The impact of crop diversification towards high-value crops on economic welfare of agricultural households in eastern India

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Eastern India is among the most backward regions of the country with underutilized agricultural potential. Diversification towards high-value crops can be a promising strategy to enhance farmers' economic welfare in the region. The present study analyses the major determinants and impact of crop diversification towards high-value crops on farmers' economic welfare in the region using large farm household-level data and advanced matching estimation methods. The findings reveal that cultivation of high-value crops plays a significant role in enhancing farm income, consumption expenditure and reducing poverty. Growers need to allocate at least 40% area for high-value crops to have significant income enhancement and poverty reduction.

Keywords: Agricultural households, diversification, economic welfare, high-value crops.

EASTERN India comprising states such as Bihar, Chhattisgarh, Jharkhand, Odisha, West Bengal and eastern Uttar Pradesh, is one of the most backward regions of the country. In 2011–12, 33% of the rural population was found to live below the poverty line in this region against a national average of 25.7% (ref. 1). The per capita GDP in the region in 2017–18 was about ₹ 70,709, about three-fifth of the national average. The region is also the hotbed of under and malnutrition with 40.7% children under the age of five and 57.4% women in the rural areas being underweight and anaemic respectively.

Agriculture is an economically important sector in the region and contributes to about 18% of GDP. About 66% of the rural workforce is engaged in agriculture. However, the agricultural sector in the region is underdeveloped and marred by low crop yield, high risk, biotic and abiotic constraints, fragmented holdings, inadequate infrastructure and weak institutions. But good soil and groundwater potential of the region provide opportunities for bringing the Second Green Revolution[2].

'Diversification towards high-value crops' is identified as a significant strategy among the major potential sources of growth in farmers' income operating within the agriculture sector. Shifting 1 ha area from staple crops to commercial high-value crops has the potential to increase gross returns up to ₹ 101,608/ha (ref. 3). Crops such as fruits, vegetables, flowers, spices and condiments, medicinal and aromatic plants, and plantation crops which generate higher net income per unit land area compared to other crops are considered as high-value crops. Feasibility of using crop diversification towards high-value crops like fruits and vegetables in small holdings as a management strategy is well documented[4]. The literature suggests that the direction of diversification towards more remunerative crops can enhance farmers' income security, risk-bearing ability and sustainability[5–8]. An inverse relationship between the degree of diversification towards high-value crops and likeliness of being poor is empirically established, which is specifically true for smallholders[9,10].

In eastern India, diversification within the crop sub-sector has the potential to generate gainful employment opportunities by diversifying towards high-value crop cultivation[11]. Earlier studies indicate a positive relationship between the level of crop diversification and agricultural growth in eastern India, and suggest crop diversification as a promising strategy to address the challenge of rice monocropping and subsequent fallowing and declined productivity in the region[12–14].

However, there is a paucity of studies empirically establishing the impact of cultivation of high-value crops on economic welfare of farm households in eastern India. In this context, the present study aims to understand the determinants of high-value crop cultivation in the region and the impact of crop diversification towards high value crops on income, household consumption expenditure and poverty status of agricultural households based on two rounds of a nationally representative survey.

Methods

Data

The study relies on farm level data from two rounds of the 'National representative survey of agricultural households in rural areas' conducted by the National Sample

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Survey Organization (NSSO), Government of India in 2003 and 2013 (refs 15, 16). The surveys assess the status of farmers and farming, and provide information on important indicators of rural agricultural households.

The first situation assessment survey was conducted during January to December 2003. In this survey, a farmer was identified as a person who operated on some land (owned or taken on lease or otherwise possessed) and performed agricultural activities during the last 365 days preceding the date of survey, and a farm household was one with at least one farmer. The situation assessment survey of agricultural households in 2013 (January–December) was conducted as a repeat survey. Considering the changed agricultural scenario of the country, the survey dropped the criterion of land possession for considering a household for survey and instead used the concept of 'agricultural production unit'. We retained information only of those households in eastern India having/rented land for cultivation in the 2013 survey to ensure comparability of data of the two surveys. Therefore, our final sample size for analysis was 23,360 farm households.

Methodology

Our main objective was to assess the impact of cultivation of high-value crops on farmers' economic welfare. To ensure robustness and consistency of our findings, we have used propensity score matching, coarsened exact matching and dose response function analysis. We have also identified the factors determining farmers' participation in cultivation of high-value crops using logit model.

Determinants of high-value cultivation in eastern India

We assessed the determinants of growing high-value crops in eastern India using the logit model. The dependent variable is binary, taking a value of 1 for growing high-value crops, and 0 otherwise

$$Y_i = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \sum \beta_i X_i, \tag{1}$$

where p is the probability that Y_i will have the value 1, i.e., the household growing high-value crops, X_is are the factors that influence a household's decision to grow high-value crops and β_is are the coefficients of the explanatory variables X_is.

Impact of crop diversification towards high-value crops on economic welfare of farm households

We assessed the impact of growing high-value crops on the economic welfare of farm households in eastern India. We used net farm income per hectare (NFI) monthly per capita consumption expenditure (MPCE) and poverty status as indicators of economic well-being of the agricultural households. The treatment variables for the impact analysis included binary and continuous variables. The binary treatment variable considers whether households grow high-value crops or not, and continuous treatment variable is the percentage of area share under high-value crops.

For a better assessment of the impact, we used matching techniques. Non-reliance of the matching techniques on the correct specification of the functional form of the relationship (e.g. linearity or log linearity) between the outcome and the covariates is a significant advantage. We employed propensity score matching (PSM) and coarsened exact matching (CEM) for the binary treatment variable and dose–response function (DRF) approach for the continuous treatment variable.

Propensity score matching

Propensity score matches the observations based on the distance between point estimates of the propensity score and this helps minimize the problems arising from selection biases from the sample. We used the PSM technique based on binary treatment, i.e. whether households have grown high-value crops or not. In this method, a comparison was done between a non-treated (non-growers of high-value crops/control) and a treated (high-value crops growers) group in all important observable characteristics. We estimated the average treatment effects (ATT) on the treated variable. The balancing test is normally required after matching to ascertain whether the differences in covariates in the two groups in the matched sample have been eliminated, in which case the matched comparison group can be considered as a plausible counterfactual[17].

Let D_i be an indicator of whether an agricultural household is growing high-value crops or not. The potential welfare outcome of a high-value crops grower, represented by i, for each farming household is defined as $i(D_i)$. The ATT on the treated is computed as

$$\Delta_{\mathrm{ATT}} = E(\Delta|D=1) = E\,[(\tau(1)|D=1] - E\,[\tau(0)|D=1], \tag{2}$$

where $E\,[\tau(1)|D = 1]$ is the expected outcome variable of high-value crop growers and $E\,[\tau(0)|D = 1]$ is the expected outcome variable of the non-growers. PSM requires imposing conditional independence and common support assumptions for identification. If these two assumptions are met, the PSM estimator for Δ_{ATT} is given as

$$\Delta\frac{\mathrm{PSM}}{\mathrm{ATT}} = E_{p(x)|D=1}\{E[(\tau(1)\mid D=1,\, p(X)]\,,$$

$$-E[(\tau(0)\mid D=1,\, p(X)]\}. \tag{3}$$

We estimated propensity scores using a logit model. Following Heckman *et al.*[18], we included only those explanatory variables that might influence high-value crop growers and the outcome.

Coarsened exact matching

The PSM approach does not guarantee that the matched samples will be balanced with respect to the covariates X. However, the CEM technique proposed by Iacus *et al.*[19] overcomes this limitation. With CEM, continuous variables are converted to discrete-interval data, and exact matching strata are constructed. The treated units and their controls are balanced with respect to the covariates X. This procedure estimates weights with zero weight for unmatched units. Matched units belonging to the treatment group get a weight equal to one. If they belong to the control group, the weight is estimated as

$$\frac{m_{\mathrm{C}}}{m_{\mathrm{T}}} \cdot \frac{m_{\mathrm{T}}^{\mathrm{S}}}{m_{\mathrm{C}}^{\mathrm{S}}}, \tag{4}$$

where m_{C} is the total number of control units, m_{T} the total number of treatment units, and $m_{\mathrm{C}}^{\mathrm{S}}$ and $m_{\mathrm{T}}^{\mathrm{S}}$ are their counterparts in stratum s. The weights make the treatment and control groups balanced with respect to X. The weights obtained from CEM are applied in regressions that use the full panel of observations. As CEM outperforms other matching methods in terms of variance of ATT, bias and execution time, we used this approach and the results were compared with those of PSM.

Dose–response function approach

We employed dose–response function technique to assess the impact of area share of high-value crops on economic welfare of farm households in eastern India, using continuous treatment approach based on generalized propensity score. We followed the methodology developed by Hirano and Imbens[20]. 'Dose' is the area share of high-value crops and 'response' is welfare indicators.

For each household i, we have a $p \times 1$ vector of pretreatment covariates X_i, the treatment T_i (area share of high-value crops) and the outcome variable Y_i (indicator of welfare) associated with the treatment. The basic assumption is that, given pretreatment covariates, the area share of high-value crops for each farm household is random. We divided the sample into three subgroups based on the level of treatment T_i to check the balancing property, i.e. less than 30% (group 1), above 35% (group 2) and above 45% (group 3). After checking the balancing property and conditional expectation, we estimated the average potential outcomes $\hat{E}[Y_i]$ using the estimated coefficients using the dose–response equation.

Results and discussion

Status of cultivation of high-value crops in eastern India

Figure 1 illustrates the percentage of area allocated to high-value crops in gross cropped area during 2002–03 and 2012–13 in eastern India. During this decade, the area share of high-value crops in eastern India had increased from 9% to 12%. It increased in all the eastern states, except Bihar for the period under consideration. The area share stagnated at 15% in Bihar. Among the eastern states, Odisha had highest share of area under high-value crops (27%) in 2012–13. Fruits, vegetables and floriculture segment constituted a significant share of the total value of output from agriculture and allied activities in Odisha[21]. About 14% of the gross cropped area was under vegetable cultivation in Odisha and West Bengal during 2012–13. Odisha mainly grows low-weight high-value vegetables such as brinjal, tomato, cauliflower, okra and cabbage, whereas West Bengal, Bihar and Uttar Pradesh are major potato (high-weight, low value vegetables) producers. Mango is the major fruit grown in Odisha, Bihar and Uttar Pradesh. Earlier studies also suggested area diversification away from foodgrains towards horticultural crops over the years in the eastern states[22]. Inter-state variation in area share under high-value crops is striking. The agro-climatic and geographical advantage of the eastern region in high-value crop production is limited by lack of modern marketing systems, efficient value-chains and processing facilities[23,24].

Determinants of cultivation of high-value crops in eastern India

Table 1 shows the characteristics of high value crop growing and non-growing farm households in eastern

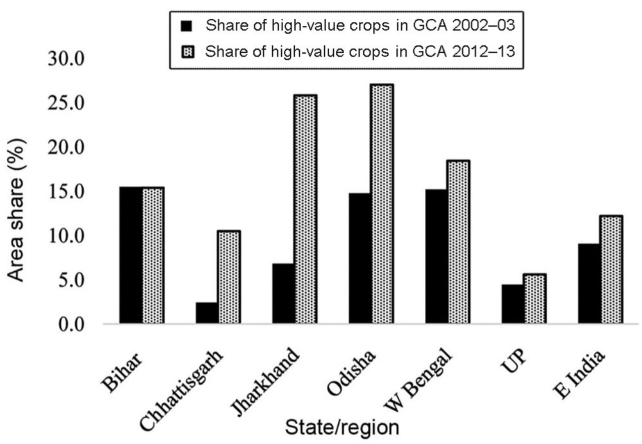

Figure 1. Percentage share of high-value crops in gross cropped area for 2002–03 and 2012–13. Source: Authors' calculations based on Government of India.

Table 1. General characteristics of high-value crop growers and non-growers in eastern India

Variables	2003 HVC non-growers	2003 HVC growers	2003 *t*-Test	2013 HVC non-growers	2013 HVC growers	2013 *t*-Test
Socio-demographic variables						
Age of the household head (years)	45.6	48.3	2.7***	48	49.7	1.7***
Household size (nos)	5.5	6.3	0.8***	5.1	5.5	0.4***
Land size (ha)	0.71	0.91	0.2***	0.63	0.73	0.1***
Education level (%)						
Illiterate	49.3	40.7	–8.6***	45.4	36.1	–9.3***
Below primary	14.9	13.6	–1.3	13.5	15.9	2.4
Primary and middle school	22.7	29.1	6.4***	24.1	28.7	4.6***
Secondary and above	13.1	16.7	3.6***	17.1	19.2	2.1***
Social structure by caste (%)						
Scheduled Castes and Scheduled Tribes	35.9	27	–8.9***	33.9	31.4	–2.5
Other backward castes	40.5	43.7	3.2	45.4	38.3	–7.1***
Other castes	23.4	28.9	5.5***	20.7	30.2	9.5***
Agricultural income as the principal source of household income (%)	62.9	73.6	10.7***	68.3	73.4	5.1***
Households receiving income from remittance (%)	3.2	1.9	–1.3***	4.9	4.9	0
Source of technical advice (%)						
Government agents like extension agents, KVKs and SAUs	4	2.8	–1.2**	6.2	6.9	0.7
Private commercial agents	13.1	13.3	0.2**	5.8	9.1	3.3***
Progressive farmers	11.8	15	3.2***	18.6	20.4	1.8
Radio/TV/newspaper/internet	14.4	23.5	9.1***	12.7	18.6	5.9***
NGOs	0.52	0.34	–0.18	1.1	2.1	1***
Loan from formal sources (%)	15.4	17.4	2***	13.8	18.8	5***
Access to irrigation (%)	63.9	85.8	21.9***	69.3	76.4	7.1***
MSP awareness (%)	19.4	28.8	9.4***	30.6	32.4	1.8***

Source: Authors' calculations from NSS 59th and 70th round, Situational Assessment Survey of Agricultural Households.
***Significant at 1% level, **Significant at 5% level.
HVC, High-value crops; KVKs, Krishi Vigyan Kendras; SAUs, State Agricultural Universities, NGOs, Non-governmental organizations; MSP, Minimum support price.

India for 2003 and 2013. Table 2 shows the parameter estimates for factors influencing an agricultural household's decision to grow high-value crops in eastern India. The cultivation of high-value crops is being significantly and positively affected by the socio-demographic characters like age of the farm household head, household size, land size and educational qualification. Access to technical advice from progressive farmers and mass media also motivates cultivation of remunerative crops in the region. Access to irrigation, access to credit from formal sources and awareness about price support measures are significant factors positively influencing cultivation of high-value crops in eastern India.

Age of the household head, as a proxy of experience and skill, positively and significantly influences the cultivation of high-value crops. Household size, which represents the assured labour availability, is also a significant factor positively influencing cultivation of high-value crops. The extra attention required during cultivation and their post-harvest treatment necessitates extra labour. Land size also has a significant positive effect on the decision of a farming household to grow high-value crops. An additional unit of land increases the cultivation of high-value crops by 3%. Birthal *et al.*[25] reported mixed effect of size of land holdings on the cultivation of high-value crops such as fruits and vegetables. Land availability may be a constraint for smallholders who also need to meet their own subsistence requirements with grain, whereas large holders may allocate higher area share to high-value crops because of more land availability. Households availing income from agricultural sources are more likely to grow high-value crops, which seems to be rational.

The inclination towards cultivation of high-value crops is directly related to the level of education of the household head, as evident from the marginal effect values. Farmers with secondary education and above are 4% more likely to grow high-value crops than their uneducated counterparts. Educated farmers may be more aware of the better management practices and marketing opportunities of high-value crops. Their learning chances may also be higher due to exposure to technical advice from extension agents and mass media. Kumar *et al.*[26] also reported positive influence of education on crop diversification in favour of vegetable cultivation in eastern India.

In eastern India, access to technical advice has mixed effects on the decision to grow high-value crops based on their source. Farmers getting technical advice from the mass media (like radio, newspaper) are more likely to

Table 2. Determinants of growing high-value crops in eastern India

Variables	Logit model		Marginal effects	
	Coefficient	Standard error	dy/dx	Standard error
Dependent variable: Growing high-value crops (yes = 1, otherwise)				
Log of age of household head	0.248***	(0.061)	0.041***	(0.009)
Log of household size	0.302***	(0.034)	0.050***	(0.006)
Land size (ha)	0.202***	(0.017)	0.033***	(0.003)
Caste (Scheduled Castes and Scheduled Tribes as base)				
Other backward castes (yes = 1, otherwise = 0)	0.104**	(0.044)	0.017**	(0.007)
Other castes (yes = 1, otherwise = 0)	–0.017	(0.046)	-0.003	(0.008)
Education level (illiterate as base)				
Below primary (yes = 1, otherwise = 0)	0.180***	(0.052)	0.029***	(0.009)
Primary and middle school (yes = 1, otherwise = 0)	0.256***	(0.043)	0.042***	(0.007)
Secondary and above (yes = 1, otherwise = 0)	0.252***	(0.050)	0.042***	(0.008)
Agricultural income (yes = 1, otherwise = 0)	0.304***	(0.040)	0.050***	(0.006)
Income from remittance (yes = 1, otherwise = 0)	–0.085	(0.109)	–0.014	(0.018)
Source of technical advice				
Government agents like extension agents, KAUs or SAUs (yes = 1, otherwise = 0)	0.116	(0.077)	0.019	(0.012)
Private commercial agents (yes = 1, otherwise = 0)	–0.109	(0.057)	–0.018	(0.009)
Progressive farmers (yes = 1, otherwise = 0)	0.237***	(0.047)	0.039***	(0.008)
Radio/TV/newspaper/internet (yes = 1, otherwise = 0)	0.195***	(0.043)	0.032***	(0.007)
NGOs (yes = 1, otherwise = 0)	0.336*	(0.193)	0.055*	(0.032)
Loan from formal sources (yes = 1, otherwise = 0)	0.172***	(0.044)	0.035***	(0.007)
Access to irrigation (yes = 1, otherwise = 0)	0.980***	(0.053)	0.161***	(0.008)
MSP awareness (yes = 1, otherwise = 0)	0.206***	(0.039)	0.034***	(0.002)
Year (2013 = 1, otherwise = 0)	0.097***	(0.036)	0.016***	(0.006)
Constant	–4.698***	(1.070)		
Observations	23,138			
District fixed effect	Yes			
Log pseudo likelihood	–11504.009			

Source: Authors' calculations from NSS 59th and 70th round, Situational Assessment Survey of Agricultural Households.
***Significant at 1% level, **Significant at 5% level, *Significant at 10% level.

Table 3. Growing high-value crops in eastern India – net farm income, MPCE and poverty

Variables	2003			2013		
	HVC growers	HVC non-growers	*t*-Test	HVC growers	HVC non-growers	*t*-Test
Net farm income (Rs/ha)	31664.5	17783.5	13880.9***	26840.3	18763.3	8077***
MPCE (Rs/person)	1025.4	909.8	115.6***	1034.6	890.8	143.9***
Poverty (%)	28.2	40.2	–12***	26.5	34.2	–7.7***

Source: Authors' calculations from NSS 59th and 70th round, Situational Assessment Survey of Agricultural Households.
***Significant at 1% level. MPCE, Monthly per capita consumption expenditure.

grow high-value crops. Progressive farmers have a positive and significant influence on the cultivation of high-value crops. Farm households that are aware of minimum support prices (government assistance programmes) are more likely to grow high-value crops – the probability increases by 0.03 for eastern India. Access to irrigation facilities motivates farmers to cultivate crops earning better income. Assured irrigation increases the probability of cultivation of high-value crops by 0.16. Access to institutional credit also encourages cultivation of remunerative crops in eastern India. Year (proxy for technological advancement and experience) also has a significant and positive influence at 1% level.

Impact of growing high-value crops on the economic welfare of farm households in eastern India

Table 3 compares the average net farm income (NFI) per ha, MPCE and poverty status of high-value crop growing households and non-growing farm households for 2003 and 2013. Cultivation of high-value crops is associated with higher net farm income of households for both periods. The NFI per ha is higher by ₹ 8077 for high-value crop growing households in eastern India.

Households growing high-value crops have higher MPCE compared to non-growing farm households. Between high-value crops growers and non-growers,

Table 4. Average treatment effect on the treated households using matching techniques for growers of high-value crops in eastern India – results of PSM and CEM approaches

	With PSM approach		With CEM approach	
Outcome variables	ATT	SE	ATT	SE
Net farm income	3160.03***	1987.855	3786.86***	1975.12
MPCE	32.50***	13.81	31.13***	12.85
Poverty status	–0.04***	0.01	–0.05***	0.01

Source: Authors' calculations from NSS 59th and 70th round, Situational Assessment Survey of Agricultural Households.
***Significant at 1% level.
ATT, Average treatment effects; PSM, Propensity score matching; CEM, Coarsened exact matching.

significant difference is evident in MPCE for both periods. We observed a significant difference in poverty between growers and non-growers of high-value crops in the region. The poverty incidence was about 12% and 8% lower for high-value crop growers than for non-growers in 2003 and 2013 respectively.

Impact of growing high-value crops on farm income, MPCE and poverty status in eastern India: result of matching techniques

We estimated ATT using PSM and CEM approaches. Table 4 presents the results. For eastern India, the matching techniques indicated a positive and significant impact of cultivation of high-value crops on the economic welfare of farmers. With regard to NFI per ha, the treatment impact was ₹ 3789 for CEM approach. In other words, farm households growing high-value crops had a higher net farm income than non-growing farm households with matched characteristics. Growing high-value crops resulted in an enhanced MPCE of about ₹ 32, according to the matching approaches. Our results are consistent with findings in the literature[9,27]. We also assessed the ATT of growing high-value crops on poverty status. In eastern India, we found that growing high-value crops is associated with reduced probability of being poor. According to the results, growing high-value crops helps reduce poverty status by about 4–5% in the region.

Impact of area share of high-value crops on farm income, MPCE and poverty status in eastern India: result of dose–response function

We also assessed the effect of area share of high-value crops on farm income, consumption expenditure and poverty of agricultural households in eastern India. Figure 2 *a–c* shows the results of DRF. Figure 2 *a* plots the DRF and marginal treatment effect function (MTEF) for the dose/treatment (area share of high-value crops) on response function (NFI per ha) for eastern India. The middle line in the graph represents for DRF and MTEF. The NFI/ha increased with increase in the treatment level. The figure indicates that higher area share of high-value crops results in higher net farm income. In eastern India, to enhance farm income through high-value crops, farmers need to allocate at least 40% of the cropped area under high-value crop cultivation. Although we found a slight decline in the marginal treatment effect on NFI/ha for the treatment levels 20–40, marginal treatment effect increased at higher treatment levels (greater than 40). Figure 2 *b* depicts the DRFs and marginal treatment effect functions for MPCE in the region. The effect of treatment on MPCE was positive after an initial declining trend. Area share of high-value crops above 40 resulted in higher MPCE. The marginal treatment effect on MPCE declined with increase in the treatment level. Figure 2 *c* shows the DRF and MTEF for poverty status. In eastern India, a higher level of treatment has been associated with reduction of poverty status after a certain treatment level. The probability of poverty reduction was higher for treatment level in the range 40–60. In other words, allocating a major portion of land towards growing high-value crops reduced the probability of being poor in eastern India. Results from the marginal treatment function showed that after the treatment level of 20%, the slope of the marginal treatment effect declined. Similar results have been observed in some earlier studies[9,27].

Conclusion

The present study examined the relationship between crop diversification towards high-value crops and the economic well-being of farm households in eastern India. Using large unit-level farm household samples, we found statistically significant effects of cultivation of high-value crops on the welfare indicators used in the study. The average treatment effects quantified the enhancement in NFI per unit cropped area and MPCE. The inverse relationship between cultivation of remunerative crops and probability of being poor has also been empirically established for the region and needs urgent policy

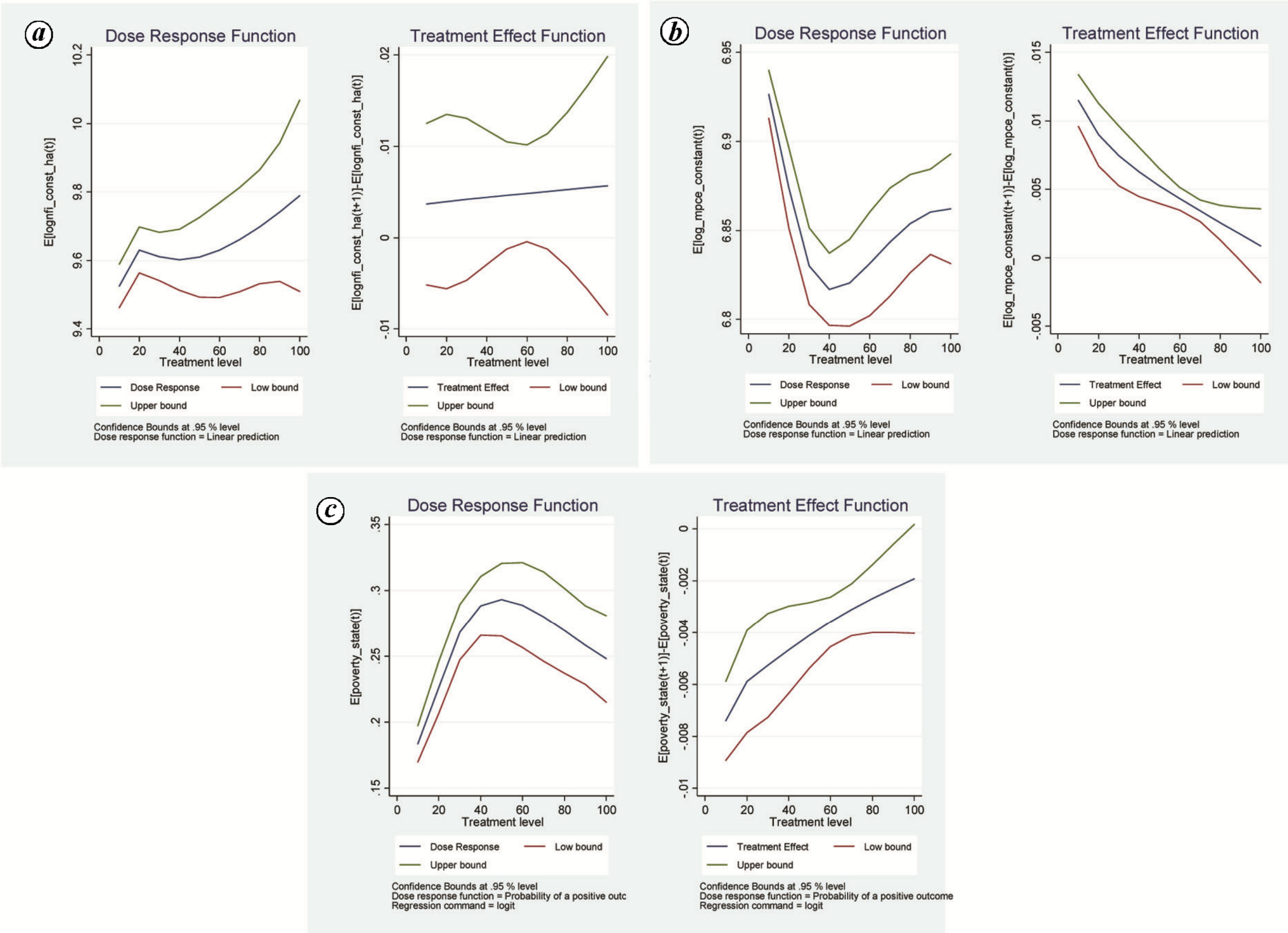

Figure 2. Parametric dose–response and treatment effect functions (dose function : area share of high-value crops). ***a–c***, Dose–response and treatment effect functions for (***a***) log NFI/ha; (***b***) log MPCE; (***c***) poverty status.

attention. The dose–response captured optimum level of area for cultivation of high-value crops for income enhancement and poverty reduction.

This study has important policy implications. Enhancing farmers' income and welfare is given atmost priority for eastern India. With the findings of significant improvement in NFI, MPCE and reduction in poverty from crop diversification towards high-value crops, concentrated efforts need to be taken to promote high-value crop cultivation in the region. There is a need to ensure parallel development of supporting market environment encompassing backward and forward market linkages.

1. GoI, Report of the expert group to review the methodology for measurement of poverty. Planning Commission, Government of India, 2014.
2. Joshi, P. K. and Kumar, A., In *Transforming Agriculture in Eastern India: Challenges and Opportunities* (eds Ramasamy, C. and Ashok, K. R.), Academic Foundation, New Delhi, 2016.
3. Chand, R., Doubling farmers' income rationale, strategy, prospects and action plan. NITI Policy Paper No. 1, GoI, 2017.
4. Joshi, P. K., Laxmi, T. and Birthal, P. S., Diversification and its impact on smallholders: evidence from a study on vegetable production. *Agric. Econ. Res. Rev.*, 2006, **19**(2), 219–236.
5. Ryan, J. G. and Spencer, D. C., Future challenges and opportunities for agricultural R&D in the semi-arid tropics. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, 2001.
6. Van den Berg, M., Hengsdijk, H., Wolf, J., Ittersum, M. V., Guanghuo, W. and Roetter, R., The impact of increasing farm size and mechanization on rural income and rice production in Zhejiang Province, China. *Agric. Syst.*, 2007, **94**, 841–850.
7. Kahan, D., Managing risk in farming. In *Farm Management Extension Guide 3*, Food and Agriculture Organization of the United Nations, Rome, Italy, 2008, pp. 29–87.
8. Sharma, H. R., Crop diversification in Himachal Pradesh: patterns, determinants and challenges. *Indian J. Agric. Econ.*, 2011, **66**(1), 97–114.
9. Birthal, P. S., Roy, D. and Negi, D. S., Assessing the impact of crop diversification on farm poverty in India. *World Dev.*, 2015, **72**, 70–92.
10. Thapa, G., Kumar, A. and Joshi, P. K., Agricultural diversification in Nepal: Status, determinants, and its impact on rural poverty. Discussion Paper 01634, IFPRI – South Asia Office, New Delhi, 2017.
11. Kumar, A., Rural employment diversification in eastern India: trends and determinants. *Agric. Econ. Res. Rev.*, 2009, **22**, 47–60.

12. Dasgupta, S. and Bhaumik, S. K., Crop diversification and agricultural growth in West Bengal. *Indian J. Agric. Econ*., 2014, **69**(1), 107–124.
13. Bhatt, B. P. and Mishra, J. S., Prospects of bringing second green revolution in eastern India. In Souvenir of the 4th International Agronomy Congress, 2016, pp. 22–36.
14. Nayak, D. K., Changing cropping pattern, agricultural diversification and productivity in Odisha – a district-wise study. *Agric. Econ. Res. Rev*., 2016, **29**(1), 93–104.
15. National Sample Survey Organization (NSSO), Unit-level data of NSSO. 59th Round Situation Assessment Survey of Farmers, Ministry of Statistics and Programme Implementation, GoI, 2003.
16. NSSO, Unit-level data of NSSO. 70th Round Situation Assessment Survey of Farmers, Ministry of Statistics and Programme Implementation, GoI, 2013.
17. Ali, A. and Abdulai, A., The adoption of genetically modified cotton and poverty reduction in Pakistan. *J. Agric. Econ*., 2010, **61**(1), 175–192.
18. Heckman, J., Ichimura, H. and Todd, P., Matching as an econometric evaluation estimator: evidence from evaluating a job training programme. *Rev. Econ. Stud.*, 1997, **64**, 605–654.
19. Iacus, S., King, G. and Porro, G., Causal inference without balance checking: coarsened exact matching. *Pol. Anal.*, 2001, 1–24.
20. Hirano, K. and Imbens, G. W., The propensity score with continuous treatments. In *Applied Bayesian Modeling and Causal Inference from Incomplete – Data Perspectives* (eds Gelman, A. and Meng, X. L.), Wiley Inter Science, West Sussex, England, UK, 2004, pp. 73–84.
21. Anwarul, H., Rajkhowa, P. and Gulati, A., *Transforming Agriculture in Odisha: Sources and Drivers of Agriculture Growth*, Working Paper No. 337, Indian Council for Research on International Economic Relations, New Delhi, 2017.
22. Haque, T., Bhattacharya, M., Sinha, G., Kalra, P. and Thomas, S., Constraints and Potentials of Diversified Agricultural Development in Eastern India, Project Report, Council for Social Development, New Delhi, 2010.
23. GoI, Report of the Working Group on Agricultural Development in Eastern and Northeastern India for the Formulation of the Tenth Five Year Plan, Planning Commission, Government of India, 2001.
24. Smriti, V., Gulati, A. and Hussain, S., Doubling agricultural growth in Uttar Pradesh: sources and drivers of agricultural growth and policy lessons. Working Paper No. 335, Indian Council for Research on International Economic Relations, New Delhi, 2017.
25. Birthal, P. S., Joshi, P. K., Roy, D. and Thorat, A., Diversification in Indian agriculture towards high-value crops – the role of smallholders, Discussion Paper No. 00727, Markets, Trade and Institutions Division, International Food Policy Research Institute, Washington, DC, USA, 2007.
26. Kumar, A., Kumar, P. and. Sharma, A. N., Crop diversification in eastern India: status and determinants. *Indian J. Agric. Econ.*, 2012, **67**(4), 600–616.
27. Thapa, G., Kumar, A., Roy, D. and Joshi, P. K., Impact of crop diversification on rural poverty in Nepal. *Can. J. Agric. Econ*., 2018, **66**, 379–413.

Received 27 January 2020; accepted 30 January 2020

doi: 10.18520/cs/v118/i10/1575-1582