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Assessing the economic viability of onion production across various land tenure systems in Pabna District

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ABSTRACT

This research investigates the land tenurial arrangements, input usage, profitability and challenges faced by onion farmers in some selected areas of Pabna district. The research employs Cobb-Douglas production function model to analyze data from 120 sample farmers, categorized into three tenurial groups namely, owner, owner-cum-tenant and tenant operators. Findings reveal disparities in annual incomes, farm sizes, input utilization and profitability among these groups. Owner farmers typically experience higher levels of income and operate larger farms; however, they also face increased input expenditures. Benefit Cost Ratio (BCR) for onion were 1.92, 1.87, 1.80 for owner, owner-cum-tenant and tenant farmers, respectively which implies that one-taka investment in onion production generated Tk. 1.92, Tk. 1.87, Tk. 1.80 for respective tenurial groups which demonstrate profitability in onion production for all groups. The profitability of owner farmers is significantly higher than the tenant farmers. The result also showed that human labor, seed, urea, TSP and irrigation have significant effects on onion production. Owner-cum-tenant and the tenant farmer's realized reduced total output compared to owner farmers, holding other variables constant. Onion farmers also face some challenges related to seed quality, storage, operating capital, and irrigation costs. To enhance onion production and tenant performance, public and private interventions are recommended.

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I. INTRODUCTION

Land is the most important asset for the people of Bangladesh, with the majority of households relying on land-based activities (especially agriculture) for their livelihood. Land tenure refers to the arrangements (i.e., rules, institution, and process) through which people gain legitimate access to land (Islam and Maharjan, 2014) while the land tenure system outlines the legal and customary relationships between land, cultivators and other stakeholders. It regulates land ownership, control and use and methods of cultivation as well as socio-economic incentives available to farmers. As a key factor in agricultural development, it significantly affects productivity and the distribution of benefits (Ahmed and Billah, 2018). Resource use and production across different land tenure groups in developing countries are widely debated topic in development literature (Haque and Jinan, 2017). When households are unable to cultivate their own land, they often turn to working on or sharecropping land owned by others (Tenaw *et al.*, 2009). Various forms of land tenure arrangements play a crucial role in providing rural households with access to land. Typically, large farm owners cultivate only a portion of their land and lease out the rest through sharecropping or leasing agreements (Akanda *et al.*, 2008). Dominancy of owner farmers is observed all over Bangladesh while in Pabna district, both the numbers of owner and owner-cum-tenant farmers have increased while the number of tenant farmers has decreased, respectively in 2022 as compared with 2021 (Table 2).

Table 1: Distribution of farm holdings by type of tenure in Bangladesh (area in '000 acres)

Tenure group	Division							
	Dhaka	Rajshahi	Chattogram	Sylhet	Barishal	Rangpur	Mymensingh	Khulna
Owner	6685.9	3447.1	4905.9	1371.7	1560.4	2832.5	2091.5	2856.6
Owner-cum-tenant	946.6	1003.3	850.8	328.4	306.1	956.9	473.8	821.6
Tenant	255.1	202.8	14.2	149.4	40.4	247.8	59.9	164.1

Source: BBS (2022)

Table 2: Distribution of Farm Holdings by Type of Tenure in Pabna District (area in acres)

Tenurial category	2021	2022
Owner	339986	450000
Owner-cum-tenant	129087	132639
Tenant	64136	34006
All holding	533209	643112

Source: BBS (2022)

In Bangladesh, agricultural tenancy becomes especially common during cropping seasons, particularly when off-farm employment opportunities are scarce. Marginal and landless rural farmers heavily rely on tenancy arrangements, and over time, the number of landless households in rural areas has continued to rise. Farmers can be categorized into three groups based on tenurial arrangements; those cultivating only their own land (owner), those cultivating

both owned and rented land (owner-cum-tenant) and those working only on others' land (tenant). Sharecropping is the most prevalent kind of tenancy in which landowners and tenants split the crop produce. Tenants may receive as little as 40% of the crop, however, this sharing ratio is usually 50:50 (Rahman, 2010). The second most popular option is fixed rent, in which tenants give landowners a predetermined sum in cash or in kind in return for the right to cultivate (FAO, 2004). Several studies have pointed to limitations in sharecropping systems. Braido (2008) and Dubois (2002) observed that land leased to tenants is often less fertile than land cultivated by owner-farmers, contributing to the relative inefficiency of sharecropping. Goswami (2015) noted that tenants are generally less inclined to adopt productivity-enhancing strategies and often apply fewer inputs in cultivation. Likewise, Ray (2005) found that tenant farmers tend to underinvest in productivity-improving measures on leased land.

The theoretical debate on land tenancy and agricultural productivity is often framed through the lens of principal-agent models (Pender & Fafchamps, 2005; Laffont & Matoussi, 1995; Marshall, 1920). Marshall (1920) argued that share tenancy leads to inefficient cultivation, as resources are not used optimally and they have limited incentives to maximize their effort, since a significant portion of the output is claimed by the landlord (Tesfaye & Abera, 2014; Braido, 2008). However, this "Marshallian inefficiency" view is challenged by Johnson (1950), who suggests that if landlords closely monitor tenants, they may be motivated to apply inputs efficiently. Supporting this, Jacoby and Mansuri (2009) found that tenant farmers under regular supervision tend to be more productive than those who are not monitored. Thus, access to land remains a key prerequisite for households to produce food for both subsistence and market purposes (Khan, 2008). In many Asian countries, owner cultivation is considered as the optimum form of agricultural production. In contrast, tenant farming is often seen as less efficient due to tenure insecurity and disincentive created by output-sharing arrangements which discourage long-term investment (Otsuka, 2007). Kyomugisha (2008) argued that secure land tenure is a critical institutional factor that influences the adoption of new technologies by smallholder farmers, as it encourages greater investment in land productivity. When property rights are insecure, farmers often lack a sense of ownership or emotional attachment to the land, which can negatively impact land productivity (Tenaw *et al.*, 2009).

Onion is the most common spice in Bangladeshi cuisines and ranked first among all spices in terms of production and area. Bangladesh produced an astounding 9.6% more onion in the fiscal year 2023-2024, surpassing the objective of 3.67 million tonnes with 3.79 million tonnes (Zaman, 2024). Bangladesh faces a closing land frontier and the prospect of increasing production by increasing land area has been exhausted since the 1980s (Husain *et al.*, 2001). Therefore, most viable option to increase production lies in increasing productivity. The literature on technical efficiency of rice farming in Bangladesh’s agriculture is substantial (Wadud and White, 2000; Rahman, 2003; Rahman and Rahman, 2008; Asadullah and Rahman, 2009; Baree *et al.* 2011; Anik and Bauer, 2015; Yahaya *et al.*, 2019). As well as, a number of recent studies calculate profitability of onion in the country (Hasan, 2021; Anjum and Barmon, 2017; Yeshiwas, 2023; Khan *et al.*, 2022; Bapari *et al.*, 2016). An attempt has been made by Ahmed and Billah (2018) to highlight the tenancy structure in onion farming and its impacts on agricultural productivity in Khulna District of Bangladesh.

In West Bengal Banerjee *et al.* (2002) found that stronger land rights such as improved crop shares and greater tenure security for tenants can positively impact crop productivity. Similarly, Nasrin and Uddin (2011) concluded that land tenancy structures significantly influence the

input use and production costs, which in turn affect the productivity of rice farmers. In comparison to sharecroppers, Moon *et al.* (2020) discovered that owner farmers and cash tenants were more productive and profitable suggesting Marshallian inefficiency in the production of Boro rice. Thus, the relationship between onion production and land tenure system has not been yet well explored in in the northern part of Bangladesh where onion production is one of the major agricultural activities and most of the peoples' livelihood is related to it. Nevertheless, based on the background discussion, an ongoing controversy is very common on different sharing arrangement and its impact on productivity of onion production. Consequently, this paper has made an effort (a) to explore major socio-demographic characteristics and the existing tenurial arrangements in onion production; (b) to measure and compare the input uses and profitability of onion production under different land tenurial arrangements; and (c) to assess the impact of land tenure system on profitability of onion production.

II. MATERIALS AND METHODS

Although onion is grown all over Bangladesh, Pabna is one of the most important districts where it is grown quite extensively. Two upazilas namely, Santhia and Faridpur under Pabna district were purposively selected for the study mainly because of the availability of a large number of onion growers and the presence of similar physical characteristics such as topography, soil, and climate which are conducive to onion production. High cooperation from respondents was also anticipated, ensuring reliable and accurate data for the research.

By following simple random sampling technique, 40 onion farmers from each of the three tenant, owner-cum-tenant and owner-groups were selected which makes a sample size of 120. This equal sample size from each group ensures a balanced comparative analysis, statistical reliability and feasibility within time and resource constraints. This avoids bias that can arise if one group dominates the sample and ensures that statistical tests (like ANOVA, regression, etc.) have similar reliability across groups. Primary data were obtained through interviewing onion growers in the designated regions through field survey method. The focus of the interview was to evaluate the onion producer's current management techniques, input usage and cost of production. Data collection was done during April to May (2023). The interview schedule, designed to collect data through several questions, was refined based on pretest feedback to ensure relevance and efficiency. After addressing the recommended changes, it was finalized and approved. Face-to-face interviews were then conducted according to the revised schedule. Various descriptive statistical measures (i.e., sum, average, percentages, etc.) were used to examine the objective (a). Profit equation and regression analysis were employed for analysing the objectives (b) and (c). The undiscounted BCR is a relative measure, which is used to compare benefit per unit of cost. The formula of calculating BCR (undiscounted) is shown below:

$$\textit{Benefit-cost ratio} = \textit{Total benefit}/\textit{Total cost}$$

The Cobb Douglas production function is one of the most utilized production functions. It is a widely used economic model that describes the relationship between inputs and outputs (Rahman, 2003; Coelli *et al.*, 2005; Binam *et al.*, 2004; Khai and Yabe, 2011). It is mathematically simple but powerful, works well with log-linear transformation, and is easy to estimate with farm survey data. This is why it is chosen in impact assessment of land tenure, on

crop production. Incorporating dummy variables into a Cobb-Douglas production function with three categories, owner farmers, owner-cum-tenant farmers and tenant farmers allows us to analyze how different types of tenancy arrangements affect production levels while controlling for other inputs such as labor, capital, fertilizer, insecticides and irrigation.

$$lnY_i = lna + b_1 lnx_{1i} + b_2 lnx_{2i} + b_3 lnx_{3i} + b_4 lnx_{4i} + b_5 lnx_{5i} + b_6 lnx_{6i} + b_7 lnx_{7i} + b_8 lnx_{8i} + b_9 lnx_{9i} + b_{10} D_1 + b_{11} D_2 + Ui$$

Where,

Y = Onion output (kg/farm); X_1 = Human labour (man-days/farm); X_2= Land preparation (Tk/ farm); X_3 = Seed (kg/ farm); X_4 = Urea (kg/ farm); X_5 = TSP (kg/ farm); X_6 = MoP (kg/ farm); X_7 = Gypsum (kg/ farm); X_8 = Irrigation (Tk/farm); X_9 = Insecticide (Tk/farm); $D1$: 1 = Owner-cum-tenant, 0 = Otherwise; $D2$: 1 = Tenant, 0 = Otherwise; $b_1, b_{2,\ldots\ldots}, b_{11}$ = Coefficients of the respective variables; Ui = Error terms; ln = Natural logarithm; and i = 1,2,3,……

III. RESULTS AND DISCUSSION

3.1 Socio-demographic characteristics of onion farmers

Age plays a significant role in farming activities and management. Older farmers are often considered more experienced, familiar with production practices, and better at managing inputs efficiently, with a tendency to be more risk-averse. Conversely, younger farmers are believed to adopt new technologies more quickly. Age distribution of respondents across three tenure groups of onion farms highlights the proportion of farmers in different age categories. Only 5% of owner-cum-tenants and 2.5% of tenants are below 18 years old implying that onion farming is generally not practiced by very young individuals. Working-age group (18-60 years) is the dominant age group across all tenure categories. About 77.5% of owners, 75% of owner-cum-tenants, and 95% of tenants are within this age range. Onion farming is primarily carried out by active, working-age adults. Notably, the tenant group has the highest share (95%) of individuals in this productive age range, implying that younger and more energetic farmers tend to operate on rented land. A moderate portion of owners (22.5%) and owner-cum-tenants (20%) are above 60 years old, while only 2.5% of tenants belong to this group (Table 3). This pattern shows that older individuals are more likely to be landowners, reflecting generational accumulation of land rights, whereas younger farmers are more likely to rent or lease land.

Table 3: Age distribution of onion producers

Age categories	Owner		Owner cum tenant		Tenant	
	Number	%	Number	%	Number	%
0-18 years	0	0	2	5	1	2.5
18-60 years	31	77.5	30	75	38	95
Above 60 years	9	22.5	8	20	1	2.5
Total	40	100	40	100	40	100

Source: Field survey, 2023.

A substantial number of farmers have families with more than six members emphasizing the prevalence of larger households. These findings suggest that onion farming in the region is often supported by family labor, which plays a crucial role in agricultural productivity. The overall average family size across all tenurial groups is approximately 5.64 members, which is slightly higher than the national average family size in Bangladesh, as reported by the Household Income and Expenditure Survey (BBS, 2022).

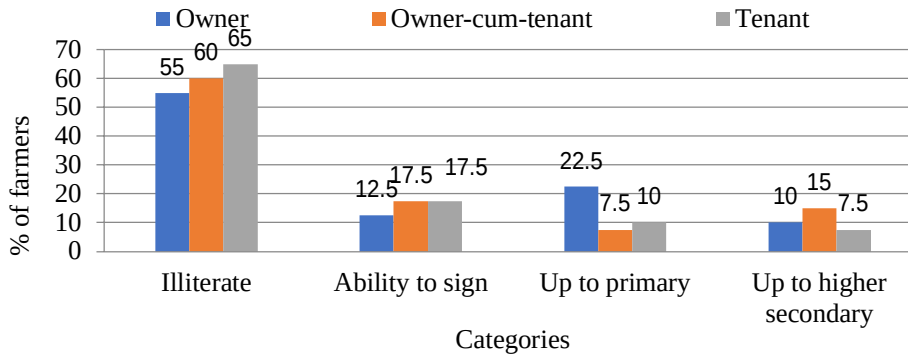

Figure 1: Educational status of onion farmers (%)

Education influences household decision-making in agricultural production. Educated farmers can better access technical information, improve cultivation practices, and make more rational economic decisions, leading to efficient resource management and higher profits. The educational status of respondents was categorized into five groups: illiterate, able to sign, up to primary, up to secondary, and up to higher secondary. Findings reveal that illiteracy was highly prevalent among the tenure groups (Figure 1). Many farmers were able to sign only while some farmers had secondary education. Primary education was also prominent among owner farmers.

Onion farmers participated in various occupations, with agriculture serving as their primary source of employment. The term "main occupation" refers to the work a person engages in throughout the entire year. The occupations of the farmers were categorized into three groups: agriculture, business, and services. Table 4 shows that 85% of owner farmers, 88% of owner-cum-tenant farmers and 91% of tenant farmers listed agriculture as their main occupation. Business and service occupations were less common, only 9% of owner farmers and 6% of both owner-cum-tenant and tenant farmers being involved in business. Accordingly, these farmers were mainly dependent on crop production, sales of fruits and vegetables, livestock animals and fishes for generating income. The average annual income (except crop cultivation) of owner, owner-cum-tenant and tenant farmers was Tk 62000, Tk 46500, Tk 41500, respectively (Table 5).

Table 4: Occupational status of onion farmers

Occupation	Owner		Owner-cum-tenant		Tenant	
	Number	%	Number	%	Number	%
Agriculture	35	85	36	88	37	91
Business	3	9	2	6	2	6
Service	2	6	2	6	1	3
Total	40	100	40	100	40	100

Source: Field survey, 2023.

Table 5: Average annual income other than crop cultivation (BDT/year)

Source	Owner		Owner-cum-tenant		Tenant	
	Amount	%	Amount	%	Amount	%
Vegetables	30000	48.38	28000	60.22	14000	33.74
Livestock & livestock products	5000	8.06	3500	7.53	4000	9.64
Fisheries	2000	3.23	1000	2.15	3000	7.23
Service	10000	16.13	5000	10.75	9000	21.68
Business	8000	12.90	4000	8.60	6000	14.46
Day labour	-		3000	6.45	4000	9.64
Miscellaneous	7000	11.29	2000	4.30	1500	3.62
Total	62000	100	46500	100	41500	100

Source: Field survey, 2023

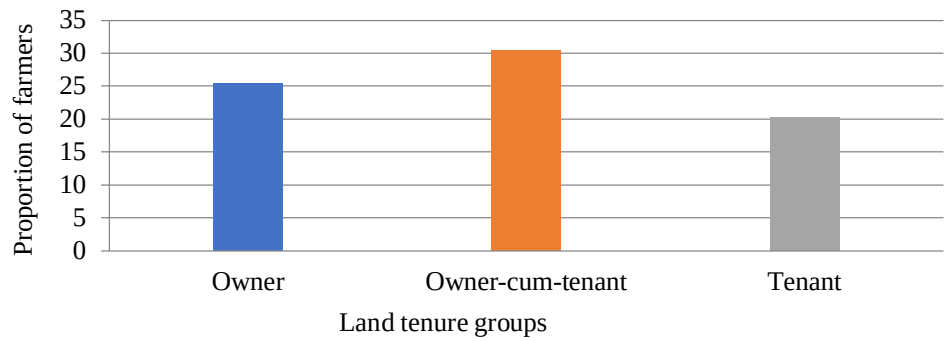

Figure 2: Extension service received by onion farmer

Extension services improve the knowledge and skills of the farmers. Different government and non-government institutions provide extension services to the farmers for the improvement of onion cultivation practices. In the study area, 25% of owner farmers, 30% of owner-cum-tenant farmers and 20% of tenant farmers received such extension services with the fact that majority did not receive any training or visits by extension agents (Figure 2).

Farm size refers to the total land area worked by farmers. It is computed by adding the area of land owned, rented-in, mortgaged-in and leased-in from others and subtracting the area rented-out, mortgaged-out and leased-out to others. Study found that owner farmers have the largest

farm size (89.25 decimals), followed by owner-cum-tenant farmers (85.75 decimals) and tenant farmers (80.5 decimals). This indicates that land ownership is positively associated with larger farm holdings as tenant farmers operate on comparatively smaller land areas. The Land Reform Act of 1950, which ended the Zamindar system and gave farmers property rights, is the source of Bangladesh's current land tenure structure. However, it failed to ensure equitable land distribution, with local elites benefiting the most (Nasrin, 2011).

3.2 Financial profitability analysis of onion production

Net return per hectare of onion production has been calculated in the present study. For that, at first the cost of production and then the value of output (gross return) have been calculated. Net return was obtained by deducting the gross costs from its gross return. Cost items of onion production were classified into two major groups; (i) variable costs and (ii) fixed costs. Variable cost of onion production includes cost for human (hired) labour, land preparation and planting cost, cost of bulbs/seeds, Cost of fertilizers (urea, MoP, TSP, Gypsum), cost of insecticides, cost of irrigation and interest on operating capital. On the other hand, fixed costs include cost for family labor and land use cost. Farmers used both home supplied and purchased inputs in the production processes of onion. The costs of purchased inputs were calculated on the basis of actual payments made by the farmers and for home supplied inputs; opportunity cost principle was used to determine their value.

Human labour is the most important and largely used input in the production process of onion. Human labour is required for various activities and management such as: land preparation, weeding, fertilizing, irrigating, using insecticides and herbicides, harvesting and post harvesting. Both family and hired labour were the sources of supply of labour in the study area. Family labour included the farmer himself and his family members like his children and wife. Human labour was measured in terms of man-day unit which consisted of 8 hours of work by an adult man. Labor hour for female and child was calculated by converting all women and children hours into man equivalent hours by assigning a ratio of 2 children =1 women =1 adult man. The valuation of family supplied labour was done considering opportunity cost principle. In the study area, the average wage rate was Tk. 500.00 per man day. However, this rate was increased to 600 Tk. per man-day during harvesting season.

Land preparation is considered one of the most important components in the production process. Land preparation for onion production included ploughing, laddering and other activities needed to make the soil suitable for planting bulb. It was revealed that the number of ploughing varied from farm to farm and location to location. Cost of land preparation for owner, owner-cum-tenant and tenant operators were Tk 21195 per ha, Tk 23295 per ha and Tk 23674 per ha, respectively. Seed is the single most important cost item for onion production. In the study area, it was found that farmers used both home supplied and purchased seeds. Most of the tenant farmers used purchased seed in the study area. The cost of seed was calculated on the basis of actual prices paid by them. Seed cost for owner, owner-cum-tenant and ternant operators were Tk 24990 per ha, Tk 22971 per ha and Tk 21746 per ha, respectively. Commonly used fertilizers for onion production were urea, TSP, gypsum, MoP and Zinc. All the fertilizers were purchased at market prices. Tenant operators incurred highest cost for fertilizers in the study locations compared with other operators. Irrigation water is another important input in onion production. Farmers need to pay a fixed rate for irrigation water as they had to depend on rented deep tube-well. Some farmers also use their own shallow tube-

well water. Farmers also applied insecticides to protect their onion from the attack of pests and diseases. The actual price paid by the farmers for insecticides was taken into consideration for calculating the cost of insecticides. Among the fixed costs, per hectare land use cost was highest for owner farms and lowest for owner-cum-tenant farms. Interest on operating capital was determined on the basis of opportunity cost principle.

Table 5: Per hectare costs, returns and profitability onion production (Tk/ha)

Particulars	Owner	Owner-cum-tenant	Tenant
A. Gross Returns			
Main Product	429678	388675	385643
Total Returns	429678	388675	385643
B. Variable Costs			
Human labour	79500	67500	72000
Land preparation	21195	23295	23674
Seed	24990	22971	21746
Urea	8255	8787	8564
TSP	8787	6175	7654
MoP	6601	7410	7543
Gypsum	3031	2871	2980
Irrigation	17345	16010	15460
Insecticides	14356	14301	14721
Total	182956	168673	174242
Interest on operating capital	6098	5622	5808
C. Fixed Costs			
Land use cost	34434	33980	34100
D. Gross costs (B+C)	223488	208275	214150
F. Net Return (A-D)	206190	180400	171493
G. Undiscounted BCR	1.92	1.87	1.80

Source: Field survey (2023)

Operating capital represents the average expenses occurred during the production period. Interest on operating expenses is calculated using the following formula and considering 9 percent interest rate and four months of production period:

$$IOC = AIit$$

Where, IOC = Interest on operating capital; i = Interest rate; AI = Total investment/2, t = Total cycle time. After calculating the variable and fixed cost of onion production, gross cost was found highest for owner farms and lowest for owner-cum-tenant farms. Gross returns are the monetary value of crops produced in the concerned plots. Output from onion production includes the physical quantities of the main product. Per hectare total returns were calculated by multiplying the total amount of products with their respective market prices. Total return was found that per hectare total return (main product) for the owner, owner-cum-tenant and tenant operators were Tk, 429678, Tk. 388675 and Tk. 385643, respectively. Here again, owner farmers gained highest return. Accordingly, they get the most profit from onion production in the study areas (Tk 206190 per ha) (Table 5).

Benefit Cost Ratio (BCR) for onion were 1.92, 1.87, 1.80 for owner, owner-cum-tenant and tenant farmers, respectively which implies that one-taka investment in onion production generated Tk. 1.92, Tk. 1.87 and Tk. 1.80, respectively for respective tenurial groups indicating profitability across all categories. It also shows that there exists a remarkable difference in profitability among tenurial groups which implied that land ownership and tenurial class have substantial influence on input use and output produced. Several studies have examined the BCR of onion production highlighting its profitability under different conditions. Yahaya *et al.* (2019) in their research on onion farming in Northern Nigeria found a BCR of 2.5 suggesting significant profitability. In another study, Yeshiwas (2023) reported a BCR of 2.2 for owner farmers in Ethiopia which is higher than the BCR for tenant farmers underlining that although onion production is profitable, postharvest losses greatly affected overall returns. Overall, while the BCR values vary across different regions and farmer categories maximum research demonstrate that onion production is profitable with variations largely dependent on factors like farm management practices, input costs and local conditions.

Table 6: Profitability disparities among onion farmers under different land tenure groups

Types of farmer	Profitability difference	T-value	P-value
Owner-Owner cum tenant	25637.39	2.39	0.085
Owner-Tenant	34721.21	2.14	0.018
Owner cum tenant-tenant	8958.61	0.72	0.238

Source: Author's estimation

Table 6 presents the results of mean difference tests showing how onion farming profitability varies among different land tenure categories of farmers. The average profitability difference between owners and owner-cum-tenants is statistically significant at 10% level, suggesting that owners earn significantly higher profits than owner-cum-tenants. Likewise, the profitability gap between owners and tenants is highly statistically significant at the 5% level, indicating that owner farmers earn significantly higher profits than tenant farmers. This could be due to lower land rent costs and greater investment incentives among landowners. On the other hand, the difference between the profits of owner-cum-tenants and tenants is not statistically significant. Thus, land ownership positively influences onion farming profitability. Farmers who fully own their land tend to earn higher profits compared to those who rent land, likely because they avoid rental expenses and have greater motivation to invest in land productivity.

3.3 Impact of land tenure arrangement on onion production

The results from estimated Cobb-Douglas production function with other relevant statistics are presented in the following table. Two dummy variables are used in the regression, D_1 for owner-cum-tenant operators and D_2 for tenant operators. In both cases, owner operators were considered as base category. Here, the dependent variable is the amount of onion production (Kg) per farm.

Table 7: Estimated values of regression coefficients and related statistics of Cobb-Douglas production function for onion farmers

Particulars	Estimated coefficient	Std. error	t-value
Constant	9.98	10.483	0.53
Human labor (man-day/farm)	0.149**	0.078	1.91
Land preparation (Tk/farm)	-0.026	0.875	-0.029
Seed (kg/ farm)	0.043***	0.016	2.688
Urea (kg/ farm)	0.905*	0.501	1.806
TSP (kg/ farm)	-0.350**	0.165	-2.12
MoP (kg/ farm)	0.110	0.765	0.144
Gypsum (kg/ farm)	-0.591	0.943	-0.627
Irrigation (Tk/farm)	0.908*	0.483	1.879
Insecticide (Tk/farm)	-0.419	0.831	-0.504
D_1	-0.546	0.765	-0.714
D_2	-0.030	1.895	-0.016
Model statistics			
R^2	0.725		
F-value	7.62		
Returns to Scale	1.67		

Source: Author's Estimation (2023)

Note: *** Significant at 1 percent level; ****** Significant at 5 percent level; ***** Significant at 10 percent level

The estimated coefficient for labor input was statistically significant at the 5 percent level, indicating that a 1 percent increase in labor input leads to an approximately 0.149 percent increase in output, holding other variables constant. The study highlights labor as a critical factor in onion production, but profitability varies across tenure groups due to differences in labor utilization. Owner farmers have the highest profitability despite having higher labor costs (Tk. 79500 per hectare) while owner-cum-tenant and tenant farmers face inefficiencies in production due to over- or under-utilization of labor. Tenant farmers rely more on hired labor (88 man-days) than family labor (56 man-days), leading to higher production costs. The coefficient for land preparation cost was found to be insignificant; suggesting that variations in land preparation expenses do not significantly impact onion production. This indicates that beyond a certain level, additional land preparation does not contribute to higher productivity. Owner-cum-tenant and tenant farmers, who spend slightly more on land preparation than owners, may not be seeing proportionate returns from this investment.

The estimated coefficient for seed input was statistically significant at 1 percent significance level meaning that a 1 percent increase in seed cost leads to a 0.043 percent increase in output, holding other factors constant. Seed quality and proper application are essential for productivity. However, the relatively smaller coefficient value suggests that while increasing seed use does improve yield, its impact is less substantial compared to other inputs like urea and irrigation. This implies the need for better seed selection rather than simply increasing seed quantity. Among different fertilizers, coefficient for urea and TSP turned out statistically significant at 10 percent and 5 percent, respectively. The results suggested that a 1 percent increase in urea use would increase onion output by approximately 0.905 percent. Urea has a strong positive impact on productivity, making it one of the most crucial inputs for onion

farming. However, its overuse could lead to soil degradation in the long term, affecting sustainable farming practices. Similarly, MoP use had positive impact on onion production although it was statistically insignificant. This indicates that potassium application is either adequate or unnecessary beyond a certain level. Soil testing and targeted fertilizer use could optimize MoP application.

On the other hand, impact of TSP was negative implying that a 1 percent increase in TSP usage decreases output by 0.35 percent. This further implies that TSP is being misapplied, leading to inefficiencies. Farmers may be applying phosphorus without balancing it with other nutrients, reducing soil fertility in the long run. The coefficient for gypsum was also negative (-0.59) and insignificant, indicating that its use does not contribute significantly to productivity. Gypsum is typically used for soil conditioning, but its negative effect suggests improper application or limited necessity in the study area. Farmers should assess soil conditions before applying gypsum. Impact of irrigation was statistically significant at the 10 percent level, meaning a 1 percent increase in irrigation investment leads to a 0.908 percent increase in output. This confirms that irrigation is one of the most critical factors for onion productivity. Efficient water use strategies, such as drip irrigation or scheduled watering, could further enhance onion returns in the study areas. Insecticide had negative and insignificant (-0.419) impact of onion production indicating that increased insecticide use does not significantly enhance productivity. Overuse of insecticides may lead to plant stress, pesticide resistance, and unnecessary costs, reducing overall profitability. Integrated Pest Management (IPM) strategies could improve productivity.

The coefficient for D_1 was -0.546 meaning that owner-cum-tenant farmers produce 0.546 percent less output compared to owner farmers, holding other factors constant. Land tenure insecurity limits investment in land improvements (e.g., soil fertility management, irrigation). Their less profitability suggests that while they manage a balanced mix of family and hired labor, land ownership constraints affect long-term productivity. Similarly, the coefficient for D_2 was -0.030, indicating tenant farmers produce 0.03 percent less output than owner farmers, but the effect is relatively small. Tenant farmers lack investment incentives, leading to less profitability due to differences in cost structure, rent payments, and reduced control over input and output decisions. Thus, although tenant farmers show a statistically significant difference in profit compared to owner farmers, but their production differences remain statistically insignificant.

Overall, the estimated model was significant as suggested by the F-value which means that the selected variables jointly explain variations in output. The R^2 value of 0.725 suggests that 72.5 percent of the variation in onion production is explained by the model's variables, indicating a strong explanatory power. The returns to scale value of 1.67 indicates increasing returns to scale, meaning a proportional increase in all inputs leads to a more than proportional increase in output. Expanding farm size and increasing input use can significantly enhance productivity. Policies supporting access to credit, technology, and irrigation infrastructure could help farmers scale up operations. Thus, while onion production remains profitable across all tenure groups, labor utilization plays a significant role in shaping profitability. Efficient labor management, avoiding over- and under-utilization of fertilizers is crucial to optimizing returns, especially for tenant and owner-cum-tenant farmers.

3.5 Problems related to onion production under different tenurial groups

Onion producers in Pabna district face several challenges that hinder profitability and sustainability. These problems stem from multiple factors, including financial constraints, input costs, land tenure issues, and technical difficulties. Based on the survey findings, the following major problems have been identified:

High seed costs remain one of the most significant challenges, particularly affecting tenant farmers (30%) who have limited financial capacity compared to owner farmers (20%). The cost burden often prevents them from using high-quality seeds, reducing yield potential. Another pressing issue is the lack of quality storage facilities, which impacts 20% of farmers overall. Inadequate storage leads to post-harvest losses, particularly for tenant farmers (25%) who have limited access to proper storage solutions. High irrigation costs are another major constraint, affecting 23% of farmers overall. Tenant farmers (28%) bear the highest burden as they often rent land with limited irrigation access, forcing them to pay higher water charges. Similarly, labor shortages and high wages significantly impact onion farming. Tenant farmers (22%) are the most affected due to financial constraints, making it difficult for them to hire laborers during peak farming seasons (Table 8).

Table 8: Problems faced by onion farmers

Problems faced by farmers	Owner farmers (%)	Owner-cum-tenant farmers (%)	Tenant farmers (%)	Overall (%)
High seed costs	20	25	30	25
Lack of quality storage facilities	15	20	25	20
High irrigation cost	18	22	28	23
Labor shortages and high wages	12	18	22	17
Price fluctuations in the market	14	16	18	16
Limited access to credit	10	15	20	15
Land tenure insecurity	11	12	16	13
Pest and disease outbreaks	9	10	12	10
Insufficient extension services	8	9	10	9

Source: Field survey (2023)

Market price fluctuations also pose a considerable risk, affecting all farmer categories with an overall impact of 16%. Farmers face unpredictability in onion prices, leading to financial instability. Additionally, limited access to credit disproportionately impacts tenant farmers (20%) who struggle to obtain loans for farm investments, whereas owner farmers (10%) have better financial standing and collateral. Land tenure insecurity remains a pressing issue, with tenant farmers (16%) experiencing the most uncertainty regarding land access and long-term investment in farming. This lack of security discourages tenants from making improvements to land productivity. Pest and disease outbreaks further exacerbate the challenges, with 12% of tenant farmers affected due to limited access to pest control measures. Finally, insufficient

extension services hinder farmers' ability to adopt modern farming techniques, with tenant farmers (10%) again being the most disadvantaged.

IV. CONCLUSIONS

Land tenure arrangements significantly influence the profitability of onion production among owner, owner-cum-tenant, and tenant farmers. While all three tenure groups were able to generate profits from onion farming, notable differences were observed in profitability especially among owner and tenant farmers. The terms and conditions for tenancy arrangements should be favourable to the tenants that would help foster an emotional connection between farmers and their land. Moreover, regular communication and involvement by the owners regarding how their land is being used by tenants could contribute to the debate over the link between tenancy arrangements and crop productivity. Such engagement can encourage tenants to put forth their best effort in the production of onions.

Despite land constraints limiting the expansion of onion cultivation in Bangladesh, there is considerable potential to boost production through improvements in existing farming technologies. The study highlights several difficulties regarding farming practices, such as lack of storage facilities, seed cost, price fluctuation, tenure insecurity are barriers to realizing this potential. One of the primary concerns expressed by farmers is the high cost of inputs, which limits their ability to apply the recommended doses of fertilizers and other essential inputs. To address this, the government should facilitate access to affordable credit for onion farmers, enabling them to invest in their operations, purchase necessary inputs, and enhance their productivity. Furthermore, many farmers reported being deceived by low-quality inputs, such as seeds, pesticides, and fertilizers, purchased from local markets. Policymakers should, therefore, implement stringent quality control measures, including certification programs for suppliers, to ensure that farmers have access to high-quality agricultural inputs.

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