

**TECHNICAL AND RESOURCE USAGE EFFICIENCY OF
POTATO PRODUCTION IN SOME SELECTED AREAS OF
BOGURA DISTRICT IN BANGLADESH**

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PRODUCTION IN SOME SELECTED AREAS OF BOGURA
DISTRICT IN BANGLADESH**

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CERTIFICATE

*This is to certify that the thesis entitled “**TECHNICAL AND RESOURCE USAGE EFFICIENCY OF POTATO PRODUCTION IN SOME SELECTED AREAS OF BOGURA DISTRICT IN BANGLADESH**” submitted to the Department of Agricultural Finance and Management, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka in partial fulfilment of the requirements for the degree of Master of Science (MS) in, Agricultural Finance and Management embodies the result of a piece of bona fide research work carried out by **TASNIA THANIM MATHIN, Registration No. 21-010007** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

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Dedicated to my Beloved Parents

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ABSTRACT

In Bangladesh, potatoes are comparable to rice and wheat in terms of nutrients and are easily assimilated. The environment is ideal for potato growing, with plenty of sunshine, well-fertilized soil, and adequate moisture content. This study investigates the socioeconomic aspects of potato farming, profitability, technical efficiency, resource efficiency, and recommendations for aiming to improve resource efficiency. This study focuses on the potato cultivation in six Upazilas in Bogura district: namely Shibganj, Sonatola, Shariakandi, Dhunat, Nandigram, and Kahalu. A multi-sampling technique was employed to select a representative sample of 200 potato farmers. In-person interviews were conducted from December 2022 to January 2023. Profitability is assessed using the profitability equation. To delve deeper into operational efficiency, stochastic frontier analysis is employed, utilizing the Cobb-Douglas function to evaluate technical efficiency. Resource utilization efficiency is scrutinized by calculating the ratio of marginal value product (MVP) to marginal factor cost (MFC), with an ideal ratio of 1. The majority of farmers have 5 to 10 years of experience in potato cultivation, with 80%. The majority of farmers have land holdings ranging from 2 to 3 hectares. Majority of respondents are actively engaged in Farmer Co-operative Societies. A significant number of farmers received training on potato cultivation. The total variable cost for potato production per hectare is Tk 629,253.12 Tk. Fixed costs account for 14.73%. Revenue generated from potato production per hectare is Tk 990,821.09. The gross margin is Tk 361,567.97, and the net return is Tk 252,842.50. The return per taka invested is 1.34 units. The production function reveals that if the expenditure on land preparation for potato production is increased by 1%, the revenue of potato would decrease by 0.099%. The cost of insecticide/pesticide is also negative, indicating that 1% amount is increased, the revenue would decrease by 0.225%. The cost of tillage is positive, indicating that if 1% amount is increased, the revenue would increase by 0.120%. The cost of urea is positive, indicating that if 1% amount is increased, the revenue would increase by 0.051%. The cost of DAP is negative, indicating that if 1% amount is increased, the revenue would decrease by 0.045%. The cost of biofertilizer is also negative, indicating that if 1% amount is increased, the revenue would decrease by 0.075%. The cost of manure is also found negative. Factors such as age, education, family size, distance of NGOs, cooperation societies, experience, and market distance do not significantly affect technical inefficiency in potato farming. The average efficiency is 86.99. Most of the farmers technical efficiency is ranged from 81-90% range. The MVP/MFC ratios indicate excessive use, with hired labor, irrigation, insecticides/pesticides, tillage, urea, TSP, DAP, MOP, biofertilizer, and manure showing significant over-utilization. Overall, the study underscores the importance of technical and resource use efficiency of potato farming in Bangladesh.

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LIST OF ABBREVIATION

BARI	Bangladesh Agricultural Research Institute
AEZ	Agro Ecological Zone
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistic
BCR	Benefit Cost Ratio
BDT	Bangladeshi Taka
BER	Bangladesh Economic Review
DAE	Department of Agricultural Extension
et al.	and others (at elli)
GDP	Gross Domestic Product
GR	Gross Return
ha	Hectare
HIES	Household Income and Expenditure Survey
HSC	Higher Secondary Certificate
HYV	High Yielding Variety
IOC	Interest on Operating Capital
kcal	Kilocalorie
kg	Kilogram
Ln	Natural Logarithm
ML	Maximum Likelihood
MoP	Muriate of Potash
M.Ton	Metric Ton
NGO	Non-Government Organization
No.	Number
t	Ton
TC	Total Cost
TE	Technical Efficiency
TFC	Total Fixed Cost
Tk.	Taka
TSP	Triple Super Phosphate
TVC	Total Variable Cost
Govt.	Government
IRRI	International Rice Research Institute
US	United States
USDA	United States Department of Agriculture
VRS	Variable returns to scale
\$	Dollar
%	Percentage

CHAPTER I

INTRODUCTION

1.1 Background of the study

After rice, maize, and wheat, potatoes (*Solanumtuberosum L.*) are the world's fourth most important food crop. They are a staple crop in many parts of the world and a crucial part of the majority of the world's food supply (Ezekiel *et al.*, 2013; Zhang *et al.*, 2016). China produced 21.31% of the 354 million tonnes of potatoes produced worldwide in 2019. Germany (2.99%), Ukraine (5.71), Russia (6.22%), India (14.15%), and the United States (5.43%) were the other leading manufacturers. Bangladesh views potatoes as a crop with great promise for addressing the difficulties of the twenty-first century. It has produced a staggering number of potatoes, placing it seventh in the world with 2.72% of the global harvest. Although it has expanded at the fastest rate in recent decades in southern and eastern Asia, it is still a vital crop in Europe, where per capita production is still the greatest in the world (FAO, 2023). Bangladeshi consumers' vegetable baskets would not be completed without potatoes. It makes up 55% of Bangladesh's total vegetable production (BBS, 2018, 2023a). Bangladesh's potato production is growing daily as a result of appropriate cultivars, different production packages, and consistent input supply. After wheat and paddy, potato is the third most significant crop (Kundu *et al.*, 2013). Potatoes are comparable to rice and wheat in terms of nutrients. It is easily assimilated. Despite being a temperate crop, potatoes may be cultivated in the winter in most of the nation (Azimuddin *et al.*, 2009). Bangladesh's environment is ideal for potato growing, with plenty of sunshine, well-fertilized soil, and adequate moisture content. The range of 15 to 21 degrees Celsius is necessary for the best growth and development. Since 1960, Bangladesh has been growing this unusual vegetable, which is imported specifically from the Netherlands (Sohel *et al.*, 2022). The total area planted to potatoes in FY 2021-22 is 4,64,011 hectares, up from 4,68,680 hectares in FY 2020-21. Volume is down 0.996% from the previous year. In FY 2021–22, the total amount of potato crop produced was 101,44,835 MT, up from 98,87,242 MT in FY 2021-22. 2.61% more has been yielded than the previous year. (BBS, 2023b). With enhanced production techniques and high yielding cultivars, Its production can be increased to 30–40 tons/ha (Chowdhury & Hassan, 2013). Due to its plentiful availability, it makes up the second-largest crop in terms of planted area (after

rice), accounting for 3% of Bangladesh's total area and up to 6.0% of the daily per-capita calories and protein consumed in rural regions. In many homes, it is considered a partial replacement for rice (BBS, 2018; Hossain & Abdulla, 2016). In Bangladesh, potatoes are grown once a year. During the cultivation stage, farmers fight to obtain sufficient yields and confront numerous challenges. However, their output revenue is insufficient for marketing, which puts the farmer at risk of responsibility once more (Hossain & Abdulla, 2015). In Bangladesh, the majority of farmers lack formal education. It is necessary to expand the sharing of market data in order to provide farmers with a fair price for potatoes (Rahman *et al.*, 2022). Potatoes have grown in importance as a crop for food security in recent years, particularly during periods of severe monsoon flooding. The only crop whose seed is maintained in cold storage so that it may be planted right away following flooding is potatoes. Good quality seed and effective resource management can lead to increased potato output, even on a small scale (Siddique *et al.*, 2015).

In Bangladesh, potatoes are the second most significant crop in terms of consumption in some regions, such as the Munshigonj district, after rice (Boro-irrigated rice, Aman-rainfed rice, and Aus-short duration rice) (Hossain *et al.*, 2014). Due to its quick economic payback and numerous uses as a vegetable and delectable processed food, it has recently gained importance and popularity as a food crop. Bangladesh's districts of Munshigonj, Sherpur, Narayanganj, and Dhaka produce more potatoes (World Food Security Atlas, 2021). This study demonstrated that growing potatoes is quite profitable and gives farmers a source of income. Production of potatoes was more profitable than that of any other winter produce. Potatoes were found to have greater gross return and per unit yield than other competitive crops (S. Ahmed *et al.*, 2013). Siddique *et al.* (2015) claim that potatoes have more potential to improve food security and reduce poverty in Bangladesh. Too far, Bangladesh has been the site of several studies on the agronomic, economic, and physiological aspects of potato growing. In a study on the profitability of potato farming, the average output of potatoes was 4720 kg per hectare, while the average gross return was TK 33040 per hectare (Ahmed *et al.*, 2013).

Due to urbanization, nutritional changes, and population growth, there has been a steady increase in the need for potato production. Consequently, the area under cultivation for potatoes has gradually increased; this growth is projected to occur at a pace of 1.25% annually (Reilly & Fuglie, 1998). The realization that potatoes have the ability to

improve food security and provide revenue for smallholder farmers is reflected in this expansion. Potato production has several obstacles in spite of its promise, especially when it comes to smallholder farming. Abiotic variables including soil salinity and temperature fluctuations pose serious risks to potato crops (Sultana *et al.*, 2023). Climate change can affect potatoes in a number of ways, such as temperature extremes that harm foliage, salinity in the soil, and severe heat that prevents tuber formation. Poor irrigation techniques or a high salt concentration in the soil can cause salinity in the soil, which can have a detrimental effect on potato output and growth (Nasir & Toth, 2022). In addition, restricted access to resources and technology limits the number of potatoes that smallholder farmers can produce. It might be difficult for small-scale farmers to obtain high-quality seeds, fertilizers, and pesticides, which can hinder their capacity to produce the best yields possible (Bajracharya & Sapkota, 2017; Bashir *et al.*, 2021; Muthoni & Shimelis, 2020). Moreover, the productivity and efficiency of potato cultivation are hampered by the absence of machinery and sophisticated farming practices. This implies that unless action is made to increase potato output, the contribution of potatoes to the national economy will gradually decrease. Significant improvements in potato production raise the level of living for both the producers and the global society in addition to promoting local economic growth. According to Bajracharya and Sapkota (2017) and Al-Hachami *et al.* (2020b), the primary obstacles to smallholder potato productivity are the following: a lack of high-quality seeds; a shortage of fertilizers at the appropriate times; a labor shortage; a poor market; a lack of technical knowledge regarding pest management; and geographic barriers. Lower prices and a restricted amount of output are the results of these difficulties (Marcomini *et al.*, 2023). Smallholder farmers are consequently unable to participate successfully in markets that are competitive. The problem of land fragmentation has also resulted in a delay in the commercialization process.

Smallholder potato farmers are subsistence farmers who do not have access to improved technologies, sufficient extension services, sufficient road networks and infrastructure, or sufficient market facilities. As a result, their productivity as potato growers is lower, their profitability is lower, and their use of resources is inefficient. The sustainable growth of potato production from an ecological and economic standpoint depends on the efficient use of resources. To reduce waste and its negative effects on the environment, this involves managing water, fertilizers, and pesticides in an efficient

manner. Energy costs have an impact on these products' manufacturing, packing, and shipping, which raises their total cost (Popp *et al.*, 2013). Furthermore, the cost of running potato farming equipment and irrigation systems is directly impacted by the rising prices of fuel and electricity. Agricultural resource use efficiency is critical, especially in developing countries like South Africa where production is typified by small-scale subsistence agriculture and often takes place on fragile soils (FAO, 2023). Consequently, raising resource utilization efficiency can avoid adverse environmental effects, lower production costs, and maximize yields. In developing nations, potatoes are an important food crop that are frequently farmed on a large scale. Potato production is susceptible to shocks and upsets, inefficient and effective use of inputs, and technological limitations, despite the crop's enormous potential to address food security and provide revenue for smallholder farmers (Devaux *et al.*, 2021). By improving the efficiency with which agricultural resources are used, addressing these issues through better agricultural practices, increased access to resources, and increased adoption of technology can improve the sustainability and productivity of potato farming, which will ultimately benefit both farmers and increase productivity, livelihoods, and sustainability in the agricultural sector as well as the larger population. Therefore, in order to guarantee higher-quality revenues to finance their expanded access to technology that would seriously advance the transformation process, it is imperative to strive toward strengthening and establishing the market involvement of potato farmers. Analyzing the profitability and resource efficiency of potato production in the Eastern Cape Province is the goal of this research. It focuses on how potato farm profit efficiency is influenced by input and output market variables. Through the implementation of strategic planning, local condition knowledge, and continuous improvement, farmers can enhance efficiency and profitability by optimizing resource allocation and management (Adewumi & Ayanlere, 2008; Sigigaba *et al.*, 2021).

Farmers are using elaborate farming procedures that increase the usage of chemical pesticides and fertilizers in order to maximize potato yield. Consequently, this raises the farmers' cost of production and lowers their profit margins. Farmers suffered enormous losses as a result of the recent potato boom. The profitability of the potato crop from a variety of angles, including economies of scale, sustainable agricultural techniques, input output ratios, benefit cost ratios, etc. It is crucial to perform a regular economic study of the crop to pinpoint problems with input-output marketplaces and

the cost-benefit relationship (Ahmad *et al.*, 1999; Iqbal, 2015). A non-parametric linear programming technique called data envelopment analysis uses sample data to predict a production frontier based on best practices. It allows for the inclusion of numerous inputs and outputs in the study and estimates the distance between each decision-making unit and this frontier (Tingley *et al.*, 2003). The ratio of a production unit's actual to prospective output is known as technical efficiency, or TE. Then, efficiency measurements are essentially computed by contrasting actual performance with a predetermined concept of standard performance. The ability and desire of a production unit to operate at peak efficiency is known as Total Equipment Effectiveness (TE). Farrell (1957) conducted the first empirical study to use a deterministic/non parametric border approach to compute TE for a cross-section of production units. As a result, border efficiency comparisons are now referred to as the "Farrell measurement of efficiency." According to Farrell, the sample data can be used to create a parametric function like the Cobb-Douglas form or a non-parametric piece-wise linear technique (Shanmugam & Venkataramani, 2006).

1.2 Research questions

1. What is the socioeconomic profile of potato farmers in Bogura District?
2. What determines technical efficiency among potato farmers, and how do farm size, access to credit, extension services, and experience influence it?
3. How efficiently do potato farmers use resources like land, labor, capital, seeds, fertilizers, and pesticides, and what factors affect resource use?
4. What is the overall resource use efficiency of potato cultivation in study area, and how does it vary by farm size, production practices, and socioeconomic characteristics?
5. What are the main constraints faced by potato farmers?

1.3 Justification of the study

The justification for conducting a study on the resource usage and technical efficiency of potato production in selected areas of Bogura District, Bangladesh, is rooted in the critical role of potato cultivation in the country's agricultural landscape and economy. As one of the major staple crops, potatoes contribute significantly to food security and livelihoods in Bangladesh. However, there is a pressing need to optimize resource usage and enhance technical efficiency within potato production systems to ensure sustainable

agricultural practices, increase yields, and improve farmers' incomes. By investigating the current resource allocation patterns, technological adoption, and efficiency levels in potato cultivation, this study aims to identify key constraints and opportunities for enhancing productivity and sustainability in potato production in Bogura District. Such insights are crucial for informing policymakers, agricultural extension services, and farmers about targeted interventions, technological advancements, and best practices to foster more efficient and resilient potato farming systems in Bangladesh.

1.4 Objectives of the study

This study's main goal is to look into the socioeconomic elements of potato farming in a particular region of Bangladesh. The following are the study's particular objectives:

- ✓ To examine the socio-economic characteristics of the potato farmers;
- ✓ To determine the profitability of potato production;
- ✓ To determine the technical efficiency of the potato farmer; and
- ✓ To estimate efficiency of resources used of the potato cultivation.

1.5 Significance of the study

The significance of this study lies in its comprehensive analysis of the resource usage and technical efficiency within potato production in selected areas of Bogura District, Bangladesh. By examining the socio-economic characteristics of potato farmers, this research sheds light on the demographic and economic factors influencing agricultural practices, thereby offering valuable insights for policy formulation and targeted interventions. Determining the technical efficiency of potato farmers allows for the identification of best practices and areas for improvement, contributing to enhanced productivity and sustainability in agricultural production systems. Moreover, by estimating the efficiency of resources employed in potato cultivation, this study facilitates resource optimization, promoting cost-effectiveness and environmental sustainability. Additionally, the assessment of constraints faced by farmers provides a nuanced understanding of the challenges impeding optimal potato production, guiding the development of tailored support mechanisms and interventions to alleviate these constraints and enhance agricultural resilience in the study area. Overall, this research contributes to the advancement of knowledge in agricultural economics and offers practical implications for stakeholders ranging from policymakers to farmers, fostering

informed decision-making and sustainable development in potato farming communities.

1.6 Organization of the thesis

The comprehensive study on potato farming efficiency begins with a thorough exploration in Chapter I, laying the groundwork by delving into the background of potato cultivation and its overall efficiency. Building upon this foundation, Chapter II meticulously reviews existing literature, synthesizing the collective wisdom of past research to inform the current study. In Chapter III, the methodology for the research is meticulously outlined, providing a clear framework for subsequent analysis. Chapter IV shifts focus to the socio-economic characteristics of potato farmers, offering insights into the demographics and circumstances that shape their endeavors. Moving forward, Chapter V evaluates the profitability of potato production, shedding light on the economic viability of this agricultural pursuit. Chapter VI examines technical efficiency and resource utilization within potato cultivation, unraveling the intricate dynamics that govern productivity in this domain. Finally, Chapter VII culminates in a synthesis of findings, drawing together key insights to offer a comprehensive summary, actionable conclusions, and practical recommendations for stakeholders in the potato farming sector. Through this meticulous examination, the study not only enriches our understanding of potato farming but also provides valuable guidance for optimizing efficiency and sustainability in agricultural practices.

CHAPTER II

REVIEW OF LITERATURE

2.1 Introduction

This chapter presents a comprehensive review of existing literature pertaining to resource usage and technical efficiency in potato production, focusing particularly on the selected area of Bogura District in Bangladesh. The review synthesizes past research findings, theoretical frameworks, methodologies, and empirical evidence related to the efficient utilization of resources in potato cultivation. By delving into prior studies, this chapter aims to provide a solid foundation for understanding the dynamics of potato production systems, resource constraints, and avenues for enhancing technical efficiency within the context of the Bogura District.

2.2 Literature review

Stepnyh *et al.* (2023) conducted a study focused on analyzing data to identify ways to save resources in crop production in the Kurgan region, emphasizing the importance of diversifying acreage and utilizing digital methods for resource management. Results showed that diversification of crops led to more efficient field work distribution, resource savings, higher incomes, and stabilized financial conditions for agricultural enterprises. Implementation of parallel driving systems and equipment monitoring helped in saving fuel, fertilizers, seeds, and plant protection products, contributing to increased crop yields by 5-10%. Designing technologies based on electronic maps and field history books allowed for the differentiation of resources by fields based on soil and agrochemical conditions.

Sultana *et al.* (2023) assessed a study compared Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) to evaluate potato farming efficiency in Bangladesh. SFA showed higher efficiency scores than DEA, indicating a better fit of the SFA frontier. Variable returns to scale (VRS) technical efficiency in DEA enveloped data more closely than constant returns to scale (CRS) efficiency. Significant economic, technical, and allocative inefficiencies were found in potato farming, suggesting room for improvement in production levels through efficiency enhancements. Infrastructure and socio-economic factors were identified as influencing potato production variability, highlighting the need for attention to these aspects for efficiency improvement.

Hatai (2022) analyzed the profitability and resource use efficiency of potato cultivation in East Siang district of Arunachal Pradesh, India during 2019–20. Cost of cultivation varied across farm sizes, with total costs per hectare being 41604, 44150, and 44608 for small, medium, and large farms respectively. Human labor was a significant cost contributor, accounting for about 30% of the total cost of cultivation. Gross returns ranged from 117927 to 179914 per hectare, with benefit-cost ratios varying between 3.16 to 5.63. The study highlighted challenges such as price fluctuations, high marketing costs, inadequate storage facilities, and lack of competitive marketing in the potato sector. Recommendations included adopting new production technologies, optimizing resource use, constructing cold storage units, and improving market intelligence services to enhance potato production and marketing in the region.

Ajibare *et al.* (2022) conducted a study on Resource Use Efficiency and Profitability Analysis of Tomato Production. Majority of tomato farmers in Nigeria were male, with a significant proportion above 41 years of age. Factors influencing tomato output included household size, farm size, seed input, and labor input. Labor costs represented a substantial portion of production costs in tomato farming. Constraints faced by farmers included issues like land tenure systems, lack of good roads, inadequate capital, high input costs, and absence of price control. Recommendations included providing financial support, promoting female participation, offering improved seed varieties, organizing training on post-harvest practices, encouraging cooperative formations among farmers, and facilitating access to inputs and negotiation of prices.

Kravchenko *et al.* (2022) conducted a study focused on assessing the economic efficiency of technological innovations in ecological agriculture, specifically in the potato farming industry in Russia. Technical innovations in Agriculture 2.0 were examined, showcasing their role in enhancing soil cultivation, plant propagation, and increasing crop yields. Implementation of resource-saving technologies and agrotechnical measures led to a 2.9 times improvement in profitability, 2.5 times increase in revenue, and a 6% decrease in the total cost of production in potato farming.

Ettah *et al.* (2022) study focused on assessing the technical efficiency of sweet potato farmers in Delta state, Nigeria, revealing that the least efficient farmers need to increase their production levels by at least 68% to operate at the production frontier. Factors influencing technical inefficiency included the age of farmers, farm size, household size, educational qualification, type of cropping, and farming experience.

Recommendations included providing access to improved sweet potato varieties, modern storage technologies, markets, extension services, financial assistance, and credit facilities to enhance crop output for sweet potato farmers.

Widanage *et al.* (2022) conducted a study on smallholder farmers in the Western Highlands of Guatemala face challenges in potato productivity, with current levels 29% lower than the world average. Stochastic production frontier analysis revealed that farmers operate at an average efficiency of 57%, indicating significant room for improvement in potato farming practices. Factors contributing to inefficiency include higher elevation, smaller farm size, and farm locations. Enhancing technical efficiency in potato farming could lead to substantial economic welfare gains, with the potential for US\$ 8.79 million increase in producer surplus annually in Guatemala.

Fitri and Nainggolan (2022) assessed research focused on analyzing the technical efficiency of potato farming in Kerinci Regency, with an average technical efficiency value of 0.936 among respondent farmers. Farmers in the study area utilized inputs such as seed potatoes, fertilizers (SP 36, KCl, phonska), fungicides, insecticides, and labor to achieve a productivity of 17.06 tons/ha. The analysis revealed that 33.9% of farmers were classified under IRS, 16.1% under DRS, and 50% under CRS, indicating varying levels of efficiency in resource utilization.

Fitri *et al.* (2022) analyzed the optimization model of production inputs to enhance potato farming efficiency, revealing that the optimal use of inputs could significantly increase production levels. Factors such as seed production, fertilizers (SP-36, KCL, urea), and insecticides were crucial in determining optimal production levels. The research found that the technical efficiency of potato farming was moderate, with sources of inefficiency linked to land area, farmer's age, and distance of farming land. Additionally, income, farming experience, education, and family size were identified as factors reducing technical inefficiency in potato farming. Overall, the study highlighted the importance of optimal input use in enhancing productivity and efficiency in potato farming.

Bordoloi and Lama (2022) study on potato cultivation in Brahmaputra Valley of Assam revealed that technical efficiency plays a significant role in influencing productivity. Factors such as seed quality, fertilizer, and manure costs were found to positively impact potato productivity. The research indicated that the mean technical efficiency among

farmers was 78%, with the highest efficiency observed in semi-medium and large land holdings. Land size was identified as a positive influencer, while the capital-labor ratio had a negative effect on technical efficiency in potato cultivation. Recommendations included promoting the use of quality seeds and plant nutrients to enhance productivity, as well as encouraging extensive farming practices and labor utilization for improved technical efficiency.

Nugraheni *et al.* (2022) conducted a study on potato farming efficiency. The average food consumption for potato commodities in Indonesia is 2.20 kg/capita/year, with a 9% increase from 2013. Potato production growth rate is lower than consumption, necessitating increased productivity. Certified seed usage can enhance potato production, with an average technical efficiency of 70.10% in Pangalengan district. No significant difference in technical efficiency between farms using certified and non-certified seeds was observed. Land ownership status significantly affects technical efficiency in potato farming.

Mazur and Mironova (2022) assessed that optimal technological methods for seed potato growing were determined through research, including the ideal nutrition background, fertilizer application method, weight of planting tubers, and potato varieties. The highest economic efficiency was observed when local application of Nitroammophoska ($N_{45}P_{45}K_{45}$) was combined with phosphorus-potassium fertilizer and semi-roasted manure, resulting in significant net profits for specific potato varieties and seed tuber fractions. Energy efficiency was also highest in the same experimental setup, with varying energy yields depending on the seed tuber fraction and varietal composition, showcasing the importance of proper nutrient management in seed potato cultivation.

Tapera *et al.* (2021) assessed the technical and resource use efficiency of smallholder potato farmers in Nyanga District, Zimbabwe. Technical efficiency was found to be 55.5%, with seed, labour, and fertilizers positively contributing to efficiency. Allocative efficiency analysis revealed overutilization of seed and underutilization of fertilizers and labour. Factors like farmer age and experience influenced technical efficiency, with younger farmers needing support and training for improved efficiency. The study highlighted constraints faced by farmers, including high input costs, water shortages, capital constraints, and landownership proof issues affecting access to credit.

Onuwa *et al.* (2021) analyzed the technical efficiency of sweet potato production, revealing a mean technical efficiency of 62% among farmers in the study area. Factors such as sweet potato seeds, labor, farm size, fertilizer, and herbicides significantly influenced production efficiency. Socioeconomic variables like farm capital, education, access to credit, farming experience, extension contact, and cooperative membership also played a role in affecting efficiency levels. Recommendations included subsidizing input costs, promoting appropriate farming practices, enhancing access to agricultural inputs and technology, improving market linkages, and developing indigenous technologies for sweet potato production.

Karpukhin and Keita (2020) research focused on determining the economic and energy efficiency of cultivating Gala variety potatoes under different feeding areas and fungicide use in the Middle Urals. The study found that the best results were achieved when using the fungicide "Shirlan" with a feeding area of 2450 cm², resulting in a high yield of 36.6 t/ha, low-cost price, high profit, and profitability. The economic efficiency of potato production was influenced by factors such as yield, gross yield, production costs, and selling price. The economic assessment allowed for determining the effectiveness of the results obtained and choosing the most optimal variant for potato cultivation.

Yadav *et al.* (2020) analyzed resource use efficiency on potato farms in Azamgarh district, focusing on factors like cropping intensity, investment, and costs of cultivation. It found that the cost of seed and manures/fertilizers significantly influenced farm outcomes across different farm sizes. The study highlighted decreasing returns to scale in potato cultivation and emphasized the importance of investing in inputs to enhance profitability. Utilizing the Cobb-Douglas production function, the research identified the most suitable model for studying resource use efficiency in potato production.

Afroj *et al.* (2020) analyzed technical efficiency, capital financing, and the value chain of potato farming in Bangladesh, focusing on key districts like Rangpur, Munshigonj, Bogra, and Rajshahi. Significant factors impacting efficiency included K fertilizer, irrigation, seed cost, education, farm size, and credit availability. Government support is recommended for variables like N fertilizer and pesticides to enhance farmer efficiency. In the potato value chain, farmers, small traders, large traders, Aratdar, commission agents, rural and urban retailers, processing companies, and cold storage facilities all play distinct roles in the distribution process. The findings aim to guide

policymakers in developing strategies to improve farmer efficiency and enhance the overall potato value chain in Bangladesh.

Al-Hachami *et al.* (2020a) estimated that 90.6% of inefficiency in potato production was due to technical inefficiency, emphasizing the importance of improving technical practices. Factors like human work hours, seed quantity, and DAP fertilizer significantly influenced production efficiency, with positive or negative effects. The research highlighted the significance of variables like local seed provider, agricultural season, farmer experience, and irrigation frequency in impacting technical inefficiency and efficiency levels. The average technical efficiency of the potato farms in the study sample was 50%, indicating room for improvement through measures like providing imported seed tubers for increased productivity.

Adhikari *et al.* (2020) assessed that Nepalese improved potato varieties adopter farmers exhibited higher efficiency (73%) compared to Indian (66%) and local (59%) varieties. Irrigated potato farming showed higher efficiency (71%) than rainfed potato farming (61%). The study emphasized the importance of using improved potato varieties and proper irrigation practices to enhance the technical efficiency of potato farmers in Nepal.

Adino Andaregie and Tessema Astatkie (2020) conducted a study on determinants of technical efficiency of potato farmers in northern Ethiopia. Factors influencing technical efficiency include chemical fertiliser, seed potato, plot size, and labour. Average technical efficiency score was estimated at 75%, with education, experience, off-farm income, household size, and membership in a farmers' association being significant factors. Other significant factors affecting efficiency were the use of irrigation water, extension contact, use of improved seed, access to product market, and weak coordination of stakeholders. Recommendations include government intervention to strengthen market linkages and provide training to agricultural extension agents.

Sujan *et al.* (2017) conducted a study on resource use efficiency and profitability of potato. A total of 52 farmers were selected randomly from the study area. Profitability analysis, Cobb-Douglas production function, MVP, MFC and Farm Budgeting model were used to analyze the objectives. Average gross return, gross margin and net return were found Tk. 3,47,200, Tk. 1,47,125 and Tk. 1,17,300, respectively. Benefit-cost ratio was found 1.51 and 1.74 on full cost and variable cost basis, respectively. Resource use

efficiency analysis revealed that farmers were not efficient in using resources in potato cultivation. Human labor, land preparation, insecticide and irrigation were under-utilized and therefore increasing use of those resources could maximize the profitability.

Begum *et al.* (2017) carried out a study to assess the profitability of potato cultivation in some selected areas of Sylhet district in Bangladesh. A total of 50 farmers were selected from different villages of Fenchugong upazila in Sylhet district. On an average 50% of the total income obtained from potato production. The annual savings of the sampled farmers was found to be higher in large farm followed by medium and small farm. On an average BCR was the highest in large farms (1.68) appearing lowest in small farms (1.34). The study identified some major problems like nonavailability of quality seeds and high potato, low market potato, shortage of human labor, lack of storage facilities etc.

Sarkar and Yesmin (2014) reported the government of Bangladesh has been maintaining a crop diversification strategy to reduce the dependency on potato by increasing the consumption and production of potato. In Bangladesh, the amount of cultivable land is gradually decreasing because of infrastructural and industrial development activities. For that reason, production strategies require to be formulated according to the demand of the situation and time so that farmers can increase food production. The cultivation of potato was a profitable business and the medium farm was more profitable than the small and marginal farms.

Suraiya (2008) studied on an economic analysis of some selected summer vegetables production in Purbadhala Upazila of Netrokona District. The selected vegetables were potato, okra, white gourd and snake gourd. The major findings of the study revealed that all the selected vegetables cultivation were profitable.

Saiyem (2007) investigated the potato marketing system in selected areas of Rangpur district. The samples include 60 sample farmers and intermediaries. In this study production cost, yield, marketing cost, marketing margin, net margin and channel of marketing were estimated.

Hossain (2007) studied the potato marketing system in selected areas of Bogra district. This study was mainly based on Sadar Upazila of Bogra district. The sample included 30 farmers and 30 intermediaries. Production cost, yield, marketing cost, marketing

margin and net margin of potato farmers and intermediaries were calculated in this study.

Shaikh (2006) conducted a study on Agricultural Research and Development in Bangladesh: Present and Future, Agribusiness. The study found that in exporting marketing channels the vegetables farmers sold their major portion of potato to selected agents. The study revealed that it was more profitable to export potato to Asian countries compared to Middle East countries. Although profit was the highest in exporting potato to EU countries, there exists a lot of formalities and risk for exporting potato in those countries. The fresh vegetable exporters were facing problems in exploiting export market due to lack of required cargo facilities and high frigate rate charge by the Biman Bangladesh Airlines.

Hossain (2004) conducted a research on a comparative economic analysis of some selected high yielding varieties of winter vegetables in an area of Bangladesh. The major findings of the study revealed that production of all selected homestead potato was profitable. Per acre gross cost of production of potato Tk 75215.50 and gross returns were Tk 148540. Per acre net returns of potato was Tk 73324.50. Benefit cost ratio of was 1.97.

Rahman (2000) conducted women's employment in Bangladesh agriculture and composition determinants and scope. The major findings of the study were that the potato production was profitable from the viewpoint of marginal, small, medium and large farmers and it helps to women employment.

Naher (1998) reported that the farmers of Mymensingh district were profitable to get the bumper production of potato in 1998. About 20 thousand farmers of the upazilla, who were cultivating potato on there a total of 180 hectares of land, were brought under potato cultivation in that year.

Islam and Karim (1997) conducted a study to assess the comparative profitability of selected winter vegetables like potato, cauliflower and tomato. It revealed that all the vegetables were profitable. Per hectare total costs of production of potato, cauliflower and tomato were tomato Tk. 51396.79, Tk. 64406.06 and Tk. 61663.87, respectively and the corresponding gross incomes were Tk. 99401.44, Tk. 119165.12 and Tk. 93442.24, respectively. The estimated net return of producing potato, cauliflower and tomato were Tk.48004.65, Tk. 54759.06 and Tk. 31778.38 respectively. However, for

producing three alternate winter vegetables, net returns were the highest for cauliflower followed by potato and tomato.

Rahman (1993) conducted a cooperative study of HYV potato and wheat production in some area of Jamalpur District. Potato cultivation is getting popular in Jamalpur. Farmers have become inclined because sustainable cost and good production.

Roy (1993) conducted research on relative profitability of potato-based cropping patterns in Bangladesh: A study in a selected area of Lalmonirhat district. He found that sixty three percent potato growers reported that their income, 57.00 percent children education, 80.00 percent household furniture increased due to potato production. Improvement of health and sanitation for potato growers was better than before. Sixty three percent overall socioeconomic improvements occurred due to potato cultivation. Finally, he found that livelihood of potato farmers was better off than before and from non-potato growers.

Miah (1987) conducted a study in Sadar thana of Mymensingh district to assess the performance of crops and potato producing on the marginal land and resource efficiency of the farmers. Profitability's of different cropping patterns were compared in respect to farm size and types of land. In order to measure the efficiency to dominant cropping patterns, potato grain equivalent, land use efficiency and production efficiency were calculated. In the most cases, these are the highest in the cases of vegetable-based cropping patterns. The author found that farmers achieved more profit from potato than other crops.

2.3 Research gap

Despite the presence of various studies examining aspects of potato production in Bangladesh, there is a noticeable gap in the literature regarding the comprehensive assessment of resource usage and technical efficiency in specific regions, particularly within the Bogura district. While some research has been conducted on the profitability of potato production across different areas of the country, there remains a significant dearth of studies focusing on the intricate dynamics of resource allocation and technical efficiency within the context of potato farming in Bogura. To date, no study has specifically delved into the nuanced aspects of resource utilization efficiency and technical efficiency in potato production within the selected areas of Bogura district. This absence of research leaves a critical gap in understanding the factors influencing

productivity and sustainability in potato farming practices in this region. Consequently, this research gap serves as a compelling motivation for undertaking a comprehensive investigation into the resource usage patterns and technical efficiency of potato production in Bogura district, Bangladesh.

CHAPTER III

METHODOLOGY

3.1 Introduction

This chapter outlines the methodology employed in assessing the resource usage efficiency and technical efficiency of potato production in selected areas of Bogura District, Bangladesh. The methodology adopted in this study is crucial for ensuring the validity and reliability of the findings and for providing a comprehensive understanding of the factors influencing potato production efficiency. The chapter begins by presenting an overview of the research design, including the selection of the study area and the sampling strategy used to identify representative potato farms. It then describes the data collection process, detailing the types of data gathered, the sources of data, and the instruments used for data collection. Additionally, the chapter discusses the methods employed to analyze the data, including both descriptive and inferential statistical techniques.

3.2 Selection of the study area

The Bogura district in Bangladesh was chosen as the study area for assessing the resource usage and technical efficiency of potato production due to several compelling reasons. Firstly, Bogura is renowned for its significant contribution to the agricultural sector, particularly in potato cultivation, making it an ideal location for studying potato production efficiency (Akter *et al.*, 2016). Secondly, previous research has identified Bogura as one of the key regions for potato production, highlighting its importance in the country's agricultural landscape (Juthy, 2020). Additionally, the district offers a diverse agricultural environment, providing an opportunity to analyze variations in resource usage and efficiency across different areas within Bogura. Furthermore, the accessibility of data and cooperation from local stakeholders facilitated the research process, ensuring comprehensive insights into the dynamics of potato production in the region. Thus, Bogura district serves as an appropriate and representative setting for examining the resource allocation patterns and technical efficiency of potato farming in Bangladesh.

In this study conducted in Bogura district, six Upazilas were meticulously chosen as study points: Shibganj, Sonatola, Shariakandi, Dhunat, Nandigram, and Kahalu. These

Upazilas stand out as significant contributors to potato production, boasting fertile lands and conducive climatic conditions. Their selection underscores their pivotal role in the agricultural landscape, particularly in potato cultivation. With their combined expertise and resources, these Upazilas epitomize the epitome of efficient potato production, serving as vital hubs for the region's agricultural economy.

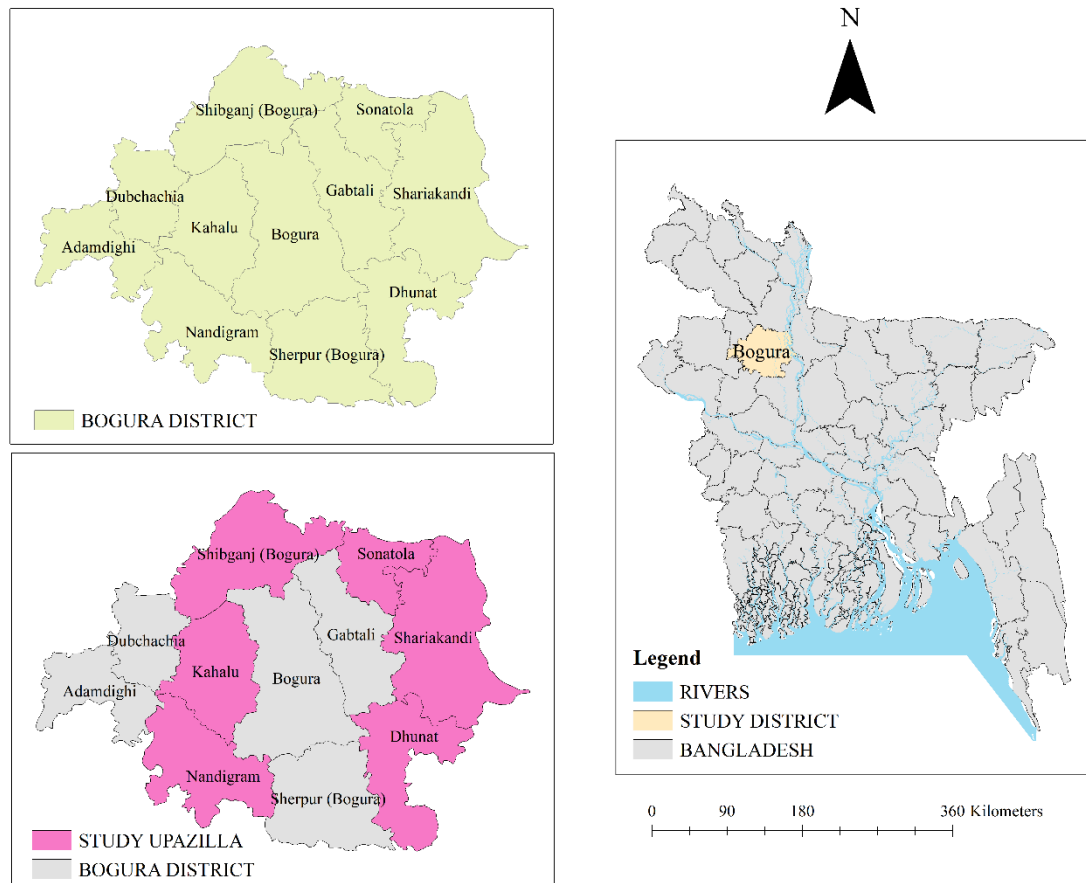


Figure 3.1: Study Area

3.3 Method of investigation

Survey research is a method used in quantitative research to collect data from a predefined group of respondents through standardized questionnaires or interviews (Ponto, 2015). This method involves asking specific questions to gather information about people's preferences, behaviors, attitudes, or opinions (Check & Schutt, 2011). Survey methods can include various techniques such as online surveys, paper surveys, telephone interviews, or face-to-face interviews. It's a widely used approach for gathering data efficiently and systematically (Singleton Jr *et al.*, 1988).

In this study, the methodology employed to gather pertinent information involved utilizing surveys as the primary data collection tool. The researcher, driven by the understanding that the approach to studying and the objectives at hand significantly influence the information gathering process, opted for this method. Personally, engaging with individuals involved in potato farming within the targeted areas, the researcher distributed questionnaires and conducted interviews. By directly interacting with the proprietors of potato farms, valuable insights and perspectives were obtained, enriching the study's dataset with firsthand experiences and knowledge from those deeply involved in the subject matter.

3.4 Sampling methodology and sample size

In conducting a study on potato farming, a multi-sampling technique was employed to select a representative sample of 200 potato farmers. This sampling methodology was chosen to ensure diversity across various regions and farming practices, providing a comprehensive understanding of potato cultivation techniques and challenges. The sample size of 200 was determined to strike a balance between statistical significance and practical feasibility, aiming to capture a broad spectrum of perspectives while maintaining manageable data collection efforts. By employing this approach, the study aims to yield insights that can inform agricultural policies, improve farming practices, and enhance the overall productivity and sustainability of potato farming operations. Firstly, it ensures a representative sample by selecting participants from different stages of the production process, enhancing the generalizability of the findings (Adino Andaregie & Tess Astatkie, 2020). Secondly, it allows for the inclusion of diverse farm sizes and conditions, capturing variations in practices and resources among smallholder farmers (Fikadu & Kerorsa, 2023). Thirdly, employing such a technique aid in reducing selection bias, as it involves a systematic approach to selecting participants, minimizing the risk of over or under-representing certain groups (Shavgulidze *et al.*, 2017). Moreover, it enhances the precision of estimates by capturing the heterogeneity present in the population, leading to more accurate assessments of technical efficiency (Mengui *et al.*, 2019). Overall, employing a multi-stage sampling technique is crucial for obtaining robust and reliable insights into the technical efficiency of potato farming practices. Overall, the adoption of multi-sampling techniques is indispensable for acquiring comprehensive and actionable insights into potato farming practices.

Equation (1) shows that a total of 200 farmer samples were selected using Cochran's proportional allocation sampling technique (Cochran, 1977).

$$n = \frac{z^2 pq}{e^2} \quad (1)$$

where;

n=Sample size estimation

z^2 = Selected critical value of desired level of confidence or risk

p= Estimated proportion of an attribute that is present in the population or maximum variability of the population

q= (p-1)

e = error margin for instance at 95% confidence interval

Here,

P=0.5

Q= 0.5

E=0.06

Z= 1.645

Now the predicted sample is,

$$\begin{aligned} n &= \frac{1.645^2 \times 0.5 \times 0.5}{0.06^2} \\ &= 187.92 \end{aligned}$$

For the study purpose the total sample determined as 200 for this study.

3.5 Preparation of the survey schedule

The preparation of a survey schedule is a crucial step in ensuring effective data collection. To create a robust schedule, define the survey's purpose, craft concise and relevant questions, and maintain simplicity to enhance participant comprehension. Striking a balance between question types and avoiding bias contributes to the survey's validity (Krosnick, 2018; Owens, 2002). Additionally, planning for field data collection

involves clear protocols for each component, optimizing survey response rates and feedback opportunities further improve survey quality (Aguinis *et al.*, 2021).

An effective interview schedule is essential to the research and survey's effectiveness. A schedule of interviews was created with the study's aims in mind in order to get the necessary data. The study's objectives guided the preparation of the draft schedule, which was created prior to the final schedule. After then, a pre-test of the schedule was conducted to confirm the questions' applicability and the type of answer. Following pre-testing and any required modifications, the final survey schedule was created. The information listed below was included in the final survey schedule, which was created in logical order:

1. The socioeconomic status of potato farmers;
2. Information about potato farms;
3. Farm families' sources of revenue;
4. Seed costs;
5. Labor costs for humans;
6. Machineries use costs;
7. Equipment and tool costs;
8. Revenue from the potato;
9. Issues that potato farmers confront and;
10. Solutions that potato farm operators recommend.

In-person interviews with respondents were conducted from December 2022 to January 2023 in order to gather data for the current study. Throughout that time, the researcher performed several field excursions in order to gather data.

3.6 Collection of data

The collection of data is vital for potato-related studies due to several reasons. Firstly, data provides empirical evidence and insights into various aspects of potato cultivation, consumption, and its impact on society, economy, and health (Salmensuu, 2021). Secondly, thorough data collection enables researchers to analyze trends in potato prices, consumption patterns, and market participation, aiding in understanding market dynamics and informing policy decisions (Demisse *et al.*, 2022). Additionally, data on the nutritional content of potatoes and their role in human diet and health help in promoting awareness about the nutritional benefits of potato consumption (Beals,

2019). Moreover, historical data on potato cultivation and its contribution to population growth and urbanization provide valuable insights into the historical significance of this crop (Nunn & Qian, 2011). Overall, the collection of data facilitates comprehensive analyses, informed decision-making, and advancements in potato-related research, ultimately contributing to the sustainable development of potato agriculture and its positive impact on various sectors.

Getting accurate and reliable information out in the field is tough. How a study turns out depends a lot on how good the data is and how consistent it is. How researcher gather the data really affects how reliable it is. We need clear schedules to make sure our surveys are right. We got data straight from the people we were studying using interviews made just for this study. This helped us make sure the data was dependable. We used schedules to get info from potato farmers too. Before the interviews, we explained what we were doing so everyone felt comfortable speaking up. We didn't ask unnecessary questions to save time for both the people we talked to and ourselves. We were careful when we collected the data to make sure it was right and dependable. We also thought about how the people we were talking to preferred to communicate, and we kept things friendly. We also looked at info from other sources like books, journals, and agencies including the Bangladesh Economic Review (BER) and the Bangladesh Bureau of Statistics (BBS), Sher-e-Bangla Agricultural University Archive.

3.7 Problems faced in collecting data

The researcher encountered the following issues and challenges when gathering primary data:

1. The majority of farmers in the chosen regions were hesitant to provide accurate information regarding their sources of income. Because they were reluctant to provide true information because they believed the researcher to be a government agent.
2. The fact that the respondents in the chosen areas did not maintain written records meant that the researcher in charge of data collection had to rely entirely on the respondents' recollection. This presented another significant challenge.
3. The majority of respondents in the research areas lacked any information of research studies. Thus, it was challenging to persuade them of the significance of the findings.

4. Occasionally, the farmers refused to work with the researcher voluntarily. They could not see any need to provide the researcher with information.
5. The researcher frequently had to spend more time and effort gathering information from farm respondents who were not available at home.

3.8 Processing and tabulation of data

Data processing has many parts, and one important step is tabulation. Tabulation means putting data in tables, making it easier to compare and analyze. First, raw data is turned into numbers. Then, numbers are given to different categories in a process called coding. Tabulation helps summarize data neatly, making it easier to understand and study. It's a key part of processing data, helping organize numbers so we can find patterns and understand what they mean (Christanto *et al.*, 2012; Habibi & Machdi, 2014). Researcher needed to process data to reach the study's goals. After collecting data, researcher organized and summarized it. Then, we put the interview data into a special computer program called STATA (version 16). We made tables and used different math methods to find what we were looking for.

3.9 Analysis of data

3.9.1 Analytical techniques

Data were analyzed to achieve the objectives of the study. For this study, the following techniques were used.

- a) Tabular technique and
- b) Functional technique

3.9.1.1 Tabular technique

Tabular technique of data analysis involves presenting and organizing data in a structured format using rows and columns. This method simplifies the comprehension of information, making it easy to identify patterns, trends, and relationships within the dataset. Tabular presentation is widely employed in exploratory data analysis (EDA) for tabular data, aiding in quantitative and qualitative analysis as well as temporal and spatial assessments (Behrens & Yu, 2003; Wainer, 1993). By systematically arranging data, the tabular technique enhances the accessibility and clarity of information, serving as a foundational tool for various analytical processes (Li *et al.*, 2020). Typically, the tabular technique is employed to determine the unrefined correlation or fluctuations

among variables. The tabular technique was employed in this study since it was commonly utilized, simple to calculate, and easy to comprehend. The study used a number of statistical measures, including sum, average, percentage, and so forth. Both total cost and variable cost were included in the profitability study.

To evaluate the profitability of potato farms, the following profitability equation was developed.

$$\Pi = PbQb + PLQL - \sum(Pxi.Xi) - TFC$$

Where,

Π = Profit (Tk.);

P_b = Per unit price (Tk./kg);

Q_b = Quantity (Kg.);

P_L = Per unit price of used materials and excreta (Tk./kg);

Q_L = Quantity of waste (Kg.);

P_{xi} = Per unit price of i th (variable) inputs used in the potato farm (Tk.);

X_i = Quantity of i th (variables) inputs used in Kg;

$i = (1, 2, 3, \dots, 200)$ and

TFC = Total fixed cost

3.9.1.2 Statistical Technique

Technical efficiency refers to how well a farm can make the most stuff with what it has and the tools it uses. If a farm is technically good, it does its job well compared to other farms. Basically, a company is technically efficient if it uses its production method to make the most stuff possible with the technology it has. In simpler terms, a company is efficient if it operates at the best point possible, rather than inside that point. To make stuff well, the ingredients used must be the same. The amount of stuff made from certain ingredients shows how efficient the process is, but it's not always clear if the ingredients used are the same as the best ones for that process. When different companies use different quality ingredients, their efficiency depends on both the quality of what they use and how well they manage it. But if differences in ingredients are the same across all companies, it doesn't affect efficiency (Coelli *et al.*, 2005).

3.9.1.3 The stochastic frontier models

The best way to figure out how well something works is by using the stochastic frontier model. This method is better than other methods because it looks at both sides of the error – the one we know about and the one we don't. It also considers things like mistakes in measurement and random events that affect how well a business operates. This means the model can be different for each business. Jondrow *et al.* (1982) first introduced this model, which is often called the stochastic frontier model made it even better. Other methods assume that all businesses work the same way, ignoring the fact that some things can affect how well a business does, like broken equipment or bad weather. But the stochastic frontier model looks at all the different factors that can affect a business and separates out what the business can control from what it can't. This means the results it gives are fair.

3.9.1.4 The stochastic frontier with cobb-Douglas production function

Cobb-Douglas production function, a formula in economics that calculates output based on inputs developed by Douglas (1928). The Cobb-Douglas way of figuring out how much stuff farms make is really popular because it's easy to do the math for it and understand it (Heady *et al.*, 1960). This technique plays a crucial role in assessing the relationship between production outputs and inputs like labor and capital. By employing output elasticity measures, it gauges the responsiveness of output to changes in these input levels. Real-world applications include estimating average production levels in manufacturing, cost minimization strategies, and assessing the overall productivity of industries. This statistical approach provides valuable insights into resource allocation and production optimization, contributing to informed decision-making in various economic sectors (Bounthavong, 2019; Dritsaki & Stamatiou, 2018). Even though it makes curved lines on graphs, it can't handle things that don't rely on each other or compete, and it can't show all the different stages of production well because it's limited in how it can switch between different inputs. Basically, if we assume that one thing is usually smaller than another (which is usually the case), then how much stuff farms make from each worker or acre keeps going down as they use more workers or acres. But for some kinds of making things, where everything sort of works the same no matter what, the Cobb-Douglas can still give a pretty good guess.

Also, it's easy to figure out the numbers for it because they're simple and straightforward (Beattie & Taylor, 1985).

The formula for a Stochastic frontier with Cobb-Douglas Production is:

$$Y_i = f(X_i, \beta) \exp.(V_i - U_i) \quad i = 1, 2, 3, \dots, N$$

The stochastic production frontier is represented by the expression $f(X_i, \beta) \exp.(V_i)$, where V_i has a symmetric distribution to reflect the random effects of measurement error and external shocks that cause the placement of the deterministic core $f(X_i, \beta)$ to differ among firms.

The one-sided error component $U_i > 0$ thus captures the technological inefficiency compared to the stochastic production frontier.

The following model was used in this study:

$$Y = aX_1^{b_1}aX_2^{b_2}aX_3^{b_3}aX_4^{b_4}aX_5^{b_5}aX_6^{b_6}e^{U_i}$$

Where Y is the frontier output, X is physical input, b the elasticity of Y with respect to X , a is intercept and $\varepsilon = V - U$ is a composed error term as defined earlier. For simplicity, we have ignored the subscript.

The function was estimated as follows:

$$\begin{aligned} \ln Y = & \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 \\ & + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} \\ & + U_i \end{aligned}$$

Where,

Y = Gross return (Tk./kg);

a = Constant or intercept value;

X_1 = Cost of hired labor for i th farm (Tk./ha);

X_2 = Cost of irrigation for i th farm (Tk./ha);

X_3 = Cost of insecticide/pesticides for i th farm (Tk./ha)

X_4 = Tillage cost for i th farm (Tk./ha)

X_5 = Cost of urea for i th farm (Tk./ha)

X_6 = Cost of TSP for i th farm (Tk./ha)

X_7 = Cost of DAP for ith farm (Tk./ha)

X_8 = Cost of biofertilizer for ith farm (Tk./ha)

X_9 = Cost of manure for ith farm (Tk./ha)

U_i = Error term;

$i = 2, 3, \dots, 200$;

$b_1, b_2, b_3, b_4, b_5, b_6$ = Regression co-efficient of respective variables, and $\ln$ = Natural log.

The model of the technical inefficiency effects in the stochastic production frontier equation is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + W_i$$

Where,

$Z_1, \dots, Z_7$ are explanatory variables.

The equation can be written as:

$$U_i = \delta_0 + \delta_1 \text{Age} + \delta_2 \text{Education} + \delta_3 \text{Family Size} + \delta_4 \text{Training} \\ + \delta_5 \text{Experience} + \delta_6 \text{Social member} + \delta_7 \text{Market Distance} \\ + W_i$$

V is a two-sided uniform random variable that is independent of the farmer and has a distribution of $N(0, \sigma^2)$, U is a one-sided technical inefficiency effect that is controlled by the farmer and has a distribution of $V_i | N(0, u^2)$, and W_i is a two-sided uniform random variable. W is a random variable that cannot be seen and has a positive half-normal distribution. STATA and R studio were both used at the same time to estimate the model.

3.10 Resource use efficiency (RUE)

As long as the value of the new product outweighs the cost of the additional resources used to produce it, using more resources will help achieve the goal of profit maximization, or the optimal use of resources. In order to retain the maximum profit, resources are deemed efficiently used when the ratio of marginal value product (MVP) to marginal factor cost (MFC) approaches one, or when MPV and MFC are equal for

every input. Multiplying the marginal physical product (MPP) by the product price yields the marginal value product (MPV). Marginal factor cost is the cost of one unit of input (MFC).

The equality criteria of MVP and MFC would determine the best usage of a specific input:

$$\frac{MVP}{MFC} = 1$$

When all other inputs are maintained constant, the marginal productivity of a given resource is the increased value-added gross returns that result from using one more unit of that resource. By considering the gross return (Y) and resources (Xi) at their geometric means, the most relevant estimate of MVP can be found. Since all of the model's variables were expressed in monetary units, the function that represented the MVP was created by multiplying the production coefficient—or, in this case, the elasticity of a given resource by the geometric mean ratio of its input and output variables.

$$\frac{dy}{dxi} = b_i \frac{Y(G.M)}{Xi(G.M)}$$

Where,

Y= Mean value (GM) of gross return.

Xi= Mean value (GM) of ith input cost.

i=1,2,3,4.

Therefore,

$$MVP(Xi) = b_i \frac{Y(G.M)}{Xi(G.M)} P_{yi}$$

Where,

b_i = Co-efficient

P_{yi} = Per unit price of output

G.M. = Geometric mean

Therefore, the ratio of MVP to MFC can be expressed using these MVPs, which show the value product per input. The optimal factor use is indicated by a ratio equal to one; a ratio greater than one suggests that using more of the resource could increase the gross return; and a value less than one indicates that there is excess resource use, which should be reduced to minimize loss. These are the criteria for determining resource use efficiency.

3.11 Process for calculating benefits and costs

All cost items must be computed in order to determine profit or loss. In order to assess costs and advantages, the market price at which goods or services are actually exchanged for has been taken into consideration. The cost components were divided into two major groups: (1) Fixed costs and (2) Variable costs. For a year, the expenses and profits were calculated per hectare potato production. The following headings were used to group the cost items.

CHPATER IV

SOCIO-ECONOMIC CHARACTERISTICS OF THE POTATO FARMERS

4.1 Introduction

Potato farming in Bogura District represents a significant livelihood for many households, contributing substantially to the local economy and food security. As such, an in-depth analysis of the socio-economic characteristics of potato farmers is essential for policymakers, agricultural extension services, and development practitioners to formulate targeted interventions and policies aimed at enhancing the efficiency and sustainability of potato production systems. This chapter seeks to elucidate the socio-economic context in which potato farmers operate, thereby providing a comprehensive understanding of the factors influencing their decision-making processes, adoption of technologies, and overall agricultural performance. Through a nuanced examination of these characteristics, this study aims to contribute to the ongoing discourse on agricultural development and resource management in Bangladesh, with specific relevance to potato production in Bogura District.

4.2 Age

The age profile of potato farmers was categorized into three distinct groups: middle age, older age, and young. This classification reflects the diversity within the farming community, with each group likely facing unique challenges and opportunities. Middle-aged farmers, likely comprising individuals in their late 30s to early 50s, may bring a balance of experience and vitality to their agricultural practices. Older farmers, typically beyond their mid-50s or older, may possess extensive wisdom and traditional knowledge but may also face challenges related to physical limitations or technological adaptation. Meanwhile, young farmers, often in their late teens to early 30s, represent the future of the agricultural industry, bringing innovation, enthusiasm, and potentially a fresh perspective to farming methods and management practices. Understanding and addressing the needs of each age group is essential for promoting sustainable agriculture and ensuring the continued vitality of potato farming communities (Lepcha, 2022).

Table 4.1: The responders' age profile

Age group	Frequency (Percentage)
Young (< 30 Y)	12 (6.0)
Middle Age (30-55 Y)	88 (44)
Older Age (>55 Y)	100 (50)

Source: Field survey, 2023

The age profile of responders is presented in Table 4.1. The majority, comprising 44% of the total, fall into the middle age category. This indicates a significant portion of the sample population belonging to this demographic segment. Following closely behind, the older age group represents 50% of the respondents, suggesting a substantial representation of individuals in the older age brackets within the surveyed population. Conversely, the young category comprises only 6% of the respondents, indicating a smaller proportion of younger individuals participating in the survey compared to their middle-aged and older counterparts.

4.3 Gender

Gender plays a crucial role in potato farming, shaping various aspects from production to marketing. Women often contribute significantly to potato farming activities, such as seed selection, storage, and management. In many households, decisions regarding native potato varieties and their utilization are influenced by women, highlighting their pivotal role in biodiversity management (Molina *et al.*, 2022). Moreover, women are heavily involved in agricultural labor, including tasks like hoeing and planting, contributing to the overall productivity of potato farming operations. Understanding and addressing gender dynamics in potato farming is essential for promoting equitable participation, enhancing productivity, and ensuring sustainable agricultural practices (Mwesige *et al.*, 2019).

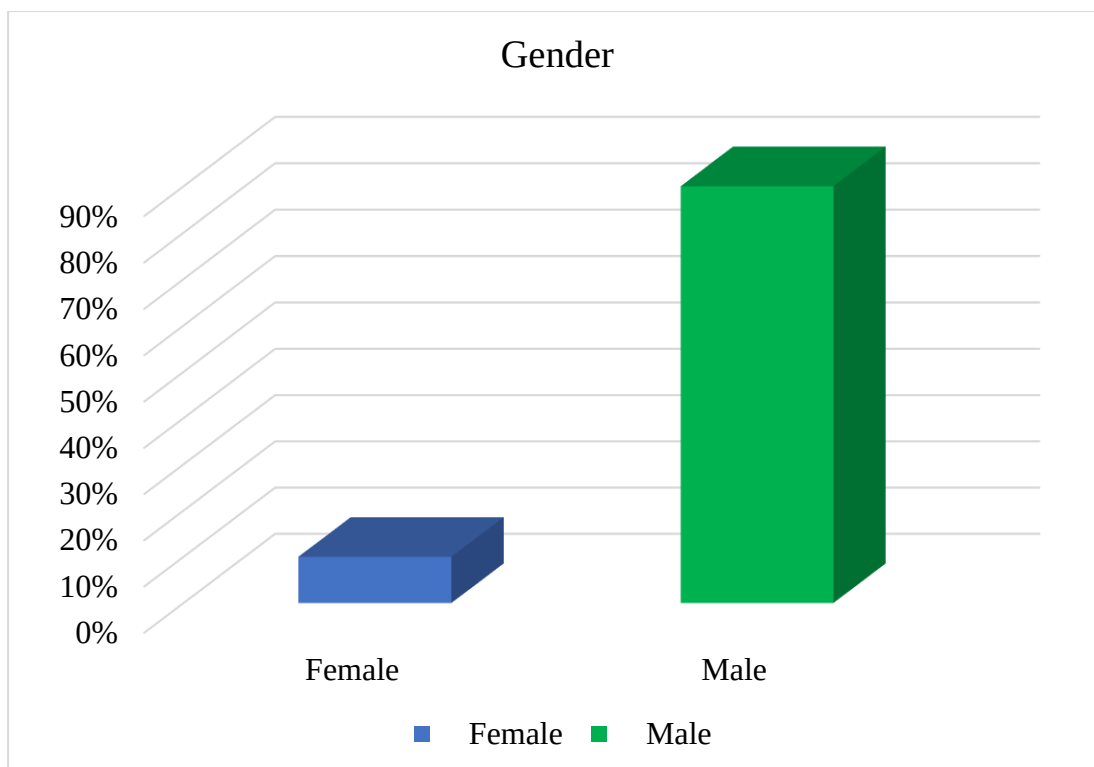


Figure 4.1: The responders' gender profile

Source: Field survey, 2023

In Figure 4.1, the gender profile distribution among potato farmers is illustrated. The data showcases a significant disparity between male and female representation within this demographic. Specifically, males constitute the predominant portion, accounting for 90% of the potato farming population. In contrast, females comprise a notably smaller proportion, representing only 10% of the total.

4.4 Education

The education profile of potato farmers can be categorized into three distinct groups based on their educational background: higher educated, primary, and secondary. Higher Educated farmers likely possess advanced degrees or specialized training relevant to agriculture, which may influence their farming practices and decision-making processes. Primary farmers typically have basic education and may rely on traditional farming methods passed down through generations, while Secondary farmers fall somewhere in between, having completed secondary education but lacking advanced training or specialized knowledge. This segmentation suggests a diverse range of educational backgrounds among potato farmers, potentially influencing

farming techniques, adoption of new technologies, and overall productivity (Sarkar, 2014).

Table 4.2: The responders' educational profile

Education level	Frequency (Percentage)
Primary	19 (9.5)
Secondary	104 (52)
Higher educated	77 (39)

Source: Field survey, 2023

Among the surveyed potato farmers, the majority, comprising 52%, have attained a secondary level of education. This indicates a significant portion of the population has received education beyond the primary level, which could potentially influence their farming practices, decision-making abilities, and engagement with agricultural innovations. Moreover, the data reveals that 39% of potato farmers are categorized as "Higher Educated," suggesting a substantial portion possesses education beyond the secondary level. This higher educational attainment could signify a deeper understanding of agricultural techniques, access to advanced farming resources, and potentially greater adaptability to changing market dynamics. Conversely, a smaller percentage of potato farmers, constituting 9.5%, have received only primary education. While this segment is comparatively minor, it still represents a portion of the farming population that may have different needs, perspectives, and challenges compared to those with higher levels of education. Understanding the educational distribution among potato farmers is crucial for designing targeted interventions, educational programs, and support systems to cater to the diverse needs of this agricultural community.

4.5 Experience

The experience profile of potato farmers segmented into three distinct groups: those with 5-10 years of experience, those with more than 10 years of experience, and those with less than 5 years of experience. Each group likely exhibits different levels of expertise, knowledge, and strategies in potato cultivation, contributing to the diversity

within the farming community. Farmers with 5-10 years of experience may be considered moderately seasoned, having gained practical insights and skills over the years but still open to learning and adaptation (Kumari *et al.*, 2023). Those with over 10 years of experience likely possess extensive knowledge and mastery in potato farming, possibly incorporating advanced techniques and innovations into their practices. Conversely, farmers with less than 5 years of experience may represent a newer generation entering the industry, characterized by enthusiasm, experimentation, and the adoption of modern agricultural technologies to enhance productivity and efficiency (Culas & Pombre, 2023; Mukul *et al.*, 2013).

Table 4.3: The responders' experience profile

Experience in potato cultivation (Years)	Frequency (Percentage)
Below 5	7 (3.5)
5-10	33 (17)
Above 10	160 (80)

Source: Field survey, 2023

Among the surveyed farmers, 33 individuals, constituting 17% of the total, reported having 5 to 10 years of experience in potato cultivation. The majority of farmers, comprising 80% of the respondents, indicated that they have been involved in potato cultivation for more than 10 years, totaling 160 individuals. Additionally, a smaller portion of the respondents, 7 individuals or 3.5%, reported having less than 5 years of experience in cultivating potatoes.

4.6 Family size

Potato farmers' families are categorized into three distinct groups based on their size: large, medium, and small. This classification likely considers factors such as the number of family members involved in farming activities, the scale of agricultural operations, and possibly socio-economic considerations. Large families may have more manpower available for farming tasks, allowing for larger-scale cultivation and management practices. Medium-sized families might strike a balance between labor

availability and farm size, while small families likely operate on a smaller scale with fewer resources at their disposal (Pandit *et al.*, 2010).

Table 4.4: The responders' family size

Family size	Frequency (Percentage)
Large (>6 people)	44 (22)
Medium (3-6 people)	120 (60)
Small (< 3 people)	36 (18)

Source: Field survey, 2023

The distribution of family sizes among potato farmers is presented in Table 4.4. Large families, comprising 44 instances, represent approximately 22% of the total surveyed population. Medium-sized families, constituting the majority with 120 instances, make up around 60% of the surveyed households. Finally, small families, amounting to 36 instances, account for roughly 18% of the surveyed population.

4.7 Employed member

Potato farming operations have organized their labor force into two clear categories based on household size: those with 1-2 members and those with more than 2 members. This division reflects the diverse needs and capabilities within the farming community, with smaller households likely to require less manpower compared to larger ones. The allocation of labor in this manner enables efficient resource utilization and ensures that tasks are appropriately distributed among households according to their capacity. It also underscores the collaborative nature of potato farming, where families work together to maximize productivity while adapting to the specific dynamics of their own households.

Table 4.5: Employed member in household

Employed member in household	Frequency (Percentage)
1-2 Person	192 (96)
Above 2 Person	8 (4.0)

Source: Field survey, 2023

In Table 4.5, the distribution of employed members within potato farmer households is outlined. The data showcases that the majority, specifically 96%, of these households have 1-2 individuals who are employed. This suggests that a significant proportion of potato farming households rely on a relatively small number of members for employment. Conversely, a very small fraction, precisely 4.0%, of these households have more than two individuals employed.

4.8 Land holdings

In the context of potato farming, land holdings among farmers are categorized into three distinct groups based on size. These categories are delineated as follows: farms with land holdings ranging from 2 to 3 hectares, those with holdings exceeding 3 hectares, and farms with land holdings below 1 hectare. This division provides insights into the diversity of land sizes among potato farmers, highlighting variations in scale and potentially impacting agricultural practices, productivity, and economic outcomes (Begum *et al.*, 2018; Peer *et al.*, 2013).

Table 4.6: Land holdings size

Land holdings (ha)	Frequency (Percentage)
Below 1	62 (31)
Above 3	25 (13)
2-3	113 (57)

Source: Field survey, 2023

The distribution of land holdings among potato farmers is outlined in Table 4.6. The table reveals that the majority of potato farmers, comprising 57% of the surveyed population, possess land holdings ranging from 2 to 3 hectares. This indicates a significant portion of farmers operating within this moderate-sized range of agricultural land. Following closely behind, 31% of farmers have smaller land holdings, falling below 1 hectare. Despite constituting a smaller percentage, these farmers still represent a substantial portion of the demographic. Conversely, a comparatively smaller fraction of potato farmers, accounting for 13%, possess land holdings exceeding 3 hectares. This segment likely represents larger-scale agricultural operations within the surveyed population.

4.9 Annual income

The annual income of farmers is categorized into three distinct groups based on the amount earned. These groups are delineated as follows: first, farmers earning below 50,000 Tk; second, those earning between 50,000 and 500,000 Tk; and finally, farmers earning above 500,000 Tk annually (Rahman *et al.*, 2019).

Table 4.7: The responders' annual income

Annual income (Tk)	Frequency (Percentage)
Below 50000	17 (8.5)
50000 - 500000	151 (76)
Above 500000	32 (16)

Source: Field survey, 2023

The Table 4.7 reveals a spectrum of income distribution within this demographic. A notable portion of farmers, constituting 8.5% of the total, reported an annual income below 50,000 Tk. This segment represents individuals facing financial challenges, potentially indicating a struggle to meet basic needs or invest in farm improvements. The majority of potato farmers, comprising a significant 76%, fall within the income bracket of 50,000 to 500,000 Tk annually. This sizable group likely represents the core workforce in the potato farming sector, earning a moderate income sufficient to sustain their livelihoods and possibly reinvest in their farms. Conversely, a smaller yet

noteworthy segment of 16% reports annual earnings surpassing 500,000 Tk. These individuals likely represent a more affluent subset within the potato farming community, potentially characterized by larger land holdings, access to advanced farming techniques, or participation in high-value market segments.

4.10 Source of credit

The farmers' sources of credit are divided into five distinct groups: ASA, Bank, Brac, Friends, and NGO. These diverse sources reflect the multifaceted nature of agricultural income generation, encompassing financial institutions such as banks and microfinance organizations like ASA and Brac, as well as informal networks like friends. Additionally, the involvement of NGOs highlights the role of non-profit organizations in supporting agricultural livelihoods and rural development initiatives. By leveraging these various channels, farmers can access a range of financial resources, assistance programs, and community support networks to sustain and enhance their income-generating activities (Islam, 2020; Miah *et al.*, 2006)

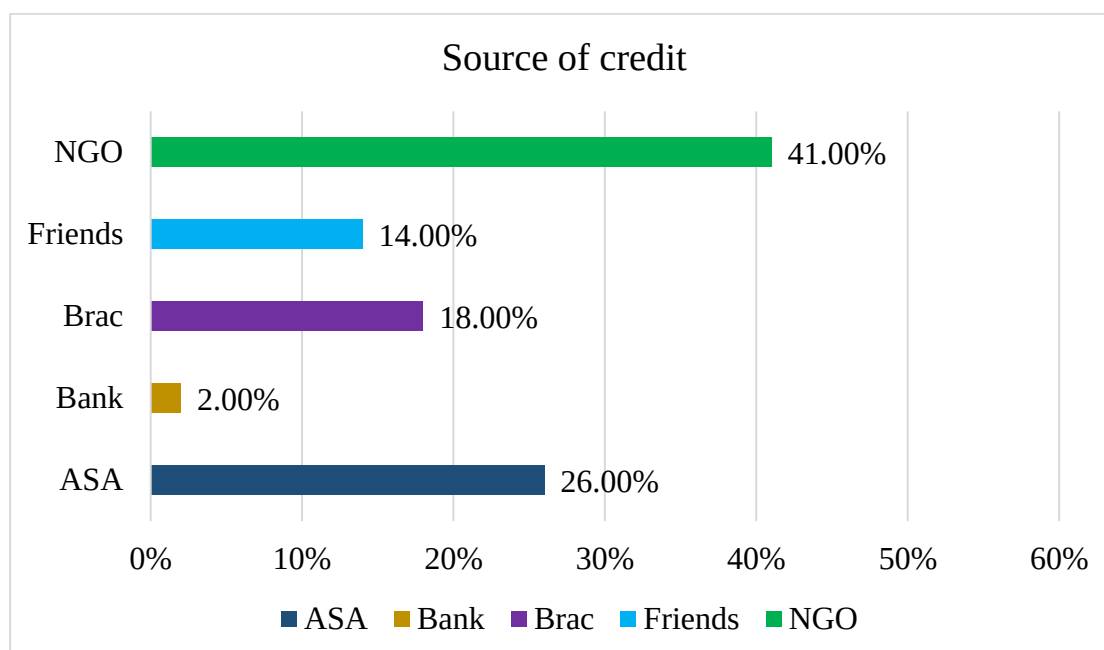


Figure 4.2: The responders' source of credit

Source: Field survey, 2023

In Figure 4.2, the data illustrates the distribution of responders' sources of loans. Among the sources the highest proportion of responders, constituting 41%, acquired their loans from Non-Governmental Organizations (NGOs). This indicates a significant reliance

on NGOs for financial assistance among the respondents. Following NGOs, the next prominent source is ASA, representing 26% of the responders. This suggests that a considerable portion of the respondents sought loans from microfinance institutions like ASA. Brac, another well-known NGO, accounted for 18% of the respondents' loan sources, indicating a notable reliance on this organization as well. Notably, friends also played a substantial role, with 14% of the responders obtaining loans from this informal source. Comparatively, a much smaller percentage, only 2.0%, acquired loans from banks, indicating a lower reliance on traditional banking institutions among the respondents surveyed.

4.11 Soil type

Bogura predominantly features loamy soil, specifically sandy loam. This type of soil composition suggests a mixture of sand, silt, and clay particles, with a higher proportion of sand. Loamy soil is known for its excellent drainage properties, moisture retention, and fertility, making it ideal for agricultural purposes. Sandy loam, in particular, is characterized by its relatively high sand content, contributing to good aeration and water drainage while still retaining essential nutrients for plant growth. The prevalence of loamy soil in Bogura suggests favorable conditions for agriculture and plant cultivation, providing farmers with fertile land that can support a variety of crops (Hoque & Sultana, 2012; Hossain *et al.*, 2014).

Table 4.8: Soil type of the respondents' area

Soil type	Frequency (Percentage)
Loamy Soil	149 (75)
Sandy Loam	51 (25)

Source: Field survey, 2023

In Table 4.8, the soil type distribution of the respondents' areas is presented, revealing a predominant presence of loamy soil, accounting for 149 instances, which corresponds to approximately 75% of the total responses. Following loamy soil, sandy loam emerges as the second most prevalent soil type, with 51 instances, representing approximately 25% of the total responses.

4.12 Distance of NGO office

The distance of NGO offices is categorized into three distinct groups: those located within 1-8 kilometers, those situated between 8-15 kilometers, and those positioned beyond 15 kilometers. This division likely reflects considerations related to accessibility, operational logistics, and community engagement strategies. NGOs located closer to communities they serve less than the 8 kilometer range may benefit from easier access for both staff and beneficiaries, potentially facilitating more direct involvement in local initiatives and projects.

Table 4.9: Distance of NGO office

Distance of NGO office (km)	Frequency (Percentage)
Less than 8	152 (76)
8-15	33 (17)
Above 15	15 (7.5)

Source: Field survey, 2023

The Table 4.9 illustrates that the majority of NGO offices are located relatively close, with 152 offices (76%) situated within a distance of 1 to 8 kilometers. This proximity suggests a concentration of NGO activity within a relatively compact geographical area. However, there are also notable numbers of offices located further away. Specifically, 33 offices (17%) are situated within a distance of 8 to 15 kilometers, indicating a significant but smaller proportion compared to those in closer proximity. Additionally, there are 15 offices (7.5%) located at distances greater than 15 kilometers. This indicates a smaller but still notable presence of NGO offices at more distant locations, which might serve areas where infrastructure or resources are scarcer or where specific needs require targeted attention.

4.13 Distance of DAE office

The distance to the Department of Agricultural Extension (DAE) Office is categorized into three distinct groups: 1-8 kilometers, 8-15 kilometers, and above 15 kilometers. This division likely facilitates logistical planning, resource allocation, and service delivery strategies based on the proximity of agricultural stakeholders to the DAE

Office. By segmenting the distances in this manner, the DAE can tailor its outreach efforts and support services more effectively, considering factors such as transportation accessibility, communication networks, and regional agricultural priorities within each distance range. This approach likely enables the DAE to prioritize interventions, allocate resources efficiently, and enhance agricultural extension services across different geographical areas, ensuring equitable access to support and guidance for farmers and agricultural communities (Khalil *et al.*, 2013; Moniruzzaman *et al.*, 2021).

Table 4.10: Distance of DAE office

Distance of DAE office (km)	Frequency (Percentage)
Less than 8	92 (46)
8-15	88 (44)
Above 15	20 (10)

Source: Field survey, 2023

The distance of the Department of Agricultural Extension (DAE) office is delineated In Table 4.10. The data showcases that the majority of the DAE offices are situated within a relatively close proximity, with 92 instances, constituting 46% of the total, falling within the 1-8 kilometers range. Following closely behind, there are 88 instances, making up 44% of the total, located at distances ranging between 8 to 15 kilometers from their respective locations. Interestingly, a smaller proportion of offices, specifically 20 instances (10% of the total), are positioned at distances exceeding 15 kilometers.

4.14 Distance of input/output market

The distance between farms and input/output markets is categorized into three distinct groups: 1-5 kilometers, 8-12 kilometers, and above 12 kilometers. This classification likely reflects the proximity of farms to key market centers and transportation hubs. Farms located within 1-5 kilometers of the market likely benefit from easier access to both inputs such as seeds, fertilizers, and machinery, as well as outputs such as selling crops or livestock. Those situated within the 8-12 kilometers range may face slightly greater logistical challenges, but still maintain reasonable access to market facilities.

Farms positioned beyond 12 kilometers from the market face a more significant distance barrier, potentially encountering higher transportation costs and logistical complexities in both acquiring inputs and selling produce (Shaheb *et al.*, 2015).

Table 4.11: Distance of input/output market

Distance of input/output market (km)	Frequency (Percentage)
< 5	80 (40)
8-12	70 (35)
> 12	50 (25)

Source: Field survey, 2023

The majority of markets, constituting 40% of the total frequency, are located within a close proximity of 1-5 kilometers. Following this, the next significant portion, accounting for 35%, falls within a slightly farther distance range of 8-12 kilometers. Notably, markets situated at distances exceeding 12 kilometers constitute the smallest proportion, with a frequency of 50, representing 25% of the total.

4.15 Involvement in farmer co-operative society

The involvement in farmer co-operative society can be categorized into two distinct groups: those who involved and those who do not. Those who choose not to engage in cooperative societies may have various reasons, such as a lack of awareness about the benefits, skepticism about the effectiveness of cooperatives, or individual preferences for alternative farming methods or business models. On the other hand, individuals who actively participate in farmer co-operative societies are typically motivated by the advantages offered by such organizations, including collective bargaining power, access to resources, knowledge sharing, and mutual support among members. Their involvement signifies a commitment to collaborative efforts aimed at improving farming practices, enhancing productivity, and fostering socio-economic development within agricultural communities (Msimango & Oladele, 2013; Uwaramutse *et al.*, 2022).

Table 4.12: Involvement in Farmer Co-operative Society

Involvement in farmer co-operative society	Frequency (Percentage)
Involved	23 (11)
Not involved	177 (89)

Source: Field survey, 2023

The data presented in Table 4.12 illustrates the level of involvement in farmer co-operative societies. Out of the total sample size, which appears to be 200 individuals, 177 of them, constituting approximately 89% of the respondents, are actively engaged in Farmer Co-operative Societies. Conversely, 23 individuals, representing about 11% of the surveyed population, indicated no involvement in such cooperatives.

4.16 Member in social organizations

The farmers who are members of social organizations can be categorized into two distinct groups. Firstly, there are those who are not members of such organizations ("No"). These farmers may operate independently or have limited interaction with broader social networks within the agricultural community. Secondly, there are farmers who actively participate in social organizations ("Yes"). These individuals are engaged in community-based or commodity-based groups, which may focus on resource-sharing, market access, knowledge exchange, or advocacy. These organizations play a vital role in empowering farmers, enhancing their collective voice, and addressing common challenges in agriculture (Chamala & Shingi, 1997; Farmer, 2006; Msuta & Urassa, 2015).

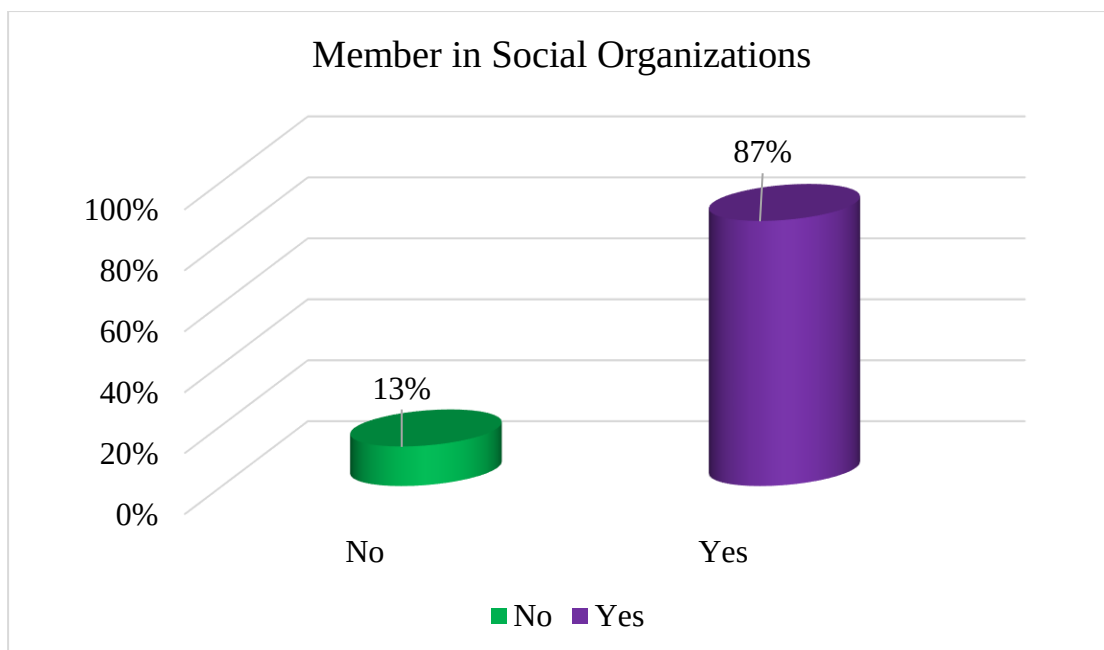


Figure 4.3: Member in social organizations

Source: Field survey, 2023

In Figure 4.3, data pertaining to membership in social organizations is presented. The data illustrates that a significant majority of respondents, comprising 87%, are affiliated with social organizations. Conversely, a smaller proportion, accounting for 13%, indicated no membership in such groups. This suggests a prevalent engagement within the community, with a notable majority actively participating in various social organizations. The high percentage of individuals involved in these groups implies a strong sense of community involvement or interest in social causes among the surveyed population. This data underscores the significance of social networks and communal activities in the lives of those surveyed, highlighting a trend towards active participation and engagement within social circles or organized groups.

4.17 Visit of agricultural extension officer

The visit of agricultural extension officers can be divided into two distinct sections based on whether they visit potato farms or not. When extension officers visit potato farms, they can provide valuable guidance and assistance to farmers, offering insights on best practices, pest management techniques, crop rotation strategies, and the adoption of new technologies. These visits serve as personalized consultations, allowing officers to address specific concerns and tailor their advice to the farmers' individual needs. Conversely, when extension officers do not visit potato farms, farmers

may miss out on crucial information and support that could enhance their productivity and income. Thus, the effectiveness of agricultural extension services in potato farming communities' hinges significantly on the frequency and quality of farm visits conducted by extension officers (Danso-Abbeam *et al.*, 2018).

Table 4.13: Visit of agricultural extension officer

Visit of agricultural extension officer	Frequency (Percentage)
Not visited	82 (41)
Visited	118 (59)

Source: Field survey, 2023

In Table 4.13, data regarding the visit of agricultural extension officers is presented. The table illustrates that out of the total observed instances, which amount to 200 in this case, 118 visits were recorded, constituting approximately 59% of the total. This indicates that a majority of visit from an agricultural extension officer was done. Conversely, in 82 instances, no visit from such officers was reported, representing approximately 41% of the total cases. This result suggests that while a significant portion of cases receive visits from agricultural extension officers, there is still a notable proportion where such visits do not occur.

4.18 Training on potato cultivation

The training on potato cultivation is structured into two sections, distinguishing between those who have undergone training and those who have not. This division likely aims to address the varying levels of knowledge and expertise among potato farmers. Those who have received training are equipped with specialized skills and techniques (Harahagazwe, 2016), potentially leading to higher yields and better crop management practices. On the other hand, farmers who have not undergone training may lack access to crucial information and modern agricultural practices, which could hinder their productivity and overall success in potato cultivation. By offering training programs, agricultural authorities or organizations aim to bridge the knowledge gap and empower farmers with the necessary tools and knowledge to optimize their potato cultivation efforts (Hossain, 2011).

Table 4.14: Training on potato cultivation

Training on potato cultivation	Frequency (Percentage)
No	27 (14)
Yes	173 (87)

Source: Field survey, 2023

The Table 4.14 indicates that out of the total instances recorded, 27 cases, constituting 14% of the total, received no training on potato cultivation. Conversely, the majority, accounting for 173 cases or 87%, had received training in this domain. This result suggests a significant prevalence of individuals who have undergone training in potato cultivation, highlighting the potential emphasis on knowledge and skill development in this agricultural sector.

CHAPTER V

PROFITABILITY OF POTATO PRODUCTION

5.1 Introduction

The profitability analysis of potato production serves as a critical component in understanding the economic dynamics and viability of potato cultivation within the selected areas of Bogura District, Bangladesh. This chapter aims to delve into the financial aspects of potato cultivation, examining the costs involved, revenue generated, and ultimately, the profitability levels achieved by farmers. By conducting a thorough analysis, we seek to gain insights into the economic performance of potato farming enterprises within the study area. Additionally, this chapter endeavors to identify the key determinants of profitability and explore potential strategies for enhancing the economic sustainability of potato production systems.

5.2 Variable cost

The total variable cost for potato production per hectare is documented as Tk 629,253.13. This variable cost encompasses expenses such as seeds, fertilizers, pesticides, labor, and other inputs directly related to the cultivation process. Notably, it constitutes a significant portion, accounting for approximately 85.27% of the total cost. This indicates that the majority of expenses incurred in potato production are associated with variable factors that fluctuate depending on factors such as market conditions, agricultural practices, and input prices.

5.2.1 Seed cost

On potato cultivation one significant component is the seed cost, which amounts to 52 units per kilogram with a total quantity of 1000 kilograms, resulting in a total seed cost of Tk 52000.00. This seed cost accounts for approximately 7.05% of the total cost of potato production. It reflects a crucial initial investment in acquiring the necessary seed stock for planting, constituting a substantial portion of the overall expenditure in the production process. Efficient management of seed costs is essential for optimizing the economic viability and sustainability of potato farming operations.

Table 5.1: Per hectare cost of potato production (Tk)

Cost Item	Unit	Per hectare cost of potato production			
		Unit Price (Tk)	Quantity (Kg)	Total Cost (Tk)	Percentage Of Total Cost
A. Variable Cost				629253.13	85.27
Seed Cost	Kg	52	1000.00	52000.00	7.05
Hired Labor Cost	Man Day	512.59	29.74	15262.60	2.07
Irrigation Cost	Tk			208812.50	28.30
Cost of Pesticides	Tk			273142.50	37.01
Tillage Cost	Tk			11422.50	1.55
Urea Cost	Tk	25	475.94	11898.44	1.61
TSP Cost	Tk	27	285.56	7710.19	1.04
DAP Cost	Tk	21	152.30	3198.30	0.43
MOP Cost	Tk	18	418.82	7538.85	1.02
Bio Fertilizer Cost	Tk	40	19.038	761.50	0.10
Manure Cost	Tk	25	1500.23	37505.75	5.08
B. Fixed Cost	Tk			108725.47	14.73
Family Labor Cost	Man Day	450	16.00	7200.00	0.98
Land Use Cost	Tk			56525.47	7.66
Interest on Operating Capital	Tk		9%	45000.00	6.10
Total Cost (A+B)	Tk			737978.60	100.00

Source: Author's own calculation

5.2.2 Hired labor cost

The unit price for labor was Tk 512.59 per man day. Over the course of production, a total of 29.74-man days are required in potato production, resulting in a total labor cost of Tk 15262.60. This cost represents a relatively small percentage (2.07%) of the overall total cost of potato production. Hired labor is a crucial component in agricultural operations, involving tasks such as planting, harvesting, and general maintenance throughout the growing season.

5.2.3 Irrigation cost

The total cost attributed to irrigation for potato cultivation is Tk 208,812.5, representing 28.30% of the overall expenses incurred in potato production per hectare. This indicates that irrigation constitutes a significant portion of the total expenditure, underscoring its importance in ensuring optimal growth and yield of potato crops.

5.2.4 Cost of pesticides

The total cost of pesticides is recorded as Tk 273,142.50. This expenditure constitutes a significant portion of the overall production cost, accounting for approximately 37.01% of the total cost. This highlights the substantial financial investment required for pesticide usage in potato farming, indicating its importance in ensuring crop health and yield optimization.

5.2.5 Tillage cost

The total cost attributed to tillage stands at Tk 11,422.50, representing approximately 1.55% of the overall expenses associated with potato cultivation per hectare. Tillage costs typically encompass various activities essential for preparing the soil for planting, including plowing, harrowing, and seedbed preparation. While tillage is a fundamental aspect of potato farming, its proportionate share of the total production costs indicates its significance within the broader financial framework of potato cultivation.

5.2.6 Urea cost

The unit price of Urea was Tk 25, with a quantity of 475.94 kilograms used in potato production, resulting in a total cost of Tk 11,898.44. Interestingly, this Urea cost constitutes only a small percentage, specifically 1.61%, of the total production cost.

5.2.7 TSP cost

The unit price is Tk 27 per kg. A quantity of 285.56 kg is required, resulting in a total cost of Tk 7710.19. This represents approximately 1.04% of the total cost.

5.2.8 DAP cost

The unit price is Tk 21 per kg. A quantity of 152.30 kg is needed, resulting in a total cost of Tk 3198.30. This constitutes about 0.43% of the total cost.

5.2.9 MOP cost

The unit price is Tk 18 per kg. A quantity of 418.82 kg is required, resulting in a total cost of Tk 7538.85. This accounts for approximately 1.02% of the total cost.

5.2.10 Bio fertilizer cost

The unit price is Tk 40 per kg. A quantity of 19.03 kg is needed, resulting in a total cost of Tk 761.50. This represents around 0.10% of the total cost.

5.2.11 Manure cost

The unit price is Tk 25 per kg. A quantity of 1500.23 kg is required, resulting in a total cost of Tk 37505.75. This comprises about 5.08% of the total cost.

5.3 Fixed Cost

The total fixed cost for potato production is Tk 108,725.47, representing 14.73% of the total production cost. Fixed costs are significant contributors to the overall expenses incurred in potato farming and play a crucial role in determining the economic viability and profitability of potato cultivation operations.

5.3.1 Family labor cost

Family labor cost is calculated at Tk 450 per man-day, with a total of 16 man-days required, resulting in a total cost of Tk 7200.00. Notably, family labor constitutes 0.98% of the total production cost, indicating its significant contribution to the overall expenses.

5.3.2 Land use cost

The total cost incurred in land use was Tk 56525.47, constituting 7.66% of the total cost.

5.3.3 Interest on operating capital

This represents the interest paid on the capital used for operating expenses related to potato production. The total interest paid is Tk 45000.00, accounting for 6.10% of the total cost.

5.4 Total cost (A+B)

The overall total cost of potato production is Tk 737978.60, representing 100% of the expenses incurred for potato cultivation on a per hectare basis.

5.5 Return

The primary aim of commercial potato cultivation is to generate a profit through the sale of harvested potatoes. To assess the return on potato cultivation, it is necessary to compute both the gross and net returns. The gross return from potato farming involves calculating the revenue generated from selling harvested potatoes. This includes the proceeds from selling potatoes in their fresh or processed forms, as well as any by-products such as potato peels or waste. By considering the total income derived from potato sales, the gross return can be determined.

Table 5.2: Gross return from potato cultivation

Per hectare potato production			
Items	Yield kg/ha	Tk/kg	Tk/ha
Potato	35029.32	28	980821.09
By Product			10000.00
Total			990821.09

Source: Author's own calculation

5.5.1 Gross return

The total yield of potato per hectare is 35029.32 kg or 35.02 ton/ha with the sell value of cost of Tk 28 per kg. The total revenue generated from potato production per hectare is Tk 990,821.09.

5.5.2 Gross margin

After subtracting the cost of production, the gross margin stands at Tk 361,567.97. This represents the profit before considering other expenses.

5.5.3 Net return

After deducting all costs including production expenses, the net return is Tk 252,842.49. This reflects the final profit or income realized from potato cultivation per hectare.

Table 5.3: Gross margin, net return, and benefit cost ratio of per hectare potato production

Margins & Returns	Per hectare potato production
A. Gross return	990821.09
B. Total variable cost	629253.12
C. Total cost	737978.56
D. Gross margin (A-B)	361567.97
E. Net return (A-C)	252842.49
F. Return per taka invested (Total cost basis) A/C	1.34

Source: Author's own calculation

5.5.4 Benefit cost ratio

The return per taka invested is noted as 1.34. This indicates that for every unit of taka invested, the return is 1.34. This ratio suggests the efficiency or profitability of investing in potato production, indicating that for each taka spent, the return is 1.34.

CHAPTER VI

TECHNICAL EFFICIENCY AND RESOURCE USE

EFFICIENCY OF POTATO CULTIVATION

6.1 Introduction

Efficiency in agricultural production is imperative for ensuring food security, economic sustainability, and environmental conservation, particularly in regions like Bogura district in Bangladesh, where potato cultivation plays a significant role in the agricultural landscape. Understanding the technical efficiency and resource use efficiency of potato production in this context is crucial for identifying potential areas for improvement and informing policy interventions aimed at enhancing agricultural productivity and livelihoods of farmers. In this chapter, we delve into an in-depth analysis of the technical efficiency and resource use efficiency of potato cultivation in selected areas of Bogura district. Technical efficiency refers to the ability of farmers to maximize output given a set of inputs, while resource use efficiency involves the optimal allocation and utilization of resources such as land, labor, capital, and technology in potato production. By employing robust econometric techniques such as stochastic frontier analysis (SFA) and data envelopment analysis (DEA), we aim to evaluate the efficiency levels of potato farmers, identify the determinants of inefficiency, and assess the impact of various factors such as farm size, education level of farmers, access to credit, and adoption of modern agricultural practices on efficiency levels.

6.2 Interpretation of stochastic frontier production function

The first thing to do when making a maximum likelihood guess is to come up with a math equation called the Likelihood Function for the sample information. This equation helps figure out how likely it is to get a certain set of data, based on a chosen probability model. We don't know the exact values for certain parts of this model. The maximum likelihood guesses, called MLEs, are the values for these parts that make the sample data the most likely.

For the production of potato by farmers, the maximum likelihood estimates for the parameters of the Cobb-Douglas production function with stochastic frontier and the technological inefficiency impact model are shown in Table 6.1.

6.2.1 Cost of hired labor (X_1)

The regression coefficient of hired labor cost (X_1) of potato production was negative and significant at 0.1% level of significance which indicates that if expenditure on land preparation was increased by 1% keeping other factors constant, revenue of potato would be decreased by 0.099%.

6.2.2 Cost of irrigation(X_2)

The regression coefficient of irrigation cost (X_2) of potato production was positive and significant at 0.1% level of significance which indicates that if expenditure on land preparation was increased by 1% keeping other factors constant, revenue of potato would be increased by 1.269%.

6.2.3 Cost of insecticide/pesticides(X_3)

The regression coefficient of insecticide/pesticide cost (X_3) of potato production was negative and significant at 0.1% level of significance which indicates that if expenditure on land preparation was increased by 1% keeping other factors constant, revenue of potato would be decreased by 0.225%.

6.2.4 Tillage cost (X_4)

The regression coefficient of tillage cost (X_4) of potato production was positive and significant at 0.1% level of significance which indicates that if expenditure on land preparation was increased by 1% keeping other factors constant, revenue of potato would be increased by 0.120%.

6.2.5 Cost of urea (X_5)

The regression coefficient of urea cost (X_5) of potato production was positive and significant at 0.1% level of significance which indicates that if expenditure on land preparation was increased by 1% keeping other factors constant, revenue of potato would be increased by 0.051%.

Table 6.1: Parameters of Stochastic Frontier Production Function for potato production

Independent variables	Coefficient	Standard Error	p-value	Sig
Stochastic Frontier				
Cost of hired labor (X ₁)	-.099	.023	0.000	***
Cost of irrigation(X ₂)	1.269	.058	0.000	***
Cost of insecticide/pesticides(X ₃)	-.225	.029	0.000	***
Tillage cost (X ₄)	.12	.025	0.000	***
Cost of urea (X ₅)	.051	.019	.006	***
Cost of TSP (X ₆)	-.038	.024	.117	
Cost of DAP (X ₇)	-.045	.027	.092	*
Cost of MOP (X ₈)	.001	.022	.978	
Cost of biofertilizer(X ₉)	-.075	.013	0.000	***
Cost of manure (X ₁₀)	-.075	.013	0.000	***
Constant	5.574	.249	0.000	***
Inefficiency Model				
Constant	-5.491	.119	0.000	***
Age (Z ₁)	-.002	.029	.935	
Education (Z ₂)	-.071	.092	.44	
Family size (Z ₃)	.107	.173	.535	
Distance of NGO (Z ₄)	-.027	.041	.508	
Member of cooperation society (Z ₅)	-.321	.696	.644	
Experience (Z ₆)	.028	.046	.546	
Membership in social organization (Z ₇)	.102	.792	.897	
Visited by extension Officer (Z ₈)	-1.979	.929	.033	**
Training received (Z ₉)	-.363	.725	.616	
Distance of DAE office (Z ₁₀)	-.097	.096	.316	
Distance of Market (Z ₁₁)	-.367	.099	0.000	***
$\sigma_s^2 = \sigma_v^2 + \sigma_u^2$	0.0038689			***
$\gamma = \sigma_u^2 / \sigma_s^2$	0.9204165			***
Log Likelihood Function	250.36			

Source: Author's own calculation

6.2.6 Cost of DAP (X₇)

The regression coefficient of DAP cost (X₇) of potato production was negative and significant at 10% level of significance which indicates that if expenditure on land

preparation was increased by 1% keeping other factors constant, revenue of potato would be decreased by 0.045%.

6.2.7 Cost of biofertilizer (X_9)

The regression coefficient of biofertilizer cost (X_9) of potato production was negative and significant at 0.1% level of significance which indicates that if expenditure on land preparation was increased by 1% keeping other factors constant, revenue of potato would be decreased by 0.075%.

6.2.8 Cost of manure (X_{10})

The regression coefficient of manure cost (X_{10}) of potato production was negative and significant at 0.1% level of significance which indicates that if expenditure on land preparation was increased by 1% keeping other factors constant, revenue of potato would be decreased by 0.083%.

6.3 Interpretation of technical inefficiency model for potato farmer

6.3.1 Age (Z_1)

The negative but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.2 Education (Z_2)

The negative but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.3 Family size (Z_3)

The positive but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.4 Distance of NGO (Z_4)

The negative but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.5 Member of cooperation society (Z₅)

The negative but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.6 Experience (Z₆)

The positive but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.7 Membership in social organization (Z₇)

The positive but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.8 Visited by extension Officer (Z₈)

The negative coefficient of extension officer visit implies that farmers whose farm visited by extension officer are technically more efficient than others, although the regression coefficient of extension officer visit is significant with 5% level.

6.3.9 Training received (Z₉)

The negative but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.10 Distance of DAE office (Z₁₀)

The negative but insignificant coefficient of total land size implies that this factor has no impact on technical inefficiency. This factor does not reduce or increase technical inefficiency of potato farming.

6.3.11 Distance of Market (Z₁₁)

The negative coefficient of market distance implies that farmers who live within a short distance of the market are technically more efficient than others, although the regression coefficient of market distance is significant with 0.1% level.

6.3.12 γ -parameter

The γ -parameter associated with the variance in the stochastic production frontier model is estimated to be close to one (0.9204165) and highly significant. Although the γ -parameter cannot be interpreted as the proportion of the total variance explained by the technical inefficiency effects, the result indicates that technical inefficiency effects do make a significant contribution to the level and variation of potato production in the study area.

6.4 Distribution of technical efficiency

The distribution of technical efficiency among potato farmers presented in Table 6.2. The efficiency levels are categorized into three ranges: 50-80%, 81-90%, and 91-100%. Within these ranges, there are respective counts of farmers and their percentages. For the 50-80% efficiency range, there are 41 farmers, constituting 20.5% of the total. In the 81-90% range, there are 103 farmers, accounting for 51.5% of the total. The highest efficiency range, 91-100%, comprises 56 farmers, making up 28% of the total. The minimum value recorded is 68.00, while the maximum value reaches 99.00. On average, the efficiency stands at 86.99. Additionally, the standard deviation (SD) is calculated to be 8.29.

Table 6.2: difference between frequency distribution of technical efficiency of potato farmer

Efficiency (%)	No. of farmers	Percentage of farmers
50-80	41	20.5
81-90	103	51.5
91-100	56	28
Total	200	100
Minimum	68.00	
Maximum	99.00	
Average	86.99	
SD	8.29	

Source: Author's own calculation

Regarding the SFA technique, the majority of farms 89% fall into the (70–100%) efficiency class and are technologically efficient, whereas 11% of farms are in the (1–69%) efficiency class. Regarding AE, 32% of farms are in the 1–69% efficiency class, and 68% of farms are in the 70–100% efficiency class. Regarding EE, 36 percent of farms are in the 70–100% efficiency class, and 64 percent are in the 1–69% efficiency class. There are large differences in farm efficiency. The computed average of allocative, technical, and economic efficiencies shows that there are significant allocative, technical, and economic inefficiencies in potato cultivation, and that production can be raised by increasing efficiency. As can be seen, TE has the greatest mean value whereas EE has the lowest (Sultana *et al.*, 2023). It has been noted that the Bamyan Province average technical efficiency of potato farmer is roughly 71.5%. It indicates that farmers can improve their technical efficiency by an average of 28.5% if they make the best use of their inputs and adhere to management principles. The technological efficiency ranges from 26.9% at the lowest to 92.7% at the highest, meaning that there is a 65.8% gap between the most and least efficient producers of potatoes. A mere 1.04% of farmers have attained technological efficiency levels exceeding 90%. It is evident that not a single farmer was able to reach maximum technical proficiency (Hakimi *et al.*, 2023).

6.5 Resource use efficiency

In Table 6.3, the Marginal Value Products (MVP) and Marginal Factor Cost (MFC) of various inputs within the production function are outlined. Costs incurred are as follows: hired labor (14,749.43) with an MVP/MFC ratio of -2.3, indicating over-utilization; irrigation (166,566.87) with a ratio of 2.6, also over-utilized; insecticides/pesticides (18,229.34) with a ratio of -4.2, indicating excessive use; tillage (9,114.67) with a ratio of 4.4, again over-utilized; urea (9,494.45) with a ratio of 1.8, showing over-use; TSP (6,152.4) with a ratio of -2.1, signifying over-utilization; DAP (2,552.11) with a ratio of -5.9, indicating over-utilization; MOP (6,015.68) with a ratio of 0.1, slightly over-utilized; biofertilizer (607.64) with a ratio of -41.5, showing significant over-utilization; and manure (303.82) with a ratio of -83.0, indicating severe over-utilization. These findings highlight the need for more efficient resource management in potato farming to reduce costs and improve productivity.

Table 6.3:: Marginal Value Products (MVP) And Marginal Factor Cost (MFC) of different inputs included in production function

Variables (Quantity)	Potato production					
	Geometric mean	Co-efficient	MVP	MFC	MVP/MFC	Comment
Gross Return (Y)	336283.00					
Cost of hired labor (X ₁)	14749.43	-0.099	-2.26	1	-2.3	Over-utilization
Cost of irrigation(X ₂)	166566.87	1.269	2.56	1	2.6	Over-utilization
Cost of insecticide/pesticides(X ₃)	18229.34	-0.225	-4.15	1	-4.2	Over-utilization
Tillage cost (X ₄)	9114.67	0.12	4.43	1	4.4	Over-utilization
Cost of urea (X ₅)	9494.45	0.051	1.81	1	1.8	Over-utilization
Cost of TSP (X ₆)	6152.4	-0.038	-2.08	1	-2.1	Over-utilization
Cost of DAP (X ₇)	2552.11	-0.045	-5.93	1	-5.9	Over-utilization
Cost of MOP (X ₈)	6015.68	0.001	0.06	1	0.1	Over-utilization
Cost of biofertilizer(X ₉)	607.64	-0.075	-41.51	1	-41.5	Over-utilization
Cost of manure (X ₁₀)	303.82	-0.075	-83.01	1	-83.0	Over-utilization

Source: Author's own calculation

To optimize potato revenue, it is crucial to reassess the utilization of various inputs. Among these, the costs of hired labor (X₁), irrigation (X₂), insecticide/pesticides (X₃), tillage (X₄), urea (X₅), TSP (X₆), DAP (X₇), biofertilizer (X₉), and manure (X₁₀) are

currently underutilized. Enhancing the utilization of these inputs can significantly improve revenue generation for potato farmers. Conversely, the cost of MOP (X_8) is being overutilized, thereby diminishing its efficiency in contributing to revenue. By reducing the utilization of MOP and reallocating resources towards underutilized inputs, potato farmers can optimize their operations and maximize profitability.

CHAPTER VII

SUMMARY, CONCLUSION & RECOMMENDATIONS

7.1 Summary

Potatoes are the world's fourth most important food crop, followed by rice, maize, and wheat. They are a staple crop in many parts of the world and a crucial part of the global food supply. In Bangladesh, potatoes are considered a crop with great promise for addressing the challenges of the twenty-first century. They make up 55% of Bangladesh's total vegetable production and are grown daily due to appropriate cultivars, different production packages, and consistent input supply. In Bangladesh, potatoes are comparable to rice and wheat in terms of nutrients and are easily assimilated. The environment is ideal for potato growing, with plenty of sunshine, well-fertilized soil, and adequate moisture content. The total area planted to potatoes in FY 2021–22 is 4,64,011 hectares, up from 4,68,680 hectares in FY 2020–21. Potatoes have grown in importance as a food crop for food security in recent years, particularly during periods of severe monsoon flooding. The only crop whose seed is maintained in cold storage so that it can be planted right away following flooding is potatoes. In Bangladesh, potatoes are the second most significant crop in terms of consumption in some regions, after rice. Growing potatoes is quite profitable and gives farmers a source of income. Potatoes have more potential to improve food security and reduce poverty in Bangladesh. Potato production has seen a steady increase due to urbanization, nutritional changes, and population growth. This growth is projected to occur at a pace of 1.25% annually, with potatoes having the potential to improve food security and provide revenue for smallholder farmers. However, potato production faces several obstacles, including abiotic variables such as soil salinity and temperature fluctuations, climate change, poor irrigation techniques, limited access to resources and technology, and the absence of machinery and sophisticated farming practices. Smallholder potato farmers often lack access to improved technologies, sufficient extension services, road networks, infrastructure, or market facilities, leading to lower productivity, profitability, and inefficient resource use. Sustainable growth of potato production depends on efficient use of resources, which can be achieved through better agricultural practices, increased access to resources, and increased adoption of technology. In developing countries like South Africa, potato production is susceptible to shocks, inefficient use

of inputs, and technological limitations. By improving resource utilization efficiency, farmers can avoid adverse environmental effects, lower production costs, and maximize yields. To guarantee higher-quality revenues and finance their expanded access to technology, it is crucial to strengthen and establish market involvement of potato farmers. This study investigates the socioeconomic aspects of potato farming in Bangladesh, focusing on farmers' socio-economic characteristics, profitability, technical efficiency, resource efficiency, and recommendations for interventions to increase potato production, aiming to improve resource efficiency.

This study focuses on the potato cultivation in six Upazilas in Bogura district namely Shibganj, Sonatola, Shariakandi, Dhunat, Nandigram, and Kahalu. These Upazilas are crucial for efficient potato production and serve as vital hubs for the region's agricultural economy. Survey research was used to gather data from a predefined group of respondents through standardized questionnaires or interviews. The researcher engaged with potato farming proprietors in these areas, distributing questionnaires and conducting interviews. A multi-sampling technique was employed to select a representative sample of 200 potato farmers, ensuring diversity across various regions and farming practices. The sample size of 200 was chosen to balance statistical significance and practical feasibility. In-person interviews were conducted from December 2022 to January 2023 to gather data for the current study. Data processing involved tabulation, which organized raw data into numbers and categorized them for easier comparison and analysis. The researcher then put the interview data into a computer program called STATA and used various math methods to find the desired results. Analytical techniques were employed to analyze the data, including tabular technique and functional technique. Tabular technique simplifies the comprehension of information by organizing data in a structured format using rows and columns. This method aids in quantitative and qualitative analysis, as well as temporal and spatial assessments. The profitability equation was developed to evaluate the profitability of potato farms. Technical efficiency refers to how well a farm can make the most stuff with its resources and tools. A company is technically efficient if it operates at the best point possible, using the best ingredients for the process. The stochastic frontier model was used to determine the effectiveness of a business by considering both known and unknown errors, mistakes in measurement, and random events. This approach allows for more accurate results and considers factors that can affect a business's performance.

Overall, the study aimed to understand the factors that contribute to a business's success and provide valuable insights for future research. Resource use efficiency (RUE) is determined by the ratio of marginal value product (MVP) to marginal factor cost (MFC) approaching one, or when MPV and MFC are equal for every input. The optimal factor use is indicated by a ratio equal to one, indicating that using more of the resource could increase the gross return.

The majority of potato farmers, comprising 44% of the population, fall into the middle age category, with the older age group comprising 50% of respondents. The gender distribution is significant, with males accounting for 90% of the population. 52% of farmers have attained a secondary level of education, with 39% being "Higher Educated." The majority of farmers have 5 to 10 years of experience in potato cultivation, with 80% having been involved for more than 10 years. Family sizes are large, medium-sized, and small. 96% of potato farming households have 1-2 employed members, while 4.0% have more than two. The majority of farmers have land holdings ranging from 2 to 3 hectares, with 31% having smaller holdings below 1 hectare. A small fraction of farmers has land holdings exceeding 3 hectares. The income distribution is diverse, with 8.5% reporting an annual income below 50,000 Tk, 76% falling within the 50,000 to 500,000 Tk range, and 16% reporting annual earnings exceeding 500,000 Tk. These individuals represent a more affluent subset within the potato farming community. The data shows that 41% of respondents received loans from Non-Governmental Organizations (NGOs), with ASA representing 26%. Friends also played a significant role, with 14% obtaining loans from informal sources. Banks were the least reliant, with only 2.0%. The soil type distribution showed a predominant presence of loamy soil, followed by sandy loam. The majority of NGO offices were located relatively close, with 152 offices (76%) within 1 to 8 kilometers. The Department of Agricultural Extension (DAE) offices were also located within a relatively close proximity, with 92 instances (46%) within 1-8 kilometers. The majority of markets were located within a close proximity of 1-5 kilometers, with 35% falling within 8-12 kilometers. At least 89% of respondents are actively engaged in Farmer Co-operative Societies, with 177 active members. A significant majority of respondents are affiliated with social organizations, with 87% actively participating in these groups. A significant proportion of cases receive visits from agricultural extension officers, with 118 visits recorded. A significant number of cases received training on potato

cultivation, with 87% receiving training. This highlights the importance of knowledge and skill development in the agricultural sector.

The total variable cost for potato production per hectare is Tk 629,253.12, accounting for 85.27% of the total cost. This includes expenses such as seeds, fertilizers, pesticides, labor, and other inputs related to the cultivation process. The seed cost is a significant component, accounting for 7.05% of the total cost. Labor costs are relatively small, accounting for 2.07% of the total cost. Irrigation costs account for 28.30% of the total expenditure, while pesticides account for 37.01%. Tillage costs are 1.55% of the overall expenses, accounting for 1.55% of the total costs. Urea costs are 1.61% of the total production cost, while fixed costs account for 14.73%. Family labor costs are 98% of the total production cost, accounting for 98% of the total costs. Land use costs account for 7.66% of the total cost, and the total revenue generated from potato production per hectare is Tk 990,821.09. The gross margin is Tk 361,567.97, and the net return is Tk 252,842.49. The return per taka invested is 1.34 units, indicating the efficiency or profitability of investing in potato production.

The study examines the technical inefficiency of potato farming, focusing on factors such as hired labor, irrigation, insecticide/pesticides, tillage, urea, DAP, biofertilizer, and manure. The regression coefficients show that increased expenditure on land preparation would decrease potato production revenue by 0.099%, 1.269%, 0.225%, 0.120%, 0.051%, 0.045%, 0.075%, and 0.083%. The study also considers factors like age, education, family size, distance of NGO, cooperation society, experience, membership in social organization, extension officer visit, training received, distance of DAE office, and market distance. The distribution of technical efficiency among potato farmers is presented in Table 6.2, with efficiency levels categorized into three ranges: 50-80%, 81-90%, and 91-100%. The study finds that the cost of hired labor with an MVP/MFC ratio of -2.3, indicating over-utilization; irrigation with a ratio of 2.6, also over-utilized; insecticides/pesticides with a ratio of -4.2, indicating excessive use; tillage with a ratio of 4.4, again over-utilized; urea with a ratio of 1.8, showing over-use; TSP with a ratio of -2.1, signifying over-utilization; DAP with a ratio of -5.9, indicating over-utilization; MOP with a ratio of 0.1, slightly over-utilized; biofertilizer with a ratio of -41.5, showing significant over-utilization; and manure with a ratio of -83.0, indicating severe over-utilization. These findings highlight the need for more

efficient resource management in potato farming to reduce costs and improve productivity.

7.2 Conclusion

This study investigates the socio-economic characteristics of potato farmers in Bogura District, Bangladesh, focusing on their decision-making processes and overall performance. The socio-economic analysis reveals that farmers' demographic composition, educational levels, landholding sizes, and access to agricultural inputs significantly influence their decision-making. Despite challenges like fluctuating market prices and input costs, potato cultivation remains a viable option for farmers in Bogura District. However, continuous monitoring and adaptation to market dynamics are needed to sustain profitability. The technical efficiency of farmers is assessed using frontier production functions, revealing variations in efficiency, highlighting areas for improvement. Inefficiencies in resource utilization are identified, which can be addressed through targeted interventions like training programs, access to credit facilities, and precision agriculture techniques. The study recommends several interventions to improve production practices, enhance technical efficiency, and ensure sustainable growth in potato cultivation. These may include promoting farmer education, facilitating access to modern agricultural technologies, strengthening market linkages, and supporting research and development initiatives.

7.3 Recommendations

Enhance access to agricultural inputs and credit

Develop and implement programs that offer subsidized agricultural inputs and low-interest loans tailored for small and medium-sized potato farmers. Collaborate with agricultural cooperatives and local financial institutions to streamline the credit disbursement process.

Implement training and extension services

Organize regular training sessions and field demonstrations on modern potato farming techniques, pest management, and post-harvest handling. Employ agricultural extension officers to provide continuous support and guidance to farmers.

Promote mechanization and modern farming techniques

Facilitate access to affordable farming machinery, such as planting and harvesting equipment, through government subsidies or rental services. Encourage the adoption of precision agriculture technologies to optimize resource use and increase yields.

Strengthen market linkages and price support mechanisms

Establish farmer-producer organizations (FPOs) to collectively market produce and negotiate better prices. Develop infrastructure for cold storage and transportation to maintain the quality of potatoes and reduce post-harvest losses. Implement minimum support prices (MSPs) to protect farmers from market price fluctuations.

Conduct regular assessments and monitoring

Set up a system for regular monitoring and evaluation of potato farming practices and outcomes. Use this data to identify areas for improvement and to tailor support programs. Collaborate with research institutions to develop and refine methodologies for assessing technical and resource efficiency in potato cultivation.

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APPENDIX

Appendix I : Interview Schedule

PROFITABILITY AND TECHNICAL EFFICIENCY OF POTATO PRODUCTION IN SOMESELECTED AREAS OF BOGURA DISTRICT IN BANGLADESH

Sample No.

Date: _

General information:

Name: Upazilla:.....

District:.....Contact

No.:.....

Gender: ☐ Male (1) ☐ Female (2)

Respondent's profile:

Sl. No.	Relationship	Age(yrs)	Education(yrs)	Occupation	
				Primary	Secondary: Yes= 1, No= 2
1	Self				
2	Spouse				
Family Size(member)					
Employed Members of the Household					
Unemployed Members of the Household					

*Educational Status: 1= Illiterate, 2= Primary; 3= SSC; 4= HSC

*Occupation: 1 =Agriculture, 2= service, 3=business, 4= unemployed, 5=others

Farm Size:

Land Type	Area(Decimal)
Net cultivation land	
Leased in land	
Leased out land	
Mortgage in	
Mortgage out	
Potato cultivation land	

1. Source of Income

Agricultural Service:

Sector	Income per year(Tk)
Crop	
Poultry	
Animal production	
Fisheries	

Nonagricultural Service:

Sector	Wage/day	Income per year (Tk)
Day labor		
Rickshaw puller		
Construction worker		
Tailoring		
Shop keeping		
Others (if any)		

2. Credit Access: (sources of credit facilities)

Sources of credit	Loan Amount	Duration of finance(years)	Rate of interest	How much interest did you pay?	Outstanding amount
Commercial banks					
Agricultural bank					
NGOs					
Govt. credit					
Relatives					
Friends					
Money Lender					
Others					

3. Annual Income:

Agricultural source Tk

Non Agricultural source (if any).....Tk

4. Annual expenditure:

Consumption expenditure Tk/yr

Non consumption expenditure Tk/yr

5. Do you have off-farm income source? Yes () NO ()
6. Do you have livestock? Yes () NO ()
7. Do you have formal bank in your village? Yes () NO ()
8. Distance of bank from your house? Km
9. Distance of NGO from your house? Km
10. Do you have relatives working in bank / NGO? Yes() NO ()
11. Do you belong to any potato related co-operative/association? YES () NO()
12. Years of experience (How long have you been in Potato farming)?
.....
13. Do you have membership in any social organization? YES () NO ()
14. Have you ever been visited by an extension agent? YES () NO ()
18. If yes, how many times in last one year?
19. Do you received any training for Potato cultivation? YES () NO ()
20. If yes,
- ✓ How many times.....
 - ✓ How many days.....

21.Distance of your farm land from DAE office KM

22.Distance of your farm land from Market..... KM

A. INFORMATION ON INPUTS

23. Planting time:

24. Month.....

25. Week.....

26. Variety Name.....

27. Soil Type.....

28. Source of Seed

Source	Kg	Tk/Kg
a) Home		
b) Purchase		

29. Cost of cultivation of crop

A. Human Labor cost (Per unit area):

Total Number of labors Hired potato Production

	Operations	Human labor (Hrs./Days)		Price/wage
		Family	Hired	
01.	Land preparation			
02.	Planting			
03.	Fertilize application			
04.	Intercultural operation			
05.	Insecticide application			
06.	Harvesting			
07.	Others			

Wage rate: (i)Male.....taka/day(ii)Female... taka/day(iii)Children...
..... taka/day

A) Material cost (Per unit area)

Irrigation cost:

Irrigation cost(tk)	
No of irrigation given	

Cost of Pesticides:

Pesticides\ Insecticide cost	
No of application	
Others cost related with pesticides\insecticide	

Tillage cost/Power use for land preparation per acre:

Category of plow	Taka
Country	
Plow/Bullock	
Power tiller	
Tractor	

Fertilizer cost

Fertilizer name	Amount	Taka\Rate
UREA		
TSP		
DAP		
MOP		
Bio fertilizer		
Manure		
Others		

$$\text{Input cost} = \text{Quantity} \times \text{Price}$$

15. Rest:**Production in survey area:****Total production cost tk****Selling price of potato tk/kg**

Product	KG	TK/KG
Main product		
By Product (Straw)		

Constraints of Potato production

- 1.
- 2.
- 3.
- 4.
- 5.

Suggest possible solution to the constraints in Potato production

- 1.
- 2.
- 3.
- 4.

Do you have access to electricity and solar energy

- a. Electricity
- b. No electricity but have solar energy
- c. No electricity

Do you have access to mobile phone

- d. Access to mobile phone
- e. No access to mobile phone

Do you have access to internet

- f. Access to internet
- g. No access to internet

Name of the enumerator:

Signature:

Thanks for your kind co-operation

Appendix II: Images of data collection



Appendix III: Stochastic frontier output

tstrev	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
hired_labour_cost	-.099	.023	-4.32	0	-.144	-.054	***
Irrigation_cost	1.269	.058	21.93	0	1.155	1.382	***
Pesticide_cost	-.225	.029	-7.81	0	-.282	-.169	***
tillage_cost	.12	.025	4.90	0	.072	.169	***
Total_urea_cost	.051	.019	2.73	.006	.014	.087	***
total_TSP_cost	-.038	.024	-1.57	.117	-.086	.01	
Total_DAP_cost	-.045	.027	-1.69	.092	-.098	.007	*
totsl_MOP_cost	.001	.022	0.03	.978	-.042	.043	
total_biofertilize~t	-.075	.013	-5.85	0	-.1	-.05	***
total_manure_cost	-.083	.013	-6.39	0	-.108	-.057	***
Constant	5.574	.249	22.41	0	5.086	6.061	***
Constant	-5.491	.119	-46.17	0	-5.724	-5.258	***
Age	-.002	.029	-0.08	.935	-.059	.054	
Education	-.071	.092	-0.77	.44	-.251	.109	
Family_Size	.107	.173	0.62	.535	-.232	.447	
Distance_of_NG O	-.027	.041	-0.66	.508	-.108	.054	
Member_of_coop erat~i	-.321	.696	-0.46	.644	-1.685	1.043	
Experience	.028	.046	0.60	.546	-.063	.119	
membership_in_so ci~o	.102	.792	0.13	.897	-1.45	1.654	
visited_by_extensi ~t	-1.979	.929	-2.13	.033	-3.8	-.158	**
training_received	-.363	.725	-0.50	.616	-1.785	1.058	
Distance_of_DAE _of~e	-.097	.096	-1.00	.316	-.286	.092	
Distance_of_Mark et	-.367	.099	-3.70	0	-.562	-.173	***
Constant	-1.675	2.011	-0.83	.405	-5.618	2.267	
Mean dependent var		12.784	SD dependent var		0.665		
Number of obs		200	Chi-square		14132.441		
Prob > chi2		0.000	Akaike crit. (AIC)		-452.701		

*** $p < .01$, ** $p < .05$, * $p < .1$