formal and non-formal sources where they availed agriculture credit. The formal sources were government banks, private banks, and MFIs and cooperatives, the two informal sources were local moneylenders and friends/relatives. The formal sources accounted for approximately 85% of the credit flow for agricultural input purposes, 62.7% of these loans were extended by MFI and cooperatives, 13.3% by private banks, 9.4% by government banks, 10.1% from local money lenders and 4.5% from friend and relatives (Table 12).

Table 12. Source-wise credit availed by the farmers.

| Purposes of Loan | Source | Agricultural Inputs | Buying Livestock | Small Business | Family Expenditure |
|------------------|--------|---------------------|------------------|----------------|--------------------|
|                  | Govt. Bank | 42 (9.4%) | 1 (2.0%) | 4 (2.9%) | 4 (2.3%) |
|                  | Private Bank | 59 (13.3%) | 5 (9.8%) | 9 (6.5%) | 9 (5.3%) |
|                  | MFIs/Cooperatives | 279 (62.7%) | 42 (82.3%) | 95 (68.3%) | 119 (69.6%) |
|                  | Money lenders | 45 (10.1%) | 3 (5.9%) | 20 (14.4%) | 21 (12.3%) |
|                  | Friend and relatives | 20 (4.5%) | 11 (7.9%) | 18 (10.5%) | 17 (10.5%) |
|                  | Total number | 445 (100%) | 51 (100%) | 139 (100%) | 171 (100%) |

Note: Figures in the parentheses indicate the percentage of column total.

Only 139 farmers had taken loans for small businesses or income-generating activities (IGA), and 68.3% of them borrowed these funds from MFIs and cooperatives (Table 12). As shown in Table 12, 171 farmers (13.6% of the total farmers) had taken loans for family expenditure purposes. Of the farmers borrowing for family expenditures, 69.6% of them (119 farmers) borrowed from local moneylenders at a high interest rate.

Sixty-three percent of the farmers availed credit from a financial institution, while 37% had no interaction with any financial institution. Of the 459 farmers who have not taken formal loans, 30% indicated that they had not availed any services from financial institutions, as they were fearful of taking loans because of high interest rates and uncertainty of loan recovery. Another 19% of these farmers had not taken any bank loans because of the excessive cost of borrowing, while another 18% had not taken any bank loans because they faced difficulties regarding loan applications and documentation, and 12% of the farmers lacked the knowledge (Table 13).
The farmers were also asked to state their desire to borrow in the future. A large portion expressed their desire to avail loans for agricultural activities. About 53% of farmers were interested in obtaining loans for irrigation and its equipment, 10% for agriculture machinery, and 27% for other necessary inputs like fertilizers, seeds, and pesticides. Only 4% were interested in obtaining a loan to purchase livestock. In addition, 38% of the surveyed farmers desired to obtain future loans for family expenditures, 12% desired additional loans for other reasons, and 1.5% wanted loans to purchase life or non-life insurance. Comparing the difference between the current numbers of farmers with loans relative to those expressing the desire to borrow in the future highlights the constraints that these farmers face when accessing credit.

### 3.4. Constraints Regarding Production, Marketing, and Livelihood

The surveyed farmers faced numerous constraints with regard to agricultural production and marketing. The production challenges that the farmers faced can be grouped into farm-level internal or managerial factors and external factors. With regard to internal/managerial challenges, the survey revealed that lack of agricultural production machinery was the most common constraint faced by respondents (12.73%), followed by low productivity of crops (12.41%), lack of proper irrigation systems (8.97%), and difficulties in purchasing agricultural inputs (8.35%) (Figure 2). Other internal/managerial constraints included lack of application of new technologies, lack of machinery for processing, and difficulties in post-harvest management and accounting. The number one constraints with respect to external factors was adverse impacts of climate and weather (39.41%), followed by difficulties accessing institutional financing (20.85%), and lack of public sector assistance. Moreover, the farmers faced problems with poultry diseases and poor soil quality (Figure 3).

#### Table 13. Reason for not accessing credit.

| Reasons                        | Farm Size |
|--------------------------------|-----------|
|                                | Landless  | Marginal | Small    | Medium   | Large    | Total |
| Lack of knowledge              | 0%        | 20.0%    | 62.5%    | 17.5%    | 0%       | 12%   |
| Lack of access                 | 3.0%      | 23.2%    | 62.3%    | 10.1%    | 1.4%     | 10%   |
| Lack of good services          | 0%        | 16.0%    | 56.0%    | 26.7%    | 1.3%     | 11%   |
| Excessive cost of borrowing    | 3.2%      | 16.8%    | 53.6%    | 24.8%    | 1.6%     | 19%   |
| Difficult application process  | 3.4%      | 16.2%    | 56.4%    | 21.4%    | 2.6%     | 18%   |
| Fear                           | 2.0%      | 23.7%    | 54.6%    | 18.7%    | 1.0%     | 30%   |

Note: Figures indicate the percentage of respondents who were not availed credit.
were difficulties in storing products (39.56%), lack of information on market conditions (28.01%), inability to meet customers’ demand (26.04%), and difficulty transporting agricultural products to their markets (21.87%). In an open-ended question, the respondents indicated that poor road conditions caused difficulties in transporting products to their markets. The poor road conditions and networks also made it expensive for the farmers to pay transporters, thereby confining the farmers to market their products locally and limiting access to other markets that would yield higher prices. They also indicated that poor storage infrastructure contributed to quality deterioration and increased post-harvest losses.

The poor-quality produce and low volumes due to post-harvest losses also inhibited farmers’ access to better markets, creating a vicious cycle. The smallholder farmers indicated they lacked information regarding markets, which further contributed to poor access to markets.

Van (51%) and rickshaw (18%) were the most used vehicles for transporting agricultural products to distant markets. Bicycle, votvoti, track, and trolley were used less frequently. Only 6% of farmers carried their agricultural commodities by head or shoulder. About 58% of farmers sold their products direct to the market, 33% of farmers sold through middlemen, and 9% of farmers sold both directly and through middlemen. About 59% of the farmers had storage facilities; 26% of the farmers stored their products to distant markets. Bicycle, votvoti, track, and trolley were used less frequently. Only 6% of farmers sold their products to distant markets. Bicycle, votvoti, track, and trolley were used less frequently. Only 6% of farmers carried their agricultural commodities by head or shoulder. About 58% of farmers sold their products direct to the market, 33% of farmers sold through middlemen, and 9% of farmers sold both directly and through middlemen. About 59% of the farmers had storage facilities; 26% of the farmers stored their products in their own homes.

About 27% of the farmers had received training and technical assistance regarding rice production. Out of these 340 farmers, 91% received training and technical assistance from various government agencies, and only 9% received training and technical assistance from various NGOs and private organizations. In addition, 160 (13%) of the respondents had availed training and technical assistance regarding the production of other crops. Only 4% of farmers had availed training and technical assistance on livestock rearing and fish cultivation. None of the respondents had taken any accounting or financial management training. However, 5% of them (out of 340 farmers who had received training and technical assistance) were interested in participating in such training in the future. Only 1.8% of the trained farmers had taken training on processing and marketing of agricultural products, and 11.21% were interested in taking such training in the future.

Respondents were also asked about constraints to their livelihood. The farmers interviewed expressed concern about the high cost of living (20.52%), lack of nutrition for their family members (16.71%), bad living conditions, (14.81%), and lack of proper means of transport (13.59%). Education (11.96%), health (12.91%), and lack of drinking water (6.25%) were mentioned as problems. The respondents also indicated facing social problems, such as conflicts among family members (1.6%) and difficulties maintaining healthy relationships with friends and relatives (1.6%).

3.5. Determinants of Agricultural Productivity

OLS regression analysis was performed to analyze the factors affecting agricultural productivity measured by rice yield in metric tons per acre. Prior to conducting the regression analysis, the correlation

![Figure 3. External difficulties in production and operations.](chart)

The major constraints that the respondents faced with regard to marketing agricultural outputs were difficulty in storing products (39.56%), lack of information on market conditions (28.01%), inability to meet customers’ demand (26.04%), and difficulty transporting agricultural products to their markets (21.87%). In an open-ended question, the respondents indicated that poor road conditions caused difficulties in transporting products to their markets. The poor road conditions and networks also made it expensive for the farmers to pay transporters, thereby confining the farmers to market their products locally and limiting access to other markets that would yield higher prices. They also indicated that poor storage infrastructure contributed to quality deterioration and increased post-harvest losses. The poor-quality produce and low volumes due to post-harvest losses also inhibited farmers’ access to better markets, creating a vicious cycle. The smallholder farmers indicated they lacked information regarding markets, which further contributed to poor access to markets.

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3.5. Determinants of Agricultural Productivity

OLS regression analysis was performed to analyze the factors affecting agricultural productivity measured by rice yield in metric tons per acre. Prior to conducting the regression analysis, the correlation
coefficients for the independent variables were calculated to check for potential multicollinearity. Most of the correlation coefficients were less than 0.05, and only two were more than 0.2, suggesting that multicollinearity was not an issue. As shown in Table 14, older farmers and those with larger farms are less productive, while farmers with more years of schooling, more years of experience, and larger households were more productive. The coefficient on years of schooling was 0.003, indicating that one additional year of education increases rice yields by 0.003 metric tons per acre. Having access to agricultural credit had a positive and significant effect on rice yields, while being adversely impacted by the climate or weather also had a negative impact. The estimated coefficients suggest that the magnitude of the effects of having access to credit and being adversely impacted by the climate on rice productivity are greater than the effects of the sociodemographic variables. Not surprisingly, farmers that use more mechanization, such as use of shallow machine rather than traditional pumps for irrigation, power tillers or tractors instead of plowing, and modern threshing rather than hand threshing had higher rice yields.

### Table 14. Regression results of the socio-demographic and cultivation factors influencing rice productivity.

| Variables                  | Coefficient | Standard Error | t-Statistic | p-Value |
|----------------------------|-------------|----------------|-------------|---------|
| Constant                   | 1.050       | 0.014          | 72.455      | 0.000   |
| Age (Years)                | −0.001      | −0.001         | −4.110      | 0.000   |
| Schooling (Years)          | 0.003       | 0.003          | 4.045       | 0.000   |
| Farming experience (years) | 0.001       | 0.001          | 2.795       | 0.005   |
| Farm size (ha)             | −0.038      | −0.038         | −18.068     | 0.000   |
| Household size (number of members) | 0.003   | 0.003          | 1.924       | 0.055   |
| Access to agricultural credit (0 = No; 1 = Yes) | 0.044    | 0.044          | 7.696       | 0.000   |
| Adverse effect of climate/weather (0 = No; 1 = Yes) | −0.029   | 0.029          | −5.176      | 0.000   |
| Land cultivation (0 = Plough; 1 = Tiller or Tractor) | 0.055    | 0.055          | 11.364      | 0.000   |
| Irrigation method (0 = Pump; 1 = Shallow machine) | 0.024    | 0.024          | 3.919       | 0.000   |
| Threshing (0 = Traditional; 1 = Thresher) | 0.031   | 0.031          | 5.023       | 0.000   |

R^2: 0.38

### 3.6. Determinants Influencing the Likelihood of Facing a Marketing Constraint

A logistic regression was used to analyze the factors that influence the likelihood that the respondent faced a marketing constraint defined as lacking access to market information, storage and/or transportation. The prevalence of respondents facing a marketing constraint is shown in Table 15 in addition to the adjusted odds ratios calculated from the logistic regression. About 50% of farmers belonged to age 36 to 55 group, 45.5% of the farmers in this age group faced a marketing constraint. The prevalence of marketing constraints was highest (56.2%) for illiterate farmers and decreased as the farmers’ education increased. Similarly, the prevalence of facing a marketing constraint was highest for the farmers with the least experience. The prevalence of facing a marketing constraint was lowest amongst the landless and marginal farmers (farm size below 1 acre). This is likely due to these farmers being subsistence farmers and not selling their products in the market. Over 60% of the farmers with low productivity faced a marketing constraint.

The adjusted odds ratios indicate that farmers with primary education, secondary education, and higher than a secondary education were significantly less likely to face a marketing constraint than illiterate farmers. Small farmers were four times more likely and medium/large farmers were 2.8 times more likely to face a marketing constraint compared to landless and marginal farmers (Table 15). The farmers having high rice productivity were less likely to face a marketing constraint, and farmers with access to credit were less likely to face a marketing constraint than farmers without access to credit.
Table 15. Prevalence and adjusted odds ratio of marketing constraint.

| Independent Variables | Faced Constraint | Odds Ratio | 95% CI Lower | 95% CI Upper |
|------------------------|------------------|------------|--------------|--------------|
| Age                    |                  |            |              |              |
| 0–35 years             | 157 (47.7)       | 1.019      | 0.741        | 1.402        |
| 36–55 years            | 286 (45.5)       | 0.929      | 0.632        | 1.366        |
| 55+ years              | 135 (45.0)       | 0.929      | 0.632        | 1.366        |
| Education Illiterate   | 239 (56.2)       |            |              |              |
| Primary                | 197 (47.7)       | 0.676 *    | 0.497        | 0.919        |
| Secondary              | 123 (34.6)       | 0.346 **   | 0.249        | 0.479        |
| Above secondary        | 19 (30.2)        | 0.331 **   | 0.175        | 0.628        |
| Farming Experience     |                  |            |              |              |
| <10 years              | 173 (53.1)       |            |              |              |
| 10–19 years            | 322 (46.1)       | 0.773      | 0.570        | 1.049        |
| 20+ years              | 83 (35.6)        | 0.873      | 0.571        | 1.336        |
| Farm size              |                  |            |              |              |
| <1 ha                  | 63 (23.4)        |            |              |              |
| 1–2.49 ha              | 371 (53.2)       | 4.000 **   | 2.725        | 5.873        |
| 2.50+ ha               | 144 (49.7)       | 2.812 **   | 1.766        | 4.480        |
| Household size         |                  |            |              |              |
| Up to 4 members        | 273 (45.3)       |            |              |              |
| 5–6 members            | 139 (49.6)       | 1.054      | 0.758        | 1.465        |
| 6+ members             | 166 (44.4)       | 0.980      | 0.721        | 1.333        |
| Rice productivity      |                  |            |              |              |
| Low (0.76–1.10 M ton/ha) | 374 (60.3)   |            |              |              |
| High (1.11–1.45 M ton/ha) | 204 (32.0)   | 0.517 **   | 0.389        | 0.686        |
| Access to credit       |                  |            |              |              |
| No                     | 248 (67.6)       |            |              |              |
| Yes                    | 330 (37.1)       | 0.288 **   | 0.216        | 0.385        |
| R²                     | 0.254            |            |              |              |

Note: Figures in the parentheses indicate percentages of a group facing a marketing constraint. * Significant at 5%, ** Significant at 1%.

4. Discussion

The descriptive statistics and regression analyses in the previous sections uncover some significant challenges impeding agricultural productivity and marketing in the studied regions of Bangladesh. We found that young and educated people are not engaged in agricultural activities in the lagging regions. Most of the respondents (74%) were older than 36 years old. A national study found similar results. Only 11% of the farmer heads of households were under the age of 30, and 24% were between 30 and 39 years old [33]. The majority of our study respondents were also illiterate or had low levels of education. A national study found similar results, with 34% of farmers not completing primary education, 35% completing primary school, 21% completing secondary school, and 7% had higher education [33]. However, the rates of illiteracy and only primary or secondary levels of education are higher in this study than the findings of Sharmin et al. [34]. The discrepancy might be due to this study focusing on the most disadvantaged regions of the country. Our results are consistent with prior findings that suggest agriculture is becoming less attractive to youths who have greater financial opportunities outside of agriculture [35]. Given the existing trend, the agriculture sector in the lagging regions of Bangladesh may face a labor crisis as older farmers retire from farming activities, or they become unable to work. This problem may further deepen if educated young people do not come back to farming. However, if educated young individuals return to farming, they could drive farming toward mechanization, provided they receive adequate technical training. Our findings indicate that only around one-quarter of the farmers in the lagging regions had received training on rice production, and approximately 13% had received training on other crops. Our findings also indicate that about
33% of the surveyed medium-sized farmers had higher levels of education, which may suggest that the medium-sized farmers are more conscious about education or perhaps that farmers with more education are more successful. The regression results suggest that educated farmers are more successful as rice yields increased with education. However, more research is needed to unpack the relationship between education, farming profits, and farm size in the lagging regions.

The average household size of study respondents was 5.52, which was larger than the national average rural household size of 4.83 [32]. The average household size of medium-sized farms (6.56) was exactly equal to the findings of Kumar and Rahman [36], while the average sizes of marginal and small farms were approximately equal to theirs. However, the average household size of large farms in this study is larger than their findings. The overall pattern of land distribution in surveyed villages was very similar to the average distribution pattern of land in Bangladesh [2]. The average area of homestead land (0.18 acre) and small farm holder’s own land (1.65 acres) found in this study exactly matched prior findings [37], but total land was 30% higher in this study. Homestead land is not efficient because it leaves productive space unused. On average, survey respondents rented 48% of their total farmland or cultivable land. The current practice of land tenancy, which is common throughout Bangladesh, could be further encouraged by creating easier access to credit for small, marginal, and landless farmers. Relaxing credit constraints will likely improve agricultural productivity as the lack of access to credit had a significant effect on productivity (rice yield) in our analysis. Approximately 26% of the total land owned by the respondents in the various lagging regions was non-cultivable (the national figure is 27.4% [2]) and hence left fallow. The government could increase agricultural productivity by introducing programs to improve the cultivability of these lands, such as soil improvement and ground modification programs. However, the benefits of doing so must be balanced against possible environmental degradation as the lagging regions are in areas vulnerable to natural disaster and climate change.

The unemployment status of the farm households in the lagging regions was not severe. However, most households had only 1–2 earning members. Farmers receive income from many sources. The most common sources were from the sale of agricultural products, business activities, services, and wages from working as day laborers. The landless and marginal farmers have very low incomes, with one or two family members usually earning income from services and as day laborers. Small and medium farmers usually earned income from their businesses as well. These findings suggest that farmers in the lagging regions diversify their sources of income to provide for their households as they cannot rely solely on agricultural income.

Due to differences in soil potential, quantity of inputs used, and other factors, production costs, including purchased inputs, leased land, and wages for labor vary from farm to farm. The survey results indicate that per acre expenses were highest for large farms, whereas for small and medium farms per acre costs were about 81.4% and 90.7% of the amount incurred by large farmers. However, it should be noted that these costs do not account for the opportunity costs of owned land or family labor. While difficult to calculate and hence omitted here, these costs could be significant. Our findings are similar to prior findings that found the highest per-acre costs were paid by large farmers with small and medium farmers paying 81.1% and 88.6% of the cost of large farmers, respectively [38]. A possible justification is that small farmers with less cultivable land purchase less labor and other inputs like fertilizer because of budget constraints. Additionally, large farmers are more dependent on hired labor. The results also suggest that landowners with larger holdings of lands invested more in inputs and labor wages. This is likely due to these large farmers not leasing land and hence having more capital to spend on other inputs and wages. Large farmers were the least productive, while medium and marginal farmers were the most productive. This finding is consistent with prior research [39].

Despite the presence of two specialized agricultural banks and four other state-owned commercial banks, their market share was only 9% in this study. Informal sources accounted for 14% of the credit flow. Specifically, 10% of loans were borrowed from local moneylenders. The current allocation of credit to agriculture (percentages of agricultural credit over total bank credit) is very small (3%–5%),
considering the importance of the agricultural sector for achieving self-sufficiency in food [40]. In our study, marginal and landless farmers who borrowed from local moneylenders indicated that they demanded additional credit, however, credit from formal sources, including MFIs or cooperatives, was not available. Reducing the burden of accessing credit on these two groups of farmers could be facilitated through subsidized low-interest loans by MFIs or banks. To improve overall financial inclusion, simpler and faster loan processing is necessary, as many respondents indicated that the application process was burdensome. Interestingly, the vast majority of loans granted to farmers by MFIs and cooperatives were for family consumption and family expenditure rather than agricultural purpose or other income-generating activities.

Farmers indicated that they faced marketing constraints due to lacking necessary information. Specifically, they would like more information regarding what commodities are demanded, where and when the commodities are demanded, quantities demanded, grades and standards required, prices offered, and terms of delivery and payment. This information is necessary for farmers to make decisions regarding production. Unfortunately, this type of information is scarce and difficult for the studied farmers to access. Due to the low level of literacy, most smallholder farmers are not able to understand the dynamics of agricultural marketing. Most farmers in the study lacked the skills to undertake basic business practices, such as record keeping and gross margin analysis, which would help them set appropriate prices for their commodities. The respondents also faced difficulties in procuring adequate amounts of fertilizer and quality seeds.

To better understand the constraints to agricultural productivity, we analyzed the factors affecting agricultural productivity using regression analysis. We found that older farmers had lower yields. Older farmers may reduce their workload as their health declines or as income needs decline [41]. We also found a positive effect of farming experience on rice yield. However, the effect of farm size was negative and highly statistically significant. This result might be due to the fact that marginal and small farmers provide their own labor and tend to focus on rice production while larger farms tend to hire more laborers who may be less attentive to maximizing yields, and large farms tend to grow a more diverse set of crops. This result agrees with the findings of a prior study by Nmadu and Ibiejemite [42] that showed that farm output did not significantly increase with farm size but contrary to the finding obtained by Basoru and Fasakin [43]. Access to credit is found to have a positive and statistically significant impact on rice productivity. This result is in line with economic theory and is consistent with the empirical investigations of other studies [44–46]. Credit receipt allows farmers to purchase improved seeds, fertilizer, and pesticides and use more efficient production methods that ultimately enhance the productivity of the farmers. Prior studies found that a 10% increase in agricultural credit is associated with 1.2 ton per hectare increase in productivity [47], and paddy production can be increased 8.5% by increasing credit by 10% [48]. Not surprisingly, we found farmers that used more mechanization, and more advanced irrigation methods had higher yields. These suggest that the government should promote and subsidize agricultural loans and technology adoption. Adverse weather also negatively impacted yields. The impact of weather is likely to become more problematic as climate change continues. Thus, the government should design programs to help farmers mitigate the risks of weather, such as crop insurance programs or subsidizing drought-resistant varieties of seeds.

Prior research suggests that demographic factors, such as age, education level, and household size, influence farmers’ choice of marketing outlet [49]. Thus, we investigated the factors affecting the likelihood of the farmer facing a marketing constraint. We found that the education level of the farmer had a significant and positive effect on reducing the likelihood of the farmer facing a marketing constraint. Education level is an indicator of access to knowledge and information, as well as the farmers’ ability to synthesize information into a usable form. More educated farmers tend to be more willing to adopt new ideas and modern techniques. Access to market information increases farmers’ bargaining power and empowers them to negotiate with buyers for higher prices. A prior study found that better access to market information stimulated participation in a direct market among rural
farmers [50], which is consistent with our findings. This study found that more experienced farmers were less likely to face marketing constraints. This is consistent with prior findings that farming experience had a positive influence on modern market participation [51,52]. A prior study found that family size was negatively associated with high-value market participation [53]. However, we found no significant effect of household size on the likelihood of facing a marketing constraint. Access to credit significantly decreases the likelihood of a farmer facing a marketing constraint. Access to credit allows farmers to store their goods after harvest until prices are more favorable. Marginal and landless farmers were less likely to face a marketing constraint than larger farms. This is likely due to marginal and landless farms producing mostly for substance purpose rather than producing for the market.

5. Conclusions and Recommendations

In Bangladesh, farmers usually live in rural villages, and these villages tend to be disadvantaged relative to other parts of the world. However, the administrative districts and Upazilas in this study were selected because they were the most disadvantaged regions of the country. However, it should be noted that not all farmers in the same sampled Upazila are equally disadvantaged. The farmers in these regions face challenges in all aspects of farming activities. Lack of availability of inputs, high input prices, especially labor costs, limited access to institutional credit, and adverse weather and climate are major constraints to increasing agricultural productivity in these lagging regions. Farmers also face difficulties transporting their products to market, post-harvest losses, low output prices, and lack market information. To minimize these problems and increase crop productivity, the following recommendations should be considered by the government and policymakers.

General and product-based technical education and training focused on mechanization and improving the farming system should be offered by government institutions in the lagging regions since many of the farmers in these regions lack formal education and have not yet received such training. As supported by the regression results, farmers using more mechanization have higher yields. Furthermore, various sociodemographic groups have lower rice yields and hence more room for improvement. Thus, any effort to improve rice production should consider the specific needs of various sociodemographic groups. While rice productivity varied across sociodemographic groups, access to agricultural credit, and the effect of climate and weather had larger impacts on rice productivity than the sociodemographic factors. Hence, policymakers and planners should be conscious of these variables in the planning and implementation of development strategies in the lagging regions. Specifically, programs that help mitigate the negative effects of climate change, such as crop insurance, should be pursued.

Commercial banks and other credit institutions should improve their loan procedures to facilitate farmers’ access to credit within these regions, as many respondents found the procedures to be burdensome. Agricultural extension agents could educate farmers on the available sources of credit, as many respondents did not know what sources of credit were available. In addition, extension agents could provide assistance in completing the application process. Interest rates on agricultural loan interests should be capped or subsidized to discourage farmers from borrowing from moneylenders. Allocation of agricultural credit should be increased, and the government should provide support to the financial institutions in undertaking agricultural credit programs for the farmers of the lagging regions as we found the desire for credit far exceeded the availability of credit.

Technical training on high yielding cultivation procedures and processing and marketing of agricultural products should be introduced to help overcome the marketing constraints that many of the respondents faced. The government could undertake initiatives to establish storage facilities and transportation for agricultural products in rural villages. The government could also assist in the establishment of cooperatives in each village or union to provide short-term storage of perishable products and to facilitate marketing.

Finally, priority should be given to developing agricultural policies to bridge the development gaps between the lagging regions and the rest of the country. The challenges faced by farmers in the lagging
regions and imbalances between the regions should continue to be monitored to formulate strategies for balanced agricultural development in lagging regions, the overall growth of the agricultural sector, and to track the progress of policies and initiatives. This study can be used as a baseline against which to benchmark the progress of future policy initiatives in the study regions. However, a limitation of this study is that only farmers in the lagging regions were surveyed. Hence, we are unable to directly compare and contrast the lagging regions with other more developed regions. Furthermore, the survey data were cross-sectional. Thus, we are unable to comment on how the development situation has changed over time in the study areas.

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