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Beyond production: how can diversification enhance farm income in the North-Eastern region of India?

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Abstract Raising the production and productivity in agriculture and improving the level of living of smallholders is a major challenge for the planners and policy makers in Tripura. Due to dominance of ultra-small landholdings the traditional farming may not be sufficient for raising income. The present study captures the nature and extent of crop diversification through Simpson index using data obtained from 400 farm households. Further, it identifies the determinants of crop diversification and its role in augmenting farmers' income. The results show diversification as pivotal in augmenting farm income.

Keywords Diversification, farm income, Simpson index, cropping pattern, Tobit model

JEL codes Q12, Q15, Q18, Q19

Introduction

Doubling farmers' income by 2022 is the main thrust of the Government of India since the Prime Minister of India set the target in 2016. Odisha is the only state where the income has doubled during the last decade. In other states, farmers' income has increased but not doubled (Chandrasekhar and Mehrotra 2016).

Crop diversification is one of the approaches to enhance agricultural productivity and increasing farmers' income (Lama 2019). Several researchers have articulated the need for crop diversification to improve farm productivity and boost smallholders' income (Bigsten and Tengstam 2011; Birthal et al. 2008; Jha 2001; Vyas 1996). Some studies (Sharma 2007; Mondal and Bezbaruah 2013; Lama 2019) have identified a positive impact of crop diversification on farmers' income. The north-eastern region of India consists of eight states, which account for about 8% of the country's geographical area. The north-eastern region has a limited cultivable area because of hilly topography. In such circumstances, crop diversification toward high-value crops is a means of enhancing farmers' income. Tripura is the third smallest state in the country, having the highest population density. About 75% of the state's rural population is engaged in agriculture. Crop farming is the main activity, accounting for about half of the household' income (Ranganathan 2013).

Crop diversification towards high-value crops may be a strategy in Tripura also. The magnitude of crop diversification at the macro-level is moderate. The productivity of different crops is low, but the share of high-value crops like fruits and vegetables in gross cropped area is increasing. Further, there is not much improvement in the cropping intensity, indicating that crop diversification is basically shifting from one crop to another instead of bringing additional land under cultivation.

The forces for crop diversification can be numerous including reduction in production and market-related risks, arresting depletion of natural resources, enhancing farm income, increasing cropping intensity, minimizing migration, engaging female farmers in income generating activities, and managing insect, pest and weed problems (Acharya et al. 2011). The present study is an attempt to answer the following questions:

Is crop diversification taking place in Tripura? Who is diversifying? Is crop diversification towards high-value crops or food grains? Is crop diversification improving farm household income? What are the factors responsible for crop diversification?

Methodology

We have followed mixed method of data collection covering the entire Tripura state. Secondary information was collected from all the districts, while primary information was collected from respondents following multistage sampling. The sampling plan has been designed to select a representative sample of district, subdivision, block, village and households covering all the areas in the state and in probability proportionate to different size groups. At the first stage we have selected all four districts (before 2012) purposively. At each subsequent stage, we randomly selected one subdivision followed by one block and two villages. Thus a total of eight sample villages were selected, and final respondents were selected in probability proportionate to different size categories within a village. It is to be noted here that there was not a single large farmer in the selected villages.

Primary data were collected from 400 farm households through personal interview during 2016-17 (Table 1). Primary data includes both quantitative and qualitative information based on long-term experiences of the households as crop diversification analysis requires both qualitative and quantitative information of the households over time. The data were collected from the sample households on various aspects related to farming and farm households.

To capture the extent of crop diversification, we used Simpson diversification index (SI) the most suitable measure of diversity (Joshi et al. 2004). In fact SI is derived from the Herfindahl Index (HI):

SI =1- HI

$$H.I. = \sum_{i=1}^{N} P_i^2$$

Where, N is the total number of crops grown by a particular farmer and P_i represents the proportion of area under i^{th} crop in the gross cropped area. Its value is bounded by zero and one. With the increase in diversification, the Herfindahl index would decrease. The index value is one when there is a complete specialization and approaches zero as N gets large, i.e., if diversification is perfect.

In order to identify determinants of crop diversification, a Tobit model has been used. The available literature provides the possible determinants to crop diversification. These include agro-climatic conditions, capabilities of the farmers, resource endowments of the farmers, compulsions, risks, profitability and infrastructural facilities available with the farm farmers as well as within the locality. Initially, we have tried the regression model with many explanatory variables. However, due to the problem of multi-collinearity required to drop several variables like age of the farmer, distance from agricultural market, amount of crop loan availed, land-man ratio, membership to social bodies, etc. We have also tried with the share of non-farm income (NFARM) instead of per-capita non-farm income (PCNF), and amount of credit (LOAN) instead of access to credit (CREDIT). But PCNF gave better test statistics than NFARM, and similarly CREDIT than LOAN. We have tried the model with different combinations of these variables but chose the

Table 1 Sampling frame

Sampling stage	Numbersof units	Sampling technique	Selected units			
Districts	4	Purposive	North	Dhalai	West	South
Sub-Divisions	One from each district	Random	Panisagar	Long Tarai valley	Kishangarh	Udaipur
Blocks	One from each sub-division	Random	Jubarajnagar	Manu		Kishangarh Malabari
Villages	Two from each block	Random	Jubarajnaga, Zhang	Panama, Taichung	Nabinagar, Jaipuijala	Portia, Jowalikhamar
Households	400 (50/ village)	PPS	50	50	50	50

combination which gave the best fit to our model.

Since the dependent variable (SI) is bounded between 0 and 1, an ordinary regression model is not suitable as the predicted value from a linear model will not necessarily be contained within the interval of 0 and 1 (Roy et al. 2018a). Even a logit transformation may not be appropriate, under such context, because in a cluster of observations the dependent variable takes the value of 0 (mono-cropping). Therefore, a Tobit model is used to avoid any information loss (see Kumar et al. 2012; Mondal and Bezbaruah 2013). The model is formulated with the help of a latent variable Y_j^*, which can take any possible value but is not always observable. The observed dependent variable Y_j (i.e., SI) is linked to the latent variable. The Tobit model used is:

$Y_j^* = \beta_i X_i + \mu_i \qquad \mu_i \ 4 \ N(0, \sigma^2)$ i=1, 2, 3,....., n

$Y_j = Y_j^* \quad$ if $Y_j^* > 0$

$Y_j = 0 \quad$ otherwise

where Y_j^* is the unobserved latent variable (linked with Y_j), Y_j is the observed censored dependent variable (representing SI), β_i represents the vector of parameters and X_i represents a vector of exogenous explanatory variables. The random disturbances μ_i are assumed to be independently and normally distributed with zero mean. The model was estimated by Maximum Likelihood Estimation (MLE).

The coefficients of Tobit model (β_i) need to be interpreted in a slightly different way than OLS estimates, as it tells us the linear effect of an explanatory variable on the uncensored latent variable (Y_j^*), rather on the observed outcome (Y_j). The β coefficients are not the effect of X_i on Y_i rather a combination of the change in Y_i of those above the limit, weighted by the probability of being above the limit, and the change in the probability of being above the limit, weighted by the expected value of Y_i.

Further, we have examined how crop diversification helps raise farm and total household income. Accordingly, we estimated two models: Model-I and Model-II. In Model-I the dependent variable is family income, and in Model-II the dependent variable is farm income. In both models, the set of explanatory variables kept unchanged. The impact of crop diversification on household total income and farm income has been explored through a linear multiple regression model.

$I = \tau_0 + \tau_i Z_i + \mu_i$

where I is the dependent variable. τ_i represents a vector of parameters associated with Z_i a vector of explanatory variables. The explanatory variables include SI, amount of loan, percent area under irrigation, education of the head of the family, percent area under high value crops, family size, distance from market, farm size and farm category dummies. The model has been estimated by ordinary least square (OLS) technique.

Results and discussion

Descriptive statistics

Table 2 shows a wide variation across the farm categories in land-man ratio, cropping intensity and area under irrigation. The net irrigated area is 27.80% varying from 11.18% on medium farms to 33.86% on marginal farms. The table also shows a very unfavorable land-man ratio (0.13) for marginal farmers and less than 100% per cent cropping intensity for medium farmers. It indicates that a large portion of land owned by the medium farmers remains uncultivated.

Table 2 Basic characteristics of sample households in Tripura

Category	Average family size	Average operated area (in ha)	Landman ratio	Cropping intensity	Net irrigated area (%)	Education of head of family (years)	Market distance (in km)
Marginal	4.86	0.62	0.13	151.59	33.86	5.87	4.79
Small	5.14	1.47	0.28	113.38	21.36	5.12	6.34
Medium	4.43	2.85	0.64	77.79	11.18	5.60	10.56
Total	4.39	1.10	0.22	132.64	27.80	5.61	5.83

Source Author's own calculation

Table 3 Size category-wise income of sample farmers in Tripura

Farm category	Districts				Tripura (Overall)
	North Tripura	South Tripura	West Tripura	Dhalai	
Total household income (Rs./household)					
Marginal	76540.00	55696.66	62476.56	73690.47	66708.01
Small	157924.32	165984.37	187810.00	128167.31	160970.80
Medium	140553.85	101062.50	65416.66	172272.72	129557.89
Overall	114974.00	94618.00	100253.00	98698.50	102135.87
Total farm income (Rs./household)					
Marginal	49806.00	40531.66	42278.12	50471.43	45602.11
Small	108348.64	110250.00	117083.33	85501.92	106179.60
Medium	84992.30	64875.00	43750.00	129090.91	87010.52
Overall	76041.00	64789.00	64808.00	68227.50	68466.37
Share of farm income (as % of total income)					
Marginal	65.07	72.77	67.67	68.49	68.36
Small	68.60	66.42	62.34	66.71	65.96
Medium	60.46	64.19	66.88	74.93	67.16
Overall	66.14	68.47	64.64	69.13	67.03

Source Author's own calculation

The average annual income of sample household is low; Rs. 102136. A perusal of the Table 3 reveals that the share of farm income in the total family income is more or less uniform across districts. On average, two-thirds of the total household income is derived from farm enterprises. Average household income is highest in North Tripura and lowest in South Tripura. So is the case with average farm income. However, one distinctive feature is that, barring in Dhalai district, average farm income, as well as family income, is the highest for small farmers and the lowest for marginal farmers.

Nature and extent of diversification

We captured the nature and extent of crop diversification through three measures viz: average number of crops grown per farmer, cropping pattern and changes therein and use of crop diversification indices. Farmers grows many crops. In all the districts and among all categories of farmers, the average number of crops grown has increased substantially during the last 10 years. This shows a very encouraging trend towards crop diversification (Table 4). Further, it is evident that almost all the groups of farmers have

Table 4 Average numbers of crops grown in Tripura

Farmer groups	Average numbers of crops grown									
	North		South		West		Dhalai		Total	
	Past	Present	Past	Present	Past	Present	Past	Present	Past	Present
Marginal	3.70	6.34	2.72	4.63	2.53	4.95	2.38	4.58	2.83	5.19
Small	3.24	6.55	2.81	6.47	2.67	6.73	3.12	5.92	2.96	6.29
Medium	2.76	6.07	2.62	5.25	2.50	5.16	4.94	5.64	3.20	5.52
Overall	3.41	6.50	2.74	5.27	2.59	5.50	3.48	5.07	3.05	5.63

Source Author's own calculation

Note Past means 10 years earlier

Table 5 Cropping pattern across different farm size groups in Tripura

Crops	Share in total cropped area (%)			
	Marginal farmers	Small farms	Medium farms	Overall
Jhum	1.49	6.15	6.17	4.24
Paddy	57.41	42.87	30.37	46.75
Oilseeds & pulses	3.66	1.87	0.47	2.37
Vegetable	18.25	12.98	6.04	13.98
Fruits	3.35	10.66	12.74	8.00
Nuts & Plantation	15.83	25.48	44.21	24.63
Total	100.00	100.00	100.00	100.00

Source Author's own calculation

increased the numbers but with varying rates. However, small farmers are the main agents in this process.

The cropping pattern is highly diversified. Though the share under paddy is the highest (Table 5). What is encouraging is that the share of high-value crops like fruits, vegetables and nuts is quite high and has been increasing. Small farms are the most diversified towards high- value crops.

Crop diversification is presented in Table 6. Crop diversification should not be measured only in terms of a number of crops or cropping patterns but on the degree of reliance on multiple crops. It is pertinent to mention here that, the value of the Simpson Index changes with the change in level of measurement. For example, in a situation where individual farmers are practising mono-cropping (but different crops), their level of diversification at household level will be zero, but at an aggregate level (village/district/state), it may represent a diversified cropping system. Therefore, while drawing conclusions based on the Simpson Index's value, the measurement level is very important.

The average value of Simpson Index is more than 0.5. The household-level crop diversification varies across districts and size categories of farmers. It varies from 0.59 in North Tripura to 0.43 in Dhalai. The crop diversification index for South Tripura and West Tripura is 0.48 and 0.57, respectively. The reason for a lower level of crop diversification in South Tripura and Dhalai is that many farmers in these districts are practicing mono-cropping with either paddy or plantation crops.

Across farm categories, the value of Simpson Index is the highest on small farms and in all the districts.

Determinants of crop diversification

Results of the censored regression (Tobit) model are presented in Table 7. The model produced a reasonably good fit as indicated by Log Likelihood, McFadden

Table 6 Crop diversification index at household level in Tripura

Farmer groups	Simpson Index									
	North		South		West		Dhalai		Total	
	Past	Present	Past	Present	Past	Present	Past	Present	Past	Present
Marginal	0.31	0.59	0.34	0.41	0.41	0.52	0.28	0.40	0.33	0.48
Small	0.27	0.61	0.31	0.60	0.40	0.68	0.27	0.53	0.34	0.61
Medium	0.39	0.56	0.42	0.48	0.43	0.54	0.39	0.34	0.40	0.48
Overall	0.33	0.59	0.34	0.48	0.41	0.57	0.28	0.43	0.34	0.52

Source Author's own calculation

Note Past means 10 years earlier

Table 7 Determinants of crop diversification in Tripura

Explanatory variables/ particulars	Dependent variable: SI (Simpson Index of crop diversification)	
	Estimated co-efficient value	Standard error
Farm size (in ha)	0.0332	0.0226
Irrigation facilities (% area irrigated)	0.0027**	0.0003
Family size (Numbers)	0.0258**	0.0062
Access to Credit (Institutional=1; Otherwise=0)	0.1821**	0.0215
Tenancy (Owned cultivation=1; Otherwise=0)	0.0929**	0.0223
Caste (ST=1, Otherwise=0)	-0.0141	0.0192
Education of head of family (No. of years of schooling)	-0.0039	0.0030
Per capita non-farm income (thousand rupees/annum)	0.0091**	0.0013
Small Farm Dummy (Small farm=1,Otherwise=0)	0.1110**	0.0431
Marginal Farm Dummy (Marginal farm=1, Otherwise=0)	0.0609	0.0558
Dummy for North Tripura (North=1, Otherwise=0)	0.1068**	0.0255
Dummy for South Tripura (South=1, Otherwise=0)	0.0171	0.0233
Dummy for Dhalai (Dhalai=1, Otherwise=0)	-0.0295	0.0242
Constant	-0.0024	0.0790
Number of observations	400	
Log Likelihood	89.397	
McFadden Pseudo R^2	1.925	
F (13, 400) or LR χ^2 (13)	372.16	

** 1% level of significance, * 5% level of significance

Pseudo R^2, and Likelihood Ratio of χ^2. Further, all the estimated coefficients, except of caste and education, have expected signs, and most of them are statistically significant.

Irrigation turns out to be a significant determinant influencing farmer's decision toward crop diversification. Assured irrigation reduces production risk. High-value crops are riskier than traditional crops; thus, unavailability of irrigation may expose the farmers to higher risks. Further, in irrigated land, farmers can go for multiple crops. This is one of the critical reasons for the increase in area under vegetables. Provision of assured irrigation helps farmers in the cultivation of winter as well as summer vegetables.

Family size has a positive and significant impact on crop diversification. In hilly areas and in traditional societies, farming operations are done mostly manually. High-value crops are labour intensive.

Access to institutional credit induces farmers to cultivate more crops. Most of the farmers are resource-poor and are unable to borrow from non-institutional sources at a high rate of interest. A diversified cropping pattern requires more capital, quality inputs, and improved technologies. Such a cropping pattern, therefore, requires typically a large number of purchased inputs. Access to credit helps the resource poor farmers to arrange for such inputs. In line with our expectation, ownership cultivation leads to higher crop diversification than any other tenurial arrangements. Share cropping is basically concerned with subsistence crops rather than high value crops (Mondal and Bezbaruah 2013).

Non-farm income is found to have a significant and positive impact on crop diversification. Non-farm income helps farmers to invest more on farm machinery, HYV seeds, fertilizers and pesticides.

To know whether farm size influences crop diversification we have included dummies for different size categories. The coefficient on small farms is positive and statistically significant, but not in the case of marginal farms. The regression results also show

that caste has no relationship with crop diversification. Surprisingly, the coefficient on education is negative though it is statistically non-significant.

District dummies were incorporated to capture the influence of location-specific characteristics on crop diversification. Dummy for North Tripura is found to be positive and statistically significant, indicating a higher degree of diversification.

Crop diversification and household income

The relationship between crop diversification and household income is judged by comparing the average household income of mono-croppers (farmers with no crop diversification) with that of farmers with low level of crop diversification, moderate level of crop diversification, and high level of crop diversification (Table 8). Farmers are categorized into four groups i.e., complete specialization (SI=0), low diversification (SI=0.1 to 0.25), moderate diversification (SI=0.26 to 0.50), and high diversification (SI=.>0.50).

A close perusal of the table indicates a clear trend that, across all the districts, the farm income is invariably very low for farmers practicing mono-cropping. And, as the level of crop diversification increases, there is a commensurate increase in farm income.

Table 8 Level of crop diversification and farm income in Tripura

(in Rupees/household/annum)

Category	Level of crop diversification			
	Complete specialization (SI=0)	Low diversification (SI= 0.1 to 0.25)	Moderate diversification (SI=0.26 to 0.50)	High diversification (SI =>0.50)
North Tripura				
Marginal	11250.00	29600.00	38446.15	57011.76
Small	NA	NA	59150.00	117693.33
Medium	NA	36000.00	87766.66	78400.00
Overall	11250.00	32800.00	50818.18	85108.11
South Tripura				
Marginal	21690.00	39500.00	41894.73	46980.76
Small	NA	NA	81062.50	119979.16
Medium	45000.00	NA	NA	71500.00
Overall	25575.00	39500.00	53500.00	80892.86
West Tripura				
Marginal	36187.50	32500.00	43166.66	43390.69
Small	NA	NA	55925.00	126492.30
Medium	NA	60000.00	34200.00	42075.00
Overall	36187.50	41667.00	45641.17	72916.43
Dhalai				
Marginal	18438.09	35000.00	40881.25	84136.00
Small	10925.00	NA	60166.66	123266.66
Medium	105000.00	64000.00	136400.00	100000.00
Overall	24762.00	44667.00	62366.66	96989.74
Tripura				
Marginal	22343.90	34150.00	41131.66	55696.09
Small	10925.00	NA	64970.00	121521.51
Medium	75000.00	49000.00	108833.33	71566.00
Overall	26339.36	39100.00	54510.10	82369.83

Source Author's own calculation; NA=Not Applicable (No farmers)

It is important to examine the scope for enhancing farm or non-farm wage income through crop diversification and other interventions. This has been explored through a linear multiple regression model discussed in detail in the methodology section.

The results of regression analysis of determinants of rural household income in Tripura is presented in Table 9. The coefficient of Simpson Index is positive and statistically significant in the case of household as well as farm income. This suggests that apart from being a risk mitigation strategy, crop diversification can also be an essential strategy to augment income. This is because of diversification towards high-value crops like fruits, vegetables, spices, condiments, nuts, flowers, and medicinal plants.

Institutional credit has a positive and statistically significant impact. This implies that the availability of institutional credit can induce farmers to practice crop diversification towards high- value crops. Moreover, most of the farmers are resource-poor. Hence, credit availability from institutional sources may enable them to carry on farming operations better by providing them financial assistance to purchase the necessary inputs at a relatively lower interest rate. This eases their liquidity constraints to purchase modern farm inputs necessary for a diverse cropping pattern. The coefficient of irrigated area is positive and statistically significant only in Model-II. Access to irrigation is found to impact per hectare farm income positively. This is because access to irrigation facilitates farming in the rabi season and the use of high yielding varieties of seeds and chemical fertilizers, which in turn contributes towards an increase in the productivity of crops. Therefore, a positive relationship between irrigation and per hectare farm income is quite obvious.

Table 9 Determinants of rural household income in Tripura

Explanatory variables/particulars	Dependent Variables	
	Model-I Family income	Model-II Farm income
Simpson Index	94070.301** (17523.611)	45648.420** (11217.651)
Institutional Credit (in '000 rupees)	1.390** (0.374)	0.475* (0.239)
Irrigation facilities (% area irrigated)	148.824 (131.128)	94.156* (44.941)
Education of head of family (No. of years of schooling)	3188.235 (1123.334)*	733.373 (719.097)
Share of high value crops (% of GCA)	286.794* (116.450)	148.012* (74.545)
Family size (No of family members)	746.269 (2260.760)	1039.775 (1447.215)
Market distance (Distance of the nearest market in Km)	-173.374* (86.113)	-31.310 (279.816)
Small Farm Dummy (Small farm=1,Otherwise=0)	17879.100 (11509.901)	14906.930* (7368.007)
Marginal Farm Dummy (Marginal farm=1, Otherwise=0)	-62250.100** (11260.420)	-39231.600** (7208.301)
Constant	39677.890* (19531.340)	38705.390** (12503.021)
Number of observations	400	400
Adjusted R^2	0.444	0.396
F (9,399)	36.406	30.114

** 1% level of significance, * 5% level of significance, Figures in the parenthesis are standard errors

It is not surprising to see that education strongly affects household income but not farm productivity. In a traditional agricultural system, formal education may not have much role in the package of practices to be adopted, but lack of it definitely puts an entry barrier for many non-farm job avenues. The coefficient of education is positive and statistically significant at 5% level of significance. This may due to the fact that more educated individuals often seek opportunities in non-farm activities rather than getting engaged in low-paid wage activities. The coefficient of share of high value crops having positive and significant effect on family income as well as farm income. Rural infrastructure, particularly marketing infrastructure (proximity to town), is found to be significant determinants for enhancing per capita household income. Proximity (reverse of distance) to market or town gives rural farmers an opportunity for better livelihood outcomes in terms of earning higher incomes from the nearby cities or towns.

The negative and statistically significant coefficient for marginal farm dummy suggest that ceteris paribus, per hectare farm income as well as per capita household income is lower if a farmer belongs to marginal farm size category. This means that if land holding can be increased beyond one hectare there will be an increase in both farm productivity and household income. This will increase farm income and provide an opportunity for off-farm and non-farm employment through self-employment. One of the main problems in rural Tripura is over dependence on land based agricultural activities with very small size of holding. Due to population growth, sub-division and fragmentation of land holding is on the rise and average land holding is continuously declining. Therefore, consolidation of holding may be an important intervention to make farm units economically viable. The coefficient of constant is statistically significant, thereby implying that there are few other factors that determine the farm income as well as household income. The results are inconsistent with the findings of several studies (Birthal et al. 2005; Birthal et al. 2007; Joshi et al. 2003; Joshi et al. 2007; Mahmud et al. 1994; Minot and Roy 2007; Ryan and Spencer 2001; Hazra 1997; Pingali et al. 2005; Barghouti et al. 2005; World Bank 1990; Abro 2012; Abro and Sadaqat 2010; Ahmad and Isvilonanda 2003; Alam 2005; Pingali 2004; Vyas 1996).

Conclusion

Agriculture is the main source of income in rural Tripura, and it has been diversifying gradually towards high-value crops. This has led to higher farm income as well as household income, implying crop diversification is an important means to enhance income of small and marginal farmers. Other than crop diversification, availability of institutional credit, development of irrigation facilities, consolidation of land holdings, education and development of rural markets can augment farm and family income.

The future agenda for sustainable development of agriculture should focus on expanding irrigation, encouraging use of modern farm inputs; increasing cropping intensity; ensuring regular flow of institutional credit, and promoting crop diversification towards high-value crops.

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