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DETERMINANTS OF CROPPING INTENSITY IN DROUGHT PRONE AREAS OF BOGURA

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ABSTRACT
This study assessed cropping intensity and its influencing factors in the drought-prone areas of Bogura district, Bangladesh. Data were collected from 105 randomly selected farmers across four villages using a structured interview schedule. Cropping intensity, calculated as the ratio of gross cropped area to net sown area, ranged from 200% to 300%, with an average of 277.9%. The majority (84.7%) of farmers achieved more than 268% cropping intensity. Key factors positively influencing cropping intensity included the use of machinery for tilling, water management through underground water extraction, and the cultivation of short-duration crops. However, challenges such as surface water scarcity, poor drainage, inadequate infrastructure, low soil organic matter, and limited natural water bodies hindered intensification. Additionally, farmer’s education levels, annual income, and access to communication media significantly impacted cropping intensity. The study highlights the need for improved irrigation facilities, enhanced extension services, and better infrastructure to sustain high cropping intensity in drought-prone regions.

KEY WORDS
Cropping Intensity, drought-prone areas, agricultural productivity, farm mechanization, water management, soil management, crop diversification.

Agriculture is a vital sector in Bangladesh, supporting a significant portion of the population and contributing around 20% to the national GDP. The country’s agricultural regions vary in cropping patterns, with Bogura district being a prominent agricultural area characterized by both economic reliance on farming and vulnerability to drought. Cropping intensity, defined as the ratio of gross cropped area to net sown area, is a key indicator of agricultural productivity. While the national average cropping intensity is 191%, Bogura exceeds this with 234%, reflecting the region's efforts in crop diversification and multiple cropping systems.

However, dry areas like Bogura face challenges in maintaining high cropping intensity due to water scarcity, inadequate infrastructure, and soil degradation. Factors such as the use of modern agricultural machinery, efficient water management, and short-duration crop cultivation significantly influence cropping intensity. Additionally, socioeconomic factors like farmers’ education, income, and access to communication media play crucial roles in determining cropping practices.

This study aims to identify the major cropping patterns, determine factors influencing cropping intensity, assess related challenges, and explore the relationship between farmers’ characteristics and cropping intensity in the drought-prone areas of Bogura. The findings are expected to provide insights for policymakers and agricultural extension services to enhance cropping intensity and ensure sustainable agricultural development.

LITERATURE REVIEW

Cropping intensification is a strategy designed to maximize agricultural productivity by optimizing the use of resources such as soil, water, nutrients, and solar radiation. According to Shrestha et al. (2021), intensification involves sustainable yield-increasing technologies, supplementary irrigation, improved crop varieties, and better management practices.

Deguines et al. (2014) further emphasized that increased cropping intensity enhances yields and reduces variability.

Dry areas are characterized by inadequate precipitation and frequent droughts, significantly affecting agricultural productivity. Abebe (2021) noted that these regions cover over 40% of the Earth's surface and are home to 2.3 billion people. Mujiyo et al. (2023) found that lower soil moisture in arid zones leads to reduced crop productivity. Adopting drought-resistant crops and effective irrigation systems is essential for sustaining agricultural output (Ben-Enukora et al., 2023).

Anshori et al. (2023) highlighted the common challenges of soil dryness and reduced fertility in dryland agriculture. Mridha and Rahman (2021) reported that water scarcity in Bogura during dry seasons negatively impacts irrigation and reduces cropping intensity. Sustainable water management, efficient irrigation methods, and alternative water sources are necessary to address these challenges (Mustaqimah et al., 2022).

Islam et al. (2018) investigated cropping intensity across Bogura, reporting values ranging from 183% to 291%, with an average regional intensity of 234%. The highest intensity was observed in Khetlal (291%), while Bogura Sadar and Kahalu upazilas reported intensities of 282% and 274%, respectively.

Adamu et al. (2021) found that over 50% of farmers in their study were aged 40 or older, with reduced productivity observed in older farmers (Adeleke et al., 2021). While age can influence agricultural output, other factors like resource management and environmental conditions also play a role (Fanadzo et al., 2010).

Higher education levels are associated with increased adoption of modern practices, leading to greater cropping intensity (Emran et al., 2021). Educated farmers tend to cultivate high-value crops and apply sustainable farming techniques (Swain, 2018; Silva et al., 2020).

Kumar et al. (2021) and Ukwuaba and Ileka (2024) found that larger farms tend to have higher cropping intensities due to increased resource access and crop diversity.

Studies by Li et al. (2023) and Rosenzweig & Schipanski (2019) suggest that increased cropping intensity often results in higher annual incomes. Expanding irrigation and shifting to cash crops further enhances income levels (Kumar et al., 2021; Yang et al., 2022).

Effective use of communication media significantly influences cropping intensity by providing access to agricultural information (Mpiima et al., 2019; Thomas & Prakash, 2024).

Active participation in agricultural organizations fosters knowledge exchange and innovation adoption, resulting in higher cropping intensity (Goswami et al., 2020; Swain, 2018). While mechanization can enhance productivity, Sarkar et al. (2020) cautioned against soil compaction caused by heavy machinery. However, reduced tillage techniques can mitigate adverse effects (Townsend et al., 2015).

Groundwater irrigation has been shown to significantly increase cropping intensity (Kumar et al., 2021; Devi, 2023). Improved irrigation infrastructure further supports higher productivity (Paria et al., 2021).

Mechanized harvesting and post-harvest processing reduce labor costs and improve efficiency, positively impacting cropping intensity (Chandra et al., 2024; Jha et al., 2022).

Access to water, fertilizers, and technology is crucial for achieving high cropping intensity. Water management and organic inputs enhance productivity, even in dry areas (Rufino et al., 2021; Nathan et al., 2020; Singh & Narayanan, 2016).

The conceptual framework for this study is based on the model of Rosenberg and Hoveland (1960). It examines the relationship between selected characteristics of farmers and cropping intensity in Bogura's dry areas. This approach captures the interplay between socio-economic, environmental, and technological factors that influence agricultural intensification.

METHODS OF RESEARCH

Methodology plays an important role in any scientific research. Careful considerations are needed before conducting a social study. The research methodology must describe the sorts of research design, method and procedure to be followed in collecting valid and reliable data and the analysis and interpretation of those for arriving at a concrete conclusion. Methods and procedures followed in conducting this study have been discussed in this chapter.

This study employed both quantitative and qualitative research approaches in order to get a comprehensive view of determinants of cropping intensity in dry areas. Qualitative methods such as focus group discussion (FGD) and key informant interview (KII) were used to cross check the data given by the respondents and to have a clear view about the determinants of cropping intensity. The quantitative survey approach was used to collect data about the aforesaid issues related to crop production in dry areas in the study area.

Bogura, which is located in the northwest of Bangladesh, offers unique conditions for studying the factors that influence cropping intensity because of its distinctive socioeconomic and meteorological features. There are twelve upazila in Bogura district, among which western part of Sadar and Kahalu Upazila was selected purposively because of the severity of dryness. The area is typical of dry regions where agricultural productivity faces major challenges because of its semi-arid climate and erratic, frequently minimal rainfall. The study was conducted in Fapor union of Sadar upazila and Sadar union of Kahalu upazila because of dry soil condition and minimal rainfall status of these areas. Prior to selection of these unions, through discussion with the concerned GOs and NGOs personnel and local elites were made by the researcher in order to identify the suitable area for conducting the survey.

Figure 1 – A map of Sadar and Kahalu upazila showing the study area

This study employed a combination of qualitative and quantitative research approaches to comprehensively investigate the determinants that influence cropping intensity in the dry areas of Bogura. The study utilized qualitative research methods, specifically Focus Group Discussion (FGD) and Key Informant Interview (KII), to identify the factors that enhance cropping intensity. A study design was implemented to ascertain the factors that influence cropping intensity in the dry areas of Bogura:

The Bogura District, located in the Rajshahi division, has an area of 2898.68 square kilometers and has a population of 3400874. The location is situated within the latitudinal range of 24°32' to 25°07' north, and the longitudinal range of 88°58' to 89°45' east. Sadar and Kahalu upazilas, two of its twelve upazilas, have been chosen as the study areas. Bogura Sadar is situated at around 24.85° latitude N and 89.37° longitude E. It is located at an elevation of around 20 meters above sea level and spans an area of 176.58 square kilometers. The total population of Bogura Sadar is 555,014. Kahalu is situated at coordinates 24.75° N 89.33° E and has an elevation of around 25 meters above sea level. It spans an area of 240.42 square kilometers and has a population of 222,376 (BBS, 2011). The study area is covered by reddish brown soil of Barind Clay which is a south-eastern part of Barind Tract, a Pleistocene terrace of the Bengal Basin. Furthermore, the area is generally experiences tropical to sub-tropical monsoon climate characterized by wide seasonal variations in rainfall, warm to hot temperatures and high humidity which is one of the main geological factors in the formation process of the residual soils. The studied soils are silt dominated which contains 54.40 to 80.60% silt with 9.40 to 41.30% sand and 4 to 14.10% clay and moisture content ranges from 13.96 to 33.45%.

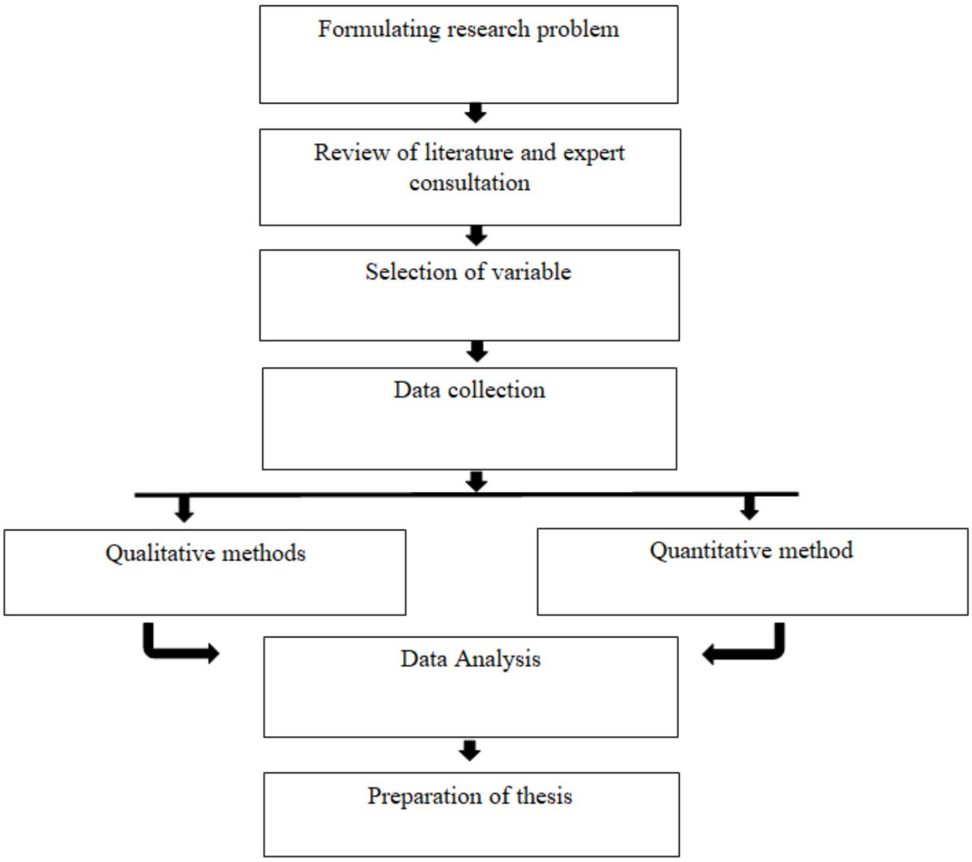

Figure 2 – Research design of the study

Every research methodology employs distinct data collection equipment to conduct a study. Data identification should be conducted consciously, with precise selection and systematic collecting. Precision and accuracy are essential characteristics when it comes to measuring in studies. This study utilized the method of conducting face-to-face interviews. This method is the most efficient and cost-effective way in social research since it enables the collecting of empirical data within a limited timeframe and budget. A meticulously prepared structured interview schedule was constructed with the precise purposes in mind to collect relevant data for the study. The schedule has been incorporated into Appendix II. The interview schedule was created in Bengali to ensure a clear understanding by the respondents. The questions in this schedule were formulated with clarity and precision and were arranged in a logical sequence to facilitate understanding for the respondents. The survey consisted of questions that were both closed-ended and open-ended. The schedule was deliberately designed to include suitable scales as needed for the purpose of measuring distinct characteristics of the farmers and the dependent variable.

Before processing the data collection questions, the researcher conducted a preliminary test of the interview schedule with 15 farmers from the four communities. The pre-test allows the researcher to identify incorrect and difficult questions in the initial schedule, facilitating necessary revisions and modifications depending on the pre-test results. A total of 32 farmers were selected for Focus Group Discussions (FGDs), with 8 farmers chosen from each village. In addition, we conducted interviews with four important informants to gather their insights on the factors influencing cropping intensity in the arid regions of Bogura.

Two Focus Group Discussions (FGDs) were conducted in January 2024. A single session was conducted in each Upazila. Focus group discussions were carried out utilizing a semi-structured questionnaire. This method identified cropping intensity related several factors as growing of shorter duration crops, use of machines for quicker activities, adequate underground water for irrigation, suitable land for year round cultivation, productive soil, availability of inputs for cultivating crops, availability of quality seed, easy market facility. Throughout the FGDs sessions, the researcher took on the role of a facilitator. The survey methods were enhanced and refined by using the insights obtained from the FGDs. The additional data acquired from the focus group discussions (FGDs) was employed to examine the results of the survey

The interviews with four key informants were conducted in early February 2024. The key informants included the Agriculture Extension Officer (AEO), Union Parishad Member, and a highly commendable farmer from the region. The researcher acquired valuable knowledge about the present circumstances, the perspectives of farmers, their innovative farming methods, and essential agricultural facts by conducting interviews with key informants. The identified factors were examined and justified by KII.

The investigation was conducted between March 12th and April 23rd, 2024. The researcher directly gathered data of 105 farmers from a population of 310 farmers using a standardized questionnaire. The researcher established a positive relationship with the participants and clearly conveyed the objectives of the study, using the local language whenever possible. As a result, the participants responded to the questions with precision and confidence. Any difficulties in understanding were quickly resolved by providing clear explanations for the queries. The respondents and other individuals in the research field showed outstanding collaboration.

Secondary data refers to information that has been collected by someone else for a different purpose, but can be used for research or analysis. In order to establish a theoretical basis for the study, the researcher collected relevant material from a wide range of sources, such as books, journals, theses, abstracts, reports, and websites. In addition, the researcher collected data from other agencies, including the Upazila Agriculture Office, to achieve this particular purpose.

The statistical measures such as range, mean, standard deviation, percentage distribution were used to describe both the dependent and independent variables. Tables were also used in presenting data for clarity of understanding. In order to explore the relationships of the selected characteristics of the farmers with cropping intensity, the Pearson's Product Moment Coefficient was computed. Correlation matrix was also computed to determine the inner relationship among the variables. 5 percent level of significance with relevant degrees of freedom considered to reject or accept the null hypothesis. If the tabulated value was found greater than the calculated value (r) then the null hypothesis could not be rejected, i.e. there was no relationship between the concerned variables. To the contrary if the calculated value (r) was higher than the tabulated value then the null hypothesis was rejected.

A variable is defined as a characteristic, number, or quantity that possesses the potential to undergo variation or alteration. In genuine academic research, it is essential to consider a minimum of two elements, namely independent and dependent variables. The independent variable refers to the factor that is intentionally manipulated by the researcher in order to investigate its potential correlation with an observed phenomenon. The dependent variable is defined as the factor that exhibits changes, either in appearance, disappearance, or variation, in response to the introduction, removal, or alteration of the independent variable. Within the realm of scientific inquiry, the process of selecting and measuring variables assumes a paramount role. In accordance with this conceptual framework, the researcher conducted a comprehensive review of relevant literature in order to enhance their understanding of the nature and extent of the variables pertinent to this study.

Dependent Variable: In this study, "Determinants of cropping intensity in drought prone area" was considered as the reliant variable.

Independent Variable: Age, education, farm size, annual income, use of communication media, organizational participations, use of agricultural machineries in tilling, use of agricultural machineries in harvesting and post harvesting operations, availability of irrigation source and input availability were considered as the independent variables.

Cropping intensity refers to the intensive use of land by growing more crops in the same land during one agricultural year. It can be measured through a cropping intensity formula:

$$\text{Cropping intensity} = \text{Gross cropped area} / \text{Net sown area} \times 100$$

Gross Cropped Area: This is the total area sowed once or more in a given year, i.e. the area is counted as many times as there are sowings in a year. This total area is sometimes referred to as total cultivated area or total area seeded.

Net Sown Area: This is the entire area sown with crops. Areas sown multiple times in the same year are counted only once.

As the cropping intensity was basically depended on the 8 factors identified through FGD in the study area. The assessment of the factors responsible for crop intensification in the study area was established by calculating the factor index using a four- point scale (slightly agree, agree, moderately agree, strongly agree).

The selected characteristics of the farmers were the independent variables of the study. To keep the study manageable, nine independent variables were selected. The procedures of measurement of the selected variables were as follows.

The age of a respondent was measured in terms of actual years from his birth to the time of interview on the basis of his response. A score of one (1) was assigned for each year of age.

Education was measured as the ability of the respondent to read and write or the formal education received up to a certain standard. A score of zero (0) was given to a respondent who could not read and write, a score of 0.5 was given to the respondent who could sign only and a score of one (1) was given for each year of formal schooling completed by the respondent e.g. one (1) for completing class one, two (2) for class two and so on.

Farm size of a respondent was measured as the size of his farm (including jujube and other crops) on which he continued his farm practices during the period of study. Each respondent was asked to mention the homestead area, the land under his own cultivation, land given to others on borga, land taken from others on borga, land taken from others on lease system and others land (pond, poultry).

The following formula was used in measuring the farm size:

$$\text{Farm size (FS)} = F1 + F2 + 1/2(F3 + F4) + F5 + F6$$

Where: F1 = land under homestead; F2 = own land under own cultivation; F3 = land given to others on borga; F4 = land taken from others on borga; F5 = land taken from others on lease/mortgage; F6 = others land. The farm size of a respondent was calculated in hectares.

Annual family income of a respondent referred to the gross annual income obtained from agricultural crops, domestic animals, fisheries, and non-agricultural sources. Total earnings of a farmer from those sources were added together to determine his annual income and was measured in Taka. However, a unit score of 1 (one) was given for each Tk. 5000 of annual income.

Use of communication media of the respondent was measured by counting the score based on his frequency of use of media. It was categorized into low, medium & high based on the scores obtained.

Organizational participation of the respondent was measured by counting the score based on his frequency of taking participation in different organization. It was categorized into low, medium & high based on the scores obtained.

Use of agricultural machineries in tilling was measured by counting the score based on the frequency of using machine in tillage operation. It was categorized into low, medium & high based on the scores obtained.

Use of agricultural machineries in harvesting and post harvesting operation of the respondent was measured by counting the score based on his frequency of using machineries in harvesting and post harvesting operation. It was categorized into low, medium & high based on the scores obtained.

Availability of irrigation source was measured by counting the score based on the frequency of using available irrigation source. It was categorized into low, medium & high based on the scores obtained.

Availability of inputs was measured by counting the score based on the frequency of using available inputs for crop production. It was categorized into low, medium & high based on the scores obtained.

The data were analyzed in alignment with the research objectives of the study. The qualitative data were transformed into quantitative data using appropriate scoring techniques when deemed necessary. The statistical measures employed in this study included range, means, standard deviation, as well as number and percentage distribution, to effectively describe the variables under investigation. The chi-square test was employed to investigate the association between the dependent and independent variables. The study employed a significance level of 0.05 to determine the rejection of null hypotheses. All of these processes were conducted using the SPSS computer package.

RESULTS OF STUDY

Age of the farmer was determined by the number of years from his birth to the time of interview. It was found that on the basis of age farmers were classified into three categories: “Young " (Up to 40 years), “Middle” (41 to 63 years), “Old” (64 years and above) with a range of 30 to 73 years. The mean value and the standard deviation was noted as 51.27 and 11.38 respectively. Highest result was found in the middle category having 61.9 percent respondents and young was noted as the lowest with 17.1 percent respondent. 21 percent farmers were categorized into the old one.

Table 1 – Distribution of respondents depending upon their age

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Young (Up to 40 years)	18	17.1	51.27	11.38
Middle (41-63 years)	65	61.9		
Old (64 and above years)	22	21.0		
Total	105	100.0		

Education of a respondent was measured by the level of his formal education. Based on their education level the respondents were categorized into three distinct groups as Junior High school (up to 8 grade), High School (9 to 10 grade) and College (11 and above) with a range of 8 to 12. Data presented in Table 4.2 shows that a large portion of the total respondents were found in the category of college having 69.5 percent and Junior High School was found as the lowest with 9.5 percent of the total respondents. The High School category had a value of 21 percent. The mean value was noted as 9.60 and the standard deviation was recorded as 2.02.

Table 2 – Distribution of respondents depending upon their level of education

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Junior High School (Up to 8 grade)	10	9.5	9.60	2.02
High school (9 to 10 grade)	22	21.0		
College (11 and above)	73	69.5		
Total	105	100.0		

The farm sizes of the respondents were categorized into three groups: small (up to 0.5 hectares), medium (0.6 to 2 hectares), and large (2 hectares and above) with a range of 0.33 to 6.32 ha. The mean farm size was 1.01 hectare and the variability from the mean, as measured by the standard deviation, was 0.538. According to the result presented in the Table 4.3, respondents with both small and medium-sized farms had the same result of 17.1 percent, which was the lowest. However, medium-sized farm owners had the highest score, with 65.7 percent.

Table 3 – Distribution of respondents depending upon their farm size

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Small (Up to 0.5 ha)	18	17.1	1.01	0.538
Medium (0.6- 2 ha)	69	65.7		
Large (Above 2 ha)	18	17.1		
Total	105	100.0		

Annual income was estimated on the basis of total receipt goods expressed in taka. The average annual income of the farmers was 452.76 thousand and standard deviation was 256.21. On the basis of annual income of the respondents were classified into three distinct categories: “low income” (up to 197 thousand), “medium income” (198 to 709) and “high income” (709 to above) with a range of 125 to 1450 thousand taka. The distribution of the respondents according to their annual income is shown in Table 4.4 and data shown in the table show that the highest proportion (79 percent) of the respondents had medium annual income compared to 15.2percent having high and 5.7 percent under low annual income.

Table 4 – Distribution of respondents depending upon their annual income

Category (Tk. ‘000)	Respondents		Mean	Standard Deviation
	Number	Percent		
Low (Up to Tk. 197)	6	5.7	452.76	256.21
Medium (Tk. 198- Tk. 709)	83	79.0		
High (Above Tk. 709)	16	15.2		
Total	105	100.0		

The respondents were distributed depending upon their use of communication media in the table 4.5. Respondents were categorized into three groups: “low” up to 47 scores, “medium” (48 to 83 scores), “high” (above 83 scores) with a range of 1 to 5. The result presented in the Table showed that the highest 62.9 percent respondents were found into medium category to use communication media while the lowest was in high category having 18.1 percent and low category was found 19 percent. The mean value and standard deviation of the distribution was noted as 65.19 and 18.41 respectively.

Table 5 – Distribution of respondents depending upon their use of communication media

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Low (Up to 47 scores)	20	19	65.19	18.41
Medium (48 to 83 scores)	66	62.9		
High (Above 83 scores)	19	18.1		
Total	105	100.0		

Organizational participation scores of the respondents were computed on the basis of the extent of participation in different social organizations. Respondents were classified into three categories: “low” (up to 1), “medium” (2 to 3), “high” (above 3) with a range of 1 to 7. Data presented in Table 4.6 shows that the highest proportion (52.4 percent) of the respondents had medium participation in organizations compared to 17.1 percent having high organizational participation and 30.5 percent respondents were found to have low organizational participation. The mean and standard deviation was denoted as 1.38 and 1.51 respectively.

Table 6 – Distribution of respondents depending upon their organizational participation

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Low (Up to 1 scores)	32	30.5	1.38	1.51
Medium (2 to 3 scores)	55	52.4		
High (above 3 scores)	18	17.1		
Total	105	100.0		

Use of modern equipment in ploughing was evaluated on the basis of availability of mechanization facilities during tillage operation. Respondents were categorized into four distinct classes: “rare use” (up to 1 scores), “low use” (2 to 3 scores), “moderate use” (4 to 5 scores) and “frequently use” (above 5 scores) with a range of 1 to 6. Data presented in Table 4.7 shows that the highest 51.4 percent respondents had moderate use of modern equipment in ploughing compared to others while the lowest 3.8 percent respondents had no availability to use modern equipment. Rarely available and frequent use of modern equipment had the value of 9.5 and 35.2 percent respectively. The mean was noted as 2.18 and the standard deviation was 0.76.

Table 7 – Distribution of respondents depending upon their use of agricultural machineries in tilling of lands

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Rare use (Up to 1 score)	4	3.8	2.18	0.76
Low use (2-3 scores)	10	9.5		
Moderate use (4-5 scores)	54	51.4		
Frequent use (above 5 scores)	37	35.2		
Total	105	100.0		

The estimation of irrigation source use was based on the availability of irrigation source. The participants were classified into four unique categories: "unavailable" (up to 1), "rarely available" (1 to 3), "moderately available" (3 to 5), and "frequently available" (5 and above) with a range of 1 to 6. The data shown in Table 4.8 illustrates the distribution of respondents based on their utilization of irrigation sources. The category that was rarely available had the maximum value of 30.5 percent, while the moderate available category had a value of 28.6 percent. The category that was not available had the lowest value, with only 10.5 percent. The mean was calculated to be 1.79, while the standard deviation was determined to be 0.99.

Table 8 – Distribution of respondents depending upon their use of irrigation source

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Rare use (Up to 1 score)	11	10.5	1.79	0.99
Low use (2 – 3 scores)	32	30.5		
Moderate use (4 – 5 scores)	30	28.6		
Frequent use (Above 5 scores)	32	30.5		
Total	105	100.0		

Table 4.9 displays the distribution of machine use in harvesting and post-harvesting activities. The participants were categorized into four groups based on their machine utilization score in harvesting and post-harvesting activities: "not available" (up to 2), "rarely available" (2 to 3), "moderately available" (3 to 5), and "frequently available" (5 and above) with a range of 0 to 6. The table below indicates that 68.6 percent of the respondents reported frequent usage of machines, while just 4.8 percent reported not having access to machines for harvesting and post-harvesting operations, which was the lowest percentage.

The category of "rarely available" had a value of 7.6 percent, while the category of "moderately available" had a value of 19.0 percent. The mean was computed as 2.51 and the standard deviation was recorded as 0.83.

Table 9 – Distribution of respondents depending upon their use of agricultural machineries in harvesting and post harvesting operations

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Rare use (Up to 1 score)	5	4.8	2.51	0.83
Low use (2 – 3 scores)	8	7.6		
Moderate use (4 – 5 scores)	20	19.0		
Frequent use (Above 5 scores)	72	68.6		
Total	105	100.0		

Input availability is measured upon the scores of available inputs for crop production in the study area. The participants were classified into three distinct groups as follows: "not available" (up to 4), "rarely available" (5 to 9), and "moderately available" (10 and above) with a range of 1 to 10. Out of all the respondents, 65.7 percent had a rare level of access to input availability, while the category of "not available" had the lowest percentage at 14.3 percent. 20% of the respondents belonged to the category of "moderately available". The mean was estimated as 6.49 and the standard deviation was determined to be 2.18.

Table 10 – Distribution of respondents depending upon their perceived inputs availability

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Not Available (Up to 4)	15	14.3	6.49	2.18
Rarely Available (5-9)	69	65.7		
Moderately Available (10 to above)	21	20.0		
Total	105	100.0		

The observed cropping intensity was estimated on the basis of the number of crops cultivated by the participants throughout a specific agricultural year on a single field. The cropping intensity of the respondents ranged from 200% to 300% with the mean of 277.9% and standard deviation of 30.9. Based on range, the respondents were categorized into three groups: "low" (up to 233%), medium (234% – 267%) and "high" (268% and above). The data shown in Table 4.2 indicate that the highest 84.7 percent of the respondents had a higher cropping intensity whereas; only 15.3% percent had low to medium cropping intensity.

Table 11 Distribution of respondents depending upon cropping intensity

Category	Respondents		Mean	Standard Deviation
	Number	Percent		
Low (Up to 233%)	13	12.4	277.87	30.91
Medium (234% to 267%)	3	2.9		
High (268% and above)	89	84.7		
Total	105	100.0		

The evaluation of cropping patterns in the study area was based on the spatial distribution and diversity of major crops. Table 4.12 displays data showing that farmers in the study area followed six different cropping patterns: Mustard-Boro-T.aman, Vegetable-Boro-T.aman, Boro-fellow-T.aman, Potato-Boro-T.aman, Boro-Vegetable-T.aman, and Potato-Boro-T.aman. Among these patterns, cropping pattern with three cropped area accounted for a total of 88 percent of the net cropped area. Mustard-Boro-T.aman, Vegetable-Boro-T.aman, Boro-Fellow-T.aman, and Potato-Boro-T.aman were identified as the dominant cropping patterns, with 27.75, 19.75, 22, and 18.25 percent of the net cropped area, respectively. Potato-Boro-T.aman was found to be the least dominant cropping pattern.

Table 12 – Cropping patterns with percentage in the study area

Sl No	Cropping Pattern	Area (ha)	% of net cropped area	% of farmers
1	Mustard-Boro-T.aman	55.5	27.75	25.80
2	Vegetable-Boro-T.aman	39.5	19.75	21.91
3	Boro-Fellow-T.aman	44	22	20.95
4	Potato-Boro-T.aman	36.5	18.25	18.30
5	Boro-Vegetable-T.aman	16.5	8.25	9.24
6	Potato- Vegetable -T.aman	8	4	3.80
		200	100	100

The evaluation of crops cultivated by farmers in the research area was based on the total number of crops grown throughout the crop calendar. The farmers mostly boost the production of rice (Boro and T.aman), mustard, potato, and vegetables in this regard.

Table 13 – Crops grown by the respondent farmers all-round the year

Sl	Crop Name	Duration
1	Rice (Boro)	January-May
2	Rice (T.aman)	July-October
3	Mustard	Mid October- mid January
4	Potato	November- February
5	Vegetable	Year round

The assessment of the problems encountered by farmers during crop production in the research area was established by calculating the problem index using a four-point scale (no problem, low problem, moderate problem, and high problem). The Table 4.13 revealed the identification of fifteen difficulties, determined by the problem index, which varied from 280 to 145. The study area's farmers identified a significant problem with a problem index value of 280: a shortage of available surface water was found as a major problem. Additional major problems were observed, including insufficient drainage system, underdeveloped infrastructure, low organic matter content, shortage of natural water bodies and low moisture holding capacity of the soil.

Table 14 – Problems faced by the farmers during crop production in the study area

Sl No	Problems Faced by Farmers	Degrees of Problem				Problem index
		High Problem	Moderate Problem	Low Problem	No Problem	
1	Shortage of available surface water	70	35	0	0	280
2	Insufficient drainage system	43	51	11	0	242
3	Underdeveloped Infrastructure	28	29	30	18	172
4	Low organic matter content	23	38	26	18	171
5	Shortage of natural water body	31	26	24	24	169
6	Low moisture-holding capacity of soil	23	35	27	20	166
7	Improper weed management	22	32	32	19	162
8	Insufficient electricity supply	24	32	26	23	162
9	Underdeveloped roadway facilities	22	32	28	23	158
10	Disposal, price and marketing outlets	19	33	32	21	155
11	Unawareness on government support	17	33	38	17	155
12	Low natural fertility	20	33	28	24	154
13	Improper fertilizer management	18	30	31	26	145
14	Lack of quality seed of improved varieties	18	28	35	24	145
15	Improper insect-pests management	18	30	31	26	145

The Table 15 revealed the identification of eight factors, determined by the factor index, which varied from 390 to 267: use of machineries for quicker activities was revealed as the major factor for crop intensification in the study area. Additional major factors were observed including adequate underground water for irrigation and growing of shorter duration crop.

This section deals with the relationships with ten selected characteristics of the farmers and cropping intensity in dry areas of Bogura. The selected characteristics constitute independent variables and the cropping intensity is considered as a dependent variable.

Table 15 – Factors responsible for crop intensification in the study area

Sl. No	Factors	Degrees of factor				Factor Index
		Strongly Agree	Moderately Agree	Agree	Slightly Agree	
1	Growing of shorter duration crops	52	38	12	4	350
2	Use of machineries for quicker activities	72	34	0	0	390
3	Adequate underground water for irrigation	68	38	0	0	386
4	Suitable land for year round cultivation	24	36	28	18	278
5	Productive soil	28	28	32	18	278
6	Availability of inputs for crop production	30	26	26	24	274
7	Availability of quality seeds	23	35	22	26	267
8	Easy market facility	24	36	28	18	278

Table 16 – Correlation co-efficient of the selected characteristics of the respondents with the cropping intensity in dry areas of Bogura

Dependent Variable	Independent Variable	Computed value for 'r'	Table value of 'r'	
			0.05	0.01
Cropping intensity in drought prone area	Age	0.116	0.193	0.252
	Level of education	0.642**		
	Farm size	-0.50		
	Annual income	0.194*		
	Use of communication media	0.584 **		
	Organizational participation	0.009		
	Use of agricultural machineries for tilling	0.707**		
	Use of agricultural machineries for harvesting and post harvesting operations	0.674**		
	Use of irrigation sources	0.918**		
	Input availability	0.904**		

*Note: 1) **Correlation Significant at the 0.01 level (2-tailed); 2)* Correlation Significant at the 0.05 level (2-tailed). A list wise N=105.*

Pearson's correlation co-efficient "r" was used to test the hypothesis concerning the relationships between two variables and 0.05% level of significance was used as the basis for acceptance or rejection of the hypothesis.

DISCUSSION OF RESULTS

The majority (61.9%) of respondents were middle-aged, compared to 21% in the older category and 17.1% younger farmers. Middle-aged farmers, often between 21 and 50 years, are considered to be in their most productive agricultural years (Stephen et al., 2021).

A significant proportion (69.5%) of respondents had attained college-level education, attributed to the proximity of the study area to urban centers. Higher education levels in these regions result in increased agricultural knowledge and adoption of modern practices (Zhou et al., 2023).

More than half (65.7%) of respondents owned medium-sized farms. With better educational exposure, these farmers were equipped to implement advanced agricultural practices on moderate landholdings. Similar findings were reported by Jayne et al. (2019) in Sub-Saharan Africa.

Most respondents (79%) reported a medium annual income. Agricultural incomes in dryland regions are heavily influenced by climate variability and resource availability, a trend also noted by Muralikrishnan et al. (2021).

Around 62.9% of farmers had medium levels of communication media usage. Effective communication fosters access to agricultural knowledge, enhancing resilience and adaptive practices in dry regions (Fadairo et al., 2023; Esariti et al., 2022).

The majority (52.4%) reported medium organizational participation, facilitating knowledge sharing and collaboration. Fu and Zhu (2023) also highlighted the positive influence of organizational engagement on agricultural productivity.

A substantial 86.6% of respondents used modern tilling machinery, reflecting the influence of education on technological adoption. Asadullah and Rahman (2009) similarly observed a correlation between education and mechanization in dry areas.

While 30.5% of respondents reported both frequent and rare access to irrigation, groundwater remained a primary resource. Studies by Panahi et al. (2021) and Shahid (2010) confirm the reliance on groundwater for irrigation in dryland agriculture.

About 68.6% of farmers used mechanized harvesting and post-harvest technologies. Barman et al. (2019) reported a positive association between education and mechanization adoption in dry regions.

Limited input availability was observed, with 65.7% of farmers reporting infrequent access. However, improved input supply was linked to increased cropping intensity. Nathan et al. (2020) demonstrated the role of inputs in enhancing soil water retention and mitigating drought effects.

The study revealed a higher average cropping intensity (277.86%) compared to the regional average of 234% reported by Islam et al. (2018). This suggests effective adaptation practices in the study area.

A non-significant correlation (r=0.116r = 0.116r=0.116) was found between age and cropping intensity, suggesting that age alone did not influence cropping patterns.

A significant positive relationship (r=0.642r = 0.642r=0.642) was observed, indicating that higher education levels enhanced agricultural productivity through the adoption of modern technologies.

Farm size showed no significant correlation with cropping intensity (r=−0.50r = -0.50r=−0.50), suggesting that smaller or medium-sized farms can achieve higher cropping intensity through efficient management.

A significant positive correlation (r=0.194r = 0.194r=0.194) was detected, emphasizing the role of income in facilitating resource access and crop diversification.

The study found a strong positive correlation (r=0.584r = 0.584r=0.584), reflecting the role of information access in enhancing agricultural decisions and adaptive practices.

No significant relationship (r=0.009r = 0.009r=0.009) was observed, indicating that informal networks and other knowledge sources might have a stronger influence on cropping intensity.

A significant relationship (r=0.707r = 0.707r=0.707) was established, underlining the role of mechanization in increasing productivity.

A strong positive correlation (r=0.674r = 0.674r=0.674) indicated that access to reliable irrigation significantly enhanced cropping intensity.

The strongest correlation (r=0.918r = 0.918r=0.918) was observed, highlighting the substantial role of mechanized harvesting and post-harvest management in boosting productivity.

A highly significant relationship (r=0.904r = 0.904r=0.904) was found, affirming that increased input availability directly enhanced cropping intensity.

Findings regarding the selected characteristics of the farmers in the dry areas of Bogura are summarized as follows:

Around 61.9% of respondents were middle-aged, 17.1% were young, and 21% were old. This shows a predominance of middle-aged farmers in the study area.

Approximately 65.5% of the farmers had a higher level of education (college), 21% had secondary education (high school), and 9.5% had primary education (junior high school). This indicates a high literacy rate among farmers in the study area.

65.7% of respondents had medium-sized farms, and 17.1% had small and large farms.

79% of respondents had a medium annual income, 5.7% had low income, and 15.2% had high income.

62.6% of farmers had a medium level of engagement with communication media, while 18.1% had high and 19% had low engagement.

52.4% of respondents had medium participation, 17.1% had high, and 30.5% had low organizational participation.

51.4% of respondents had moderate access to agricultural machinery for tilling, 35.2% had frequent access, and 9.5% had rare access. 3.8% did not use machinery in tillage operations.

30.5% of respondents had both frequent and rare use of irrigation sources, 28.6% had moderate access, and 10.5% did not have access to irrigation.

68.6% of respondents had frequent use of machinery for harvesting and post-harvesting, 19% had moderate use, 7.6% had rare use, and 4.8% had no access.

65.7% of respondents reported moderate availability of agricultural inputs, 20% had frequent access, and 14.3% had no access.

The null hypothesis was tested to examine the relationship between ten selected characteristics of farmers and cropping intensity. The findings are summarized as follows:

Education, annual income, use of communication media, use of modern equipment for ploughing, irrigation, use of machines for harvesting and post-harvesting, and input availability showed a positive significant relationship with cropping intensity. However, age, farm size, and organizational participation did not show a positive significance with cropping intensity.

CONCLUSION

The following conclusions were drawn based on the findings:

- Farmers in the study area cultivated rice, mustard, potatoes, and vegetables year-round.
- The prominent cropping patterns were Mustard-Boro-T.Aman, Vegetable-Boro-T.Aman, Boro-Fallow-T.Aman, and Potato-Boro-T.Aman.
- The use of machinery for quick agricultural activities, availability of irrigation water, and growing short-duration crops were key factors in cropping intensification.
- The major problems faced by farmers included a shortage of surface water, insufficient drainage systems, underdeveloped infrastructure, low organic matter content, and limited natural water bodies.

RECOMMENDATIONS

Based on the findings and conclusions, the following policy recommendations are:

- Intercropping and relay cropping can be introduced to further intensify cropping practices.
- The government should provide subsidies to farmers in drought-prone areas to facilitate the adoption of agricultural machinery.
- Low-cost irrigation systems should be introduced through cooperatives or government-led irrigation projects.
- Non-formal education and training programs should be initiated by government and non-governmental organizations to enhance farmer awareness and foster communication with media from other regions.

Considering that short-term studies focused on specific locations may not provide comprehensive insights, the following recommendations are suggested for future research:

- This study should be replicated in other dry areas of Bangladesh to capture a broader understanding.
- Future studies should examine additional factors like family size, farm facilities, social status, and marketing infrastructure to provide a more complete analysis of cropping intensity.
- Further studies should be conducted to monitor changes in cropping intensity over time to better inform policy development.
- While this study used surveys (quantitative tools) for data collection, further research could incorporate different methods to improve the accuracy and depth of findings.

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