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Food security through crop diversification in Manipur: Application of Heckman Sample Selection Model

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ABSTRACT

The paper demonstrates the household food security of crop diversified farm in the state of Manipur. A study was conducted at College of Post Graduate Studies in Agricultural Sciences at Barapani, Meghalaya of Central Agricultural University, Imphal during 2015–16 to 2017–18 by taking two districts namely; Ukhrul and Thoubal selecting one from each region, viz. hill and valley of the state, respectively. A sample of 200 households was drawn by using probability proportional to size. Heckman Sample Selection model was used to analyze the data. The study found that most of the households diversified their crop enterprises which in turn enhanced their household food security by way of consuming own production or generated income helped to purchase food items. Among the factors, namely socio-economic, technological and institutional factors influenced household's decision to diversify crop in the state while determinants of dietary diversity were the age of the household head, family size, extent of crop diversification, non-farm source of income and agricultural income. Hence, the results were indicative of the importance of crop diversification as a viable option in the state for enhanced food security and income of rural smallholders. Hence, wider awareness on crop diversification for realizing its benefits and improving the nutritional status of households in the state of Manipur was the need of the hour.

Keywords: Diversification, Food, Heckman, Impact, Security

Food intake in the rural India is closely tied to on-farm agricultural productions (Kumar *et al.* 2016). Among the different pathways through which agriculture and nutrition are interlinked, one of the most direct one is as a source of food. Moreover, it is believed that farming households primarily consume what they themselves produce, and hence, this seems reasonable that diversified agricultural production would lead to more diverse diets. At the household level, crop diversification is a vital pathway for household food security and nutrition through income realized from the sale of agricultural produce. Crop diversification portfolio that includes cultivation of high yielding and high-value crops, has the strongest impact on incomes at the household level. The number of crops grown or farm production diversity is positively associated with farm household dietary diversity (Herforth 2010, Jones *et al.* 2014, Chinnadurai *et al.* 2016). Diversification into high nutritive food production has also potential to improve nutritional outcomes for farm households (Kankwamba *et al.* 2012). Interventions aim at diversifying and increasing food production, therefore has a high potential of directly influencing nutritional outcomes that primarily consume from own production (Ecker *et al.* 2011).

The agricultural sector of Manipur witnessed a paradigm shift in cropping pattern in the recent years, which includes high value crops to enhance the productivity as well as farm income. However, performance of agriculture in the state mainly depends on timely rainfall and weather conditions where paddy remains the main staple food crop. A silent revolution within the crop production sector is taking place in the state, i.e. crop diversification. The strategy involves shifting from less profitable to more profitable crops, changing of variety, cropping system. This diversification is helpful in risk aversion to act as an insurance against adverse climatic conditions, business oriented motives, and finally to meet the growing demands to feed the growing population. Hence, this paper is an effort to assess household food security due to crop diversification in the state of Manipur.

MATERIALS AND METHODS

The present study was carried out at the College of Post Graduate Studies in Agricultural Sciences at Barapani, Meghalaya of Central Agricultural University, Imphal during 2015–16 to 2017–18. Manipur is a landlocked state in North

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Eastern Hill (NEH) region of India of nearly population of 2.97 million (Anonymous 2017). The state covers an area of 22.32 thousand km^2 which constitutes 12.15% of the total geographical area of the NEH region of India (GoI 2015). Physiographically, the state is characterized in two distinct physical regions, viz. the hill and the valley. The climate of the state is largely influenced by the topography of these hilly regions. Thoubal and Ukhrul districts were selected purposefully based on the highest cropping intensity in order to have a comprehensive study since the state has two distinct physical regions. One block from each selected district was selected randomly. A total of 9 villages were selected randomly from the selected block. Out of the 9 selected villages, 200 households were drawn from the villages through probability proportional to size sampling. Three year data of the year 2015–16 to 2017–18 were collected for the study.

Household dietary diversity measurement: The number of different food groups consumed over a given reference period, i.e. Household Dietary Diversity Score (HDDS) was developed by Food and Nutrition Technical Assistance (FANTA) Project of the United States Agency of International Development (USAID) and has a maximum score of 12 food groups. Later, Food and Agricultural Organisation (FAO) increased the number of food groups from 12–16 food groups which is also known as Micronutrient-sensitive Household Dietary Diversity Score (MsHDDS). The HDDS is an attractive proxy indicator to examine food security at the household and intra-household levels (Jones *et al.* 2014). Information on household food consumption was collected using the previous 24-hr as a reference period (FAO 2011).

Crop diversity measurement: Simpson Index of Diversification (SID) was calculated for all the households to compute the extent of crop diversity of the households. The index ranges from 0–1.

Crop diversification and food security: Heckman Sample Selection Model developed by James Heckman (1979) was considered most appropriate to estimate the impact of crop diversification on household's food and nutritional security since important differences in food security and nutritional outcomes exist between households itself that diversified their crop production and those that did not. The model specify one equation for whether or not a household is diversified (Selection equation) and a different equation for how much food and nutritional security is impacted given that it is a diversified household (Outcome equation). The first model estimated the probability of crop diversification indicated by the endogenous dummy variable as represented in the selection equation.

Inverse Mill's Ratio: The model calculates Inverse Mill's Ratio to check whether there is selection bias or a selection effect of crop diversification on food and nutritional security.

RESULTS AND DISCUSSION

Cropping pattern of the sampled households: The average gross cropped area of the sampled households was reported to be 1.59 ha. The households in the study area allocated more area under cereal crops (62.55%), viz. paddy and maize. Cauliflower, cabbage, tomato, brinjal, ladies finger, squash, potato, pumpkin etc were the main vegetable crops grown occupying a share of about 18% to the gross cropped area. About 15% to the gross cropped area was allocated to fruit crops (Table 1). The main fruit crops grown for commercial purpose were found to be lemon, banana, watermelon, grapes and mango. Cowpea, rice bean, broad bean and french beans were reported to be the main pulse crops while rapeseed and mustard grown through zero tillage technique was found to be one of the desired crop strategy in poor irrigated areas. Spice crops (chilly, ginger, turmeric) occupied about 4% of the gross cropped area. Sugarcane was the cash crop cultivated in the study area. Similar finding was reported by Jones *et al.* (2014) where small farmers started allocating their land towards some high value cash crops, fruits and vegetables.

Table 1 Cropping pattern of the sampled households

Crop	Area (ha)	Percentage
Cereals	0.87	62.55
Pulses	0.09	6.70
Vegetables	0.25	17.79
Fruits	0.21	15.10
Oilseeds	0.11	8.16
Spices	0.05	3.57
Cash crops	0.01	0.39
Total cropped area	1.59	
Distribution of households into different level of crop diversification		
Level of diversification	*Number of households*	*Percentage*
Low (0–0.25)	45	22.5
Medium (0.26–0.50)	48	24
High (0.51–0.75)	103	51.5
Very high (0.76–1)	4	2

Extent of household level crop diversification

Crop diversification and food security: The level of crop diversification was categorized into low, medium, high and very high (Table 1). It is found that the majority of the households had high level of crop diversification (51.5%) followed by the medium level (24%), low level (22.5%) and very high level (2%) in the study area. It can be inferred that most of the households are diversifying their crop enterprises which may be driven by the demand in the domestic market or the realization of the households to enhance their farm income. The increase in demand for high value crops may in turn be influenced by rising income or changes in the consumption pattern of the households which encourage the farming community to diversify its production portfolio in favour of high value crops. The results have been supported by Kavitha *et al.* (2016) and Mugendi (2013).

Impact of crop diversification on household food security: It can be observed from Table 2 that there is selection bias as the *rho* is positively significant. The average selection effect indicates the magnitude of the shift in the conditional food security due to the selection effect. It can be interpreted that a household sample average characteristics who selects (or is selected) into crop diversification secures 4.36% higher food security than a household drawn at random from the population with the average set of characteristics. Hence, it can be inferred that those households who had diversified their cropping activities improved their dietary diversity more than those households who did not with average sets of characteristics even though the magnitude is low. The low magnitude of impact may be due to the fact that the level of crop diversification found in the study area was not high enough to influence the farm households' decisions or activities (Table 2).

Determinants of crop diversification (Selection equation): It can be seen that the farming household heads who had attended formal education were more likely to diversify crop, as they are able to make constructive decisions to accept new ideas which in turn, enhances their willingness to diversify crop in the state. Similar finding was reported also by Rehima *et al.* (2013). The co-efficient of farm size was found to be negatively significant (Table 2) indicating that the probability of crop diversification reduces with increase in farm size. While the probability of crop diversification increases for those households who has higher agricultural asset value (P=0.36). Tools and machineries were found to be positively significant to diversify crop (P=1.03) as cultivation of varied crops require different types of tools and implements throughout the cropping season. Access to fertilizer, being one of the important inputs for crop production also influenced the household's decision to diversify crops positively and significantly. It indicates that the probability of crop diversification, increased for those household's having access to fertilizer. Similar result was also reported by De and Chatopadhay (2010). Availability of irrigation facility appears as a significant determinant for crop diversification decision and the households having regular irrigation facility are more likely to diversify crop (P=1.22). Kumar and Gupta (2015) also found a positive relationship between access to irrigation and crop diversification. Households who had access to farming information are more likely to diversify crop as accessibility to the right information at the right time may decrease the uncertainty of the household's problem associated with crop production like climatic factors etc. The findings were inconsistent with the findings by Dube and Guveya (2016). As expected, farmers who attended training related to farming regularly are found to be more likely to diversify crop (P=0.83) since the farmers who participate in training related to farming regularly may gather more advanced knowledge about farming. Market distance being an indicator of access to market provides better opportunity for the households to market their farm produce also found to be positively significant, indicating that households which are nearer to the market were more likely to diversify crop (P=0.04). Previous findings also support this hypothesis (Benin *et al.* 2004, Rehima *et al.* 2013).

Table 2 Heckman Sample Selection model estimates

Selection Equation Output		
Parameter	Estimate	P value
Intercept	-6.59***	0.00
Gender of household head	0.81	0.21
Age of household head	-0.02	0.32
Family size	0.00	1.00
Education of household head	1.05***	0.00
Farm size	-0.39*	0.06
Agricultural assets	0.36**	0.03
Farming experience	0.04	0.13
Dependency ratio	0.11	0.41
Hired labour	0.12	0.54
Access to plough	0.35	0.36
Tools and machineries	1.03**	0.03
Fertilizer	1.03**	0.02
HYV improved seed	0.08	0.82
Irrigation facility	1.22***	0.00
Exposure farming to information	0.67*	0.09
Training	0.83*	0.06
Market distance	0.04*	0.09
Rho	0.84***	0.00
Outcome equation output		
Intercept	0.29	0.16
Age of household head	-0.00	0.10
Family size	0.02**	0.01
Education of household head	0.05*	0.08
Farm size	-0.01	0.25
Crop diversification	0.42***	0.00
Livestock	0.03	0.17
Non-farm source of income	0.08***	0.00
Agricultural income	0.16***	<.0001
Sigma	0.12***	<.0001

***, ** and * denotes statistically significant at 1%, 5% and 10% level, respectively.

Determinants of dietary diversity (Outcome equation): The regression result also reveals that the age of the household head was not significant and associated with less dietary diversity of the household (Table 2). The reason for the negative association between age of the household head and dietary diversity may be because of inactiveness of the ageing person to choose a diverse set of foods. Similar findings were reported by Taruvinga *et al.* (2013). The coefficient of family size was found to be positively significant, indicating that more the number of persons in the

family, chances of consuming different food items is more. Chinnadurai *et al.* (2016) and Kavitha *et al.* (2016) also reported similar findings in positive relation of household size with dietary diversity. Education of the household head had an important positive effect on household dietary diversity and those households whose head were educated are associated with an increase in dietary diversity of about 5%. The relation of dietary diversity and farm size was found to be negative but non-significant. As stated above, larger the farm size, lowers the probability of crop diversification, which indicates that smallholders were more diversified, i.e. even the dietary diversity of the household were more for those who has small farm size or diversified farm in which the household may consume from own production or may purchase high value food commodities from the income earned through sale of agricultural produce which has been supported by Mugendi (2013). The magnitude of crop diversification of diversified households also affected positively with an increase in dietary diversity of about 42% (World Bank 2007, Jones *et al.* 2012 and Majumdar 2014). Livestock and poultry assets of the households, although not significant were found to have a positive relation to the dietary diversity. Taking into account other factors which may affect household food consumption pattern, non-farm source of income was found to be highly significant as expected and is associated with an increase in dietary diversity of about 8% which has been confirmed with the findings of Gillespie *et al.* (2012). Agricultural income was also found to be highly significant and positively related with dietary diversity of the household (Jones *et al.* 2012).

Crop diversification being one of the strategies to enhance farm income also plays a vital role in the food consumption pattern of the farm households by way of consuming from own production or from the income earned which changes purchasing decision to include high value foods in the diet. The study found that education of the household head, farm size and agricultural assets, whereas, access to tools and machineries, fertilizer, availability of irrigation facility, exposure to farming information, training and market distance from homestead area were the socio-economic, technological and institutional factors which influence households' decision to diversify crop by the households in the state. While determinants of dietary diversity were found to be age of the household head, family size, extent of crop diversification, non-farm source of income and agricultural income. Households that diversified their cropping activities secured 4.36% higher food security than the households drawn at random from the population with an average set of characteristics. It also revealed that household, which diversifies their cropping activities were more food secured than a household drawn at random from the population with the average set of characteristics. Hence, the study suggests realizing the tangible and non-tangible benefits of crop diversification by the extension machinery of the state, including Central Agricultural University, Imphal and ICAR research station. The study also advocates for identifying the diversified farmers to use as technical mentors for enhancing the diversification in the state of Manipur specifically and North Eastern Hill Region in general.

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