Crop Diversification and Land Productivity in Odisha: Role of Rural Infrastructure

Chittaranjan Nayak*

ABSTRACT

The present study examines the role of rural infrastructure, and some other factors like seed, fertiliser, marketable surplus and rural credit in crop diversification and land productivity in an eastern Indian state, Odisha. By using district-wise cross section official data for the year 2011-12, an index for rural infrastructure is prepared with help of the Principal Components Analysis, and crop diversity index is measured by the Entropy Index. An attempt has also been made to examine the regional divide in crop diversification and land productivity vis-à-vis rural infrastructure. 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. However, due to limitations in data, such inferences need micro-level verifications before generalisation.

Keywords: Agricultural productivity, Crop diversification, Regional disparity, Rural infrastructure.

1.0 Introduction

Indian agriculture is under severe pressure due to a number of factors. There has been deceleration in the growth rate in the last two decades (Sharma, 2011). The Green Revolution technology that contributed to increased foodgrain productivity has reached a plateau. Rising population pressure is squeezing agricultural land for cultivation and pastures. Furthermore, the sector is under significant adjustment pressure related to market liberalisation and globalisation.

*Faculty member, Department of Economics, Ravenshaw University, Cuttack
The growth in crop yields and total factor productivity has slowed down and, in some cases, stagnated (Evenson et al, 1999, Murgai et al., 2001 and Sidhu, 2002, Kumar and Mittal, 2006). 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 in Indian context to raise productivity 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.

Crop diversification is considered as an important indicator of agricultural development. It signifies at least the following four aspects of farm economy. One, farmers’ adaptability with market signals. In India, unlike many industrial products, most of the agricultural products are inelastic in supply. This means such products do not much respond to the market signals. In the WTO-led globalised regime, which has already brought agriculture to its ambit, Indian farmers will remain a disadvantaged lot due to lack of adaptability with market signals. Diversification is an indicator showing the degree of such adaptability. Two, farmers’ ability to reduce risk and vulnerability. Most of risk, uncertainty and vulnerability in farm sector is observed in production and marketing. Crop diversification recedes such risks. Three, progress of the farm economy towards self-reliance. Despite the fact that Indian economy still continues to be an agro-based economy, the country is importing a number of agricultural products like pulses and oil seeds. If agriculture is diversified, then such import dependence can also be arrested. Four, diversified farming systems incorporate functional biodiversity at multiple temporal and spatial scales to maintain ecosystem services critical to agricultural production.

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.
Given the importance of crop diversification, there is a need to understand the determinants of diversification, and its impact. A survey of existing literature categorises the determinants of diversification as follows: 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.

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. Apart from the importance of agriculture in the state’s economy, the soil and climatic conditions of different agro-climatic zones in the state makes Odisha a representative state of India to some extent. 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.
2.0 Review of Literature

Some studies have tried to examine linkage between infrastructure and economic development in India (Elhance and Lakshmanan, 1988; Binswanger et al. 1993; Gowda and Mamatha, 1997; Datt and Ravallion, 1998; Lall, 1992 and 1999; Sahoo and Saxena, 1999; Ghosh and De 2004). Some researchers have analysed the role of public infrastructure in productivity growth (Aschauer, 1989; Fousekis and Pantzios, 2000; Mamatzakis, 2003). Most of the above studies, however, have taken into account mostly urban infrastructure items. Only very few studies (Binswanger et al. 1993; Bliven et al. 1995; Bhatia, 1999; Zhang et al. 2001; Rao, 2005) have analysed 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).

Although there has been a good number of research on rural infrastructure and agricultural diversification, surprisingly very few have tried to examine the impact of infrastructure on diversification. A few studies have analysed the impact of rural infrastructure on productivity. Pinstrop-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. In agriculture, however, the assumption that all producers face the same relative prices is not justifiable because spatial dimensions and transportation costs are important in crop production (Takayama and Judge, 1971; Baulch, 1997).

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, 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 infrastructure.

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 (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. For better targeting and restructuring of public policy, further research is required in this area.

3.0 Variables, Data and Methods

Although rural infrastructure can comprise several items covering economic, social and institutional dimensions, this study has emphasised economic factors like irrigation, rural electrification, transportation, and communication. In addition, some other variables like credit, marketable surplus, fertiliser, and seed type have been selected on the basis of literature and data availability. The details of the selected right hand side variables (i.e., independent variables) are presented in Table 1. District-wise data pertaining to the variables are collected for the year 2011-12 from Statistical Abstract of Orissa, 2012, Odisha Economic Survey, 2013-14, and Census of India, 2011.

3.1 Normalisation

The variables have been normalised to make them 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), to be specific the Bartlett scores, has been used for the measurement of rural infrastructure index (INFI)³. Two principal components were selected on the basis of eigen value criterion. 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.
### Table 1: Items in Rural Infrastructure and other Determinants of Diversification

<table>
<thead>
<tr>
<th>Variable taken</th>
<th>Abbreviation of variables</th>
<th>Variable form</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td>PGIA</td>
<td>Percentage of gross irrigated area to gross cropped area</td>
<td>Odisha Agriculture Statistics 2011-12</td>
</tr>
<tr>
<td>Electricity</td>
<td>ELCT</td>
<td>Percentage of rural households with electricity connection</td>
<td>Census, 2011</td>
</tr>
<tr>
<td>Transport</td>
<td>RDEN</td>
<td>Density of rural roads per thousand hectare of gross cropped area</td>
<td>Statistical Abstract of Odisha, 2012</td>
</tr>
<tr>
<td>Communication</td>
<td>TELC</td>
<td>Percentage of rural household with telephone connection</td>
<td>-do-</td>
</tr>
<tr>
<td>Credit</td>
<td>CRDT</td>
<td>Agricultural credit per hectare of gross cropped area</td>
<td>Statistical Abstract of Odisha 2012</td>
</tr>
<tr>
<td>Marketable Surplus</td>
<td>MSUR</td>
<td>Total rice production less consumption (tonnes)</td>
<td>Odisha Agriculture Statistics 2011-12</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>FERT</td>
<td>NPK (in kg) used per hectare of gross cropped area</td>
<td>-do-</td>
</tr>
<tr>
<td>Seed type</td>
<td>HYV</td>
<td>Percentage of gross cropped area under High Yielding Variety paddy</td>
<td>-do-</td>
</tr>
</tbody>
</table>

The Bartlett scores are derived as follows:

\[
INF_{I_i} = \sum_{j=1}^{k} w_j \times x_{ij}
\]

where \( INF_{I_i} \) is infrastructure index of the \( i^{th} \) district,

\( w_j \) = weight of the \( j^{th} \) factor obtained as Bartlett loadings, and

\( x_{ij} \) = normalised variables of the \( j^{th} \) (ELCT, PGIA, TELC and RDEN) factor for the \( i^{th} \) district.

\[
INF_I = 0.902 \times ELCT + 0.719 \times PGIA + 0.954 \times TELC + (-) 0.129 \times RDEN.
\]

### 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.
Crop Diversification and Land Productivity in Odisha: Role of Rural Infrastructure

\[ PDVT_i = \frac{\sum_{i=1}^{13} Q_i P_i}{GCA}, \]

where \( Q_i \) = quantity of the \( i^{th} \) output
\( P_i \) 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 Herfindahl and Theil Entropy Indices.

\[ H = \sum_{i=1}^{n} P_i^2, \]

where \( P_i \) = the proportion of area under \( i^{th} \) crop in gross cropped area (GCA),
\( n \) = the number of crops, \( 0 < H < 1 \)

\[ Hn = H(normalised) = \frac{H - \frac{1}{n}}{1 - \frac{1}{n}} \]

Herfindahl Diversification Index \((CDI^H) = 1 - Hn,\)

\[ CDI^T = \frac{\sum_{i=1}^{n} P_i \log \frac{1}{P_i}}{\log n} \]

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

3.5 Regression Model

The analysis has fitted a linear multiple regression models with CDI and PDVT as the left hand side variables and the variables explained in table 1 as the right hand side variables. It may be noted that MSUR is derived out of total product, the source from
which PDVT is also derived. If MSUR is taken as a right hand side variable, it may create endogeneity problem. So MSUR is dropped as an explanatory variable in equation 2.

\[ CDI^T_i = \beta_0 + \beta_1 INFI_i + \beta_2 CRDT_i + \beta_3 MSUR_i + \beta_4 FERT_i + \beta_5 HYV_i + \epsilon_i, \tag{1} \]

\[ PDVT_i = \theta_0 + \theta_1 INFI_i + \theta_2 CRDT_i + \theta_3 MSUR_i + \theta_4 FERT_i + \theta_5 HYV_i + \nu_i, \tag{2} \]

where \( i = 1, 2, \ldots, 30 \) (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 \textit{a priori} as stated in Table 2.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
\textbf{Variable Name} & \textbf{Expected impact on CDI} & \textbf{Expected impact on PDVT} & \textbf{Reason} \\
\hline
INFI & ↑ or ↓ & ↑ & Facilitates production, obviously raises productivity. Holistic development of infrastructure promotes diversification, but selective development promotes concentration. \\
\hline
CRDT & ↑ & ↑ & Credit enhances investment and risk-taking ability of farmers. \\
\hline
MSUR & ↑ or ↓ & ↑ & Sourcing of MSUR matters a lot. If one crop contributes for MSUR, there may be a tendency for concentration. If it is sourced from a number of crops, it promotes further diversification. As regards productivity, since higher MSUR increases investible fund it may be expected to increase PDVT. \\
\hline
FERT & ↓ & ↑ & Increases concentration since it raises productivity of the most responsive crop to fertiliser. \\
\hline
HYV & ↑ or ↓ & ↑ & Use of traditional seeds increase diversification, mainly due to distress. HYV seeds raise productivity but it may promote concentration. \\
\hline
\end{tabular}
\caption{Determinants of Crop Diversification and Productivity}
\end{table}
4.0 Results and Discussion

4.1 Ranking
Ranking of all the districts have been done for the three variables INFI, PDVT and CDI. The results have been stated in Table 3.

4.2 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. Categorisation of districts into high, medium and low INFI has also remained the same.

The results are stated in Table 3. As compared to 2001, only Ganjam and Anugul have slipped from ninth and tenth ranks to 12th and 13th ranks in 2011 respectively. Nayagarh progressed from 15th to 8th, and Mayurbhanj has witnessed the greatest jump from 22nd to tenth position, i.e. to the high INFI category districts, during this period.

**Table 3: Rural Infrastructure Index of Districts of Odisha in 2011**

<table>
<thead>
<tr>
<th>Rank</th>
<th>District</th>
<th>INFI</th>
<th>Rank</th>
<th>District</th>
<th>INFI</th>
<th>Rank</th>
<th>District</th>
<th>INFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jagatsingpur</td>
<td>3.953</td>
<td>11</td>
<td>Baragarh</td>
<td>1.106</td>
<td>21</td>
<td>Nabarangpur</td>
<td>0.024</td>
</tr>
<tr>
<td>2</td>
<td>Bhadrak</td>
<td>3.647</td>
<td>12</td>
<td>Ganjam</td>
<td>0.954</td>
<td>22</td>
<td>Sonepur</td>
<td>-0.120</td>
</tr>
<tr>
<td>3</td>
<td>Khordha</td>
<td>3.580</td>
<td>13</td>
<td>Anugul</td>
<td>0.564</td>
<td>23</td>
<td>Koraput</td>
<td>-0.195</td>
</tr>
<tr>
<td>4</td>
<td>Baleshwar</td>
<td>3.153</td>
<td>14</td>
<td>Balangir</td>
<td>0.489</td>
<td>24</td>
<td>Nuapada</td>
<td>-0.389</td>
</tr>
<tr>
<td>5</td>
<td>Kendrapara</td>
<td>3.125</td>
<td>15</td>
<td>Dhenkanal</td>
<td>0.425</td>
<td>25</td>
<td>Debagarh</td>
<td>-0.422</td>
</tr>
<tr>
<td>6</td>
<td>Cuttack</td>
<td>2.632</td>
<td>16</td>
<td>Sambalpur</td>
<td>0.412</td>
<td>26</td>
<td>Kandhamal</td>
<td>-0.522</td>
</tr>
<tr>
<td>7</td>
<td>Jajpur</td>
<td>2.352</td>
<td>17</td>
<td>Jharsuguda</td>
<td>0.352</td>
<td>27</td>
<td>Rayagada</td>
<td>-0.574</td>
</tr>
<tr>
<td>8</td>
<td>Nayagarh</td>
<td>2.154</td>
<td>18</td>
<td>Keonjhar</td>
<td>0.291</td>
<td>28</td>
<td>Kalahandi</td>
<td>-0.913</td>
</tr>
<tr>
<td>9</td>
<td>Puri</td>
<td>1.717</td>
<td>19</td>
<td>Sundargarh</td>
<td>0.077</td>
<td>29</td>
<td>Baudh</td>
<td>-1.043</td>
</tr>
<tr>
<td>10</td>
<td>Mayurbhanj</td>
<td>1.481</td>
<td>20</td>
<td>Malkangiri</td>
<td>0.031</td>
<td>30</td>
<td>Gajapati</td>
<td>-1.281</td>
</tr>
</tbody>
</table>

Source: Author’s calculation
Similarly, Balangir and Malkangiri, two underdeveloped districts belonging to the KBK region of south-western Odisha have seen progress from low to medium infrastructure category. On the contrary, Sonepur, Boudh and Rayagada have slipped from medium to low infrastructure category. Interestingly, Nabarangpur has jumped from the bottom to the top position in the low infrastructure category. It is observable that, despite some minor changes in the rank of many districts, the north-south divide is continuing. Districts from coastal Odisha (north-eastern) are in the top and most of the KBK districts (south) are in the low INFI category.

4.3 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 coastal Odisha occupies the top rank followed by Baragarh 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. This is a departure from the observation on district-wise land productivity for the year 2001-02 measured by Nayak (2008).

Table 4. Land Productivity in Odisha in 2011

<table>
<thead>
<tr>
<th>Rank</th>
<th>District</th>
<th>PDVT</th>
<th>Rank</th>
<th>District</th>
<th>PDVT</th>
<th>Rank</th>
<th>District</th>
<th>PDVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baleshwar</td>
<td>22732</td>
<td>16</td>
<td>Koraput</td>
<td>7606</td>
<td>27</td>
<td>Kalahandi</td>
<td>5919</td>
</tr>
<tr>
<td>2</td>
<td>Baragarh</td>
<td>22531</td>
<td>17</td>
<td>Debagarh</td>
<td>10361</td>
<td>28</td>
<td>Nayagarh</td>
<td>5283</td>
</tr>
<tr>
<td>3</td>
<td>Jagatsinghpur</td>
<td>21053</td>
<td>18</td>
<td>Jharsuguda</td>
<td>9205</td>
<td>29</td>
<td>Kandhamal</td>
<td>4175</td>
</tr>
<tr>
<td>4</td>
<td>Sonepur</td>
<td>18678</td>
<td>19</td>
<td>Baudh</td>
<td>9138</td>
<td>30</td>
<td>Baleshwar</td>
<td>3155</td>
</tr>
<tr>
<td>5</td>
<td>Mayurbhanj</td>
<td>17909</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Bhadrak</td>
<td>17513</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Cuttack</td>
<td>14973</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Kendrapara</td>
<td>14264</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Sambalpur</td>
<td>14209</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Sundargarh</td>
<td>13445</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s calculation.

4.4 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 Indices. 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 indices district-wise, coincidentally the study observes Pearson’s correlation coefficient between $CDIT$ and $CDIH$ is 0.99. In addition, the ranks of the districts are exactly the same in both measures. In order to escape from repetition, only $CDIT$ has been taken for further scrutiny. The ranking of all the thirty districts of the state on the basis of the indices is presented in Table 5.

Table 5. Crop Diversification in Odisha 2011-12: Theil Index

<table>
<thead>
<tr>
<th>Rank</th>
<th>District</th>
<th>CDI</th>
<th>Rank</th>
<th>District</th>
<th>CDI</th>
<th>Rank</th>
<th>District</th>
<th>CDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kandhamal</td>
<td>0.673</td>
<td>11</td>
<td>Balangir</td>
<td>0.479</td>
<td>21</td>
<td>Boudh</td>
<td>0.402</td>
</tr>
<tr>
<td>2</td>
<td>Rayagada</td>
<td>0.589</td>
<td>12</td>
<td>Nayagarh</td>
<td>0.458</td>
<td>22</td>
<td>Cuttack</td>
<td>0.401</td>
</tr>
<tr>
<td>3</td>
<td>Malkangir</td>
<td>0.575</td>
<td>13</td>
<td>Khordha</td>
<td>0.453</td>
<td>23</td>
<td>Mayurbhanj</td>
<td>0.384</td>
</tr>
<tr>
<td>4</td>
<td>Koraput</td>
<td>0.552</td>
<td>14</td>
<td>Kalahandi</td>
<td>0.446</td>
<td>24</td>
<td>Ganjam</td>
<td>0.377</td>
</tr>
<tr>
<td>5</td>
<td>Dhenkanal</td>
<td>0.548</td>
<td>15</td>
<td>Sundargarh</td>
<td>0.438</td>
<td>25</td>
<td>Puri</td>
<td>0.375</td>
</tr>
<tr>
<td>6</td>
<td>Anugul</td>
<td>0.540</td>
<td>16</td>
<td>Jharsuguda</td>
<td>0.432</td>
<td>26</td>
<td>Sonepur</td>
<td>0.369</td>
</tr>
<tr>
<td>7</td>
<td>Gajapati</td>
<td>0.537</td>
<td>17</td>
<td>Nuapada</td>
<td>0.414</td>
<td>27</td>
<td>Bhadrak</td>
<td>0.354</td>
</tr>
<tr>
<td>8</td>
<td>Debargarh</td>
<td>0.535</td>
<td>18</td>
<td>Baleswar</td>
<td>0.414</td>
<td>28</td>
<td>Nabarangpur</td>
<td>0.351</td>
</tr>
<tr>
<td>9</td>
<td>Keonjhar</td>
<td>0.506</td>
<td>19</td>
<td>Sambalpur</td>
<td>0.406</td>
<td>29</td>
<td>Kendrapara</td>
<td>0.349</td>
</tr>
<tr>
<td>10</td>
<td>Jajapur</td>
<td>0.479</td>
<td>20</td>
<td>Jagatsingpur</td>
<td>0.403</td>
<td>30</td>
<td>Baragarh</td>
<td>0.271</td>
</tr>
</tbody>
</table>

Source: Author’s calculation

From Tables 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 $CDIT$. 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. Analysis with help of the tables so far gives a sketchy picture on the relationship between infrastructure, productivity and diversification. The correlation matrix is presented in Table 6.
### Table 6: Pearson’s Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>INFI</th>
<th>PDVT</th>
<th>CDI</th>
<th>HYV</th>
<th>FERT</th>
<th>CRDT</th>
<th>MSUR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INFI</strong> Pearson Correlation</td>
<td>1</td>
<td>.580**</td>
<td>-.432</td>
<td>.140</td>
<td>.188</td>
<td>.768**</td>
<td>-.224</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.001</td>
<td>.017</td>
<td>.459</td>
<td>.320</td>
<td>.000</td>
<td>.235</td>
<td></td>
</tr>
<tr>
<td><strong>PDVT</strong> Pearson Correlation</td>
<td>.580**</td>
<td>1</td>
<td>-.638**</td>
<td>.633**</td>
<td>.436**</td>
<td>.548**</td>
<td>.198</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.001</td>
<td>.000</td>
<td>.000</td>
<td>.016</td>
<td>.002</td>
<td>.295</td>
<td></td>
</tr>
<tr>
<td><strong>CDI</strong> Pearson Correlation</td>
<td>-.432</td>
<td>-.638**</td>
<td>1</td>
<td>-.752**</td>
<td>-.567**</td>
<td>-.391</td>
<td>-.384*</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.017</td>
<td>.000</td>
<td>.000</td>
<td>.001</td>
<td>.032</td>
<td>.036</td>
<td></td>
</tr>
<tr>
<td><strong>HYV</strong> Pearson Correlation</td>
<td>.140</td>
<td>.633**</td>
<td>-.752**</td>
<td>1</td>
<td>.749**</td>
<td>.231</td>
<td>.545**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.459</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.219</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td><strong>FERT</strong> Pearson Correlation</td>
<td>.188</td>
<td>.436**</td>
<td>-.567**</td>
<td>.749**</td>
<td>1</td>
<td>.295</td>
<td>.404*</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.320</td>
<td>.016</td>
<td>.001</td>
<td>.000</td>
<td>.114</td>
<td>.027</td>
<td></td>
</tr>
<tr>
<td><strong>CRDT</strong> Pearson Correlation</td>
<td>.768**</td>
<td>.548**</td>
<td>-.391</td>
<td>.231</td>
<td>.295</td>
<td>1</td>
<td>-.150</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.002</td>
<td>.032</td>
<td>.219</td>
<td>.114</td>
<td>.428</td>
<td></td>
</tr>
<tr>
<td><strong>MSUR</strong> Pearson Correlation</td>
<td>-.224</td>
<td>.198</td>
<td>-.384**</td>
<td>.545**</td>
<td>.404*</td>
<td>-.150</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.235</td>
<td>.295</td>
<td>.036</td>
<td>.002</td>
<td>.027</td>
<td>.428</td>
<td></td>
</tr>
</tbody>
</table>

**. 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 and MSUR. 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 MSUR. 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.

#### 4.5 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.
(a) CDI on INFI and other explanatory variables

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

\[ CDI^T = 0.472 - 0.024 \text{INFI}_i + 0.004 \text{CRDT}_i - 0.01 \text{MSUR}_i + 0.005 \text{FERT}_i - 0.059 \text{HYV}_i + \epsilon_i \]

\[ p\text{-values} (0.000) \quad (0.034) \quad (0.810) \quad (0.426) \quad (0.755) \quad (0.002) \]

\[ R^2 = 0.686, \quad \bar{R}^2 = 0.620, \quad DWd = 2.006 \quad (\text{no autocorrelation}), \quad F = 10.47, \quad p\text{-value of } F = 0.000 \]

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, \( R^2 \) reveals that about 68.6 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 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 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 teleconnectivity 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.

(b) 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.

\[ PDVT = 9485.877 + 1662.46 \times INFI_i + 673.12 \times CRDT_i + 121.39 \times MSUR_i - 1149.07 \times FERT_i + 3904.90 \times HYV_i + \epsilon_i \]

\[
\begin{array}{cccc}
p-values & (0.000) & (0.029) & (0.542) & (0.89) & (0.278) & (0.002) \\
\end{array}
\]

\[ R^2 = 0.667, \quad \bar{R}^2 = 0.597, \quad DW \, d = 2.023 \text{(no autocorrelation)}, \quad F = 9.597, \quad \text{p-value of } F = 0.000 \]

The analysis observes that INFI and HYV have significant positive impact on land productivity. CRDT and MSUR have positive impact on productivity also, but this impact is not significant. Surprisingly the coefficient of productivity with respect to fertiliser is negative. Although 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 to 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 67 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.

5.0 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. The same was the observation by the present author in 2001. 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.

Endnotes

1. “The post-Green Revolution phase is characterized by high input-use and decelerating total factor productivity growth (TFPG). The agricultural productivity attained during the 1980s has not been sustained during the 1990s” (Kumar and Mittal, 2006).

2. For an elaboration, please refer Hazra (2001).

3. 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.

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

References


