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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.

Keywords: Cropping Intensity, Drought-Prone Areas, Agricultural Productivity, Farm Mechanization, Water Management, Soil Management, Crop Diversification.

1. Introduction

Agriculture is a vital sector in Bangladesh, supporting a significant portion of the population and contributing around 20% to the national GDP GDP (Hossain et al., 2023; Ghimire et al., 2021). 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 (Raut et al., 2011). 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 (Islam et al., 2018).

However, dry areas like Bogura face challenges in maintaining high cropping intensity due to water scarcity, inadequate infrastructure, and soil degradation (Hossain et al., 2021, Haque et al., 2021). Factors such as the use of modern agricultural machinery, efficient water management, and short-duration crop

cultivation significantly influence cropping intensity (Turky et al., 2023). 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.

2. Materials and Methods

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 3 A map of Sadar and Kahalu upazila showing the study area.

Conduction of FDG

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

Conduction of KII

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.

Population and sample:

The study was conducted in four unions namely Sadar and Kahalu Upazila of Bogura district. From these two unions 105 French bean farmers were taken as sample from a population of 310 farmers for the study following simple random sampling method.

Collection of Data

In order to collect relevant data for the study, a pretested well -structured interview schedule data were collected from the sample farmers during the period from 12th March to 23rd April, 2023.

Measurement of dependent 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:

Cropping intensity = Gross cropped area / Net sown area X 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).

3. Measurement of independent variables

The independent variables of this study were respondent's age, level of education, family size, farm size, annual income, use of communication media, organizational participation, use of agricultural machineries in tilling, use of agricultural machineries in harvesting and post harvesting operation, availability of irrigation source, availability of inputs. Age of a respondent was measured on the basis of actual age of his life and expressed in years. The education was measured by the number of years of schooling. Family size was measured by the total number of members including the farmer himself, spouse, children and other permanent dependents who lived together as a family unit. The total land area possessed by the farmer under farm and homestead was the basis of measuring farm size in this study and it was expressed in hectare. The yearly income from different sources was the annual income of the respondent. 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 were 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. Focus Group Discussion (FGD) was conducted in the study area comprising selected model farmers of the study villages, Sub-Assistant Agriculture Officers of the respective blocks, and input dealers for collecting of this research. Necessary tables and categories were used to classify the data considering their nature and distribution. As per the objective of the study, statistical tests like frequency counts, percentage, mean, standard deviation were used for analysis and interpretation of data. Correlation coefficients were used for hypothesis testing and 0.05 and 0.01 level probabilities were used as the basis for exploring relationship between the concerned variables throughout the study.

4. Results and Discussion

Socio-economic profile of the respondents

Table 1. Profile of the French bean growers

Characteristics	Categories	(Respondents%)	Mean	SD
Age (year)	Young (up to 40)	17.1	51.27	11.38
	Middle (41 -63)	61.9		
	Old (>64)	21		

Education (score)	Jounior high school (up to 8 grade)	9.5	9.60	2.02
	High school (9 to 10 grades	21		
	College ((>11)	69.5		
Farm size (score)	Small (up to 0.5 ha)	17.1	1.01	0.538
	Medium (0.6- 2 ha)	65.7		
	Large (>2ha)	17.1		
Annual income (Tk.`000)	Low (up to 197)	5.7	148.87	70.75
	Medium (198-709)	79		
	High (>709)	15.2		
Use of communication media	Low (up to 47 scores)	19	65.19	18.41
	Medium (48 to 83 scores)	62.9		
	High (> 83 scores)	18.1		
Organizational Participation (score)	Low (up to 1 scores)	30.5	1.38	1.51
	Medium (2 to 3 scores)	52.4		
	High (>3 score)	17.1		
Use of agricultural machineries for tilling (score)	Rare use (up to 1 score)	3.8	2.18	0.76
	Low use (2-3 scores)	9.5		
	Moderate use (4-5 scores)	51.4		
	Frequent use (> 5 scores)	35.2		
Use of irrigation source (score)	Rare use (up to 1 score)	10.5	1.79	0.99
	Low use (2 – 3 scores)	30.5		
	Moderate use (4 – 5 scores)	28.6		
	Frequent use (> 5 scores)	30.5		
Use of agricultural machineries in harvesting and post harvesting operations (score)	Rare use (Up to 1 score))	4.8	2.51	0.83
	Low use (2 – 3 scores)	7.6		
	Moderate use (4 – 5 scores)	19.0		
	Frequent use (> 5 scores)	68.6		
Inputs availability (score)	Not Available (Up to 4)	14.3	6.49	2.18
	Rarely Available (5-9)	65.7		
	Moderately Available (> 10)	20		

The result showed that 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 findings revealed that 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. According to statistical analysis from Table 1,30.5% 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. Finally, 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.

5. Cropping Intensity in Drought Prone Areas of Bogura

Table 2. Distribution of respondents depending upon cropping intensity

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

The findings shown in Table 2 indicates 87.6 percent of the respondents in the research area had higher cropping intensity (above 248 percent) compared to 12.4 percent having low cropping intensity (up to 248 percent) and the average cropping intensity was noted as 277.86 percent. These findings presented a higher level of cropping intensity on average in a dry area compared to the cropping intensity of other dry areas in Bangladesh as well as the whole agricultural region of Bogura. Islam et al. (2018) stated that the cropping intensity in Bogura was 234% on average while cropping intensity in Rajshahi region which is geographically dry is stated to be significantly high at 218%.

Cropping patterns with percentage in the study area

The evaluation of cropping patterns in the study area was based on the spatial distribution and diversity of major crops. Table 3 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 3 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

Crops Grown by the Respondent Farmers All-round the Year

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 4 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

Problems Faced by the Farmers During Crop Production in the Study Area

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 5 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 5 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

Factors Responsible for Crop Intensification in the Study Area

The Table 4.15 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.

Table 6 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

Relationships between the selected characteristics of the respondents and the cropping intensity

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. 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

Table 7. 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
	Age	0.116		
	Level of education	0.642**		
	Farm size	-0.50		
	Annual income	0.194*		

Cropping intensity in drought prone area	Use of communication media	0.584 **	0.193	0.252
	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

Correlation Between Selected Characteristics and Cropping Intensity

Age

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.

Education

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

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.

Annual Income

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.

Use of Communication Media

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.

Organizational Participation

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.

Use of Agricultural Machinery for Tilling

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

Use of Irrigation Sources

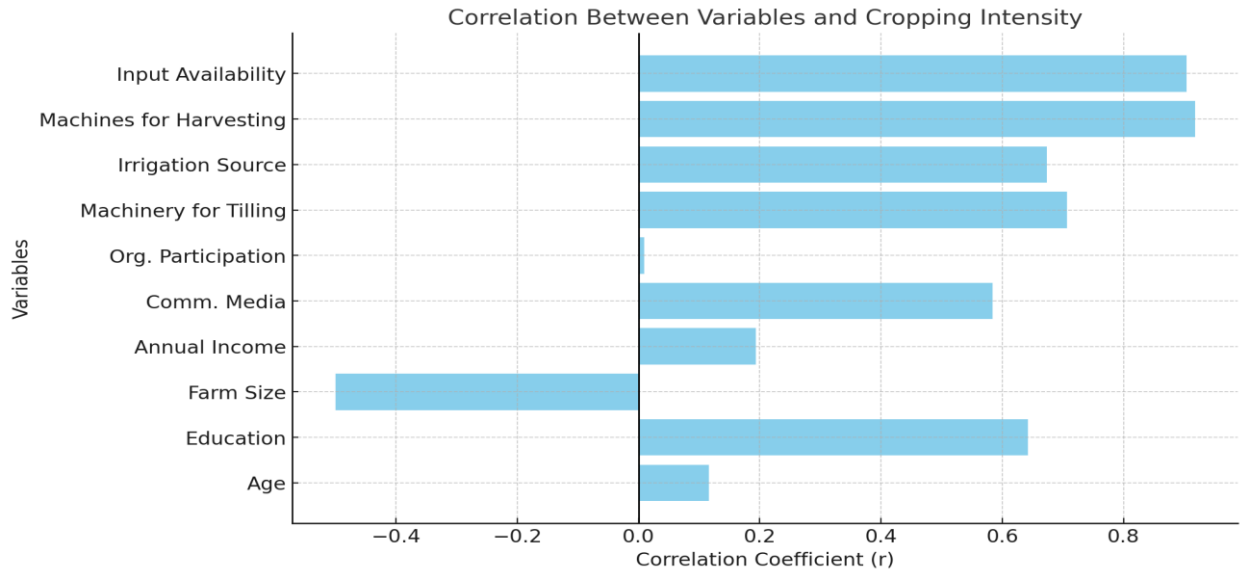
A strong positive correlation (r=0.674r = 0.674r=0.674) indicated that access to reliable irrigation significantly enhanced cropping intensity.

Use of Machines for Harvesting and Post-Harvest Operations

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.

Input Availability

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



6. CONCLUSIONS

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.

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