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Dynamics and Determinants of Crop Diversification Under Natural Farming Regime in Arunachal Pradesh: Application of Tobit Model

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ABSTRACT

The study focused on traditional cultivation practices consistent with natural farming principles in the tribal areas of East Siang District of Arunachal Pradesh. Primary data collected from 90 farmers in the Pasighat and Mebo blocks for 2022-23 were analysed using the CAGR and Markov chain model to examine the growth rates of major crops and shifts in cropping patterns. The crop diversification and concentration indexes were also calculated to assess the crop diversification and concentration level. The findings indicated that spice crops such as dry chili, ginger, and turmeric showed significant increases in area, production, and productivity. In contrast, cereal crops exhibited more modest growth rates. In contrast, cereal crops exhibited more modest growth rates. The analysis revealed substantial crop diversification, particularly in the Mebo block, which had a CDI of 0.71, compared to 0.66 in Pasighat. Notably, mustard, maize, and rice in Pasighat and ginger and arecanut in Mebo had high crop concentration indices. Farm size, educational level, net returns, and exposure to price fluctuations significantly influenced crop diversification. The declining cultivation area of food grains underscores the need for government intervention. Farmers must be informed about research-based natural farming techniques to enhance the benefits for small and marginal farmers.

Keywords: Natural farming, crop diversification, crop concentration, Markov Chain analysis.

JEL codes: C22, C61, O13.

I

INTRODUCTION

Agricultural diversification is pivotal for enhancing, securing livelihoods, and fostering ecological benefits, such as biodiversity preservation and regulating ecosystem services, including soil and water conservation (Joshi *et al.*, 2004; Sarial, 2019; Beillouin *et al.*, 2021). However, the inherent complexity of agricultural diversification leads to challenges in effectively gathering and analysing data. As Vyas (1996) outlined, diversification strategies may include transitioning from traditional farming to non-farm activities, shifting from less profitable to more lucrative crops or enterprises, and employing resources in varied yet synergistic ways. According to Dasgupta and Bhaumik (2014), enhancing crop diversification strategies could overcome these data challenges by providing a more systematic framework for analysis. This method promotes economic advancement and plays a critical role in the

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sustainable management of natural resources, underscoring its significance in economic growth and environmental stewardship.

Arunachal Pradesh is India's largest state in the Northeast Region (NER) and has abundant natural resources. It encompasses five agro-climatic zones, ranging from temperate to subtropical, which makes it suitable for diversified cultivation (Borthakur, 1993; Mishra *et al.*, 2004). Agriculture is usually practiced under natural conditions without chemical fertilisers and agrochemicals (Government of Arunachal Pradesh, 2021). It may be due to its mountainous topography, inhospitable terrain, hot and humid climate, incessant rain, deep and fertile soils, extensive forest cover, and a sparse human population with communal ownership of land (Maithani, 2005; Gupta, 2005; Bhagawati *et al.,* 2017). The state is the abode of 26 major tribes and 110 sub-tribes, which rely heavily on natural resources for their livelihood, engaging in traditional agricultural practices such as *swidden* and *terrace* cultivation in the hills and wet rice cultivation in the valleys, consistent with agroecological principles (Sinha and Lakra, 2005; Srivastava, 2009; Yumnam *et al.*, 2011; Teegalapalli and Datta, 2016). These communities follow practices that align with the attributes of natural farming, such as no-tillage, intercropping, poly-cropping, mulching, crop rotation, integration of livestock, no use of agrochemicals, indigenous traditional knowledge (ITK), functional biodiversity, crop diversity (Athawale and Singh, 2023). Natural farming has been increasingly used in the scientific literature with diverse agroecology perspectives (Rosset and Martínez-Torres, 2013; Kerr, 2020; Cabral and Sumberg, 2022; Dorin, 2022). However, there is a lack of proper documentation and common vocabulary to designate it as "natural farming" in the context of NER.

The diversity of crops cultivated in the East Siang district serves a crucial role in ensuring the food security of the region (Yumnam *et al.*, 2011). Responding to market demand, farmers in the region have increased the cultivation of high-value crops, including chilies, turmeric, large cardamom, ginger, mustard, orange, pineapple, banana, etc., along with staple cereals such as rice, maize, and small millets. Hence, a proper understanding of crop diversification in this region becomes crucial. Despite some research evidence on crop diversification in the NER (Birthal *et al.,* 2006; Pandey *et al.*, 2019; Priscilla *et al.*, 2021; Kumar *et al.,* 2022), the assessment of natural farming remains unexplored. The studies on the determinants of the natural farming regime in the NER of India are also missing. Therefore, the present study attempts to analyse the pattern of major crops in the region, the extent of crop diversification, and the factors behind crop diversification within natural farming systems in the East Siang district of Arunachal Pradesh.

II

METHODOLOGY

Sampling Plan

East Siang district is located on the upper side of the Assam border and the Northwest part of the Brahmaputra River. It is between 27^0 43' — 29^0 20' N latitude and 94^0 42' — 95^0 35' E longitude. It has a geographical area of about 4005 km^2 and an annual rainfall of 3733.6 mm. East-Siang district is endowed with rich natural resources, agro-climatic suitability, and many tropical, sub-tropical, and sub-temperate type of crops. Agriculture is the district's economy, but most farmers consider it a means of subsistence with a huge dependence on natural resources and traditional agricultural practices (Government of Arunachal Pradesh, 2024).

The study used primary and secondary data from the East Siang district. A primary survey was conducted during 2022-23 in Pasighat and Mebo blocks. In Pasighat, 46 farmers from five villages (Balek, Sibo, Diking, Mirbuk, and Mirsam) were selected by snowball sampling technique, and in Mebo block, 44 farmers from five villages (Mebo Village, Mebo H.Q., Ayeng, Bodak and Siluk) were chosen for the survey. Time series data on the area of selected crops were obtained from various published sources, the Directorate of Economics and Statistics, *Handbook of Statistics on Indian States* (2022), *Statistical Abstracts of Arunachal Pradesh, Basic Statistics of North-East India,* and NEDFI Data Bank.

Analytical Methods

Markov Chain Analysis

The direction of changes in the cropping pattern was examined using the Markov chain approach. The transitional probabilities were computed using a linear programming (LP) technique to evaluate the change in the area under crops from 2004–05 to 2020–21. Markov chain analysis develops a transitional probability matrix 'P', whose elements P_{ij} indicate the probability (share) of crop switching from the i-th crop to the j-th crop over time. Its diagonal elements represent the retention share of the respective crop in terms of area under crops. This can be algebraically expressed as an equation:

$$E_{jt}=\Sigma[E_{it}-1]P_{ij}+e_{jt} \text{——————} (3) \quad i=1,...,n$$

where,

E_{jt}= Area under j-th crop in the year 't'

E_{it}-1=Area under i-th crop during the year 't-1'

P_{it}=The probability of shift in area under i-th crop to j-th crop

e_{jt}=The error-term statistically independent of E_{it}-1, and

n=The number of crops.

The transitional probabilities P_{ij} arranged in (m×n) matrix have the following properties:

ΣP_{ij}=1and0dHP_{ij}dH1

i=1,...,n

The transitional probability matrix (T) based on LP framework is estimated using Minimization of Mean Absolute Deviation (MAD).

Min, OP*+Ie Subjected to

XP*+V=Y

GP*=1

P*>0

Where, P*is the transitional probability matrix, '0'is the zero vector, 'I' is an appropriately dimensional vector of areas, and 'e' is the vector of absolute errors.

Herfindahl–Hirschman Index (HHI)

The Herfindahl–Hirschman Index (HHI) was estimated using the following formula.

$$\text{Herfindahl} - \text{Hirschman Index (HHI)} = \sum_{i=1}^{N} P_i{}^2$$

Where, P_i is the proportion of i^{th} crop in the total cropped area.

The value of HHI ranges between zero and one. It shows complete specialization when unity and complete diversification when zero.

Crop Diversification Index

CDI = 1-HHI

The CDI has a direct relationship with diversification. The zero value of CDI indicates no diversification/Specialization, and moving towards one shows crop diversification.

Crop Concentration Index

Crop concentration refers to the variation in the density of crops cultivated in a certain area at a particular time. To do this, areas of the research area where crops are concentrated have been identified using the formula below (Hall and Tideman, 1967; De and Bodosa, 2014)

$$\text{Crop Concentration Index } (CCI) = \frac{\frac{A_{i.j}}{A}}{\frac{\sum_{i=1}^{n} A_{i.j}}{\sum A}}$$

Where, $A_{i.j}$= Area under i-th crop in j-th block

A= Gross cropped area in j-th district in the entire study period

$\sum_{i=1}^{n} A_{i.j}$=Area in the i-th crop in the district

$\sum A$ = Gross cropped area in the district

The high index values represent high concentration, and low values show a lower level of concentration. The indices were calculated for both blocks.

Tobit Model Specification

The Tobit model was employed to examine the determinants of diversification of natural farming among households in the study area. This model is preferred when the dependent variable is subject to censoring, ensuring that valuable information is retained (Greene, 2003; Lesschen *et al.*, 2005). The sample data contain zero observations as the few households engaged in monoculture (CDI = 0), which violates the basic assumption of the ordinary least squares (OLS) regression and renders OLS inappropriate for statistical estimation and inference in this case. A growing body of literature advocates applying the Tobit model in such cases (Mesfin *et al.*, 2011; Kumar *et al.*, 2012). Tobit model used was of the form of the following equation:

$$y_i^* = \beta \mathrm{x}_i' + \mu_{\boldsymbol{i}},$$
$$\mu_i \sim N(0, \sigma^2)\ i = 1, \dots n.$$
$$y_i = 0 \text{ if } y_i^* \leq 0,$$
$$y_i = y_i^* \text{ if } y_i^* > 0.$$

y_i^* is the unobserved latent variable, y_i is the observed censored variable, which is equal to the unobserved latent variable y_i^* when y_i^* is greater than zero. In all other cases, y_i is equal to zero. $\boldsymbol{\beta}$ represents a vector of parameters, and $\mathbf{x}_i'$ represents a vector of exogenous explanatory variables. The model errors μ_i are assumed to be identically and independently distributed as $N(0, \sigma^2)$ conditional on $\mathbf{x}_i'$. The model was estimated using the maximum likelihood estimation (MLE).

In applying the Tobit model, most studies have assumed a homoscedastic error structure such that the residual variance is constant. The validity of this assumption is rarely tested. However, accounting for heteroscedasticity in the Tobit model is particularly important. The Shapiro-Wilk normality test was done on the residuals to check the normal distribution. Shapiro-Wilk test may not directly check the homoscedasticity of the error structure, but the test can indirectly provide information about the homoscedasticity assumption if the residuals are normally distributed. This model was analysed using R studio software, which offers various packages for various analytical tasks. For addressing censored dependent variables, R offers the 'censReg' package for implementing Tobit regression models, which account for both heteroscedasticity and censoring, ensuring robust statistical analysis.

The list of variables used in the regression model and their a-priori impact on crop diversification is discussed in Table 1.

TABLE 1. MEASUREMENT OF THE VARIABLES USED IN THE TOBIT MODEL

Variable name (1)	Variable type (2)	Definition and unit of measurement (3)	Expected outcome (4)
Dependent variable			
Crop Diversification Index (CDI)	Continuous	Study reference category (CDI=0-1)	
Explanatory variables			
Gender	Dummy	Gender of head of the household (male =1, female = 0)	+/–
Age	Continuous	Age of household head (years)	+/–
Farm Size	Continuous	Land operated for natural farming by the household (ha)	+/–
Farming Experience	Continuous	Experience in farming of the cultivator (years)	+
Family Size	Continuous	Persons in household (number)	+/–
Education	Continuous	Number of years of formal schooling the household head attended (numbers)	+
Dependency Ratio	Continuous	Non-working members in the household (<15+ >64)/(15–64) age differences (numbers)	–
Net Return	Continuous	Net returns per hectare (₹) per season	+
Market Distance	Continuous	Length of road (km)	–
Price fluctuation problem	Dummy	Household experiencing price fluctuation problem =1, otherwise=0.	+

III

RESULTS AND DISCUSSION

Growth Rate of Major Crops

During 1998–1999 to 2019–20, the area, production, and productivity of dry chili grew annually at 3.76 per cent, 9.50 per cent, and 5.53 per cent, respectively, in the East Siang district of Arunachal Pradesh (Table 2). Similarly, the area and production of ginger grew significantly by more than six per cent, while the productivity growth was only 0.85 per cent per annum. Turmeric also exhibited positive growth in the area (1.72 per cent), production (6.03 per cent), and productivity (4.24 per cent). The growth of cereal crops was also significant but at a more gradual pace. This pattern aligns with the findings reported by Gurung and Mossang (2022) in Lohit and Lower Dibang Valley districts of Arunachal Pradesh. However, the growth rate of productivity of sugarcane and potato was negative. The area and production of sugarcane showed positive growth. The expansion in cultivation area accentuates substantial growth in crop production. However, the low productivities across cereal crops signify a reliance on traditional cultivation methods and limited use of modern inputs (Lama, 2018).

TABLE 2. COMPOUND GROWTH RATES OF DIFFERENT PERFORMANCE INDICATORS
(1998-99 to 2019-20)

Crops (1)	Area (ha) (2)	Production (tonnes) (3)	Productivity (tonnes/ha) (4)
Dry Chilli	3.76***	9.50***	5.53***
Ginger	6.14***	6.64***	0.85**
Maize	1.60	2.30	0.69
Oilseeds	1.14	1.41	0.27
Potato	1.92**	0.12	-1.76***
Rice	2.07**	2.80**	0.72
Turmeric	1.72*	6.03***	4.24***
Sugarcane	3.65*	3.64	-0.01

Source: Authors' computation.
*, ** and ***Significant at 10, 5 and 1 per cent probability level, respectively.

Changes in the Direction of Cropping Pattern

Markov Chain analysis was employed on the data from 2001-02 to 2020-21 to examine the direction of the cropping pattern of the East Siang district of Arunachal Pradesh. The crops were categorised into cereals (wheat, maize, rice, and small millets), pulses (gram, tur/arhar and other pulses), sugarcane, spices (dry chili, ginger and turmeric), fruits and vegetables, and oilseeds (rapeseed/mustard, groundnut, sesamum, soybean, and sunflower). The transition probability matrix depicted in Table 3 revealed that spices and cereal were the major crops in the East Siang district of Arunachal Pradesh, with a probability of retention of 0.8248 and 0.7999, respectively, followed by sugarcane (0.4048), fruits and vegetables (0.3934) and oilseeds (0.3833). The pulses showed instability in area retention with a zero probability value, losing their entire share to fruits and vegetables. Cereal crops lost 14.83 per cent of their area to oilseeds, 4.39 per cent to pulses, 0.53 per cent to sugarcane, and 0.27 per cent to spices. Conversely, they gained 59.52 per cent of the area share from sugarcane, 53.93 per cent from fruits and vegetables, and 47.95 per cent from oilseed crops. Fruits and vegetable crops lost their share of the area to cereals (53.93 per cent) and spices (6.73 per cent). Oilseeds lost their share of the area to cereals (47.95 per cent), fruits and vegetables (10.85 per cent), and pulses (2.88 per cent) but gained (14.83 per cent) from cereals (Table 3).

TABLE 3. TRANSITION PROBABILITY MATRIX OF EAST SIANG DISTRICT OF ARUNACHAL PRADESH

(1)	Cereals (2)	Pulses (3)	Sugarcane (4)	Spices (5)	Fruits and vegetables (6)	Oilseeds (7)
Cereals	0.7999	0.0439	0.0053	0.0027	0.0000	0.1483
Pulses	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
Sugarcane	0.5952	0.0000	0.4048	0.0000	0.0000	0.0000
Spices	0.1535	0.0000	0.0217	0.8248	0.0000	0.0000
Fruits and vegetables	0.5393	0.0000	0.0000	0.0673	0.3934	0.0000
Oilseeds	0.4795	0.0288	0.0000	0.0000	0.1085	0.3833

Crops Grown under Natural Farming in the East Siang District of Arunachal Pradesh

In the study area, farmers have adopted diversified cropping systems, primarily driven by the availability of canal irrigation. This has enabled settled cultivation near towns, providing better market access. The main cereal crops in the region are rice and maize, with finger millet also significant, collectively accounting for 51 per cent of the cropped area in Pasighat and 42 per cent in Mebo. These crops are predominantly grown using natural farming methods (Singh *et al*., 2012). Wet rice cultivation, or "Panikheti," is the most prevalent crop practice in the area, typically implemented as a monocrop. Post-harvest, these fields typically lie fallow until the next *kharif* season. The local fruit cultivation, which includes pineapples, oranges, and bananas, occupies over 20 per cent of the total farmland in both Pasighat and Mebo blocks. Vegetables like brinjal, tomato, potato, pumpkin, cucumber, and taro are also commonly grown alongside tuberous crops such as colocasia, tapioca, yam, and sweet potato, which cover 3.26 per cent and 3.70 per cent of the land in Pasighat and Mebo respectively.

Oilseeds represent a significant part of the agricultural landscape, comprising 11.54 per cent of crops in Pasighat and 5.38 per cent in Mebo. Spices like ginger, turmeric, and chili are cultivated extensively under natural conditions, accounting for 8.16 per cent and 18.99 per cent of the cropped area in Pasighat and Mebo, respectively. The traditional agroforestry crop, arecanut, is also planted on about 3 per cent of the land in each block. Mixed cropping systems integrating vegetables, spices, tubers, fruits, plantation crops, cereals, and oilseeds are prevalent, reflecting the labour-intensive nature of local agriculture, which includes manual sowing, weeding, and harvesting. These crops are deeply ingrained in the cultural identity of the *Adi* tribe, notably in the production of '*Apong*,' a traditional alcoholic beverage. Local crops like mustard leaves are consumed daily, while ginger and chilies are used in chutneys and pickling processes.

Furthermore, there's a growing trend of domesticating wild plants due to market demands, underscoring a robust link between traditional practices and modern agricultural needs (Sundriyal and Sundriyal, 2003; Angami *et al.*, 2006; Yumnam *et al.*, 2011). These findings align with other studies highlighting the prevalence of mixed cropping and traditional agricultural methods among indigenous communities in Arunachal Pradesh (Tangjang, 2009; Bhuyan *et al.*, 2012; Payum *et al.*, 2021).

TABLE 4: CROPS GROWN UNDER NATURAL FARMING BY SAMPLED HOUSEHOLDS IN THE EAST SIANG DISTRICT OF ARUNACHAL PRADESH (N=90)

	Per cent of total cropped area	
Crops (1)	Pasighat (2)	Mebo (3)
Cereals (rice + maize + finger millet)	51.32	42.14
Fruits (pineapple+ orange+ banana)	22.74	26.09
Vegetables (brinjal+ tomato+ potato + pumpkin+ cucumber + taro +yam +colocasia + tapioca)	3.26	3.70
Spices (chillies+ ginger+ turmeric)	8.16	18.99
Plantation (arecanut)	2.98	3.70
Oilseed (mustard)	11.54	5.38
Total area under NF among sample farmers	224.15	198.92

Source: Based on authors' calculations, field survey 2022-23.

Extent of Crop Diversification and Crop Concentration

The HHI and CDI values depict that both blocks exhibited high crop diversification (Table 5). Specifically, the Mebo block demonstrated relatively higher crop diversification than the Pasighat block.

TABLE 5. EXTENT OF CROP DIVERSIFICATION IN THE EAST SIANG DISTRICT OF ARUNACHAL PRADESH

Blocks	HHI	CDI
(1)	(2)	(3)
Pasighat	0.34	0.66
Mebo	0.29	0.71
East Siang district	0.31	0.69

Source: Based on authors' calculations, field survey 2022-23.

Table 6 reveals varying crop concentration indices under natural farming in the Pasighat and Mebo blocks. In Pasighat, mustard recorded the highest concentration at 1.34, followed by maize (1.15) and rice (1.08). The other significant crops included pineapple (0.97), vegetables (0.94), and bananas (0.93), with orange and arecanut also noted. Conversely, the Mebo block saw the highest concentration of ginger (1.43), arecanut (1.13), followed by orange and banana at 1.08. Vegetables and pineapple followed closely, illustrating diverse farming preferences aligned with local market demands and cultural practices.

Mustard, particularly notable in Pasighat, is a versatile crop used as a leafy vegetable, condiment, and oilseed, valued for its drought tolerance, which supports cultivation during dry spells as an alternative to wetland rice (Mishra and Padung, 2007; Singh *et al.*, 2017). Ginger, culturally significant to the *Adi* tribe, reflects the integration of traditional agricultural practices with market-driven crop selection (Singh and Singh, 2007; Singh *et al.*, 2012).

TABLE 6. CROP CONCENTRATION INDEX IN THE EAST SIANG DISTRICT OF ARUNACHAL PRADESH

Crops	CCI (2022-23)	
	Pasighat	Mebo
(1)	(2)	(3)
Rice	1.08	0.90
Maize	1.15	0.84
Pineapple	0.97	1.04
Banana	0.93	1.08
Orange	0.93	1.08
Vegetables	0.94	1.07
Ginger	0.62	1.43
Arecanut	0.88	1.13
Mustard	1.34	0.62

Source: Based on authors' calculations, field survey 2022-23.

Determinants of Crop Diversification

We employed a Tobit regression model to examine the factors influencing crop diversification under a natural farming regime. This model was chosen to handle the censored nature of the dependent variable, crop diversification index (CDI), with potential influences analysed from field survey data. The analysis focused on ten variables hypothesised to impact crop diversification: gender, age, farm size, farming experience, family size, education, dependency ratio, the net return, market distance, and price fluctuation problems. The coefficient for farm size (-0.0214) showed a statistically significant and negative association with crop diversification at 1per cent level of significance. It reflects that larger farm sizes are less likely to diversify, which may be due to the labor-intensive demands of managing a wide variety of crops under natural farming conditions. Such practices require more inputs, advanced managerial skills, and adequate draft power, which can be challenging to sustain across larger areas. This observation is supported by the findings of Mishra *et al.* (2004) and Vik and McElwee (2011), who noted that larger farms tend to specialise in exploiting economies of scale, a sentiment echoed by studies from Mussema *et al.* (2015) in Ethiopia, Meraner *et al.* (2015) in the Netherlands, and Singh *et al.* (2022) in the Indo-Gangetic Plains of India.

In contrast, the education of the household head showed a positive correlation with crop diversification. Each additional year of formal education was associated with a 1.08 per cent increase in crop diversification. This finding aligns with research by Kumar *et al.* (2012), Rehima *et al.* (2013), Aheibam *et al.* (2017), Singh *et al.* (2017), and Daya *et al.* (2022), suggesting that educated farmers are more likely to adopt diverse and innovative agricultural practices. The model also highlighted that, while statistically significant, net returns had a minimal practical impact on diversification, with a coefficient close to zero. This could be due to the subsistence nature of natural farming in the region, which is not primarily profit-driven but oriented towards sustainability and ecological balance. Literature by Birthal *et al.* (2015), Basavaraj *et al.* (2016), Basantaray and Nancharaiah (2017), and Barman *et al.* (2022) suggests that higher net returns generally incentivise diversification; however, the absence of appropriate markets in the study region may diminish these economic benefits.

Lastly, price fluctuations significantly influenced diversification, with a 13.49 per cent increase in diversification likelihood at the 1 per cent significance level. This trend indicates that farmers might use crop diversification to manage risks associated with price volatility, echoing the findings by Joshi *et al.* (2003) and Pellegrini and Tasciotti (2014). This risk management approach helps mitigate potential income losses due to price changes, enhancing farm resilience against economic fluctuations. Overall, the study highlights the complex interplay of economic, educational, and structural factors that influence crop diversification choices among farmers practicing natural agriculture in Pasighat and Mebo blocks.

TABLE 7: MAXIMUM LIKELIHOOD ESTIMATES OF TOBIT REGRESSION FOR CROP DIVERSIFICATION UNDER NATURAL FARMING

Coefficients (1)	Estimate (2)	Std. error (3)	Tvalue (4)	Pr(> t) (5)
(Intercept)	-0.2659*	0.1240	-2.144	0.0320
Gender	-0.0090	0.0364	-0.246	0.8054
Age	0.0043	0.0035	1.229	0.2192
Farm size	-0.0214***	0.0046	-4.660	0.0000
Farming experience	-0.0006	0.0030	-0.193	0.8470
Family size	0.0012	0.0063	0.190	0.8492
Education	0.0108*	0.0053	2.032	0.0422
Dependency Ratio	-0.0012	0.0008	-1.490	0.1361
Net return	0.0000***	0.0000	7.607	0.0000
Market distance	0.0017	0.0024	0.687	0.4920
Price fluctuation problem	0.1349***	0.0340	3.967	0.0000
Log Sigma	-2.0150	0.0808	-24.953	< 2e-16
Log-likelihood	38.54742			
Observation. Summary:	90	Total observations		
	9	Left-censored observations		
	81	Uncensored observations		
	0	Right-censored observations		

Source: Field survey, 2022-23.

Note: Newton-Raphson maximization, 9 iterations, df- 12 sig., ***, $p < .001$. and *, $p < .01$, respectively.

IV

CONCLUSION

Farmers in the East Siang district of Arunachal Pradesh have traditionally engaged in agricultural practices emphasising biodiversity. This study focuses on natural farming, which significantly contributes to crop diversity. An analysis of the region's agriculture reveals that while area, production, and productivity rates for spice crops like dry chili, ginger, and turmeric have shown robust growth, cereal crops have experienced more modest growth. Key cereals in the district include rice and maize, complemented by various vegetables, fruits, spices, oilseeds, and tuber crops, all cultivated under natural farming regimes. Particularly notable in the surveyed blocks of Mebo and Pasighat is the high crop diversification, with crop diversification indices (CDI) of 0.71 and 0.66, respectively. In Pasighat, mustard shows the highest crop concentration at 1.34, followed by maize at 1.15 and rice at 1.08. Conversely, in Mebo, ginger ranks highest with a concentration of 1.43, followed by arecanut, orange, and banana, each marked at 1.08.

The study indicates that farm size, education level, net returns, and price fluctuations significantly influence crop diversification choices under natural farming. Emphasising high-value crops could significantly enhance earnings and influence agricultural practices positively. The diminishing area under traditional food grains underscores the need for government intervention to provide farmers with remunerative prices and better marketing facilities. Policymakers are encouraged to adopt more pragmatic approaches to crop diversification, ensuring livelihood security and promoting long-term sustainability through education on research-based natural farming techniques.

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