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Open grazing and cropping intensity in the Brahmaputra Valley

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Abstract After farmers in the Brahmaputra Valley harvest winter rice, they let their cattle graze in the village fields. Open grazing surfaces often in discussions on the problems of agriculture in Assam, but it has not been studied yet. This paper investigates the phenomenon, and it finds that open grazing significantly limits cropping intensity. If farmer communities collaborate with extension agencies, they may be able to protect the seasonal commons nature of the fields and also grow a second crop.

Keywords Cropping intensity, irrigation, open grazing

JEL codes O13, Q15, Q12

Agricultural land is becoming increasingly scarce in eastern India,[1] including in the Brahmaputra Valley of Assam (the Valley). The pressure of the population on the land is high,[2] and it is expected that the cultivable land will be utilized more intensively—by raising the input intensity of a crop and cropping intensity.[3] About 72% of the agricultural land in the state lies in the Valley (Government of Assam 2013), where sources of surface and ground water abound.[4] Its irrigation capacity was enhanced substantially in the 1990s, when tube wells were installed in districts under several policy initiatives,[5] but its cropping intensity today compares poorly[6] with those of areas of similar conditions such as West Bengal, at least partly because irrigation capacity is low in the Valley and public irrigation projects are under-utilized (Dutta 2011). Open grazing, too, may be a reason; farmers in the plains let their cattle graze in the village fields after they have harvested winter rice, the main crop of the state. Protecting the crop from the cattle is expensive, if not impossible, and an individual farmer can rarely grow a second crop (Ramanathan 2002; Saxena 1993; Buch

1 Operational holdings average 1.10 hectare in size in Assam, and the all-India average is 1.15 hectare (Agricultural Census 2010–11).

2 The all-India population density was 382 persons per square kilometre, according to the 2011 Census, and in Assam it was 397 persons per square kilometre.

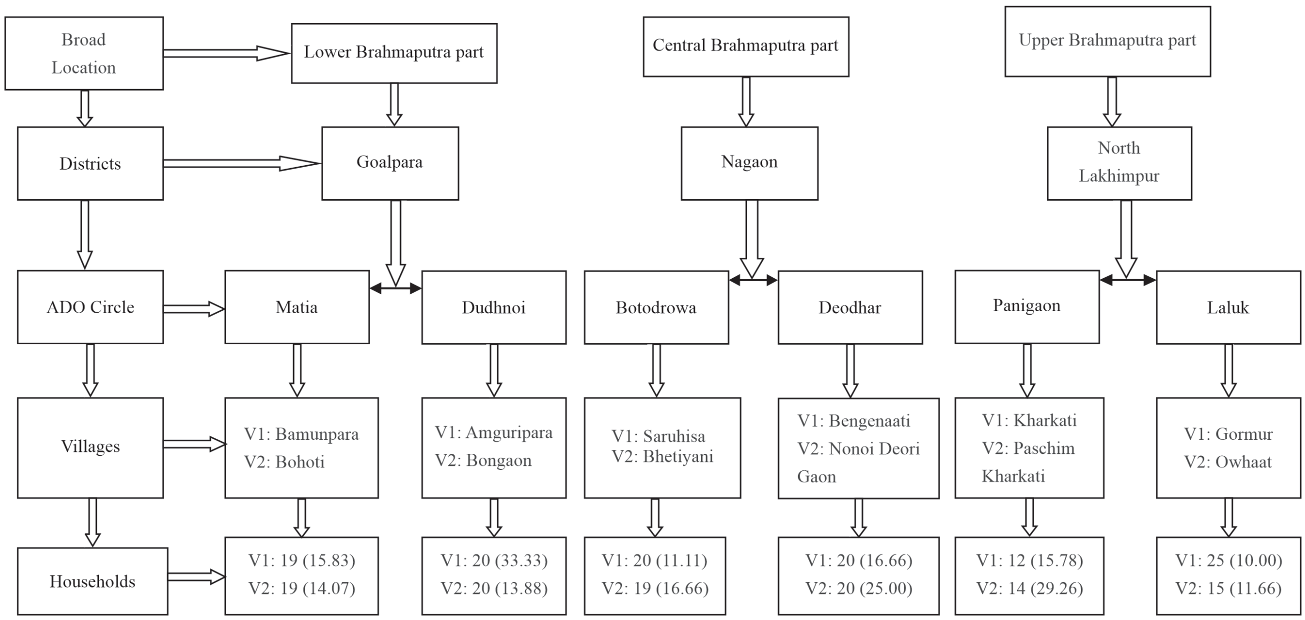
3 The cropping intensity is a measure of the number of crops raised on a plot of agricultural land in a year. It is calculated by dividing the gross cropped area by the net sown area and multiplying the number by 100. The net sown area is the area cultivated at least once during a reference year. The gross cropped area is the total area under all the crops cultivated that year. If a plot is cultivated twice in a year, its area will be counted twice in the gross cropped area and once in the net sown area.

4 We exclude the other two regions of the state—the Hill Region and the Barak Valley— from this study. The Barak Valley does not have the groundwater resources needed to develop the irrigation infrastructure for multiple cropping (Government of Assam 2013–14; Bezbaruah and Roy 2002). The land ownership and cultivation system of the Hill Region is unique, and it requires to be studied separately.

5 Such as the Accelerated Irrigation Benefit Programme (AIBP) of the central government, and the Assam Rural Infrastructure for Agricultural Services Programme (ARIASP) funded by the World Bank and the National Bank for Agriculture and Rural Development (NABARD) (Government of Assam 2013).

6 In 2010–11, the cropping intensity was 177.31 in West Bengal and 148.01 in Assam (Indian Agricultural Statistics 2014).

Table 1 Sampling procedure for primary data collection



Notes (1) V1 is Village 1 and V2 is Village 2
(2) Figures within () represent percentage of farm households in the village in the sample

1991). The problem of open grazing, often discussed in formal and informal forums, has not found formal treatment as a possible factor in limiting cropping intensity. This paper examines whether open grazing is indeed a serious hindrance to raising cropping intensity in the Valley.

Data and methods

The study is based on data collected from a primary sample survey that the authors conducted in 2015. The sample of farm households is drawn using a multi-stage sampling design (Table 1). In the first stage, we selected three districts as the locations for the survey; each located in the lower, central, and upper part of the Valley; to capture the variations in agroclimatic conditions in the Valley, we chose one district each located in the lower, central, and upper parts of the Valley.

We then consulted the District Agricultural Officers and selected two Agricultural Development Officer (ADO) Circles from each district. From each ADO Circle, we selected two villages keeping in view the representation of variations in socio-economic conditions within an ADO circle. We selected 10% of the farm households in each village at random as the ultimate sample units. Altogether 225 farm households were surveyed. The operational holding is less than 2 hectares for 67% of the sample farms; together, these farms account for 52.17% of the area under all the sample farms (Table 2).

Most of the surveyed farms are small and marginal, and the operational holdings average only 1.67 hectares in size. That is a fair representation of the agrarian situation in the Valley.

Cropping pattern

Winter rice is the main crop grown in all the locations (Figure 1).

The cropping pattern is the least diversified in the Upper Brahmaputra Valley sub-sample; as one gets to the Central Brahmaputra Valley and then the Lower Brahmaputra Valley, the diversity tends to increase. In contrast to the pattern of crop diversification, cropping intensity is the least in the Lower Brahmaputra Valley and the highest in the Central Brahmaputra Valley

Cropping intensity

The mean cropping intensity of the sample farms was 171.37; the standard deviation was 62.34 (Table 3).

Table 2 Operational holding (farm size class, %)

Operational Holding (in hectare)	Field Study Locations			Overall
	Upper Brahmaputra Valley (UBV)	Central Brahmaputra Valley (CBV)	Lower Brahmaputra Valley (LBV)	
0 – 1	29.85(13.14)	30.38(12.72)	21.52(9.71)	27.23(11.70)
1 – 2	47.76(47.84)	41.77(37.53)	45.57(37.67)	45.09(40.47)
2 – 3	14.92(22.78)	15.19(22.58)	20.25(26.14)	16.96(23.98)
3 – 4	1.49(3.19)	10.13(20.35)	7.59(13.61)	6.70(13.00)
4 – 5	4.48(13.05)	2.53(6.82)	3.80(8.92)	3.57(9.36)
5 and above	0(0)	0(0)	1.26(3.95)	0.45(1.49)
Total	100[1.60]	100[1.64]	100[1.77]	100[1.67]

Notes
1. Operational Holding = land owned + land leased in–land leased out - fallow land
2. Figures in ( ) are percentage share of area of the sample farms in respective size class
3. Figures in [ ] are average size of operational holdings
Source: Authors' own calculation from field survey data

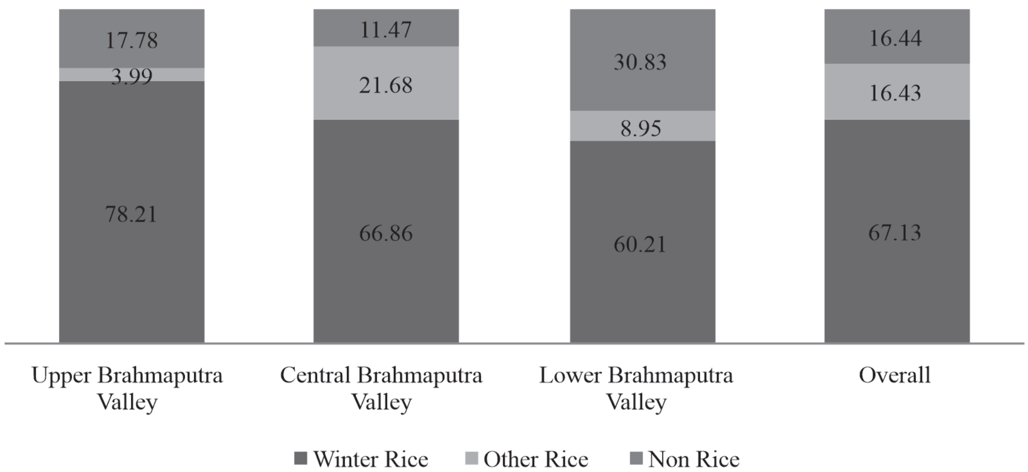


Figure 1 Crop acreage (%)

Other rice includes summer rice and autumn rice

Non rice include pulses, rapeseed and mustard, potato, sugarcane, summer vegetables, winter vegetables, chillies, jute, banana

Source Authors' own calculation from field survey data

Table 3 Cropping intensity

Field Study Location	Min.	Max.	Mean	Standard Deviation
Upper Brahmaputra Valley	102	360	171.25	64.86
Central Brahmaputra Valley	101	333	177.76	54.06
Lower Brahmaputra Valley	102	400	165.09	67.81
Overall	101	400	171.37	62.34

Source Authors' own calculation from field survey data

The open grazing problem does not affect all the farmers in the sample—only about 44% of the sample farmers hold that open grazing prevents them from raising a second crop—and those not affected experience a substantially higher cropping intensity on average than those who are (Figure 2).

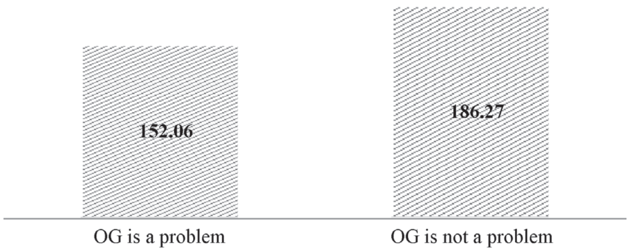


Figure 2 Mean of cropping intensity (CI) of farm household with reference to open grazing (OG)

To be able to draw this conclusion more rigorously, however, it is necessary to examine the impact of open grazing after controlling for the influence of other factors on cropping intensity. Hence, a multiple regression analysis is called for. In the model, the dependent variable Y has been modified to extent of multiple cropping, which has been defined as (CI – 100).

The open grazing factor has been captured by defining a dummy variable OG. If the sample farmer responded that the practice of open grazing prevented them from increasing cropping intensity, OG = 1; otherwise, OG = 0. The value of the variable depends on the farmer's opinion; therefore, the possibility that responder bias will influence the value cannot be ruled out a priori.

However, sufficient care was taken to elicit the farmer's response in the least subjective manner. When we surveyed a farmer, we asked why they did not increase cropping intensity; we asked an open-ended question, in other words, and did not prompt them to choose from alternatives we provided. Farmers often cited one or more reasons for the answer. One of the frequent answers happens to be the open grazing problem. The manner in which the farmer response was elicited induces us to believe that if the responder bias was there at all, it was minimal.

There is no apparent reason for a surveyed farmer to give a strategically biased response as it was not linked to any reward or penalty. Indeed, the whole exercise was earlier carried out using a different measurement of the open grazing variable to see if the results change dramatically under the alternative affiliation.

The key findings using the different definitions of open grazing problem have been found to be similar. This comparison confirms that the result is robust, and it shows indirectly that the open grazing variable has been captured without serious responder bias.

Control variables

To isolate the impact of open grazing, it is necessary to control for the other factors that influence cropping intensity. The control variables are the extent of irrigation (IRR), area under high yielding varieties (HYV), access to extension services (EXT), access to credit (CRD), factor price index (FPI), family labour (FL), farm size (FS), extent of sharecropping (ESC), and the extent of mechanization (EoM).

Extent of irrigation (IRR)

Availability of irrigation facility is a favourable condition for multiple cropping in a year (Dutta 2002; Karunakaran and Palanisami 1998; Gogoi 1993; Dhawan and Datta 1992). We define IRR as the proportion of net irrigated area in the operational holding of a farm.

Area under high-yielding varieties (HYV)

Usually, high-yielding varieties (HYV) take less time to mature and make it possible to grow another crop (Rao 1992; Birthal et al. 2007). The variable HYV is the percentage of area under HYV rice in the total rice acreage of the farmer. It is expected to positively influence cropping intensity.

Access to extension services (EXT)

Extension services provide farmers agricultural inputs and new scientific research and knowledge, and access to extension services can facilitate multiple cropping directly or indirectly (Goswami and Bezbaruah 2017). The relevant variable EXT here is a dummy; if the farmer has received any direct benefits from the government's extension service network, its value is 1 and otherwise it is 0.

Access to credit (CRD)

If a farmer practises multiple cropping, their operational expenditure increases, and access to credit at a reasonable rate of interest can be expected to facilitate cropping intensity (Poddar et al. 1995). To capture the influence of access to credit, another dummy variable CRD has been defined; it takes the value 1 if the farmer has access to institutional credit and 0 otherwise.

Factor price index (FPI)

If the factors of labour and capital equipment, like tractors and power tillers, are available and affordable, these can positively influence the cropping intensity (Patidar and Gupta 2012). To capture the effect of wages and rental rates of tractors and power tillers, we calculate the wage index and rental index by normalizing with the help of the following formula:

$$(WI)^{i} = \frac{\left(wage^{actual} - wage^{min}\right)}{\left(wage^{max} - wage^{min}\right)} \qquad \ldots(1)$$

Where, $(WI)^i$= Wage index of ith farmer

$Wage^{actual}$ = actual wage of the ith farmer

$Wage^{max}$ = maximum wage in the surveyed village

$Wage^{min}$= minimum wage in the surveyed village

$$(RI)^{i} = \frac{\left(rental^{actual} - rental^{min}\right)}{\left(rental^{max} - rental^{min}\right)} \qquad \ldots(2)$$

Where, $(RI)_i$ = rental index of ith farmer

$Rental^{actual}$= actual rental of hire in tractor/power tiller of ith farmer

$Rental^{max}$= maximum rental of hire in tractor/power tiller in the surveyed village

$Rental^{min}$ = minimum rental of hire in tractor/power tiller in the surveyed village

We combine these two indices into the factor price index (FPI)

$$FPI = \left(\frac{WI + RI}{2}\right) \qquad \ldots(3)$$

Availability of family labour (FL)

If family labour is available, absorbing it can let a farm household raise more crops in a year and also its cropping intensity. The variable FL, defined as the number of farm workers per hectare of operational holding of the farm, is hence expected to have a positive coefficient.

Farm size (FS)

Usually, smaller farms possess more labour, and they are expected to cultivate their land more frequently. We use the size of operational holding in hectares as a measure of the farm size.

Extent of sharecropping (ESC)

Sharecropping is expected to deter multiple cropping. We measure the extent of sharecropping (ESC) by calculating the percentage of leased-in land under the sharecropping contract in the farm's operational holding.

Extent of mechanization (EoM)

Small farms predominate in our study area, and these mostly use power tillers and tractors; machinery in not used in operations such as harvesting. By reducing the time taken to prepare the land and perform other agricultural processes, mechanization can facilitate multiple cropping (Chopra 1974). The EoM variable has been captured by dividing the area tilled by machines (tractors and power tillers) by the total area tilled by all forms of machine (ploughs, tractors and power tillers) for all the crops cultivated by a farm.

Location characteristics

Our field study locations span all the three parts of the Brahmaputra Valley, where agro-climatic conditions and cropping intensity vary. We take the Upper Brahmaputra Valley as the reference category, and we induct two dummies—L^1 and L^2—to capture the impact of locational factors ($L^1 = 1$ for Lower Brahmaputra Valley, 0 otherwise; and $L^2 = 1$ for Central Brahmaputra Valley, 0 otherwise). Table 4 lists the definitions of the explanatory variables and the expected signs of their coefficients.

Functional specification

The basic cropping intensity function is formulated as

$$CI = f(OG, IRR, HYV, EXT, CRD, FPI, FS, FL, ESC, EoM, L^1, L^2) \qquad \ldots(4)$$

In the regression model, the dependent variable Y is the extent of multiple cropping, defined as cropping intensity minus 100.

Thus, $Y = CI - 100$

Table 4 Explanatory variables

Variable	Notation	Definition	Expected impact
Open grazing	OG	OG is 1 for farmers citing open grazing as a problem and 0 for the other farms	_
Extent of irrigation	IRR	The proportion of net irrigated area in the operational holding	+
Area Under high yielding varieties	HYV	Percentage of HYV area in total rice acreage	+
Access to extension service	EXT	1 if farmer has received any direct benefit from extension service worker, 0 otherwise	+
Access to credit	CRD	1 if farmer has access to institutional credit, 0 otherwise	+
Factor price index	FPI	Average of wage index and rental rate index	_
Farm size	FS	Size of operational holding in hectares	+/-
Availability of family labour	FL	It is the number of farm workers per hectare of operational holding in a household	+
Extent of sharecropping	ESC	The percentage of leased in land under share cropping contract in operational holding	_
Extent of mechanization	EoM	Percentage of gross cropped area mechanically tilled	+
2 dummies for capturing local effect of the 3 locations	L^1 & L^2	L^1=1 for lower Brahmaputra valley, 0 otherwise and L^2= 1 for central Brahmaputra valley, 0 otherwise assuming upper Brahmaputra valley as a reference location	+/-

Thus, the empirical model is derived from the function

$$Y = F(OG, IRR, HYV, EXT, CRD, FPI, FS, FL, ESC, EoM, L^1, L^2) \quad \ldots(5)$$

The dependent variable Y is non-negative, and the usual linear functional form is not appropriate as the linear regression equation can return some predicted values of Y that could be negative. A semi-log linear equation would have addressed this problem, but the other features of the dependent variable demanded the exploration of other functional forms. The histogram of the log of Y *(ln Y)* indicated a negatively skewed non-normal distribution of ln Y (Figure 3).

The Jarque-Bera test confirms that the distribution is not normal.[7] Since the dependent variable is non-normal, the more appropriate formulation is the generalized linear model (GLM),[8] rather than the classical normal linear regression. As the values of the dependent variable are non-negative and the distribution is negatively skewed, the Gamma distribution with 'log' link function presents as the

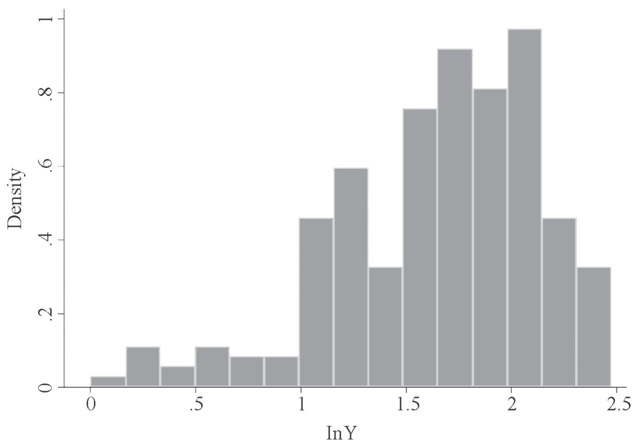


Figure 3 Multiple cropping (ln Y)
Source: Authors' own calculation from field survey data

[7] The Jarque-Bera test checks the normality of an observed distribution with the null hypothesis that the distribution is normal (the alternative hypothesis is that the distribution is non-normal). The Jarque-Bera statistics is found to be (19.73) in this case, and the p-value 0.0001, and the null hypothesis of normality is rejected at 0.01 level of significance.

[8] The generalized linear model (GLM), a flexible generalization of ordinary linear regression, allows for response variables that have error distribution models other than a normal distribution. The GLM generalizes linear regression by allowing the linear model to be related to the response variable via a link function, and by allowing the magnitude of the variance of each measurement to be a function of its predicted value.

Table 5 The extent of multiple cropping (generalized linear regression of logarithms)

Deviance = 27.80
Log likelihood = -334.50

Variables/ Constant	Estimated Coefficients/ Values	OIM Standard Error#	p- value
Constant	0.6127644***	0.102968	0.000
Open Grazing (OG)	-0.1436232***	0.051004	0.005
Extent of Irrigation (IRR)	0.0026834***	0.000668	0.000
Area under high yielding varieties (HYV)	-0.0010128*	0.000608	0.096
Access to Extension Services (EXT)	-0.0468301	0.056941	0.411
Access to Credit (CRD)	-0.0093377	0.047586	0.844
Factor Price Index (FPI)	0.0681303	0.105823	0.520
Farm Size (FS)	-0.0530892***	0.009513	0.000
Availability of Family Labour (FL)	0.0220072***	0.008283	0.008
Extent of Sharecropping (ESC)	0.0002736	0.000728	0.707
Extent of Mechanization (EoM)	0.2829873	0.178886	0.114
L^1	-0.1455718*	0.075716	0.055
L^2	-0.1738821**	0.078296	0.026

Note 1.*, **, *** indicates statistical significance at 0.10. 0.05 and 0.01 level 2. # Standard Errors obtained from the Observed Information Matrix

Source Authors' own calculation from field survey data

suitable form for operationalizing GLM. On the log scale, the gamma is left-skewed. Thus, the empirical model has been formulated along the following lines.

Let $\ln Y_i$ is the value of the dependent variable for the i^{th} sample unit. Now, the linear predictor, η, for the i^{th} observation, given the set of explanatory variables as mentioned above, can be written as

$$\eta_i = \alpha + \beta_1 OG_i + \beta_2 IRR_i + \beta_3 HYV_i + \beta_4 EXT_i + \beta_5 CRD_i + \beta_6 FPI_i + \beta_7 FS_i + \beta_8 FL_i + \beta_9 ESC_i + \beta_{10} EoM_i + \beta_{11} L_1 + \beta_{12} L_2 \quad \ldots(6)$$

The next stage is to relate this linear predictor, η, to the predicted mean of the dependent variable, i.e. E ($\ln Y_i$). For this purpose, a smooth and invertible linearized link function, g, is adopted, which transforms $E(\ln Y_i) = \mu_i$ to the linear predictor. Thus,

$$g(\mu_i) = \eta_i = \alpha + \beta_1 OG_i + \beta_2 IRR_i + \beta_3 HYV_i + \beta_4 EXT_i + \beta_5 CRD_i + \beta_6 FPI_i + \beta_7 FS_i + \beta_8 FL_i + \beta_9 ESC_i + \beta_{10} EoM_i + \beta_{11} L_1 + \beta_{12} L_2 \quad \ldots(7)$$

As the link function is invertible, we can also rewrite equation (7) as follows

$$E(\ln Y_i) = \mu_i = g^{-1}(\eta_i) = g^{-1}(\alpha + \beta_1 OG_i + \beta_2 IRR_i + \beta_3 HYV_i + \beta_4 EXT_i + \beta_5 CRD_i + \beta_6 FPI_i + \beta_7 FS_i + \beta_8 FL_i + \beta_9 ESC_i + \beta_{10} EoM_i + \beta_{11} L_1 + \beta_{12} L_2) \quad \ldots(8)$$

In the present case, g, the link function, has been taken as the log-link for the gamma distribution. Usually, several alternative link functions are associated with GLM modeling, the choice among which is dictated by specific conditions. In the present case, as on the log scale the gamma is left skewed, the log-link function is best suited (Fox 2015; Wooldridge 2005).

Results and discussion

The coefficient of the prime independent variable open grazing is statistically significant, with the expected negative coefficients (Table 5), and the study establishes that open grazing is indeed a significant factor limiting multiple cropping, and hence cropping intensity, in the Valley. The magnitude of the coefficient implies that, given other factors, the expected value of the logarithm of extent of multiple cropping is less by 0.1436 for farmers facing the problem of open grazing.[9]

[9] The explanatory variable OG is a dummy, and so its coefficient cannot be interpreted as the marginal response of the dependent variable to it.

Table 6 Estimates of the alternative functional specification of the basic econometric model of multiple cropping

Variable	Liner (OLS)		Semi-Log (OLS)		Left Censored TOBIT (ML)	
	Coefficient	p value	Coefficient	p value	Coefficient	p value
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Open Grazing (OG)[1]	-0.6235***	0.007	-0.4432*	0.092	-0.1688***	0.001
Open Grazing (OG)[2]	-28.40***	0.006	-0.0042**	0.020	-0.0042**	0.018
Extent of Irrigation (IRR)	0.5707***	0.000	0.127***	0.005	0.0078***	0.001
Area under High Yielding Varieties (HYV)	-0.1053	0.427	-0.057	0.182	-0.0024	0.240
Access to Extension Services (EXT)	-8.9964	0.486	-0.0933*	0.077	-0.1762	0.419
Access to Credit (CRD)	-10.901	0.235	-0.3426	0.260	-0.1183	0.495
Factor Price Index (FPI)	-16.592	0.541	0.2012	0.319	0.3545	0.464
Farm Size (FS)	-5.3485*	0.071	-0.848***	0.000	-0.0042	0.296
Availability of Family Labour (FL)	5.5402**	0.019	-0.0945	0.525	0.0837***	0.004
Extent of Sharecropping (ESC)	0.0101	0.939	0.01212	0.741	0.0012	0.625
Extent of Mechanization (EoM)	62.5502*	0.098	0.02042	0.751	0.8924***	0.007
Constant	4.1232***	0.000	4.881***	0.000	3.9256***	0.000
L_1	-14.736	0.397	-0.1155	0.120	-0.4140	0.100
L_2	-48.370**	0.023	0.219***	0.004	-0.41545	0.174
R^2 / Pseudo R^2	0.3026	-	0.376	-	0.1349	-
F (12, 224)	10.35	0.000	11.69***	0.000	-	-
LR Chi^2 (12)	-	-	-	-	92.37***	0.000

Notes

1. Here, OG (open grazing problem) has been captured by defining a dummy variable from response of the sample farmers. OG = 1, if the farmer cited open grazing as a problem for increasing cropping intensity. It is zero, otherwise.
2. Here, OG (Open grazing problem) has been captured by the percentage of sample farmer in a surveyed villages citing open grazing as a problem for not increasing cropping intensity.
3. ***, **, * indicates significant at 1, 5 and 10 percent respectively

Source Authors' own calculation from field survey data

The variables extent of irrigation (IRR), farm size (FS), and the availability of family labour (FL) have come out statistically highly significant. The signs of these coefficients are along the expected lines. The positive coefficients of IRR and FL imply that the availability of irrigation facilities and family labour favourably influences cropping intensity. The negative coefficient of FS implies that smaller farms cultivate their land more frequently.

The other explanatory variables found significant are HYV and the two locational dummies. The coefficient of the regressor HYV is negative, against prior expectation, and it is statistically significant, albeit at only 10%. The result, however, is not robust enough, as the coefficient is not significant in any of the alternative models experimented with for the robustness check (Table 6). Yet, it cannot be ignored that some farmers may tend not to increase the cropping intensity when they can extend the acreage of HYV rice. Counter-intuitive as the tendency is, there is prior empirical evidence of similar findings in the southern part of Assam (Bezbaruah and Roy 2002). In line with this study, the negative and significant coefficient of the HYV can be rationalized in terms of the persistence of subsistence farming among the small holder, who predominate the agrarian set-up of Assam. With relatively small land holdings, it is not uncommon for farmers to cultivate primarily for home consumption. When such a farmer is able to use HYV sufficiently, a single rice crop can produce enough food grains to meet their household requirement, but when the conditions are not conducive a farmer may be compelled to grow a second crop.

The coefficients of the locational dummies are negative and significant, implying that given other influencing factors, cropping intensity tend to be somewhat lower among the sample farms in the Central and Lower Brahmaputra Valley than in the Upper Brahmaputra Valley, the reference category.

We checked the robustness of the estimated results by estimating the basic function of the extent of multiple cropping, that is, Equation 5, using some alternative model formulations and also an alternative measurement of the key regressor open grazing (OG) (Table 6). The size and significance of the estimated coefficients of the chosen model differ from those of the alternative forms experimented with, the prime variable of interest, open grazing, is significant with the expected sign in all the sets of estimates, and the conclusion that open grazing limits cropping intensity in farms in the field study locations is fairly robust.

Conclusion and policy implications

Cropping intensity varies substantially among sample farmers—from 101 (minimum) to 400 (maximum); the average is 171.37, and the standard deviation is 62.34. This variation is influenced by the extent of irrigation, availability of farm labour, farm size and whether the farmer finds open grazing to be a problem. Expectedly, irrigation and the availability of family labour positively influence multiple cropping, thereby raising cropping intensity in farms. Given other factors, smaller farmers tend to utilize land at their disposal more intensively by cultivating their land more frequently.

In the Brahmaputra Valley of Assam, it is a common practice for village cattle to graze in the open after the winter rice is harvested; this study aimed to find out if the practice prevents farmers from raising their cropping intensity. In the estimated regression, the coefficient of the 'open grazing' variable is negative and statistically significant, and so the practice indeed restricts farmers from raising their cropping intensity. The land boundaries of individual farmers are respected during the cropping period. Once the winter rice is harvested, however, the village fields become something like seasonal, open-access common resources,[10] and the cattle of any village household can graze freely.

The village community can come together and limit open grazing to a part of the village field and let farmers cultivate a second crop on the remaining land, but this is not to suggest that the solution is easy; several tricky issues will need to be addressed, such as which areas are to be free of grazing and how this area is to be apportioned among farmers willing to raise a second crop. However, the solution lies in community initiatives only, and extension agencies can encourage village communities in searching for a solution and facilitate it.

The community has often come together to address similar problems. Community participation has been critical in managing indigenous water harvesting structures in Rajasthan (Kaushik et al 2019). Farmers' ingenuity and indigenous technical knowledge can also help solve local problems, especially if farmers collaborate with extension agents (Sharma 2002). If one or two communities are able to successfully devise the necessary arrangement, the others may quickly adopt the model, especially as significant economic benefits will be at stake for most members of the community.

References

Bezbaruah, M P and Niranjan Roy. 2002. Factors affecting cropping intensity and use of high yielding variety seed in Barak valley. *Indian Journal of Agricultural Economics* 57(2): 169–180. https://ageconsearch.umn.edu/record/297875

Birthal, P S, A K Jha and A Singh. 2007. Linking farmers to markets for high-value-agricultural commodities. *Agricultural Economics Research Review* 20 (Conference Issue), 425–439. https://ageconsearch.umn.edu/record/47437

Chopra, K. 1974. Tractorization & changes in factor inputs: A case study of Punjab. *Economic & Political Weekly* 9 (52): A -119–127. https://www.epw.in/node/77445

Dhawan, B D and H S Datta. 1992. Impact of irrigation on multiple cropping. *Economic and Political Weekly* 27 (13): A15-A18. https://www.jstor.org/stable/4397728?seq=1

Dutta, M K. 2011. *Irrigation potential of agriculture in Assam.* Concept Publishing Company (P) Ltd., New Delhi

[10] Open-access common pool resources are rival but non-excludable, and prone to the phenomenon of the tragedy of the commons, where self-interest runs contrary to the common good of all users.

Fox, John. 2015. *Applied regression analysis and generalized linear models.* Sage Publication, Inc. https://us.sagepub.com/en-us/nam/applied-regression-analysis-and-generalized-linear-models/book237254

Gogoi, B. 1993. Irrigation and agricultural development in Assam. In *Agriculture development in north-east India: constraints and prospects,* eds K Alam, 156–166. Deep and Deep Publishing House, New Delhi.

http://14.139.206.50:8080/jspui/bitstream/1/936/1/AGRICULTURAL%20DEVELOPMENT%20IN%20NORTH%20EAST%20INDIA.pdf

Goswami, B and R J Bezbaruah. 2017. Comparing public and private agricultural extension services: Insights from the Brahmaputra valley of Assam. *Economic and Political Weekly* LII (52): 72–80. https://www.epw.in/journal/2017/52/review-rural-affairs/comparing-public-and-private-agricultural-extension-services

Government of Assam. 2013. *Economic survey, Assam 2013-14*. Directorate of Economics and Statistics, Government of Assam: 53, 79 & 82. https://des.assam.gov.in/sites/default/files/swf_utility_folder/departments/ecostat_medhassu_in_oid_3/menu/document/economic_survey2013-14.pdf

Government of India. 2014. *Agricultural census 2010-11.* Ministry of Agriculture, Government of India: 12. http://agcensus.nic.in/document/ac1011/reports/air2010-11complete.pdf

Government of India. 2015. *Land use statistics.* Directorate of Economics and Statistics, Government of India. https://eands.dacnet.nic.in/allindia.htm

Gujrati, D. 2005. *Basic econometrics*. McGraw Hill, New Delhi.

Karunakaran, K R and K Palanisami. 1998. An analysis of impact of irrigation on cropping intensity in Tamil Nadu. *Indian Economic Review*, 33 (2): 207–220. https://www.jstor.org/stable/29794170

Kaushik, R, B K Pattnaik and B Rath. 2019. Community participation in effective water resource management: a comparative study in Alwar, Rajasthan. *Economic and Political Weekly* LIV (35): 53–58. https://www.epw.in/journal/2019/54/special-articles/community-participation-effective-water-resource.html

Patidar, B and Dinesh Gupta. 2012. MNGERA- Issues and challenges. *Golden Research Thoughts* 2 (3): 121–126. http://oldgrt.lbp.world/ArticleDetails.aspx?id=1458

Poddar, R S, H S V Kumar, H G S Murthy, T N Murthy and Venkatesh. 1995. Impact of credit on cropping pattern and cropping intensity of farms in unirrigated and irrigated villages in Bijapur district of Karnataka–An application of linear programming technique. *Agricultural Economics Research Review* 8 (1): 29–42. https://ageconsearch.umn.edu/record/265859

Rao, C.H. Hanumantha. 1992. Agriculture: policy and performance. In *The Indian Economy: Problem and Prospect*, eds Jalan Bimal, 116 - 140. Penguin, New Delhi.

Sharma, R. 2002. Reforms in agricultural extension: new policy framework. *Economic and Political Weekly* 37 (30): 3124–3131. https://www.epw.in/journal/2002/30/review-agriculture-review-issues-specials/reforms-agricultural-extension.html

Wooldridge, J M. 2005. *Introductory Econometrics: A Modern Approach*, 4e, CENGAGE Learning, USA.

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