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CROP DIVERSIFICATION IN ODISHA: EMPIRICAL INSIGHT FROM PANEL CORRECTED STANDARD ERROR (PCSE) TECHNIQUE

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ABSTRACTS----------
Needs for agricultural output have been increasing day by day, and diversifying agriculture towards more competitive and high-value commodities is viewed as a critical approach for tackling the issue of agricultural output needs as a result of the huge unit of rising population. In the present study, the level of crop diversification was evaluated using Simpson's index of diversity which is calculated based on the proportion of gross cropped area under different crops cultivated in 30 districts of Odisha between the time period of 1995-2019. It has been observed crop diversification is high in tribal populated districts of south Odisha. Even though the growth of crop diversification in the state is sluggish but the pace of diversification in the districts Boudh, Subarnapur, Puri, Jharsuguda, and Sundargarh is very impressive. An unbalanced panel data model was used to identify factors affecting farm household crop diversification by using the Panel Corrected Standard Error approach (PCSE). The research outcomes reveal that fertilizer consumption, irrigation intensity, and HYV seed rice promote monocropping culture, whereas access to credit, cropping intensity, and rural roads positively influence crop diversification.

KEYWORDS: *Agriculture, Crop Diversification, Simpson Index, Panel data model, PCSE*
JEL code: Q15, Q19, Q24----------

INTRODUCTION

Prior to independence, agricultural productivity in India remained basically stagnant for many decades. The post-independence national government prioritized agriculture by implementing a number of policies (Radhakrishna 2020). As India is the one of the most populous countries in the world, which is the seventh largest country as well as per its size has the large crop diversification due to its physical division. More than 55 percent of household depends on agriculture primarily in the country (IBEF 2020). Such a large unit of growing population requires or needs for agricultural production has been increasing day by day (Ali and Dahlhaus 2022). Considering the demand side factor of growing population feeding in a better way requires accessibility of diversified crop production.

Diversifying agriculture towards more competitive and high-value commodities is seen as a crucial tactic for addressing a number of these rising issues (Joshi et al. 2004). Diversification is one of the most important tools to increase the level of production in developing countries because producing a single crop will definitely not be helpful in economic development alone, hence diversification to commercial crops is a good strategy which can improve standard of living of people through increase farm revenue, employment, reduce poverty, rising the stock of foreign exchange of the nation **(** Pingali and Rosegrant 1995; Satyasai and Viswanathan 1996; Michler and Josephson 2017 **).** On the other hand, supply side agents such as farmers and sellers became profitable by producing and selling diversified crop. Hence, it can be said that commercialization and diversification of agriculture will simultaneously maximize the utility of both producer and consumer (Pingali and Rosegrant 1995). Crop diversification refers to producing verities of crop rather not a single crop in a plot of land by a farmer. Horizontal diversification and vertical diversification are the two types of diversification that exist. At the farm level, cultivating and introducing new varieties of crops, such as minor crops, fruits, and vegetables, in addition to the more traditional main crops is an example of horizontal diversification. Vertical diversification is a form of economic diversification. Farmers can engage in vertical diversification by engaging in a variety of value-added activities on their farms or by adopting some other enterprises, such as livestock farming, poultry farming, fishery farming, in addition to the cultivation of crops on their farms (Haque 1995). Thus, based on these definitions, the nature of diversification can be broadly described as (i) a transfer of resources from farming to non-farming activities, (ii) the use of resources in a more varied and complementary set of agricultural activities, and (iii) a transfer of resources from low- to high-value farming.

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LITERATURE REVIEW

Increased access to modern water, seed, and fertiliser technologies, as well as improvements to rural infrastructure like new market yards, and expansion roads, have all contributed to India's rapid economic and agricultural diversification over the last several decades (Vyas 1996). Kumar et al. (2018) estimated crop diversity and regional and zonal level indices in Uttar Pradesh and dis aggregated influence of agricultural infrastructure and climatic factors in crop diversification using secondary data sources and discovered that variables such as fertiliser, rainfall variability, and literacy rate are key determinants of crop diversity in the state however it is also found that all the variables that determines crop diversity had a positive relationship with crop diversification, however, climatic variable is only one which has a negative relation with crop diversification and suggested that good use of input technology and input will increase the degree of crop diversification and also improve the standard of living. Focusing the situation of eastern India Anuja et al. (2020) stated that Eastern part fall among backward region of India with underutilized agriculture potential and it can be minimized by shifting the structure of crop production towards high value crop which yield a high return compared to common crop production, using large farm household data and advanced matching estimation methods they found that producing high value crop will improve the standard of living of people of this area. Like eastern part of the nation the Himalayan region of the country is relatively less developed and the reason of it is highly unused land i.e., since a large proportion of land covers with mountains and forest most of the farmer of this regions have a small land holding, observing it Chand in 1996 suggested the way out by examining various scope of improving the living standard of people of the region and stated that high valued crop such as fruits production in mid hill zone, off season vegetable cultivation may rise their living standard, due to vast consumer market in Delhi and distance between Delhi and as Northern state are relatively low, the produces can easily get a market.

Joshi et al. 2004 observe the pattern, determinants of agricultural diversification in South Asia and suggested the policy implication as well, in their paper they stated that agricultural sector is highly diversified for the high valued crop such as fruits, vegetables and livestock's and also stated by analysing that government subsidy and help may increase the diversification of crop, though self-sufficiency in crops like wheat and rice achieved in countries like India and Bangladesh dependency on foreign exporter is still exist in case of vegetables and fruits. Among Indian states West Bengal is a leading producer of rice, Small - scale irrigation facilities backed by power supply, storage and marketing facilities, and so forth have all played major roles in crop diversification to varying degrees (Utpal and Manabendu 2010).

In the context of Odisha, Mohanty et al (2017) observed that changes in the cropping pattern in Odisha are often perceived as a transition from traditionally produced crops that provide less revenue to crops that yield greater revenue. Efforts have been made from the 8th Five-Year Plan onwards to increase agricultural diversity from traditionally grown crops to more revenue-generated crops. This is being done to ensure that farmers receive higher returns on their investments. The majority of the state's economy is based on agriculture, with the agricultural and animal husbandry sectors together giving employment to 65 percent of the entire labor force (Atibudhi 2015).

Pattanayak and Nayak (2003) report that more than half of the state's total cropped area is devoted to rice cultivation. This trend toward monoculture is mostly attributable to the availability of irrigation methods and the dietary preferences of the local population. In addition, Tripathy and Das's (2020) research found that farmers are shifting from relying only on rice to growing a wider variety of vegetables in south Odisha.

The study's primary aims are (i) to investigate the nature of agricultural diversification in Odisha; (ii) to examine the extent of crop diversification in Odisha and (iii) to explore the factor affecting crop diversification in Odisha from 1995-96 to 2018-19.

MATERIALS AND METHODS

The analysis is based on unbalanced panel data for all thirty districts of Odisha from 1994-1995 to 2018-19. Odisha Agriculture Statistics, released by the Directorate of Agriculture and Food Production, and Districts at a Glance published by the Directorate of Economics and Statistics, Odisha. Odisha, provided the data for this research. The nature of agricultural diversification is initially investigated via changes in land allocation to the cultivation of various crops produced throughout the year. Simpson's index was also used to investigate crop diversification.

The compound annual average growth rates of area under different crops are estimated by fitting regressions of the type $ln\ Y = \alpha + \beta t$. Y is the logarithmic function of explained variables i.e., the area of specific crops and t is the number of years and β coefficient explained about the growth rate of the area specific to the particular crops

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(Johnston 1997). The trend equations are fitted for the time span 1995–96 to 2018–19 using the OLS technique (Koutsoyiannis 1977).

We intend to look at the underlying factors that lead states to diversify their crops. Based on the conceptual framework from the previous section, an unbalanced data model was created to identify factors affecting farm household crop diversification by using Panel Corrected Standard Errors (PCSE) technique.

Variables Description

Variables Define		
Variables	**Unit of Measurement**	**Hypothesis: (+) or (−) impact on CDI**
SDI	Index	
HYV Rice	Paddy area under HYV as percent of GCA (Ratio)	-
Irrigation Intensity	Total irrigated area to GCA (Ratio)	-
Fertiliser Consumption	Per Kg/ha	+/-
Cropping Intensity	GCA to Net sown area (Ratio)	+
Access to Credit	Rupees per hectare of GCA (log)	+
Rural Road density	Per hectare of GCA (Ratio)	+
Rainfall	Dummy	+

RESULTS AND ANALYSIS

Simpson's Crop Diversification Index

Diversification provides a greater variety of crop production options in a given area. The transition from traditional, less profitable crops to higher-value crops results in higher income for the farmers. Simpson's Index of Diversification can be used to empirically assess the nature and trend of diversification. To get a better look at the changes in crop diversification index across all districts in Odisha, we divided the time period into three parts. The first two-time intervals are decadal i.e., from 1995-2004 and 2005-2014, and the last one is half-decadal i.e., 2015-2019.

Table 1: District-wise Crop Diversification Index from 1995 to 2019

DISTRICTS	1995-04	2005-14	2015-19	C.V
BALASORE	**0.47** (29)	**0.46** (29)	**0.47** (29)	**0.53**
BHADRAK	**0.41** (30)	**0.44** (30)	**0.43** (30)	**3.04**
BOLANGIR	**0.67** (12)	**0.70** (12)	**0.72** (12)	**2.50**
SUBARNAPUR	**0.50** (27)	**0.56** (26)	**0.59** (26)	**6.66**
CUTTACK	**0.67** (13)	**0.68** (16)	**0.69** (17)	**1.08**
JAGATSINHPUR	**0.64** (18)	**0.67** (17)	**0.67** (20)	**2.46**
JAIPUR	**0.67** (15)	**0.68** (15)	**0.70** (15)	**1.78**
KENDRAPADA	**0.59** (24)	**0.63** (24)	**0.63** (25)	**2.78**
DHENKANAL	**0.71** (8)	**0.74** (6)	**0.76** (6)	**2.86**
ANGUL	**0.75** (5)	**0.76** (5)	**0.76** (5)	**0.94**
GANJAM	**0.72** (6)	**0.73** (9)	**0.72** (10)	**0.56**
GAJAPATI	**0.80** (3)	**0.82** (3)	**0.82** (3)	**1.17**
KALAHANDI	**0.67** (11)	**0.69** (14)	**0.72** (11)	**2.73**
NUAPADA	**0.70** (09)	**0.71** (11)	**0.71** (13)	**1.05**
KEONJHAR	**0.68** (10)	**0.73** (08)	**0.73** (08)	**3.38**
KORAPUT	**0.78** (04)	**0.79** (04)	**0.79** (04)	**0.88**
MALKANGIRI	**0.71** (07)	**0.74** (07)	**0.73** (07)	**1.61**
NOWARANGAPUR	**0.65** (17)	**0.65** (21)	**0.69** (26)	**2.71**
RAYAGADA	**0.80** (01)	**0.83** (02)	**0.84** (02)	**1.74**
MAYURBHANJA	**0.52** (26)	**0.55** (27)	**0.54** (27)	**2.90**
KANDHAMAL	**0.80** (02)	**0.83** (01)	**0.85** (01)	**2.24**
BOUDH	**0.60** (23)	**0.66** (19)	**0.68** (18)	**5.69**
PURI	**0.58** (25)	**0.60** (25)	**0.65** (23)	**4.88**
KHURDA	**0.62** (19)	**0.66** (20)	**0.67** (21)	**3.32**
NAYAGARH	**0.66** (16)	**0.69** (13)	**0.70** (14)	**2.77**
SAMBALPUR	**0.61** (22)	**0.65** (22)	**0.65** (22)	**3.40**
BARGARH	**0.50** (28)	**0.49** (28)	**0.50** (28)	**0.46**
DEOGARH	**0.67** (14)	**0.72** (10)	**0.72** (09)	**3.77**
JHARSUGUDA	**0.61** (20)	**0.67** (18)	**0.63** (24)	**3.99**
SUNDARGARH	**0.61** (21)	**0.63** (23)	**0.67** (19)	**4.14**

Source: **Author's computation**

Note: value in parentheses represents the Rank

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The SDI of all the thirty districts of Odisha is presented in Table 1. From the table, it is observed that there is an increase in CDI of all the districts except Kendrapada, Angul, Ganjam, Gajapati, Nuapada, Keonjhar, Koraput, Malkangiri, Sambalpur, and Jharsuguda from the last decades. However, when comparing the pace of diversification through its coefficient of variation districts like Subarnapur, Boudh, Puri, Jharsuguda, Sundargarh, and Deogarh have exhibited greater variation than other districts. When we examine the CDI ranking of the districts thoroughly it is depicted that tribal-dominated KBK districts are in the top ten positions in all three times points.

Trends in Area under Different sub crop sector of Odisha at District Level

Table 3 shows the CAGR of area under various crop sub-sectors such as food crops, and non-food crops for thirty districts of Odisha from 1995 to 2019.

Table 2: Districts wise growth rate of area under different sub crop sector of Odisha, 1995 to 2019

Districts	Growth Rate of area under food crops						Growth rate of Area under Non-food Crops			Growth rate of area under crop sub-sector	
	Rice	Others Cereal	Fruits and Vegtable	Total Spices	Sugarcane	Total Pulses	Total Oilseeds	Total Fibers	Tobacco	Total Food Crops	Total Non-Food Crops
BALASORE	-0.67*	-6.81*	-0.48	-8.65*	-6.58*	-0.86	0.36	-0.66		-0.88*	0.46
BHADRAK	-0.62*	-5.83*	2.62*	-9.07*	-6.40*	-3.56*	0.49	1.61		-0.30	1.77
BOLANGIR	-0.86*	-2.33*	3.30*	5.97*	-7.28*	1.75*	-5.29*	0.28	2.18	0.10	-3.62*
SUBARNAPUR	0.92*	-1.11	4.61*	1.89	-5.52*	3.28*	0.05	7.92*		1.29*	0.98
CUTTACK	-1.37*	-4.50*	-0.56	-5.94*	-2.68*	0.48	-2.44*	0.45		-1.37*	-1.57*
JAGATSINHPUR	-1.42*	-10.95*	0.92	-14.67*	1.48	1.71*	-4.09*	10.87		-1.19*	-2.32*
JAIPUR	-1.29*	0.56	0.82	-6.08*	5.07*	-0.67	-1.27*	-1.13		-0.94*	-1.11*
KENDRAPADA	-0.75*	-4.80*	0.51	-3.98*	-1.65	2.98*	-4.32*	0.09		-0.67*	-0.05*
DHENKANAL	-2.36*	-1.61*	2.16*	-8.64*	-2.50*	-0.16	-1.87*	3.09		-1.22*	-1.50
ANGUL	-1.69*	-0.12	1.88*	-10.86*	-14.32*	1.06*	-0.26	5.12	3.06	-0.83*	0.18
GANJAM	-0.65*	-0.42	0.37	-3.08*	-1.48*	0.33	-0.64	-0.48		-0.49*	-0.60
GAJAPATI	-0.03	0.67	5.13*	-0.17	-7.83*	2.48*	-3.84*	4.30	10.45*	1.42*	-2.72*
KALAHANDI	-0.29	-0.43	1.61*	8.63*	-3.65*	1.27	-2.10*	3.18	-1.28	0.45	-1.20
NUAPADA	-0.48*	0.36	2.28*	3.65*	-10.18*	2.63*	-1.03	4.14*		0.07	-0.46
KEONJHAR	-0.98*	0.21	3.27*	-1.31	-7.85*	0.88*	-2.50*	1.37		-0.07	-1.93*
KORAPUT	-0.12	-0.76*	1.74*	-5.98*	6.83*	0.58	-3.49*	5.73	-3.30*	0.07	-2.48*
MALKANGIRI	0.64*	-1.77*	7.25*	-8.24*	-8.04*	-1.57*	1.40	-3.47	-3.07	1.33*	1.04
NOWARANGAPUR	-0.57*	4.60*	1.75*	-8.91*	0.31	-0.60	-6.57*	-7.25*	-10.37*	0.73*	-6.30*
RAYGADA	-0.48	-1.03*	3.93*	8.71*	0.75	0.16	-3.78*	2.63	-6.31*	0.98*	-2.48*
MAYURBHANJA	-0.45*	-4.42*	2.22*	-9.03*	11.93*	1.62*	-2.77*	-4.34*		-0.29*	-2.87*
KANDHAMAL	-2.01*	-0.71	4.59*	-11.67*	8.06	0.09	-1.54	14.49*	13.00*	-0.39	0.32
BOUDH	-0.29	-2.86*	5.68*	-5.57*	-10.83*	1.86*	0.35	6.93*		0.63*	1.11
PURI	-1.78*	-7.30*	0.18	-14.31*	-2.84	0.82	-0.29	9.35		-1.48*	-0.07
KHURDA	-1.45*	-7.32*	1.17	-10.06*	-1.32	-0.02	-2.32	4.06		-0.93*	-1.28
NAYAGARH	-0.49*	0.74	3.68*	-2.40	-3.46*	0.95	-2.03*	8.06*		0.30	-0.40
SAMBALPUR	0.05	4.51*	2.03*	-18.46*	-8.24*	1.68*	-0.56	-2.21		0.31	0.06
BARGARH	0.06	0.37	-1.63	-3.57*	-5.92*	2.09*	-2.49*	2.56		-0.15	-2.12*
DEOGARH	-0.29	0.24	2.61*	-9.60*	3.00*	2.09*	1.24	4.39		0.07	1.68
JHARSUGUDA	-1.15*	1.62	-1.18	-15.98*	0.49	1.74	-0.32	1.92		-1.30*	0.13
SUNDARGARH	-0.85*	0.35	1.22	-8.45*	-5.97*	0.19	0.66	2.40		-0.58*	0.90

Source: **Author's computation**

Note: * denotes statistical significance at a 5% level

It shows that under the total food crop sub-sector all the districts except Subarnapur, Bargarh, Sambalpur, and Malkangiri have registered negative growth rates for the area under Rice, which is the principal crop of the state. The growth rate of area under Fruits and Vegetables has seen significant positive in most of the districts, comprising Bhadrak, Bolangir, Subarnapur, Dhenkanal, Angul, Gajapati, Kalahandi, Nuapada, Keonjhar, Koraput, Malkangiri, Nowarangapur, Rayagada, Mayurbhanja, Kandhamal, Boudh, Nayagarh, Sambalpur, and Deogarh. Similarly, the CAGR of area under Spices found positive significance for the districts Bolangir,

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Kalahandi, and Raygada. The area under the total pulses the growth rate of Bolangir, Subarnapur, Jharsuguda, Kendrapada, Angul, Gajapti, Nuapada, Keonjhar, Mayurbhanja, Boudh, Sambalpur, Bargarh, and Deogarh have found positively significant.

Coming to the area under non-food crops Balasore, Bhadrak, Subarnapur, Malkangiri, Boudh, and Sundargarh have shown positive growth rates but not significant. Likewise, the compound annual growth rate of the total area under fibers of districts Subarnapur, Nuapada, Kandhamal, Boudh, and Nayagarh was found significantly positive. Looking at the aggregated data, the growth rate of the area under cereals crop (Rice plus other cereals) has declined in almost all districts. This suggests a change in cropping patterns away from cereal cultivation and toward high-value crops or the non-food crops sector.

Determinats of Crop Diversification at Districts Level

Before investigating the factor that affects crop diversification, the stationarity properties of the variables were examined. All variables except Agricultural Credit *(AgCrdt)* became stationary at the level, while Agricultural Credit *(AgCrdt)* became stationary at the first difference. This implies that there is no unit root for the variables. However, further misspecification tests, including heteroscedasticity, multicollinearity, and autocorrelation tests, were also conducted, and it was discovered that the model had problems with heteroscedasticity and autocorrelation (1), but no multicollinearity. As a remedy panel corrected standard error model (reference) is used for factors determining the crop diversification of Odisha. The PCSE estimation result is summarized in Table 6.

Table 3: Panel Corrected Standard Error estimation Results

Number of obs = 540		Wald chi2(7) = 676.09	
R-squared = 0.5448		Prob = 0.0000	
CDI	Coefficient	Panel corrected Std. Err.	z
HYVRice	-.0002351*	.0000438	-5.36
Cropping Intensity	.0019549*	.0001633	11.97
Fertiliser Consumption	-.0009413*	.000139	-6.77
Irrigation Intensity	-.3206666*	.0364828	-8.79
RRdensity	.0019127	.0026177	0.73
Rainfall	.0093044	.0087202	1.07
Agricultural Credit	.0030732	.0117767	0.26
Constant	.5118824	.030639	16.71

The findings of PCSE indicate that crop diversification is negatively impacted by high-yielding rice seed varieties. This suggests that farmers will concentrate on growing food crops if the supply of HYV seeds for rice (a food grain) increases and promotes monocropping culture (Mithiya et al. 2018; Nayak & Kumar, 2019).

The coefficient of irrigation intensity is statistically significant and negative, indicating that access to irrigation reduces crop diversity. With increased irrigated intensity, crop diversity in favour of horticultural commodities and heat-tolerant crops decreased. This suggests that crop diversity is more widespread in rainfed locations that lack technical advances in irrigation (Joshi et al., 2007). In Odisha, most of the rainfed districts from the KBK region came top ten positions in the diversification index and the growth rate of the heat-tolerant crops (Fibers) was found positive for the study period. However, contrary to the findings numerous research views that irrigation intensity positively affects CDI (Mandal et al. 2013; Ashok & Balasubramanim,2006; Mukherjee 2013**;** Thapa et al., 2018).

The coefficient of agricultural credit is positively related to the CDI. The study implies that households with access to credit had greater crop diversity than those without access to credit. This may be because farmers with access to credit had more cash available for agricultural investments, such as crop diversification (Pandey & Kumari,(2021); Akaakohol and Aye, (2014). Credit can also facilitate crop diversification by increasing farmers' access to productivity-boosting inputs such as seeds and fertiliser (Pingali and Shah, 1999)

Rural roads play a crucial role in crop diversification. Investment in road construction yields the highest economic return for a nation (Fan et al., 2008). This study's findings also support the idea that rural road density favourably affects the diversity index. A well-maintained road network with market access promotes agricultural diversification toward high-value commodities by maximising profitability through forward linking (Joshi et al. 2004).

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One interesting result found from the study is that the coefficient of fertiliser consumption per kg/ha found highly negative significant value. This result gives a clear picture about fertiliser consumption, that it promotes monocropping of products or crop concentration. Fertiliser use is often seen as a function of irrigation level, area seeded to high-yielding varieties (HYVs), cropping pattern, and crop and fertiliser pricing. The relation is also clearly inferred from the correlation matrix table as fertiliser consumption significantly positively correlated with irrigation and rural road density. In contrast, its farming diversification has greatly expedited the use of inorganic fertilisers owing to the need for large quantities of fertilisers, especially for high-value crops and in extremely intensive crop production (Kasem & Thapa, 2011).

To evaluate the impact of weather on crop diversity, the model includes Rainfall variables as a dummy. The variable has shown a positive sign, showing that deviates from normal encourages diversification to minimise risk. This result is consistent with the study of Joshi et al (2004).

CONCLUSION

Even though the growth of crop diversification in the state is sluggish but the pace of diversification in the districts Boudh, Subarnapur, Puri, Jharsuguda, and Sundargarh is very impressive. Most of the KBK area has a greater variety of agricultural production methods, placing it in the top ten on the Simpson diversification index. One particularly intriguing finding was a substantially negative significant value for the coefficient of fertiliser usage per kg/ha. This result gives a clear picture about fertiliser consumption, that it promotes monocropping of products or crop concentration. Looking at the aggregated data, the growth rate of the area under cereals crop (Rice plus other cereals) has declined in almost all districts. This suggests a change in cropping patterns away from cereal cultivation and toward high-value crops or the non-food crops sector.

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