Rural Infrastructure, Land Productivity and Crop Diversification in Odisha, India: An Assessment

Nayak, Chittaranjan

Ravenshaw University, Cuttack, India

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Chittaranjan Nayak
Department of Economics (UGC-DRS)
Ravenshaw University, Cuttack, India-753003
Email: crnayak@ravenshawuniversity.ac.in

Abstract

Identifying the sources of agricultural growth in India has been an unsettled area of research. The debate mainly centres around the relative efficacy of price and non-price factors. The present study examines the impact of some non-price factors including rural infrastructure. Taking land productivity and crop diversification as the two principal indicators of agricultural growth, the study measures changes in these indicators vis-à-vis the stock of rural infrastructure in Odisha, an eastern Indian state. By using district-wise cross section data for the year 2011-12, indices for rural infrastructure are prepared with help of the Principal Components Analysis, and crop diversity indices are measured by the Theil Entropy formula. The study observes that rural infrastructure has significant positive impact on land productivity. However, along with high yielding variety paddy, infrastructure contributes to concentration rather than crop diversification. In addition, the study also observes persistence of regional divide in infrastructure, which may be considered as a major concern having wider implications.

Key words:
Agricultural productivity, crop diversification, rural infrastructure, regional disparity, principal component analysis

JEL Code:
Q10, Q15, Q18

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I. Introduction

Indian agriculture is under severe pressure due to a number of factors. Rising population pressure is squeezing agricultural land for cultivation and pastures. Furthermore, the sector is under significant adjustment pressure related to market liberalization and globalization. During the Green Revolution period, both price and non-price factors including provision of basic infrastructure were part of a compact strategy for India's agricultural growth. However, the development policy since economic reforms in 1991 has squeezed the scope for price factors. The state has made it obligatory to delimit its own role in the WTO-led globalised agriculture. Under this backdrop, what seems paramount to raise productivity in Indian context is to rely heavily on the supply side factors like developing rural infrastructure, and focussing on crop diversification. Intuitively, the three terms- rural infrastructure, crop diversification and agricultural productivity- are quite interrelated.

1.1 Imperatives of crop diversification

Crop diversification is considered as an important indicator of agricultural development. It signifies at least the following four aspects of farm economy: a) farmers' adaptability with market signals, b) farmers ability to reduce risk and vulnerability, c) progress of the farm economy towards self-reliance, and d) diversified farming systems incorporate functional biodiversity at multiple temporal and spatial scales to maintain ecosystem services critical to agricultural production[1]. A study by Joshi, et al. (2006) has tried to decompose the sources of agricultural growth into area, yield, prices, diversification and interaction effects. It observes that the major contributors to agricultural growth in India are prices and diversification (crop substitution). The contribution of prices in total growth has increased from 7.7 percent in 1980s to 35.2 percent in 1990s, whereas the share of diversification has increased from 26.6 percent to 30.7 percent during this period. Though the decomposition study needs updating in terms of data and methodology, it provides an important indication about the prospect of growth of Indian agriculture, particularly in the context when the sector is confronted with numerous problems.

1.2 Focus on Land Productivity

To accommodate the rising population and reduction of land for cultivation needs upsurge the land productivity. In addition, the onslaught of ruthless industrialization has made the situation

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[1] For an elaboration, please refer Hazra (2001)

more complicated. Therefore, raising land productivity is very much essential and need of the hour. To address the production constraints of rice based cropping system on a sustainable basis in Eastern India, the Government has introduced a new programme Bringing Green Revolution in Eastern India (BGREI) which comprising of seven states namely, Assam, Bihar, Chhattisgarh. Jharkhand, Odisha, Eastern Uttar Pradesh and West Bengal. It aims to increase production & productivity by promote improved production technology of rice on massive scale including popularization of newly released HY cultivars and hybrids; bring rice fallow areas under cultivation through cropping system based approach; popularise adoption of stress tolerant rice varieties; create irrigation structures like farm ponds, lift irrigation point; promote use of farm machineries and implements suitable for small land holding sizes; and create infrastructure such as godown promote use of farm machineries and implements suitable for small land holding sizes; and create infrastructure such as godown, procurement center and marketing infrastructure.

1.3 Rural infrastructure- A critical necessity

Rural infrastructure is considered as a critical supply side factor influencing growth and diversification in agriculture. By definition, infrastructure basically includes permanent installation of capital goods which provide long term services to basic economic activities like production and exchange. Installation of these goods smoothens volatilities in prices and products by linking demand and supply, albeit with a time lag. Good infrastructure raises productivity and lowers production cost. In addition, good and balanced infrastructure is expected to promote crop diversity. Although some studies have examined the role of rural infrastructure on agricultural productivity, literature on role of infrastructure on crop diversification is scanty. Prima facie, it seems that the effect of infrastructure on diversification can be either positive or negative. If infrastructure is developed selectively, say for example sugarcane procurement and marketing network is advanced, then in every likelihood there may be concentration of sugarcane in the locality. On the contrary, if all items of infrastructure in general, viz. road, irrigation, electricity, communications, banking, marketing, etc. are developed evenly, then that may facilitate diversification.

The present paper attempts i) to make out if there is any regional divide in rural infrastructure, productivity and crop diversification in the state of Odisha; and ii) to explore if infrastructure, along with other factors, has any significant impact on crop diversification and agricultural productivity. This is a district level analysis for the state of Odisha, an eastern Indian state where over 80 percent of people still depend on agriculture. The policy documents of governments in recent times have also focussed on development of the eastern Indian states as key to overall growth. The district-level analysis as such is useful to provide some policy insight. The remainder of the paper is organised as follows: Section II presents a brief review of literature. In Section III, variables, data and methodology have been detailed. Section IV encompasses results and discussion, and finally Section V concludes.

II. Review of Literature

Although a lot of studies have tried to examine the linkages between infrastructure and economic development in India, these studies have basically focused on urban infrastructure items[2]. Only very few studies (Binswanger et al. 1993; Bliven et al. 1995; Bhatia, 1999; Zhang et al. 2001; and Nayak 2008 & 2014) have analyzed the progress and economic effects of rural infrastructure. Out of these studies, inter-state disparity in infrastructure is addressed by Bhatia (1999), which has attempted to build a composite index of rural infrastructure state-wise and examined the relationship between rural infrastructure development and growth in agriculture. However, it suffers from subjectivity and arbitrariness in selection of items and assignment of weights. Nayak (2008) has made a distinct attempt in a district-wise analysis of rural infrastructure for agricultural growth by using backward regression and principal components analysis.

Like the availability of limited studies on the impact of infrastructure on agricultural productivity, studies linking rural infrastructure with crop diversification are also very limited in number. Pinstrup-Andersen and Shimokawa (2006) have studied the impact of infrastructure on crop diversification in different countries and found the impact as significant. The significance of crop shifts in the process of agricultural transformation can be understood through the development of rural markets. If all producers choose crops on the principle of comparative advantage and face the same relative prices, land reallocation occurs only when technology or relative prices change. However as pointed out by Takayama and Judge, 1971 and Baulch, 1997, in agriculture the assumption that all producers face the same relative prices is not justifiable because spatial dimensions and transportation costs are important in crop production.

In the context of India, Chand (1995) argues that it is not the farm size, but infrastructure like access to motorable road, market and irrigation determine the extent, success and profitability of diversification through high paying crops like off-season vegetables. Similarly, a study in West Punjab reports influence of irrigation and road density on crop diversity in two periods. In general, irrigation development makes it technically feasible to grow diverse crops (Kurosaki, 2003). On the contrary, another study observes that the effect of infrastructure on diversification is mixed. While irrigation intensity, the markets and commercial vehicles has positive significant influence on crop diversification, road density has significant negative influence on diversification (Ashok,

[2] Nayak (2008) gives a detailed discussion.

et al., 2006). De and Chattopadhyay (2010) have added another dimension that marginal and small farmers play a positive role in crop diversification and that has been supported by the growth of various infrastructure.

Given the importance of crop diversification, the question arises what are the determinants of diversification, and how do they impact. A survey of existing literature categorises the determinants of diversification as follows[3]: a) Resource related factors covering irrigation, rainfall and soil fertility, b) Technology related factors covering not only seed, fertilizer, and water technologies but also those related to marketing, storage and processing, c) Household related factors covering food and fodder self-sufficiency requirement as well as investment capacity, d) Price related factors covering output and input prices as well as trade policies and other economic policies that affect these prices either directly or indirectly, and e) Institutional and infrastructure related factors covering farm size and tenancy arrangements, research, extension and marketing systems and government regulatory policies.

In the context of Odisha, some recent studies have emphasised on issues of regional disparity in rural infrastructure (Nayak, 2014), regional disparity in agricultural productivity (Nayak and Kumar, 2015; Patra, 2014), and the importance of infrastructure in crop diversification (Reddy, 2013). These studies indicate that infrastructure is paramount in ensuring growth and regional balance. However, literature is to a great extent scanty as regards empirical verification of impact of rural infrastructure on crop diversification. The interrelationship between diversification and productivity is also a matter of interest. Exploring proper determinants is paramount to better targeting and restructuring public policy. This calls for further research.

III. Variables, Data and Methods

Although rural infrastructure can comprise several items covering economic, social and institutional dimensions, this study has given emphasis to economic factors like irrigation, rural electrification, transportation, and communication. In addition, some other variables like credit, fertiliser, per capita income from agriculture, rainfall and seed type have been selected on the basis of literature and data availability. The details of the selected right hand side variables are presented in table 1. District-wise data pertaining to the chosen variables are collected from Statistical Abstracts of Orissa 2012, Odisha Economic Survey and 2013-14, Income division of Directorate of Statistics and Economics 2011-12 and Census of India 2011. An attempt has been made to make a comparison of improvement of diversification, land productivity vis-à-vis rural infrastructure in the year 2011-12.

3.1 Normalisation

The variables have been normalised to make themselves unit-free, facilitate comparison and enable algebraic operation across variables. Since, the analysis observes a high degree of correlation between the items of infrastructure resulting in multicollinearity problem, these items have been combined to be called as Rural Infrastructure Index (INFI) as a remedy.

3.2 Measurement of INFI

The method of Principal Component Analysis (PCA), specifically the Bartlett scores, has been used for the measurement of rural infrastructure index (INFI).[4] Two principal components were selected on the basis of eigen value criterion.

Table 1. Items in Rural Infrastructure and other Determinants of Diversification

Variable taken	Abbreviation of variables	Variables taken	Data Source
Irrigation	PGIA	Percentage of gross irrigated area to gross cropped area	Odisha Agriculture Statistics
Electricity	ELCT	Percentage of rural households with electricity connection	Census
Transport	RDEN	Density of rural roads per thousand hectare of gross cropped area	Statistical Abstracts of Odisha
Communication	TELC	Percentage of rural household with telephone connection	-do-
Credit	CRDT	Agricultural credit per hectare of gross cropped area	Statistical Abstracts of Odisha
Fertiliser	FERT	NPK (in kg) used per hectare of gross cropped area	Odisha Agriculture Statistics
Seed type	HYV	Percentage of gross cropped area under High Yielding Variety	-do-
Rainfall	RNF	Total rainfall from June to September in unit mm	do-
Per Capita Income	PCI	Per Capita Income from agriculture	Directorate of Statistics and Economics

[4] Bartlett factor scores are computed by multiplying the row vector of observed variables, by the inverse of the diagonal matrix of variances of the unique factor scores, and the factor pattern matrix of loadings. Resulting values are then multiplied by the inverse of the matrix product of the matrices of factor loadings and the inverse of the diagonal matrix of variances of the unique factor scores. One advantage of Bartlett factor scores over the other two refined methods presented here is that this procedure produces unbiased estimates of the true factor scores (Hershberger, 2005). This is because Bartlett scores are produced by using maximum likelihood estimates– a statistical procedure which produces estimates that are the most likely to represent the “true” factor scores.

However, the present study went by the loadings of the first principal component, which explained about 56.5 percent variation in the selected variables, and satisfied the Bartlett Criterion. The Bartlett scores are derived as follows:

$$INFI_i = \sum_{j=1}^{k} w^i{}_j \, x^i{}_j$$

where $INFI_i$ *is infrastructure index* of the i^{th} district, w_j = weight of the j^{th} factor obtained as Bartlett loadings, and x_j = normalised variables of the j^{th} (ELCT,PGIA,TELC and RDEN) factor for the i^{th} district.

$$INFI(2011-12) = 0.902\,ELCT + 0.719PGIA + 0.954\,TELC + (-)0.129\,RDEN$$

3.3 Measurement of Productivity

Agricultural productivity is measured in relation to land, labour, and technology. The present study has considered land productivity (PDVT) only.

$PDVT_i = \frac{\sum_{i=1}^{13} Q_i P_i}{GCA}$, where Q_i= quantity of the i^{th} output and P_i is the weighted average price of the i^{th} crop, GCA= gross cropped area of the district expressed in hectares. Thirteen different crops taken for the measurement of productivity are as follows:

a) Cereals: Paddy (autumn, winter, summer combined), maize, ragi, and wheat;
b) Pulses: green gram, black gram, and horse gram;
c) Oil Seeds: ground nut, mustard, and sesamum;
d) Vegetables: potato; and
e) Other crops: jute, sugarcane.

It is noteworthy that output has been measured in nominal terms. The weighted average prices per quintal of these outputs for the reference year 2011-2012 have been taken for this purpose.

3.4 Measurement of Crop Diversification

Crop Diversification has been measured on the basis of Theil Entropy Index, termed as crop diversification index(CDI) where P_i =the proportion of area under i^{th} crop in gross cropped area (GCA), n= the number of crops,

$$Theil\ Entropy\ Index(CDI^T) = \frac{\sum_i^n P_i log \frac{1}{P_i}}{\log n}$$

$0 < CDI^T < 1$, when CDI =0, there is complete concentration (no diversification), and where $CDI = 1$, there is complete diversification

Table 2. Determinants of Crop Diversification and Productivity

S. N.	Variable Name	Expected impact on CDI	Expected impact on PDVT	Reason
1	INFI	↑ or ↓	↑	Facilitates production, obviously raises productivity. Holistic development of infrastructure promotes diversification, but selective development promotes concentration.
2	CRDT	↑	↑	Credit enhances investment and risk-taking ability of farmers.
3	FERT	↓	↑	Increases concentration since it raises productivity of the most responsive crop to fertiliser.
4	HYV	↑ or ↓	↑	Use of traditional seeds increase diversification, mainly due to distress. HYV seeds raise productivity but it may promote concentration.
5	AGDP	↑ or ↓	↑	District Domestic Product from Agriculture Per Capita
6	RNF	↑ or ↓	↑	Average Rain fall during June to September. It promotes concentration.

3.5 Regression Model

The analysis has fitted a linear multiple regression models for 2010-11 with CDI and PDVT as the left hand side variables and the variables explained in table 1 as the right hand side variables.

$$CDI^{T}{}_{i} = \beta_0 + \beta_1 INFI_i + \beta_2 CRDT_i + \beta_3 FERT_i + \beta_4 HYV_i + \beta_5 PCI_i + \beta_6\ RNF_i + \epsilon_i, \quad \text{..........} \ (1)$$

$$PDVT_i = \theta_0 + \theta_1 INFI_i + \theta_2 CRDT_i + \theta_3 FERT_i + \theta_4 HYV_i + \theta_5 PCI_i + \theta_6 RNF_i + \ \nu_i, \text{..............}(2)$$

where i =1, 2, ……, 30 (no. of districts)

The model is scrutinised for possible problems in regression analysis like multicollinearity and autocorrelation. The study develops on the hypotheses that the variables explained in table 1 are the determinants of crop diversification and productivity, and their impacts are hypothesised a priori as stated in table 2.

IV. Results and Discussion

Ranking of all the districts have been done for the three variables INFI, PDVT and CDI. The results are stated below.

4.1 Rural infrastructure

An attempt has been made to understand the relative positions of all the thirty districts of Odisha in relation to rural infrastructure. Only physical infrastructure items like road, irrigation, electricity and communication have been included. A similar attempt was made by Nayak (2008) on the basis of Census, 2001 data, and the study observed that physical infrastructure has greater impact on agriculture than social and financial infrastructure. The present study develops a curiosity to examine if there has been any relative change in such rankings in the last decade. The methodology and database for the construction of INFI have remained the same[5].

Table 3. Rural Infrastructure in Odisha in 2011-12

SN	Districts	INFI	*Rank*	SN	Districts	INFI	*Rank*
1	Anugul	5.956	*15*	16	Kandhamal	2.204	*30*
2	Balangir	4.331	*22*	17	Kendrapara	10.060	*1*
3	Baleshwar	9.592	*4*	18	Keonjhar	4.930	*17*
4	Baragarh	6.789	*12*	19	Khordha	9.823	*3*
5	Baudh	4.199	*25*	20	Koraput	3.731	*27*
6	Bhadrak	9.939	*2*	21	Malkangiri	3.902	*26*
7	Cuttack	9.283	*6*	22	Mayurbhanj	4.904	*18*
8	Debagarh	4.410	*21*	23	Nabarangpur	2.696	*29*
9	Dhenkanal	7.260	*11*	24	Nayagarh	7.297	*10*
10	Gajapati	4.785	*20*	25	Nuapada	4.278	*24*
11	Ganjam	8.019	*9*	26	Puri	9.123	*7*
12	Jagatsingpur	9.592	*5*	27	Rayagada	3.274	*28*
13	Jajapur	8.470	*8*	28	Sambalpur	5.820	*16*
14	Jharsuguda	6.280	*13*	29	Sonepur	5.962	*14*
15	Kalahandi	4.295	*23*	30	Sundargarh	4.873	*19*

Source: Authors' calculation

The results are stated in table 3. It is observable that, the north-south divide is continuing (please refer Figure 1). Districts from coastal Odisha (north-eastern) are in the top and most of the KBK districts (south) are in the low INFI category. The coastal districts like Kendrapara, Bhadrak, Khordha, Baleswar and Jagatsingpur are in top five rank respectively. Whereas KBK positioned in low INFI category i.e. 27th,22nd and 23rd. As compared to 2001, only Ganjam remained same in ninth rank and Anugul have slipped from tenth ranks to 15th ranks in 2011. Nayagarh progressed from fifteen to tenth, and Mayurbhanj has jumped from 22nd to 18th position i.e. during this period. On the contrary, Baudh and Rayagada have slipped from medium to low infrastructure category. Interestingly, Nabarangpur as jumped from the bottom to the top position in the low infrastructure category.

4.2 Land Productivity

Land productivity in value terms for all the districts is presented in table 4. Like the division in infrastructure, there is no strict division between coastal Odisha and Odisha. Baleswar from

[5] In Nayak (2008), the nomenclature used for INFI was physical infrastructure development index (PIDI). Both of these convey the same meaning

coastal Odisha occupies the top rank followed by Baragarh and 4th rank by Sonepur from western Odisha, in land productivity per hectare of gross cropped area. Similarly, Puri, Khordha and Jajapur from coastal Odisha are in medium PDVT category, which also involves western Odisha districts like Debagarh, Jharsuguda and Baudh. However, it is clearly observable that the KBK districts are lying more or less in the low PDVT category. Interestingly the ST dominated districts like Mayurbhanj and Sundargarh of northern-western Odisha are in the high PDVT category.

Table 4. Land Productivity in Odisha in 2011-12

SN	Districts	PDVT	*Rank*	SN	Districts	PDVT	*Rank*
1	Anugul	4380	*27*	16	Kandhamal	4175	*29*
2	Balangir	3155	*30*	17	Kendrapara	14264	*8*
3	Baleswar	22732	*1*	18	Keonjhar	11103	*14*
4	Baragarh	22531	*2*	19	Khordha	13007	*12*
5	Baudh	9138	*19*	20	Koraput	7606	*20*
6	Bhadrak	17513	*6*	21	Malkangiri	4276	*28*
7	Cuttack	14973	*7*	22	Mayurbhanj	17909	*5*
8	Debagarh	10361	*17*	23	Nabarangpur	10898	*15*
9	Dhenkanal	11246	*13*	24	Nayagarh	5283	*23*
10	Gajapati	5515	*22*	25	Nuapada	4531	*25*
11	Ganjam	4490	*26*	26	Puri	13183	*11*
12	Jagatsingpur	20153	*3*	27	Rayagada	5205	*24*
13	Jajapur	10479	*16*	28	Sambalpur	14209	*9*
14	Jharsuguda	9205	*18*	29	Sonepur	18678	*4*
15	Kalahandi	5919	*21*	30	Sundargarh	13445	*10*

Source: Authors' calculation

Figure 1a. Rural Infrastructure in Odisha in 2011

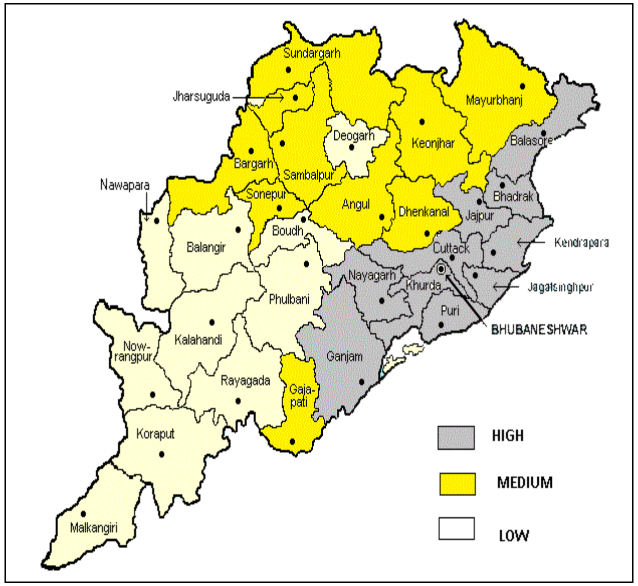


Figure 2b. Productivity in Odisha in 2011

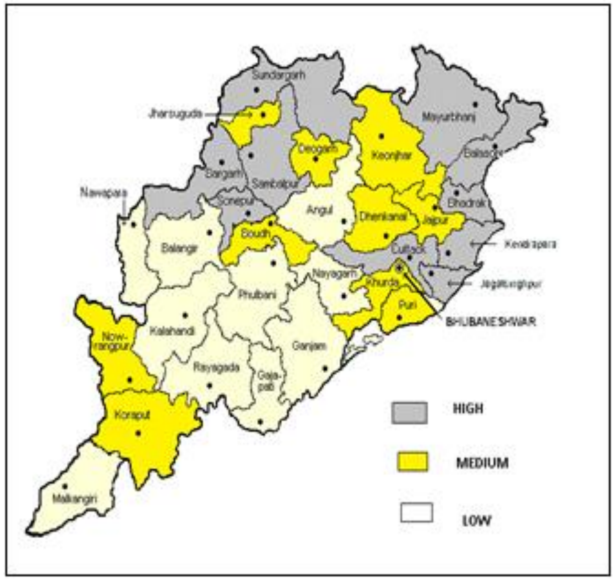
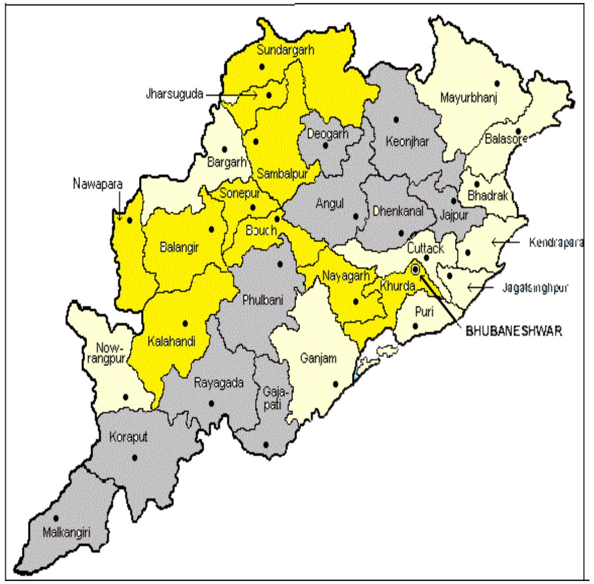


Figure 2c. Crop Diversification in Odisha in 2011



4.3 Crop Diversification

Starting from standard deviation to Atkinson Index, crop diversification can be measured in a number of ways. Some studies have also measured it by the percentage of cropped area under high-valued crops (e.g. Ashok and Balsubramanian 2006). However, the present study utilised Theil and Herfindahl Indexes. The Theil index measures an entropic "distance" the population is away from the "ideal" egalitarian state of everyone having the same value. On the other hand, the Herfindahl index measures the concentration ratio that gives more weight to larger values. It is actually a measure of concentration. But the study has converted it as explained in section III to measure crop diversification. After obtaining both the indexes district-wise, coincidentally the study observes Pearson's correlation coefficient between CDI^T and CDI^H is 0.99. In addition, the ranks of the districts are exactly the same in both measures. In order to escape from repetition, only CDI^T has been taken for further scrutiny. The ranking of all the thirty districts of the state on the basis of the indexes is presented in table 5.

Table 5. Crop Diversification in Odisha in 2011-12

SN	Districts	CDI	*Rank*	SN	Districts	CDI	*Rank*
1	Anugul	0.54	*6*	16	Kandhamal	0.67	*1*
2	Balangir	0.48	*11*	17	Kendrapara	0.35	*29*
3	Baleshwar	0.41	*18*	18	Keonjhar	0.51	*9*
4	Baragarh	0.27	*30*	19	Khordha	0.45	*13*
5	Baudh	0.40	*21*	20	Koraput	0.55	*4*
6	Bhadrak	0.35	*27*	21	Malkangiri	0.57	*3*
7	Cuttack	0.40	*22*	22	Mayurbhanj	0.38	*23*
8	Debagarh	0.53	*8*	23	Nabarangpur	0.35	*28*
9	Dhenkanal	0.55	*5*	24	Nayagarh	0.46	*12*
10	Gajapati	0.54	*7*	25	Nuapada	0.41	*17*
11	Ganjam	0.38	*24*	26	Puri	0.37	*25*
12	Jagatsingpur	0.40	*20*	27	Rayagada	0.59	*2*
13	Jajapur	0.48	*10*	28	Sambalpur	0.41	*19*
14	Jharsuguda	0.43	*16*	29	Sonepur	0.37	*26*
15	Kalahandi	0.45	*14*	30	Sundargarh	0.44	*15*

Source: Authors' calculation

From table 3 to 5, a remarkable observation can be made that there is no one-to-one correspondence between INFI, PDVT and CDI. some districts placed in High INFI are placed in Medium CDI^T . For example, coastal districts like Khordha, Baleswar, and Jagatsingpur are in High INFI but in Medium CDI categories. Cuttack, Puri, Bhadrak and Kendrapara are in High INFI but Low CDI categories. Figures 1 to 3 may be referred for a comparative picture, which are drawn on the basis of rankings. Analysis with help of the tables and maps so far gives a sketchy picture on the relationship between infrastructure, productivity and diversification. The correlation matrix is presented in table 6.

Table 6. Correlation Matrix: Pearson's Correlations

		CDI	PDVT	INFI	CRDT	FERT	HYV	AGDP	RNF
CDI	Pearson Correlation	1	-.644**	-.515**	-.394*	-.568**	-.563**	.449*	-.105
	Sig. (2-tailed)		.000	.004	.031	.001	.001	.013	.579
PDVT	Pearson Correlation	-.644**	1	.597**	.548**	.436*	.359	-.139	.392*
	Sig. (2-tailed)	.000		.000	.002	.016	.051	.463	.032
INFI	Pearson Correlation	-.515**	.597**	1	.791**	.147	.132	-.625**	.053
	Sig. (2-tailed)	.004	.000		.000	.439	.487	.000	.779
CRDT	Pearson Correlation	-.394*	.548**	.791**	1	.295	.029	-.514**	.171
	Sig. (2-tailed)	.031	.002	.000		.114	.878	.004	.365
FERT	Pearson Correlation	-.568**	.436*	.147	.295	1	.422*	-.264	.246
	Sig. (2-tailed)	.001	.016	.439	.114		.020	.158	.191
HYV	Pearson Correlation	-.563**	.359	.132	.029	.422*	1	-.188	.057
	Sig. (2-tailed)	.001	.051	.487	.878	.020		.319	.765
PCI 11	Pearson Correlation	.449*	-.139	-.625**	-.514**	-.264	-.188	1	-.137
	Sig. (2-tailed)	.013	.463	.000	.004	.158	.319		.469
RNF11	Pearson Correlation	-.105	.392*	.053	.171	.246	.057	-.137	1
	Sig. (2-tailed)	.579	.032	.779	.365	.191	.765	.469	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

The correlation table gives a clear picture of interrelationship between the variables. INFI is negatively correlated with CDI. PDVT is negatively correlated with CDI. The study observes that CDI is negatively correlated with many other variables like INFI, PDVT, HYV, FERT, CRDT and PCI except RNF. Indication is clear that these variables help in concentration of crops rather than diversification. However, we have to wait for the regression results before concluding anything like this. It is observed that INFI and PDVT are positively correlated, whereas CDI and INFI are negatively correlated. All the coefficients are statistically significant.

4.4 Regression Results

The impact of the selected explanatory variables on CDI and PDVT is assessed by running two linear regressions in which the same right hand side variables have been taken. The results are stated below

4.4.1 CDI on INFI and other explanatory variables

The results of the regression of CDI on the selected variables are as follows:

Table 7. Regression Results: Determinants of CDI

Variables	Unstandardized β Coefficients	SE	P-Values
Constant	0.619	0.106	0
INF	-0.018	0.009	0.048
CRDT	2.91E-06	0	0.504
FERT	-0.001	0	0.02
HYV	0.00E+00	0	0.036
AGDP	2.61E-06	0	0.776
RNF	7.37E-06	0	0.901
R^2	0.627		
Adjusted R Square	0.53		
F	6.457		

Dependent Variable: CDI

The individual and collective effects of the chosen explanatory variables on crop diversity need to be examined scrupulously. As a measure of goodness of fit, R^2 reveal that about 62.7 percent variation in CDI is explained by all the regressors taken together, and the p-value of F confirms that it is significant. The explanatory variables, other than HYV, FERT and INFI, do not have significant effect. However, it is important to observe that both these regressors have negative impact on CDI. This means, high yielding variety seeds, fertilizer and rural infrastructure result in concentration not diversification of crops.

Regarding HYV seeds, this result is as per our expectation. If more and more area is put to high yielding seed of principal crop, like paddy in Odisha's case, productivity rises. As a result, farmers do not develop any tendency to diversify their farming. However, as regards infrastructure, the result is contrary to the conventional wisdom that improved roads, irrigation, electricity and tele-connectivity facilitate diversification because these elements assuage the risk and uncertainty regarding production. The present study observes the opposite. Possibly, not merely quantity but the functioning and composition of infrastructure matters a lot. For example, irrigation in many places in Odisha is available for the *kharif* crop, in which only paddy is cultivated. The condition of rural roads, functioning of irrigation and availability of electricity for farm use, warehousing and marketing infrastructure are some of the factors, which could have made a difference in the result, could not be incorporated due to lack of district-wise data. Another possible interpretation is that farmers prefer those crops which have a less volatile market, as the case of paddy under minimum support price (MSP) system of the state. Better the level of infrastructure, farmers try to adopt better practices to get the optimum output from the crop. Being the predominant staple in the state backed by MSP, farmers in Odisha continue to allocate the same proportion, i.e. presently about 70 percent of gross cropped area. This has remained more or less same over the recent years.

How to break the standstill cropping pattern in the state is a subject matter for further research? Drawing any strong inference from a cross section study will be premature.

Credit and fertiliser, the study observes, have positive impact on diversification but these are not significant. Marketable surplus has negative impact on diversification. However, this impact is also not significant.

4.5 PDVT on INFI and other explanatory variables

The result from the regression of land productivity on infrastructure, credit, fertiliser and seed type is presented below.

Table 8. Regression Results: Determinants of PDVT

Variables	Unstandardized β Coefficients	SE	P-Values
Constant	-26854.308	5494.749	0
INF	1985.554	454.721	0
CRDT	0.031	0.221	0.891
FERT	39.347	17.49	0.034
HYV	17.939	9.619	0.075
AGDP	1.975	0.47	0
RNF	9.719	3.022	0.004
R^2	0.768		
Adjusted R Square	0.708		
F	12.698		

Dependent Variable: PDVT

The analysis observes that INFI and HYV have significant positive impact on land productivity. CRDT have positive impact on productivity also, but this impact is not significant. Although HYV not significant statistically, this is quite striking to notice that marginal productivity of fertiliser has turned to be negative in Odisha. A question comes from conventional wisdom that normally cropped under HYV seeds and fertiliser use are positively correlated. The present study also finds the same (please refer the correlation matrix presented in table 6). Then one has to go deep into the triviality of this opposite signs of correlation and regression coefficients. This result needs further scrutiny at micro level, that too with help of time series data. But an important indication is that the scope for raising productivity through intensive use of inputs is not plausible. Farmers might be overusing fertiliser.

The R^2 value states that about 76.8 percent variation in land productivity is explained by the right hand side variables. The overall regression is significant since the p-value of F is 0.00 and the value of F is 12.698.

5 Conclusion

The study concludes that there is a regional divide in rural infrastructure across the districts of Odisha. The coastal districts are in the top category in rural physical infrastructure, whereas the districts coming under KBK (Kalahandi-Balangir and Koraput) are in the bottom. Majority of western Odisha districts are in the medium category of infrastructure. Continuance of this regional divide has serious implications for balanced regional growth. However, a different situation is observed in land productivity. Some of the western Odisha districts are placed in high productivity, whereas some districts of the coastal Odisha are in medium productivity category. As regards crop diversification, the study observes a quite unexpected conclusion. Except for Jajapur and Khordha, all other coastal districts are in low crop diversification category. Conversely, some of the western Odisha and KBK districts are in the high diversification category.

Apart from existence of regional divide, the study also concludes that rural infrastructure along with cropped area under high yielding variety of paddy has helped in raising land productivity but not crop diversification in Odisha. On the contrary, it helps in crop concentration. It may be noted that, since rice is the predominant staple in the state covered by MSP, farmers in Odisha continue to allocate a significant proportion of cropped area to the cultivation of paddy. Possibly, in the absence of marketing infrastructure for other crops, they make use of the stock of existing infrastructure for better yield in rice cultivation. This results in crop concentration. However, the results need further scrutiny at micro level.

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