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The Role of Agricultural Technology in Attaining Food Security among Small Farmers in Char Area in Mymensingh District

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Farmers in the char areas of Bangladesh are frequently affected by food insecurity due to their low engagement in modern agriculture such as less use of modern agricultural technology. This study evaluates the socio-demographic characteristics of the sample farmers to assess their nutritional status and the factors influencing char dwellers' dietary diversity. Survey data were collected from 70 households, and focus group discussions were conducted using a semi-structured questionnaire from Nilokhiya char under the Mymensingh District of Bangladesh. An OLS regression model was used to estimate the influence of socioeconomic characteristics of sample households on the decision on factors influencing dietary diversity. The farming type of the farmers is another concern of this study where results show that 90% of farmers in the char areas rely on rice and vegetable farming, whereas more than 60% of the farmers are also involved in livestock and poultry farming at the same time. The nutritional status of char farmers shows that their diet includes a variety of foods but is deficient insufficient protein and healthy fats, which could have an impact on their overall nutrition. Cereals are a staple in the diet, as indicated by the high consumption rate (97.1%) and the substantial average intake (2.30 kg/day). Every household consumes fruits, though in smaller quantities (0.28 kg/day). Eggs are less frequently consumed (57.1%) despite a higher intake (2.64 kg/day). Dietary diversity has a strong positive correlation with supply (.913) at a 1 % significant level which means that efficient supply chains minimize delays, reduce spoilage, and ensure a continuous flow of food to markets to ensure food security. A positive correlation with total income (.373) leads to a higher total income also supports greater dietary diversity. Credit was significant at a 5% level (.267) indicating that a 1 % increase in credit leads to an increase in dietary diversity by 267%. On the contrary, Experience has a negative relationship with dietary diversity which means that experience does not influence food security. Lack of transport and communication, environmental hazards, and natural disasters are the most significant problems faced by the farmers in the char area.

Keywords: Food security; agricultural technology; char dwellers; dietary diversity; sustainable agriculture.

1. INTRODUCTION

The adoption of agricultural technologies can have a significant impact on household food consumption expenditure. Agricultural technology is becoming increasingly essential for long-term agricultural development, as it empowers farmers to boost productivity while using fewer natural resources to meet the growing demand for food, fuel, and fiber [1]. The adoption of agricultural technologies has the potential to improve household food security and reduce poverty but faces barriers related to government support and farmer training. Bangladesh is one of the world's most populous and low-middle-income nations [2]. The macroeconomic situation, including employment generation, poverty alleviation, food security, and nutritional attainment, is significantly influenced by the performance of the agricultural sector [3]. Most of the people in Bangladesh reside in char areas, which are characterized by low income, food shortages, and widespread malnutrition. According to the “National Conservation Strategy Papers” char lands are mostly distributed in 11 districts of Bangladesh covering a land area of about 0.82 million hectares [4]. A recent report by the World Bank published in 2022 mentions that about 6 million people live in the char areas in Bangladesh [5]. In the char areas, food deficit and undernourishment are significant issues, exacerbated by poverty. Approximately 160 million people in the country cannot afford a required diet due to economic constraints [6].

Food security is a major concern to millions. The global economy relies significantly on the agricultural sector, especially in emerging markets. Bangladesh holds the third largest poor population after China and India, the number of hungry people is over 60 million and half of the children in Bangladesh are underweight [7]. Food

security encompasses three elements: availability, accessibility, and utilization [8]. The schematic diagram below illustrates the three dimensions describing the food flow from availability and access to use and utilization along with the aspects of sustainability.

Food security remains a critical challenge, with many individuals consuming less than the minimum dietary energy requirement. The average calorie intake per capita is often below the necessary levels, leading to nutritional deficiencies, particularly among vulnerable populations such as women and children [10]. Dietary diversity is therefore a key element of high-quality diets and the recommendation to consume a range of foods appears in many nutritional guidelines [11].

Against this backdrop, improved agricultural technology has been introduced to reconcile the socio-economic and environmental trade-offs. Agricultural technology plays a key role in enhancing food security among the char areas in Bangladesh. Technological advancement is essential to a nation's economic growth and development because technology makes it possible to produce goods and services of greater quality more efficiently for a variety of places, including towns, villages, regions, and entire countries (Radovic et al., 2022). Many studies on technology diffusion have confirmed that farmers who adopted new technologies have been able to promote farm production [12,13]. These new technologies and innovations can include: fertilizers; new crops; more nutritious crops; and new industries [14], and incorporate these technical developments into new farming systems [15] Agricultural holding in Bangladesh is generally small but the use of modern machinery and equipment is gradually increasing rice, jute, sugarcane, potato, pulses, wheat, tea, and tobacco are the principal crops of Bangladesh. Modern agricultural technologies are not properly disseminated in the char land due to scattered, isolated, disconnected transport networks. It is evident from the initiatives of certain projects and NGOs that employing an integrated farming approach is an effective method for generating income for residents of char areas [16]. Achieving higher food production will require using reduced land, as well as decreased water, labor, and chemicals [17].

Food security is a major concern in the char areas of Bangladesh, where a significant portion of the population is chronically malnourished and suffers from silent hunger. The chars are highly susceptible to natural disasters like floods and river erosion, which can destroy crops, livestock, and homes, leading to frequent displacement and loss of livelihoods [18]. Agricultural practices in char areas are often traditional and low-cost, relying heavily on manual labor due to poor access to modern farming tools and technology. While the fertile soil can support diverse crops,

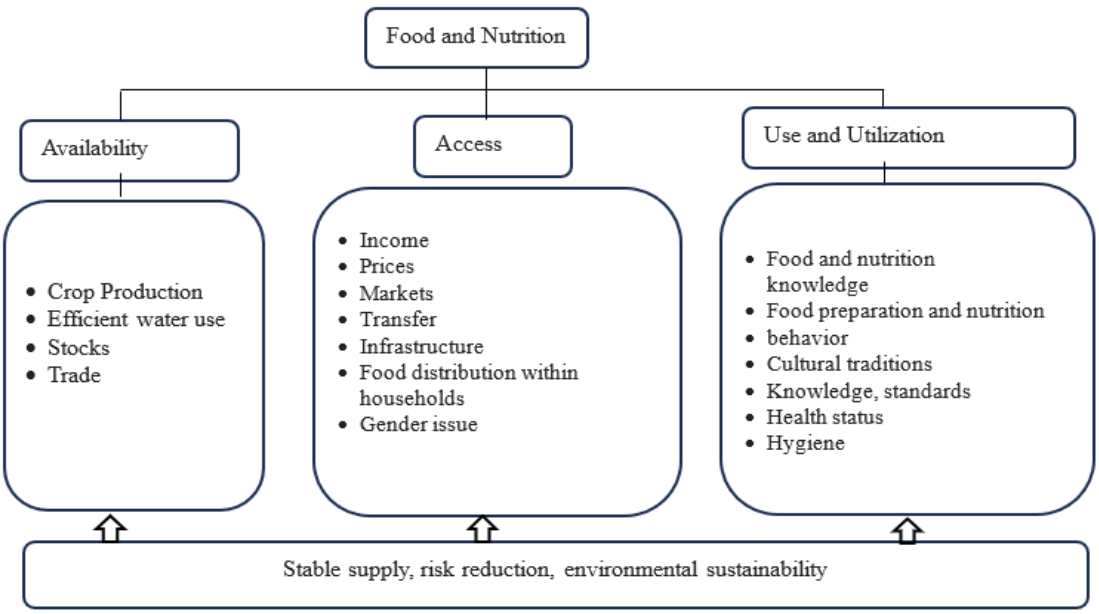

Fig. 1. Food security components (Source: FAO,[9])

the lack of infrastructure limits their ability to market surplus produce effectively. Many families engage in homestead gardening to supplement their food needs, but the scale is often insufficient to ensure food security year-round [19]. In summary, food security in char areas of Bangladesh is a complex issue shaped by poverty, environmental challenges, limited agricultural practices, inadequate access to services, and the effectiveness of social safety nets.

The importance of small-scale fisheries (including inland fisheries) concerning overall production and contribution to food security and nutrition is often underestimated or ignored. Small-scale fishing households in char areas have not received much attention in terms of research on their food and nutritional security status. Most food security studies were conducted on marine fishing households [20-22]. This study sought to investigate the socio-demographic characteristics of sample farmers, type of farming, and the nutritional status of the char areas of Mymensingh district. Furthermore, this study hunted the factors influencing the dietary diversity of the sample farmers.

2. RESEARCH METHODS

2.1 Research Approaches

Research approaches can be divided into two categories. These categories are quantitative and qualitative [23]. The mixed method (quantitative & qualitative) is advantageous for the study because it is based on objective information and explores deeper insights into real-world problems.

2.2 Selection of the Study Area

Choosing the study area is a crucial research step, greatly influenced by the study's goals [24]. Thus, thorough consideration was given to selecting an area that can meet the mentioned objectives. Considering the availability of small farmers in agricultural labor, this research has chosen Mymensingh as the study area. The research was specifically carried out in the village of Char Nilokhiya in Sadar Upazila of Mymensingh district. The map of the selected zone is as follows:

2.3 Preparation of the Survey Schedule

The success of a social survey largely depends on the survey schedule or questionnaire. Survey schedules should be designed very efficiently and properly. An interview schedule was meticulously prepared to gather the necessary data to achieve the study objectives. First, a draft survey schedule was developed, tested, and finalized after necessary corrections, modifications, and adjustments. The draft survey schedule was pre-tested by the researcher himself. The survey schedule was rearranged and modified after gathering knowledge from pretested surveys in the area.

2.4 Sample Size, Sampling Method & Data Collection

Sample size will be calculated using the following equation [25]:

$$n = \frac{NZ^2p\,(1-p)}{Nd^2+Z^2p\,(1-P)}$$

where,

n = calculated sample size (70)
N = total number of households (65852)
Z = confidence level (95% confidence level is 1.96)
P = population proportion (0.50, this maximizes the sample size)
d = error margin of 5% (0.05)

Respondents for this study were small farmers who were directly involved in agricultural activities. About 70 households were purposively interviewed to assess farmers' dietary diversity. These households were identified through a multistage stratified random sampling method. A prepared questionnaire was used in the data collection method. Primary data collected through face-to-face interviews, focus group discussions (FGD), and secondary data gathered from the Bangladesh Meteorological Department (BMD) over the past ten years. As the questionnaire is used to collect data through direct interviews it can be called an interview schedule. The farmers who were respondents were asked questions by the interviewer according to the interview schedule, and the answers were recorded. All these processes were done through personal interviews because of getting a high accuracy rate from the respondents. The relevant data were collected from June to July 2023.

2.5 Analytical Techniques

- Socio-economic characteristics: To assess the socioeconomic and socio-demographic

characteristics of the respondents, descriptive statistics have been used, which include frequency, percentage, and cross-tabulation [26]. MS Excel 2013 was used to calculate these attributes.

- Farmer Dietary Diversity (FDD):

Table 1. Different food groups for the small farmer's dietary diversity (Source: FAO, 2015)

Food Group	Food items
Starchy staples	Corn/maize, rice, wheat, sorghum, millet, or any other grains or foods made from these, potatoes, yam, or other foods made from roots
Leafy vegetables	Dark green leafy vegetables like jute leaf, spinach, etc.
Vitamin A-rich fruits & vegetables	Pumpkin, carrot, or sweet potato that are orange inside + other vitamin A rich vegetables (e.g. red sweet pepper) and ripe mango, ripe papaya + other available vitamin A rich fruits
Other fruits and vegetables	Other vegetables (e.g. tomato, onion, eggplant) + other locally available vegetables and other fruits, including wild fruits and 100% fruit juice made from these
Organ meat	Liver, stomach
Meat and fish	Beef, lamb, goat, chicken, duck, other birds, fish, dry fish
Eggs	Eggs
Legume & seeds	Seed beans, peas, lentils, nuts, seeds, or foods made from these
Milk products	Milk, yogurt, or other milk products

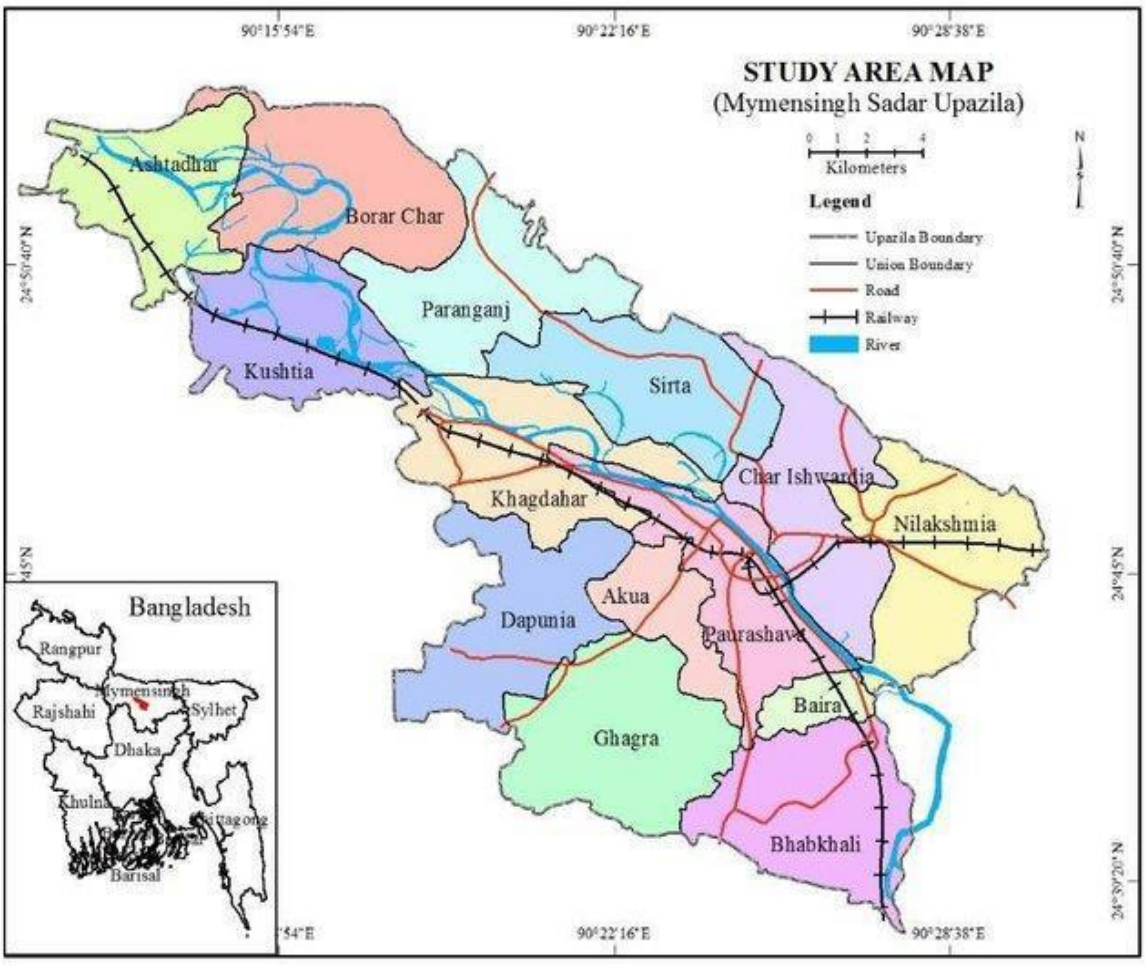

Fig. 2. Study area map (Char Nilokhiya, Mymensingh Sadar Upazila)

To measure FDD, a 24-hour recall of food consumption was used, and the foods were divided into nine food groups as suggested by the FAO. To calculate farmer's dietary diversity (FDD), the 24-hour recall of food consumption by farmers was considered. The condition was that if farmers consumed at least one specific food from a food group, that was considered value 1 and otherwise 0. If farmers consume foods from more than one group, the number of food groups is measured by a dietary diversity score. The score range is 0 to 9 because there are nine food groups.

2.6 Econometrics Technique

The OLS regression model [27] was utilized to identify the variables that impact the dietary diversity of farmers.

$$D = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + \beta_{10} X_{10i} + \varepsilon_i$$

Here,

D = the farmer's dietary diversity score.
X_i's = the independent variables explained in Table
β0 = Intercept/constant
β = regression coefficients of a predicted variable

3. RESULTS AND DISCUSSION

3.1 Socio-Demographic and Economic Profile of Char Respondents

Several variables describe the demographic characteristics of the respondents. The variables included in this analysis were the household head's age, education level, family size, annual family income, farm size, and farm types as well. Total count frequency is used to interpret the results as some variable's data were collected from family members (Table 3).

Summary statistics for demographics and socio-economic data (Table 3) show that 22.9 % of the households are within the small group (up to 4) members, followed by 40 % in the medium group (5-6) and 37.1 % in the large group (>6) respectively. The average household size of the respondents was 6.43. The average household size in rural areas obtained from the HIES 2022 survey is 4.30. It is greater than that of urban areas in all the survey years. From the focus group discussions, we found that health workers from local NGOs are not visiting the study char frequently. As a result, they were not aware of using different methods of contraception and thus population per household may be increasing.

The table shows that the majority of the respondent farmers belonged to the old category with 42.9 percent. The percentage of the young category respondent farmers was 32.9 percent and the least belonged to the last category of middle aged with 24.2 percent. In terms of education level, while we can see that the majority of the respondents (77.1 %) have a low level (literate and can sign only) of education, 70 % combined have completed primary (class 1− 5) and secondary (6− 10) level of education. 5.7% of single household heads were found to have completed upper secondary education (class > 10) or higher. From this information, we can see that about 75 % (including, can sign only) of the char dwellers are literate. The HIES 2022 reveals that the literacy rate of the population aged 7 years and above is 74.0% at the national level for both sexes. The rate of literacy in rural areas is 70.3% which is slightly lower than the national average. From this discussion, we can say that there are more primary schools needed to increase the literacy rate in char dwellers.

Another important variable considered in this demographic analysis was farm size. From Table 2 majority of the respondents were small categories (67.10 percent). As high as sixty-seven percent of respondents had small farm size while medium 22.9 and marginal 10 percent respondents. About only 31.42 % of char dwellers have their own farm and homestead land for cultivation while 68.58 % have leased farmland for cultivation. In addition, data revealed from Table 2 that the majority of the respondent farmers had up to 350 thousand with 58.6 percent. The percentage of the medium category respondent farmers was 20 percent and the last category of high income was 21.4 percent. In that way, it was normal that the farmers of low to medium wage class would be liable to take part in food security development to a more noteworthy degree to expand their income.

Table 2. Description of the independent variables (Source: Estimation of the author, 2022)

SL no.	Variable name	Unit of measurement	Definition of the variable
1.	Education	Years	Number of years of schooling by the respondent
2.	Farm Size	Hectors	The total cultivable area of the respondent
3.	Annual household income Agri.	Taka	The annual household income of the respondent from the agriculture sector
4.	Total Income	Taka	The total household income of the respondent
5.	Experience	Hours	The number of hours spent on agricultural activities daily by the respondent
6.	Market Price	Taka	The current price at which a particular good or service is bought and sold in a market
7.	Credit	Dummy	Credit is the ability to borrow money or access goods and services with the agreement to pay back later, often with interest.
8.	Choice of new technology	Dummy	Refers to the decision to adopt and use new or advanced tools, techniques, or equipment that improve efficiency, productivity, or outcomes in a particular field, such as farming.
9.	Farming Type	Dummy	Farming type refers to the specific method or system of agriculture
10.	Supply Chain	Dummy	The supply chain refers to the entire process from production to delivery.

Table 3. Demographic characteristics of the char respondents

Characteristic	Scoring system	Categories	Respondent		Mean	Standard Deviation
			N	%		
Household size	Number	Small (up to 4)	16	22.9	6.43	2.38
		Medium (5-6)	28	40.0		
		Large (>6)	26	37.1		
Gender	Code	Male	41	58.57		
		Female	29	41.43		
Age	Years	Young (<35)	23	32.9	45.46	12.65
		Middle-aged (36-50)	17	24.2		
		Old (>50)	30	42.9		
Education	Year of schooling	No schooling (0)	16	22.9	2.64	2.51
		Can Sign Only (0.5)	5	7.1		
		Primary (1-5)	42	60		
		Bellow SSC (6-9)	3	4.3		
		Above SSC (>10)	4	5.7		
Farm size (total usable land)	Hectors	Marginal (0.01-0.2 ha)	7	10	0.77	0.30
		Small (0.21-1.0 ha)	47	67.1		
		Medium (>1.0 ha	16	22.9		
Farm type	code	Homestead area (1)	14	20	0.14	0.04
		Own land (2)	8	11.42	0.32	0.20
		Leased from others (3)	48	68.57	0.41	0.22
Total income	000’ Tk	Low income (up to 350)	41	58.6	388.71	107.27
		Medium (351-450)	14	20		
		High income (>450)	15	21.4		

Source: Sample survey 2023

3.2 Annual Household Income of the Respondent

Annual household income was classified into mainly three categories, i.e. agriculture, livestock & poultry [28], and each category had three sub-categories i.e. low income (up to 350 thousand Tk.), medium (351-450 thousand Tk.) and high income (>450 thousand Tk.).

The figure shows the annual household income of the respondents in the study area. It depicts that the maximum number of farmers achieved yearly revenue from the agriculture sector than livestock & poultry and other opportunities is very low. HIES 2022 reports the average monthly household income is Tk. 32,422 at the national level, Tk. 26,163 in rural areas, and Tk. 45,757 in urban areas.

3.3 Farming Type and used Agricultural Technology in the Study Area

The type of farming practiced by respondents can be an important factor influencing dietary diversity. Different farming systems—such as crop (Paddy), vegetable, livestock, and poultry can affect the variety of foods available for household consumption (Sileyew et al., 2023). Farm production diversity has the potential to influence the diversity of household diets, an important nutrition outcome associated with the nutrient adequacy of diets, and the nutritional status of individuals [29].

From Table 4, Out of 70 respondents, all of them did not cultivate crops which is 100 per cent, while the other 94.3 per cent of farmers cultivated vegetables, 77.1 per cent rice, and 67.1 percent cash crops. The other 75.7 per cent farming type was livestock & poultry of the study area.

The most notable trends are the high participation rates in vegetable farming (94.3%) and rice farming (77.1%). Rice is the main staple food in the charred area which ensures food security among the people [30]. A majority of farmers (75.7%) are involved in livestock and poultry farming, indicating that animal husbandry is a key component of their farming system. Livestock products like milk, meat, and eggs are important sources of protein, vitamins, and minerals that complement the predominantly rice-based diet in char areas [31].

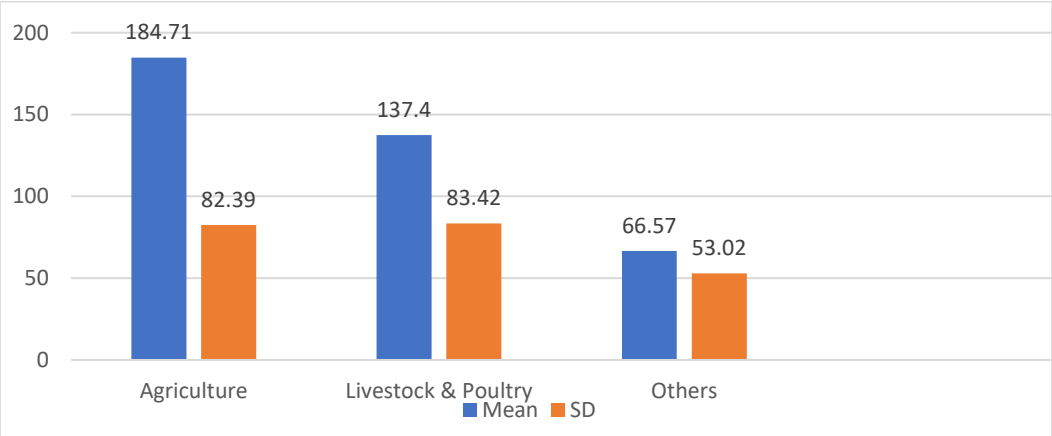

Fig. 3. Annual household income of the sample farmers

Table 4. Farming type of the respondents in the study area

Mention Farming Type	Frequency (Percentage)	
	Yes	No
Crop (paddy)	0 (0%)	70 (100%)
Rice	54 (77.1%)	16 (22.9%)
Vegetables	66 (94.3%)	4 (5.7%)
Cash-Crop	23 (32.9%)	47 (67.1%)
Livestock & Poultry	53 (75.7%)	17 (24.3%)

Source: sample survey 2023

Table 5. Agriculture technology used by the farmers in the study area

Name of Agriculture Technology	Frequency (Percentage)	
	Yes	No
HYV	61 (87.1%)	7 (12.9%)
Modern Equipment	67 (95.7%)	3 (4.3%)
Power Tiller	66 (94.3%)	4 (5.7%)
Fertilizer/pesticides/insecticide	68 (97.1%)	2 (2.9%)

Source: Sample survey 2023

The adoption of advanced agricultural technologies, such as improved seeds, irrigation systems, mechanization, and modern farming practices, often leads to higher productivity, crop diversification, and better income stability [32]. These factors, in turn, enable farmers to access a wider variety of foods, also through increased production of diverse crops or by generating higher income, which allows for the purchase of different types of food.

From Table 5, Out of 70 respondents, 61 used HYV and modern equipment in their farmland which is 95.7 per cent respectively, 4.3 per cent of farmers used power tiller and fertilizer/pesticides/insecticide in their farmland respectively.

A significant majority (87.1%) use HYV, indicating that improved seed varieties play a crucial role in enhancing crop productivity. This shows a shift toward modern agricultural practices aimed at increasing yields and improving food security. Similarly, the use of a power tiller reduces the physical labour required for land cultivation and enables timely farming operations, which is vital for maximizing agricultural output. Technologies that enhance crop yields can improve food security and allow farmers to experiment with different crops, which can enhance dietary diversity [33]. Overall, the data suggests that farmers are increasingly adopting modern technologies and inputs to improve productivity, though a small percentage still do not have access to these resources, potentially limiting their agricultural potential. These technologies can help mitigate biotic and abiotic stresses affecting food production. The report emphasizes that investments in research and development are crucial for harnessing these technologies effectively [34].

3.4 Elements used for Agricultural Production

Table 6 revealed that out of 70 respondents 32 small farmers had training on agriculture which is 45.8 percent, they have experience in agriculture 59 respondents which is 84.30 percent, and they have knowledge of market price about 58 respondents which is 82.9 percent. 94.3 percent of them carry out agriculture with loans from various NGOs. However, there was no government support for the small farmers of char areas of Bangladesh, highlighting a gap in assistance for agricultural producers. Training, credit & govt. Support can enhance farmers' skills and knowledge, leading to improved yields and food security among the farmers in char areas [35].

3.5 Household Dietary Diversity Score

The Household Dietary Diversity Score (HDDS) is a widely used indicator to assess the diversity of foods consumed by a household over a specific reference period, typically 24 hours [36]. It provides a snapshot of the variety of food groups that households have access to and consume, serving as a proxy for the nutritional quality of the diet [37]. The HDDS indicator provides a glimpse of a household's ability to access food as well as its socioeconomic status based on the previous 24 hours [38].

Among the 70 respondents of smallholder farmers, almost all of them have a variety in their diet. Observation shows that out of 70 respondents, 68 have cereals in their daily diet, 64 have roots, tubers, and plantains, 53 have pulses, legumes, nuts, and seeds, 66 have vegetables, 70 have fruits which are 100%, 43 have meats, 58 people have fish and seafood, 56 people have milk and dairy products, 40 people have eggs, 42 people have oils and fats and 47 people have Beverages in their daily food list. Cereals are a staple in the diet, as indicated by the very high consumption rate (97.1%) and the substantial average intake (2.30 kg/day). A large majority (91.4%) of households include Roots, Tubers, and Plantains in their diet. Despite the lower average intake (0.60 kg/day), the score reflects their common inclusion in daily meals. Eggs are less frequently consumed (57.1%)

despite a higher intake (2.64 kg/day), leading to a moderate score, suggesting that while some households rely on eggs, they are not as universally consumed. Every household consumes fruits, though in smaller quantities (0.28 kg/day). The perfect score suggests that fruit consumption is well-integrated into the diet. HDDS is a useful proxy for food security because it reflects both food access and consumption patterns. It can be used to track the impact of agricultural interventions or food aid programs to ensure food security [39].

3.6 Family Expenditure of Small Farmers before and after Technology Adoption

Table 8 shows the number and percentage of respondents in five different categories namely food and clothes, livestock and poultry, education, medicine, and festival. Family expenditure of farmers in all groups was very low before the adoption of agricultural technology and increased significantly after the adoption of agricultural technology. The difference in family expenditure before and after the adoption of agricultural technology is 7228.57, 30096.61, 29582.81, 13100.00, and 28800.00 in food and clothes, livestock and poultry, education, medicine, and festival respectively. HIES 2022 estimates the total monthly household expenditure at Tk. 31,500 at the national level, Tk. 26,842 in rural areas, and Tk. 41,424 in urban areas. The proportion of household expenditure devoted to food is a widely recognized indicator of food security. Households that spend a significant proportion of their income on food are often more vulnerable to food insecurity, as they have limited ability to cope with income shocks or rising food prices [40].

3.7 Empirical Results of the Factors Influencing Dietary Diversity

In this paper, we described the dietary diversity of the char area in Mymensingh, to explore what factors are influencing current diet quality. Dietary diversity is influenced by a complex interplay of socioeconomic, environmental, cultural, and individual factors [41]. The dietary diversity among farmers in the study area is shaped by multiple interconnected factors, including education, farm size, annual household income agriculture, total income, experience, market price, credit, choice of new technology, farming type, supply, etc.

From Table 9, dietary diversity has a strong positive correlation with supply (.913) at a 1 % significant level. A high correlation indicates that an increase in the supply of agricultural products is strongly associated with greater dietary diversity. The supply chain connects farmers, processors, distributors, retailers, and consumers, ensuring that food produced at the farm level reaches end consumers. Efficient supply chains minimize delays, reduce spoilage, and ensure a continuous flow of food to markets. A moderate positive correlation with annual household income agriculture (.448) significant

Table 6. Name of the elements which is used for agricultural production (sample 70 farmers)

Name of Elements	Frequency		Percent	
	Yes	No	Yes	No
Training	32	38	45.8	54.3
Experience	59	7	84.3	10
Market Price	58	12	82.9	17.1
Govt. Support	0	70	0	100
Credit	66	4	94.3	5.7

Table 7. Household dietary diversity score of small farmers of char land

Sl. No.	House Hold Dietary Diversity Elements	No.	%	Mean (Kg/day)	Score
1	Cereals	68	97.1	2.30	0.97
2	Roots, Tubers and Plantains	64	91.4	0.60	0.91
3	Pulses, Legumes, Nuts and seeds	53	75.7	0.16	0.76
4	Vegetables	66	94.3	1.21	0.94
5	Fruits	70	100	0.28	1.00
6	Meats	43	61.4	0.20	0.61
7	Fish and Seafood	58	82.9	0.27	0.83
8	Milk and Dairy Products	56	80	1.64	0.80

Sl. No.	House Hold Dietary Diversity Elements	No.	%	Mean (Kg/day)	Score
9	Eggs	40	57.1	2.64	0.57
10	Oils and Fats	42	60	0.11	0.60
11	Beverages	47	67.1	0.29	0.67

Source: Sample survey 2023

Table 8. Family expenditure of small farmers

Family Expenditure	Before		After		Different
	Mean	SD	Mean	SD	
Food and Clothes	115700.00	159418.27	122928.57	32919.45	7228.57
Livestock and Poultry	14347.83	11033.72	44444.44	25449.37	30096.61
Education	8934.43	7368.56	38517.24	21732.22	29582.81
Medicine	5942.86	4571.13	19042.86	9678.06	13100.00
Festival	20771.43	7279.46	49571.43	13070.12	28800.00

Source: Sample survey 2023

at 1 %degree of level depicts that households with higher agricultural income tend to have more diverse diets. Higher household income from agriculture improves the ability to purchase food, especially when households cannot grow enough for their needs. This is particularly important in seasons where farming productivity is low or during periods of crop failure. A positive correlation with total income (.373) leads to a higher total income also supports greater dietary diversity. Credit was significant at a 5% level (.267) indicating that a 1 % increase in credit leads to an increase in dietary diversity by .267%. New technology adoption has a positive relationship with dietary diversity. Farming type, farm size, education, and market price have a positive relationship with dietary diversity. These findings suggested that increasing quality service and training that variable can enhance the dietary diversity of the farmers in the sample area. On the contrary, Experience has a negative relationship with dietary diversity which means that experience does not influence food security. A study by Sultana et al., [42] found that socio-demographic factors like household size, occupation of the household head, and economic well-being were associated with dietary diversity in rural Bangladesh. Understanding these influences is crucial for developing interventions aimed at improving nutrition and food security [43].

3.8 Problems Faced by the Respondents in the Study Area

Table 10 ranks various problems affecting agricultural practices and community development. Lack of transport and communication, environmental hazards, and natural disasters are the most significant issues, each scoring 140 and ranked highest. Poor or non-existent transport infrastructure restricts farmers' access to markets, making it difficult to sell their produce and purchase essential food items. This isolation often leads to reduced incomes, as farmers are forced to sell their products at lower prices to local middlemen [44-46]. Environmental hazards and natural disasters, such as floods, river erosion, and cyclones, frequently affect char areas, severely impacting food security. These disasters destroy crops, livestock, and infrastructure, reducing food availability and limiting access to markets. Additionally, displacement caused by erosion and flooding disrupt livelihoods, leading to income loss and food shortages. Vulnerable communities in char areas often face heightened risks of malnutrition and long-term food insecurity. Unstable product prices follow closely with a score of 129, ranked second. Price fluctuations limit access to diverse, nutritious foods for low-income households, forcing reliance on cheaper, less nutritious staples like rice. This reduces dietary diversity, leading to potential malnutrition and poor health outcomes. Stabilizing prices through improved market access and infrastructure is crucial to enhancing food security in these vulnerable regions [47-49]. Agricultural farming and technology (60), cultural barriers (58), and lack of technical knowledge (50) rank in the middle. Religious obstacles and political crises are tied, both scoring 57, while lack of credit is the least concerning issue, with a score of 46, ranking last. In certain areas, other factors such as lack of technical knowledge, limited access to agricultural farming technologies, and cultural barriers hinder the adoption of modern farming practices, reducing productivity and food availability. Political crises and local issues further disrupt market access

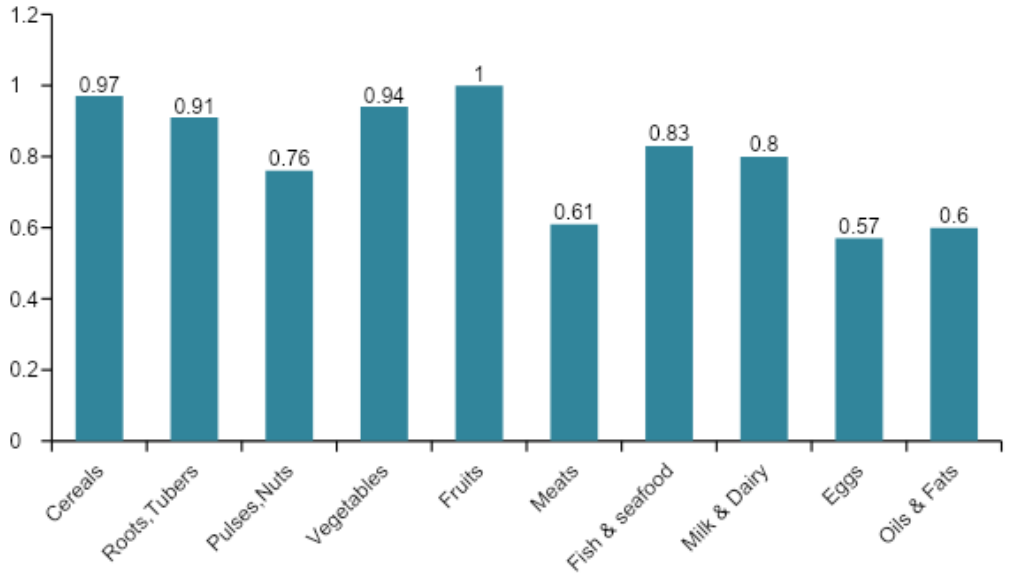

Fig. 4. Household dietary diversity score of small farmers of char land

Table 9. The Estimated value of coefficients and related statistics of the OLS regression model

	Dietary Diversity	Education	Farm Size	Annual household income Agri.	Total Income	Experience	Market Price	Credit	Choice of new technology	Farming Type	Supply Chain
Dietary Diversity	1										
Education	0.077	1									
Farm Size	0.033	0.116	1								
Annual household income Agri.	.448**	-0.067	.541**	1							
Total Income	.373**	0.019	.454**	.517**	1						
Experience	-0.031	0.039	-0.203	-0.226	-0.159	1					
Market Price	0.102	.276*	0.111	-.266*	-0.219	0.093	1				
Credit	.267*	0.118	0.103	0.097	0.101	-0.187	0.051	1			
Choice of new technology	0.004	0.041	.326**	-.303*	0.035	0.084	-0.096	0.022	1		
Farming Type	0.14	0.056	-0.188	-0.022	0.054	.352**	0.013	0.106	0.187	1	
Supply Chain	.913**	0.056	0.054	.330**	.406**	-0.019	0.165	0.217	-0.013	0.129	1

Table 10. Problems faced by the farmers in the charred area

Sl. No.	Name of the problems	High	Medium	Low	Not at all	Score Total	Rank
1	Agricultural farming and technology	0	1	58	11	60	3
2	Lack of technical knowledge	0	1	48	21	50	2
3	Lack of Credit	0	2	21	47	46	6
4	Lack of transport and communication	0	70	0	0	140	1
5	Unstable product price	0	59	11	0	129	2
6	Environmental hazard	0	70	0	0	140	1
7	Natural disaster	0	70	0	0	140	1
8	Religious obstacle	1	1	52	16	57	5
9	Cultural barriers	1	1	53	15	58	4
10	Political crisis & local issues	1	1	52	16	57	5
	Total					877	

Source: sample survey 2023

and resource distribution, exacerbating food insecurity. These factors collectively limit income opportunities and access to diverse, nutritious food, contributing to persistent food insecurity in these vulnerable regions.

4. CONCLUSION AND POLICY RECOMMENDATION

The study mainly focuses on the impact of agricultural technology on the food security of small farmers of char land. It tries to find out the present situation of the food security of small farmers of the char land of Bangladesh. The study was conducted in five villages in Mymensingh district. The number of respondents was 70. From the above discussion, it can be said that the farmers of the particular study area show a weak nutritional status but have a satisfactory dietary diversity. However, the number of low dietary diversity group farmers was also found, which is not good. The survey data suggests that efforts need to be made to reduce the share of a single crop (rice) and a single season (Boro, which accounts for over 60% of rice production) in phases. Investments in fisheries, livestock, and horticulture need to be scaled up to raise productivity and encourage farmers to diversify. Ensure affordable access to quality seeds, fertilizers, machinery, and other inputs. Promote technology adoption through subsidies or low-interest loans, especially for smallholder farmers. Furthermore, invest in roads, storage facilities, and markets to improve the supply chain and reduce post-harvest losses. Reliable infrastructure can enhance market access and food distribution, improving food security. Moreover, Farmers must be empowered by enhancing their awareness, knowledge, skills, and technology use efficiency so that agricultural production multiplies at a faster pace. Provide targeted training and technical support to farmers, focusing on climate-resilient and modern agricultural practices, such as the use of improved seeds, irrigation, and pest management. This will enhance productivity and food availability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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