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Economic Impact of Crop Diversification in North-East India: Evidence from Household-level Survey

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ABSTRACT

The study used a large farm household level data to assess the economic impact of crop diversification and also identifies the factors influencing the extent of diversification in the north east region of India. The crop sector was found to be skewed towards specialization. The result of instrumental variable technique showed that crop diversification has a positively significant impact on the income among the households. Further, fractional logit estimation found that variables like family members in the working age group, landholding size, crop loss experience, extension contact, participation in training positively affected diversification. Irrigated area, access to institutional credit, etc negatively affected the same. Diversification towards high value crops may accelerate the agricultural growth of the region and improve the wellbeing of the farmers. Measures for improvement of basic infrastructural facilities and extension services for improving backward and forward linkages are required.

INTRODUCTION

The North East Region (NER) comprising of eight states lags behind the rest of India in economic development. Primarily dependent on agriculture and allied sector directly or indirectly, more than 81 per cent of the region's population is rural and 51 per cent of the total workforce engaged in agriculture (GoI, 2011). Agriculture of the region is characterized by its subsistence nature, mono-cropping, rainfed, low input-low output, technologically lagged mixed farming system (Kumar et al., 2007). The average cropping intensity is around 132 per cent which is lower than the national average of 139 per cent. Further, more than 75 per cent of the farm households are small and marginal in nature (< 2 ha) in the region. Although, the population living below poverty line decreased by around 18 per cent between 2004-05 and 2011-12 in the region, this decline is much lower compared to the national level average decrease of around 41 per cent during the same period. In spite of its abundant natural resources (land, water, forest, biodiversity etc.), congenial climate and rich human capital, the agrarian economy of the region have been trapped in the vicious cycle of low productivity, unemployment, low income and poverty (Barah, 2007). Crop diversification is one of the strategies to alleviate poverty and achieve food and nutritional security (Gautam and Sharma, 2004; Michler and Josephson, 2017; Adjimoti, 2018). Moreover, it is considered as one of the most ecologically feasible and cost-effective way of buffering the effect of uncertainties, especially among small-scale farmers (Njeru, 2013). Considering the vast scope for crop diversification in the NER, it can be an effective strategy for agricultural growth offering multiple benefits to the smallholder farmers of this region. With this background, the study aims to test the hypothesis that for farmers under the agro-ecological and socio-economic conditions distinctive of the NER, mainly characterized by lack of infrastructure and inefficient markets, a crop diversification strategy is beneficial in terms of improving agricultural household income.

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METHODOLOGY

The study is based on the household-level data from the 70th round 'Situation Assessment Survey of Agricultural Households' conducted by National Sample Survey Office (NSSO), Government of India. The sample consists of data on 35,200 rural agricultural households spread across 4,529 villages of India collected using stratified multistage random sampling (NSSO, 2014). The data were collected for the two major agricultural seasons of India in two separate visits (January 2013–December 2013) and pertain to the year 2012–13. For the present study, data on area of various crops and other socio-economic variables besides net income of the households were compiled for the eight states in the NER of India covering 86 districts and 5100 rural agricultural households. However, the present study, excluded households which did not cultivate any crop in either of the visits and household with extreme values in the crop income distribution (top 1% and bottom 1%). Therefore, a total of 4805 households were retained for the study.

The crop area diversification was measured using Simpson Index of Diversification (SID) $SID = 1 - \sum_{i=1}^{N} p_i^2$, where, p_i is the area share of crop i in the total cropped area. The index measures diversification and is bounded by zero and one; zero implies complete specialization and one, complete diversification. The net income from crop production was estimated by deducting total expenses from total value of crop produce.

The fractional outcome logit regression model was used to identify the factors that determine rural household's engagement in crop diversification. (Papke and Wooldridge, 1996; Wooldridge, 2002). The model has been used by various studies like Fonchamnyo and Akame (2016); Adem and Tesafa (2020).
The model takes the form,

$$E(y_i / x_i) = G(x_i \beta) + u_i, \qquad i = 1,2\ldots\ldots N \qquad \ldots(1)$$

Where $0 \leq y_i \leq 1$ denotes the dependent variable SID and (the N × 1 vector) x_i refers to the explanatory variables of observation i, G (.) denotes a cumulative distribution function.

The impact of crop diversification on household net income was estimated with an ordinary least squares (OLS) regression (Eq. 2).

$$\text{Log Net Income}_i = \beta_0 + \beta_1 \text{ Crop diversification}_i + \beta_2 X_i + \eta_i + v_i \quad \ldots(2)$$

The log of net income of i^{th} household is regressed on crop diversification measured by Simpson index of each i^{th} household; a vector of household or farm level characteristics, X_i; η_1, a term capturing unobserved heterogeneity assumed to be unrelated to the explanatory variables vector X_i and applying to each household from the same state; and v_i capturing all the remaining variation with i~IIDN (0, 1). However, endogeneity between crop diversification and net income of households has been reported by several studies (Makate et al., 2016; Bellon et al., 2020). So, the present study employed instrumental variable technique to control the endogeneity between crop diversification and the household income which may result in inconsistent estimates in the regression model specified in Eq. (2). A two-stage least squares (2SLS) approach was used to take account of the endogeneity problem as follows:

$$\text{Log Net Income}_i = \lambda X_i + \delta \text{ Crop Diversification}_i + \mu_i \quad \ldots(3)$$

$$\text{Crop Diversification}_i = \beta X_i + \gamma z_i + \varepsilon_i \quad \ldots(4)$$

Here, the log of net income for the i^{th} household is the dependent variable, Crop diversification of each household measured by SID represents the endogenous regressor, X_i represents the included exogenous regressors (Eq. 3). In Eq. 4, z_i represents the excluded exogenous regressors, *i.e.*, access to public extension contacts, participation in training and households which sell crop produce. X_i and z_i are collectively called the instruments and are assumed to influence crop diversification, without exerting any 'direct' effect on the household crop income variable. μ_i and ε_i are zero-mean error terms, and the correlations between them are presumably non-zero.

The model passed the Durbin test and Wu–Hausman test for endogeneity; Hansen-Sargan test of over-identifying restrictions and the test for weak instruments which were carried out to test for the validity and relevance of the instruments. The parameter of the instruments (δ) and the other parameters of the system of equations (β, γ and λ) were jointly estimated with the 2SLS procedure using Stata 14.1 software.

RESULTS AND DISCUSSION

Majority of the respondents were male (91%) with an average age of about 51 years (Table 1). The average number of family members in the working age group of 15-64 years was 3.73. Sampled farmers had completed about 4.09 years of formal education, and very few reported themselves illiterate. 54.9 per cent of the sample comprised of ST and 76.3 per cent reported crop cultivation as their principal source of income. Only around 6.7 per cent of the households were engaged in non-farm business activities. The average size of landholding in the region is around 1.36 ha, with more than 73.55 per cent falling under small and marginal category Irrigated land constituted around 28.1 per cent of the total cultivated area.

Around 20 per cent of the households reported having experienced crop losses. About 19 per cent of the agricultural households have access to public extension system for technical advice while very few reported having access to training (4.7%) and institutional credit facilities (7%). And about 83 per cent of the respondents reported selling their crop produce. However, majority of the sale was to private local traders[1].

Table 1. Household area allocation and share under different crops

Crop	Average area (ha)	Standard deviation	Area share (%)	Percent of households
Paddy	1.05	1.10	61.92	82.62
Maize	0.05	0.25	3.08	13.24
Other cereals	0.01	0.09	0.55	2.33
Pulses	0.01	0.10	0.77	5.02
Oilseeds	0.03	0.19	1.92	4.89
Vegetables	0.23	0.42	13.33	58.34
Fruits	0.04	0.26	2.28	6.16
Spices	0.07	0.3	4.29	16.34
Plantation	0.13	0.54	7.64	14.71
Miscellaneous	0.07	0.28	4.21	20.62
Total area	1.69	1.39	100	-

[1]Local private trader (65.12%); Mandi (25.35%); Input dealers (7.95%); Cooperative & govt. agency (0.62%); Processors (2.87%); Others (8.14%). Local private traders include private traders or households to which agricultural households sell-off their produce (NSSO, 2014).

Household crop diversification and net income

Table 1 reveals that share of area under paddy is about 62 per cent of the total cultivated area followed by vegetables (13.33%). Lack of basic infrastructure, inefficient market system, and small and fragmented landholding may lead to specialization towards cereal crops especially paddy. Mono-cropping with paddy, particularly with medium and long duration varieties, is widely prevalent in the NER. Area under pulses and oilseeds and percentage of households cultivating these crops is also low. In spite of the potential of high value crops such as fruits, spices, plantation crops, *etc*. in the NER, the area under these crops were low. Further, about 69 per cent of the households diversified their crop portfolios (SID > 0). However, majority of the households had an index score of less than 0.5 indicating that the intensity of diversification within the group of diversifiers was low (Figure 1). In the region, a SID of 0.290 was observed (Table 2). Talukdar et al., (2015) also corroborated this finding and reported a lacklustre SID of 0.462 in 2001-02 and 0.279 in 2009-10 in the region. Among the states, Sikkim (0.555) and Meghalaya (0.410) observed a relatively higher SID. The average annual net income from crop cultivation in the NER was about Rs. 58469 with a standard deviation of Rs. 66074 implying wide spread variation among the households.

Factors for crop diversification

The results of the fractional logit model (Table 3) suggest that households with more members in the working age group of 15-64 years has a significant effect on crop diversification. Ghouse and Hassan (2020) however found no significant effect of age of household head on diversification. Household with larger labour endowment have the advantage to diversify even to labour-intensive crops. In north-eastern states, the level of mechanization are extremely low majorly due to hilly terrain and lack of suitable agricultural machinery for such topography coupled with small and fragmented land holding. The diversification was positively associated with the households belonging to scheduled tribes (ST). Subsistence farming through *jhum* cultivation has been prevalent among ST communities who reside mainly in the remote hilly areas of the NER. Crop diversification may act as a subsistence strategy for such households to evade the high transaction costs in accessing markets (Bellon et al., 2020).

As expected, households with crop cultivation as principal income source diversify more. In congruence with the findings of Mofya-Mukuka and Hichaambwa (2018), landholding size correlates positively and significantly with crop diversification. Nonetheless, diversification tends to plateau after 2 ha (Figure 2), it is plausibly associated with the constraints faced by the farmers of the region as discussed. Increase in proportion of irrigated area to total area significantly decreases diversification. Among the sampled households, only 28 per cent of the gross cropped area was irrigated, out of which 79.46 per cent was under paddy cultivation. Therefore, with increase in irrigation, production tends to skew towards paddy cultivation. The seasonality of irrigation facilities favouring *kharif* season may restrict the scope for diversification during *rabi* season. de Sousa et al., (2017) also reported that farmers having access to irrigation produce more traditional crops even when opportunities

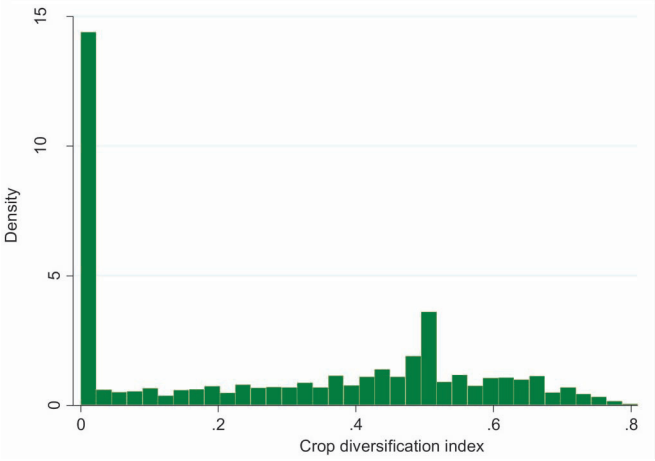

Figure 1. Distribution of the Simpson diversification index

Table 2. State-wise crop diversification index and annual net income from crop production

State	Simpson index	Annual net income (Rs.)
Arunachal Pradesh	0.329 (0.288)	59714.50 (88193.98)
Assam	0.264 (0.226)	69632.03 (70013.25)
Manipur	0.190 (0.231)	46397.48 (43052.56)
Meghalaya	0.410 (0.245)	85621.55 (88272.70)
Mizoram	0.402 (0.230)	63931.15 (75140.20)
Nagaland	0.311 (0.209)	38444.61 (43347.49)
Sikkim	0.555 (0.174)	28585.59 (28051.81)
Tripura	0.182 (0.230)	47626.13 (51529.38)
NER	0.290 (0.251)	58469.41 (66074.00)

Figures in parentheses are standard deviations

Table 3. Fractional logit estimation results for crop diversification

Explanatory variable	Coefficient	Standard error	dy/dx
Log (Age)	-0.115	0.075	-0.023
Gender	0.084	0.064	0.016
Family members in the working age group	0.045***	0.011	0.009***
Education	-0.011	0.009	-0.002
Schedule tribe	0.15***	0.043	0.03***
Crop cultivation as principal income source	0.254***	0.044	0.049***
Log (Landholding)	0.065***	0.019	0.013***
Proportion of Irrigated area	-0.421***	0.053	-0.083***
Experienced crop losses	0.155***	0.042	0.031***
Non-farm income	-0.085	0.069	-0.017
Access to institutional credit	-0.124*	0.068	-0.024*
Public extension contacts	0.083*	0.042	0.017*
Participation in training	0.25***	0.072	0.052***
Sale of crop produce	0.894***	0.060	0.152***
Assam	-0.514***	0.090	-0.097***
Manipur	-0.909***	0.101	-0.152***
Meghalaya	-0.087	0.094	-0.017
Mizoram	-0.113	0.096	-0.022
Nagaland	0.121	0.103	0.025
Sikkim	0.802***	0.098	0.18***
Tripura	-0.785***	0.098	-0.136***
Constant	-1.293***	0.318	
Log pseudolikelihood	-2700.6198		
Pseudo R^2	0.0660		
Number of obv.	4805		

*Significance level: * p < .10, ** p < .05, *** p < .01.*

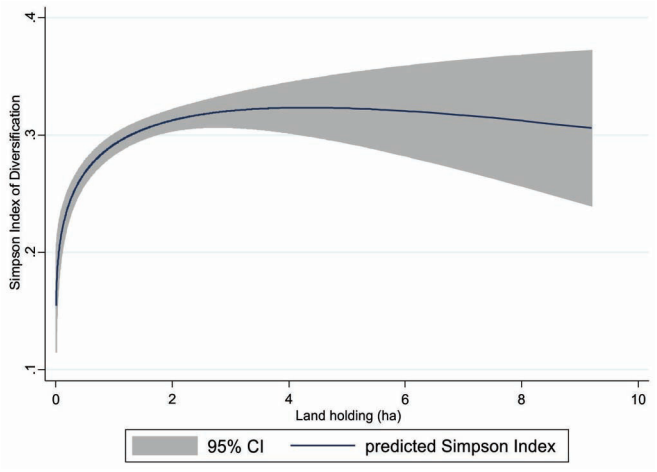

Figure 2. Relationship between crop diversification and land holding
Note: shaded region denotes 95% confidence interval

exist for growing more profitable crops. However, several studies found the positive relationship between the extent of irrigation and crop diversification (Mukherjee, 2015; Thapa et al., 2018). Farm households which have experienced crop losses (due to natural calamities, biotic and abiotic stress *etc*.) were more likely to adopt crop diversification strategies in order to cushion themselves against anticipated losses. Many studies have shown that crop diversification practices help to buffer climate change and variability (Lin, 2011; Bowles, 2020; Piedra-Bonilla et al., 2020: Raghuvanshi and Ansari, 2020; Dupdal et al., 2021).

Access to institutional credit was found to be negatively and significantly related with crop diversification. The likelihood of diversification is higher in farmers having access to public extension contacts and participation in training (Hewett, 2012). Households who sell their produce to one or more procuring agency were more likely to diversify their crop portfolios. Market access was an impediment to diversification especially among small farmers of remote areas due to high transaction costs of their small marketed surplus. About 65 per cent of the households sold the crops produce to other households or private traders.

Impact of crop diversification on net income

The OLS regression estimates show a positively significant effect of crop diversification (Simpson index) on net income (Table 4). However, considering that crop diversification might be an endogenous variable, simple OLS regression might over-estimate or under-estimate the parameter. Failure to control for endogeneity in crop diversification resulted in under-estimation of the true impact of crop diversification on the outcome. Without controlling the endogeneity, crop diversification had a positive and statistically impact on income with a coefficient of 0.205. However, after controlling for selection bias or endogeneity, the result of 2SLS regression showed a positive and statistically significant impact with a larger coefficient of 5.058. Thus, crop diversification was more beneficial than specialization in the region. Improvement in income as a result of crop diversification was probably due to increased production from diversified cropping systems and reduced production risks. The finding is in line with the study of Makate et al., (2016) and Anuja et al., (2020).

Further the result of 2SLS regression reveals that age, education, education, irrigated area and access to institutional credit positively affect the income from crops. However, household of ST communities and those which experiences crop losses significantly attenuated the income.

Table 4. Impact of crop diversification on net income

	log (Net Income)			
	OLS		2SLS	
	Coefficient	Standard error	Coefficient	Standard error
Simpson Index	0.205***	0.053	5.058***	0.381
Log (Age)	0.224***	0.052	0.319***	0.086
Gender	0.024	0.043	-0.05	0.071
Family members in the working age group	0.048***	0.008	0.006	0.013
Education	0.027***	0.006	0.036***	0.010
Schedule tribe	0.014	0.029	-0.112**	0.049
Crop cultivation as principal income source	0.23***	0.03	0.002	0.054
Log (Landholding)	0.434***	0.011	0.375***	0.020
Proportion of Irrigated area	-0.081**	0.035	0.284***	0.064
Experienced crop losses	-0.184***	0.032	-0.352***	0.054
Non-farm income	-0.049	0.048	0.015	0.079
Access to institutional credit	0.108**	0.047	0.192**	0.078
Assam	-0.041	0.058	0.426***	0.094
Manipur	-0.278***	0.062	0.505***	0.110
Meghalaya	0.114	0.063	0.09	0.104
Mizoram	-0.189***	0.068	-0.178	0.112
Nagaland	-0.255***	0.068	-0.361***	0.113
Sikkim	-0.76***	0.072	-1.73***	0.152
Tripura	-0.166***	0.062	0.469***	0.104
Public extension contacts	0.013	0.031		
Participation in training	0.095*	0.057		
Sale of crop produce	0.705***	0.034		
Constant	8.678***	0.215	7.542***	0.366
Number of obv	4805		4805	

*Significance level: * p < .10, ** p < .05, *** p < .01.*

Diversification with locally suitable pulses and oilseeds in rice-fallow should be facilitated by improving irrigation facilities, accessibility to improved seeds, mechanization and extension services. Although the region experiences high rainfall, most of it goes unutilized due to uneven topography and difficulty in construction of reservoirs (Birthal et al., 2006). Constructing water harvesting structures will help in saving the monsoon water for use during lean season. The NER has a large stock of high value crops (spices, medicinal, plantation and horticultural crops) with huge potential for further expansion (Barah, 2007). For a wider income impact, crop diversification in favour of such crops will go a long way. It is important to note that post-harvest losses especially of horticultural crops are high in the region. The region is constrained by lack of infrastructure, markets, finance and extension services. This calls for huge investment in roads, transportation, agro-processing facilities, storage facilities and development of innovative market institutions like co-operatives, self-help groups and contract farming that will provide assured markets to the producers besides quality inputs, technology and credit (Birthal et al., 2006). Another grim area is the prevalence of traditional agricultural practices leading to low crop productivity. Intensification of agriculture with improved inputs and technology is a *sine-qua-non* for improving the productivity of the diversified crops and farmer's income of the region.

CONCLUSION

Despite the existence of a large number of production possibilities of a wide range of fruit and vegetables, pulses, oilseeds, spices, plantation crops *etc*. in the NER, crop production is mainly skewed towards specialization among the agricultural households. Various socio-economic and farm characteristics determine the extent of crop diversification. Crop diversification improves farmers' income and can thus play a crucial role in alleviating poverty in the region. Promotion of pulses, oilseeds and vegetables in rice-fallow will help in ensuring the food and nutritional security in this food grain deficit region. Diversification towards high value crops may accelerate the agricultural growth of the region and improve the wellbeing of the farmers. Systematic intervention should be prioritized for improving the productivity for subsequent improvement of farmers wellbeing. Concerted measures for improvement of basic infrastructure-road, transportation, power, irrigation, storage facilities, processing facilities, finance and extension services in rural areas and development of innovative market institutions like co-operatives, self-help groups and contract farming for improve backward and forward linkages are required.

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