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Effect of Rural Infrastructure on Agricultural Development: District Level Analysis in Karnataka

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EFFECT OF RURAL INFRASTRUCTURE ON AGRICULTURAL DEVELOPMENT: DISTRICT LEVEL ANALYSIS IN KARNATAKA

Soumya Manjunath and Elumalai Kannan*

Abstract

This paper empirically investigates the relationship between rural infrastructure and agricultural productivity in the state of Karnataka. The analysis has been carried out among the districts of Karnataka for the period of 1980-2010. The paper presents a framework of availability and utilisation of rural infrastructure to analyse these linkages. By and large, existing literature has stressed the importance of making adequate infrastructure available. However, the utilisation of these infrastructures has not been considered for explaining the differences in productivity. Rural infrastructure development indices have been constructed by using principal component analysis for availability and utilisation indicators. Random effects model is applied to examine how different categories of infrastructure affect agricultural productivity. The study establishes that the role of availability of infrastructures in rural areas is contributing to agricultural productivity. Infrastructure utilisation index also turns out to be a positive determinant of agricultural productivity. Along with provision of infrastructures, fertiliser input continues to play an important role in agricultural development. Despite the fact that availability of data limited the variables that could be considered, the study throws up evidence in support of greater investment in infrastructures in rural areas while at the same time stressing the need to take steps to maximise the utilisation of existing resources. Therefore, it is important to invest in providing region specific infrastructures to resolve the disparities across region.

Keywords: Infrastructure, Productivity, Agriculture, Karnataka

Introduction

The importance of infrastructure for development of agriculture has been widely recognised in most developing economies. Development of infrastructure is crucial especially in rural areas as they have implications for productivity gains and reduction in poverty (Fan and Thorat, 1999; Hazell and Haddad, 2001). Though climatic conditions, government support mechanisms, technological improvements, policy decisions, international trade etc, can facilitate better productivity; it does not diminish the importance of provision of adequate and appropriate infrastructural facilities at the ground level.

The need to achieve balanced regional development has been one of the key challenges for India's policy planners for quite some time. Imbalances in developmental processes could also be due to the fact that only a few growing sectors dominate the progress of the economy, adding to the continuum of rural-urban differences. In this regard, agricultural sector which assumes primary importance in rural areas, has been performing relatively poorer compared to the other sectors. Its declining contribution to GDP share, despite more than half of rural population being involved in this sector, is a testimony to the relatively poor performance. Agricultural development as a strategy to minimise regional differences continues to assume prominence even today.

The state of Karnataka presents a good case to examine the relationship between agricultural development and rural infrastructure as its production performance has been quite varying (Chand et al, 2009: Kannan and Shah, 2010). With large dry areas and some districts drought-prone, the development of the regions has been lopsided with most of the Northern parts of Karnataka at lower

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levels of development. "The vast extent of dry, unirrigated land, located primarily in Northern Karnataka, casts its long shadow on the socio-economic development of the local people in many significant ways" (Planning Commission, 2006, p. 5). The differences in agricultural performance and existence of regional disparities are often attributed to variations in natural resources endowments and socio-economic and institutional factors (Deshpande, 2006). Northern districts of Karnataka are poorer than the rest of the state (Planning Commission, 2007). Given the importance of infrastructure as a strategy for agricultural development, it is imperative to examine the pathways in which targeted infrastructure can help mitigate the regional disparities. Also, the scarce resources need to be mobilised to get the expected output and augment development of this primary sector.

The present study examines the linkages between rural infrastructure and agricultural productivity across the districts of Karnataka. The study attempts to analyse how different categories of rural infrastructure affected agricultural productivity over three decades across districts in Karnataka. Along with infrastructures, other inputs and variables which are drivers of agricultural development have also been analysed in the paper.

The paper has been organised into six sections. After a brief introduction, the paper focuses on reviewing the existing literature on the relationship between infrastructure and agricultural productivity in international and Indian contexts. This section also includes a discussion of the identified research gaps. The third section presents the conceptual framework and the classification of rural infrastructure adopted in the present paper. The data sources and methodology are presented in the fourth section, followed by the results of empirical estimation. The last section of the paper presents the conclusions of the analysis.

Review of Literature

The relationship between infrastructure and productivity has been examined by various researchers and policymakers. As early as in 1989, Aschauer examined the productivity of public capital in US for which he brought in government expenditure as a proxy for public good in the production function. Since Aschauer's analysis did not include other determinants of output nor for fixed effects, the estimates are more likely to be affected by spurious correlations. Some authors have explored the relationship between public infrastructure and economic growth using pooled time series and cross-section data to eliminate the problems of time series data. Munnell (1990) used core infrastructure such as highway, water and sewer systems and others, and examined each type of infrastructure.

Most economies that are primarily agrarian in nature have sought to investigate how agricultural productivity can be augmented through specific investments in infrastructure. Using farm level data, Segun (2008) empirically examined the place of infrastructure in agricultural productivity in Nigeria and found that rural infrastructure index had the highest positive impact on agricultural productivity. In a provincial level study, Li and Liu (2009) examined the effect of infrastructure development in agricultural production technical efficiency and established that that except telecommunications, all the other infrastructure variables had a positive impact on agricultural production. Llanto (2012) used a random effects GLS regression model and found that access to electricity and paved roads had a positive and significant impact on agricultural labour productivity while irrigation had a positive but insignificant relationship with agricultural labour productivity.

Some studies used the methodology of factor analysis to arrive at aggregate indices (Rao, 1990, Majumdar, 2004, Swaminathan, 2009) and examine agricultural development. For instance, a study by Majumdar (2004) which aimed at examining the relationship between infrastructural availability and development using various indices for a twenty-year time period spanning 1971-1991 at the district level found that the association of agricultural development was strongest with power infrastructure (0.21), followed by educational (0.20) and transport infrastructure (0.17).

In the Indian context, Ashok and Balasubramanian (2009) employed total factor productivity approach for the districts of Tamil Nadu during 1998-99 to 2003-04 and found that irrigation, roads, markets and literacy had greatest positive influence. Ghosh and De (2004) in their paper investigated the role of various infrastructure facilities in determining the level of economic development across Indian states. Swaminathan (2009) adopted Biehl's methodology to arrive at a measure of infrastructure index and using a modified Cobb-Doughlas production function with infrastructure investment as an input in production. The results showed that the dispersion in social infrastructure was the maximum (0.28) followed by economic (0.21) and general infrastructure (0.17) thereby underlining the importance of social infrastructure in achieving/hindering inclusive growth in the Maharashtra economy.

Using fixed effects model with introduction of agroclimate and time interactions, Binswanger et al (1999) found that except for irrigation, all other infrastructure variables influenced aggregate crop output positively. Fan et al (1999) used a simultaneous equations model and showed that government spending on productivity-enhancing investments and rural infrastructure, directly resulted in reducing rural poverty, and indirectly resulted in agricultural productivity growth.

Thus, various studies both at the international level and in the Indian context (Spencer, 1994; Kurian, 2001, Chand, 2001; Thorat et al, 2003; Modi, 2005) pointed out the importance of economic infrastructure to boost productivity in agriculture and as a strategy for rural development. The role of transport (Spencer, 1994; Binswanger et al, 1989; Felloni et al, 2001; Thorat et al, 2003; Rajeev, 2008), irrigation and electricity (Barnes and Binswanger, 1986, Felloni et al, 2001; Thorat et al, 2003; Modi, 2005) in augmenting agricultural productivity have been highlighted in literature.

After a brief outline of the research studies, it is clear that most studies analyse the availability of infrastructure in examining its linkage with agriculture. Studies that examine the linkages between agricultural productivity and infrastructures have mainly stressed on the importance of provisioning of infrastructures. The present study seeks to establish that mere creation of infrastructures in rural areas will not influence improvements to agricultural productivity. Utilisation of these infrastructure stocks is imperative to achieve the desired levels of development. How utilisation of rural infrastructure can influence agricultural development has not been accounted for explaining differences in productivity in existing literature. The main contribution of this paper lies in empirically assessing the importance of utilisation of the existing infrastructure to achieve the desirable goals, along with the availability of infrastructures.

Analysing the relationship between infrastructure and agriculture needs to go beyond a macro analysis. The regional characteristics, agro-climatic variability, governmental policies are so varied that an analysis at the sub-national level would be useful to understand the contribution of infrastructure to agricultural development in a specific context. In this regard, the present study attempts to empirically examine the impact of rural infrastructure on agricultural productivity at the district level for three decades.

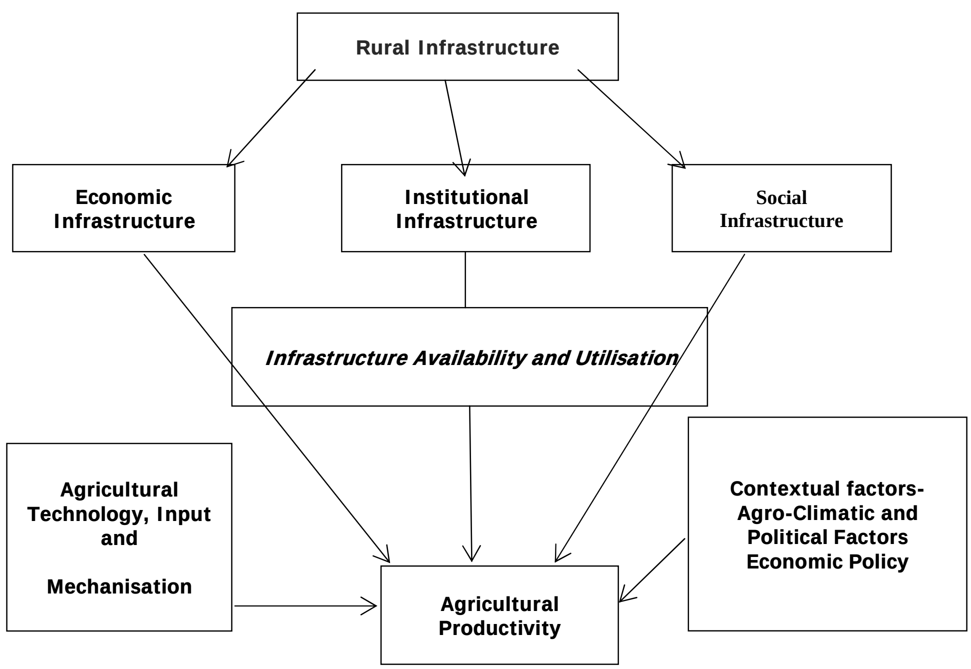
The present paper seeks to answer the following research questions:

- *Does rural infrastructure development influence agricultural productivity significantly?*
- *Which type of rural infrastructure has the greatest impact on agricultural productivity?*

Conceptual Framework

The present study considers rural infrastructure to include economic infrastructure (irrigation, electricity, transport, telecommunication); institutional infrastructure (market, credit); and social infrastructure (education and health). These infrastructures contribute to agricultural development, either directly or indirectly. Agricultural development is a multi-dimensional phenomenon where different factors and conditions should work together to achieves the potential level of output. It is influenced by various factors such as agro-climatic conditions, development of rural infrastructure, technological improvements and economic policies as shown in Figure 1.

Figure 1: A Diagrammatic Representation of the Relationship Between Agriculture and Rural Infrastructure



Source: Author's Diagram

The provision of both economic and institutional infrastructure, while making basic services and facilities available to the farming population, assumes that the producers have the required skills and competencies to tap their full potential. In this regard, the development of social infrastructure becomes important as it contributes to the development processes indirectly. Upgrading the skill formation of the farmers to achieve greater operational precision in accessing and utilisation of services by other infrastructural facilities is significant (Acharya et al, 1992). Such social infrastructure has not received as much attention in agricultural research literature as much as the economic and institutional infrastructure. When all three types of rural infrastructures are combined together with better agricultural input such as improved seeds, fertiliser and agricultural machinery, they contribute to decisions on inputs and farming practises thereby increasing agricultural production. Further, the infrastructures should be made available in rural areas. At the same time, it is proposed that, these facilities and services of the public need to be utilised to their fullest potential to benefit from these investments and reach greater levels of agricultural productivity. In our framework, economic policy and political factors are seen as exogenous factors that are required to invest in infrastructure.

Data and Methodology

1. Data Sources

Data on agricultural and rural infrastructural development indicators were collected and compiled from various secondary sources. Most of the data on agricultural development indicators were collected from the Statistical Abstract of Karnataka, Karnataka at a Glance, Quinquennial Livestock Census, District Statistical Hand Books, Human Development Reports and Karnataka Development Report. Data on infrastructure development indicators were collected from various sources such as the Statistical Abstract of Karnataka, Population Census, Reports of Karnataka Food and Civil Supplies Corporation, Departments of Co-operation and Rural Development and some unpublished documents of Directorate of Economics and Statistics. The district level data was compiled for the period 1980-81 to 2009-10 for the 19 districts in Karnataka[1].

2. Methodology

In order to construct indices of rural infrastructure, the study adopted the method of Principal Component Analysis (PCA) to combine the developmental indicators into composite indices. PCA is a widely used method where it helps in explaining the variation of the observed variables based on a set of dimensions. Many studies have used PCA to construct developmental indices (Venkataramanan et al, 1985; Gayathri, 1997; De and Ghosh, 2005; De, 2010).

The correlated original variables are transformed into a new set of uncorrelated variables using the correlation matrix. This statistical technique linearly transforms an original set of variables into a substantially smaller set of uncorrelated variables that explain most of the information in the original set

[1] One of the major concerns while performing the analysis at the district level has been the non-availability of relevant quality data across all times at the district level. Availability of existing data on infrastructure variables of rural nature at a district level is generally scarce. Selection of variables to some extent has also been guided by the availability of the data at the district level. Given the limitations, the study has attempted to analyse the relationship between agricultural development and rural infrastructure at the sub-national level in Karnataka.

of variables. The PCA technique takes N variables $x_1, x_2, .. x_N$ and finds linear combinations of these to produce principal components $Z_1, Z_2, ... Z_N$ that are uncorrelated. This can be presented in the following form:

$$
\begin{aligned}
Z_1 &= a_{11}x_1 + a_{12}x_2 + \ldots + a_{1N}x_N \\
Z_2 &= a_{21}x_1 + a_{22}x_2 + \ldots + a_{2N}x_N \\
&\ldots \\
Z_N &= a_{N1}x_1 + a_{N2}x_2 + \ldots + a_{NN}x_N
\end{aligned} \tag{1}
$$

PCA uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components. There are N principal components i.e. the same as the number of variables. The Z1 or the first Principal Component is constructed as $Z1 = a_{11} x_1 + a_{12} x_2 + \ldots a_{1N} x_N$.

PCA consists of finding the eigen values λj of the correlation matrix. The correlation coefficients between the principal components Z and the variables x are called component loadings, r (Z, x) j i. Finally, the factor loadings for the first Principal Component Z1 are obtained by dividing each column (or row) sum by the square root of the grand total. The factor loadings thus obtained are the correlation coefficients of the respective indicator with the composite index. The weights are applied to all the variables xj in Equation (1) to satisfy the conditions of being uncorrelated and that the first component accounts for the maximum possible proportion of the variance of the set of x s.

In order to rule out a single variable to have its influence on the factor loadings, the variables were standardised based on geographical area or population and then linearised to remove the scale effects (Nardo et al, 2005). The variables of infrastructure availability and utilisation used to construct the developmental indices are given in Table 1.

For estimating the relationship between rural infrastructure and agricultural productivity, we used a large panel set using random effects in which agricultural productivity is a function of infrastructure indices, human capital and natural resource factor. The data set is a balanced panel of 19 districts for the thirty-year period in the state of Karnataka.

3. Selection of Developmental Indicators

The three types of infrastructure being considered in the study are economic, institutional and social infrastructures. Each infrastructure category is normalised by geographical area if it pertains to a facility serving to an area or by rural population, if it is a service to the rural population. Overall rural infrastructure index has been constructed using availability and utilisation indicators of irrigation, electricity, transport, telecommunication, market, cooperative credit, education and health in rural areas.

In this section, we briefly describe the variables used in the paper to capture the developmental indicators of agricultural and rural infrastructural development indicators.

To indicate irrigation infrastructure, we have used the ratio of net irrigated area to net sown area to indicate availability of irrigation infrastructure and its utilisation by the ratio of gross irrigated area to total gross cropped area. Number of towns and villages electrified per thousand hectares of geographical area and irrigation pump sets per lakh hectare of net sown area are used to indicate electricity infrastructure.

The paper considers only road transport to capture the transport infrastructure since road is the major avenue of connectivity in rural areas. We use total road length (km) per thousand hectare of geographical area to indicate the spread of road network. The motor vehicles (in thousand) per lakh rural population are taken as proxy for utilisation of road transport. Number of telephone exchanges per lakh hectare of geographical area and number of telephones (in '000) per lakh rural population were used as availability and utilisation indicators of telecommunication infrastructure.

Institutional infrastructure index has been constructed using indicators of market and agricultural co-operatives. Regulated markets include those markets which are set up and maintained by the government. The availability of financial institutions is captured using number of agricultural credit co-operatives societies per lakh hectare of geographical area. Credit from agricultural co-operatives is used to capture the utilisation of these institutions.

To construct the social infrastructure index, we used the availability indicators such as number of government primary schools per thousand hectare of geographical area and the number of primary health care centres per lakh hectare of geographical area for education and health infrastructure respectively.

Table 1: List of Variables of Rural Infrastructural Development

No.	Infrastructure Types	Indicators	Variables	
			Availability	Utilization
1.	Economic Infrastructure	Irrigation	Ratio of Net Irrigated Area to Net Sown Area	Ratio of Gross Irrigated Area to Gross Cropped Area
		Electricity	No. of villages and hamlets electrified per thousand hectare of geographical area	Irrigation pump sets electrified (on '000) per lakh hectare of Net sown area
		Transport	Total road length (km) per thousand hectare of geographical area	No. of total registered motor vehicles (thousand) per lakh rural population
		Telecommunication	No. of telephone exchanges per thousand hectare of geographical area	No. of telephones in use (hundreds) per lakh rural population
2.	Social Infrastructure	Education	No. of primary schools per lakh hectare of geographical area	No. of students in primary schools per lakh child population in the age group of 5-14 years
		Health	No. of Primary Health Centres per lakh hectare of geographical area	No. of cases of immunisation (in thousands) per lakh rural population
3.	Institutional Infrastructure	Markets	No. of regulated markets per lakh hectare of geographical area	Value of Turnover (Lakhs) per thousand hectare of NSA
		Agricultural Credit	No. of primary agricultural credit cooperatives per lakh hectare of geographical area	Loans from Agricultural Credit Co-operatives per lakh cultivators

Source: Author's compilation

Agricultural NSDP (Constant Prices 1999-00) in Rs per hectare of net sown area is taken as the dependent variable as it captures incomes received by different factors of production. This is referred to as land productivity in our paper while estimating the econometric model. We use rainfall variability to capture the natural resource variable, which has direct impact on agriculture. Fertiliser consumption (kg) per lakh hectare of net sown area, percentage of area under HYV (in thousand) to net sown area and number of tractors including power tillers (in thousand) per lakh hectare of net sown area have been considered to indicate input, technology and mechanisation variables, respectively.

4. Model Specification

In order to establish the linkages between rural infrastructure and agricultural productivity, we have estimated different kinds of equations. Since we have a panel dataset consisting of 19 cross-sectional units over 30 years, using a pooled OLS estimation would not be appropriate (Kennedy, 2003). To overcome these short comings, panel data techniques are more appropriate than single equation models.

The OLS model neglects heterogeneity effects that are explicitly taken into the fixed effects model (Gujarati, 2011, p. 284). An econometric estimation using cross sectional and time series using OLS regression presents challenges such as controlling for endogeneity, possible omitted variables (unobserved fixed effects), and measurement errors in estimation (Dorosh et al, 2010, p-6).

The present paper uses the random effects model for estimation of the relationship between rural infrastructure and agricultural development in Karnataka. The random effects estimation has a generalised covariance matric to include the distribution of residuals. Random effects model includes individual error components which are not correlated with each other. Unlike the fixed effects model, in random effects model the individual intercept is uncorrelated with the regressors. The coefficient estimates in the model are the outcome of a weighted average of time series and cross sectional relationship between the variables. The Wald-Chi square test shows the overall statistical significance of the model.

We estimate the relationship between infrastructure and agricultural productivity using random effects GLS regression model.

$$y_{it} = \beta_i X_{it} + \alpha_i + \omega_{it}$$

Where,

y_{it} is the dependent variable where i = district and t = time

X_{it} represents independent variables

β_i is the coefficient of independent variables

ω_{it} is the composite error term including $\omega_{it} = u_{it} + \varepsilon_{it}$ where, u_{it} is the cross section error component, and ε_{it} is the combined time series and cross section error component

Empirical Estimation

Before we present the empirical results of the investigation of the linkages between agricultural productivity and rural infrastructure, we give the tables of descriptive statistics with the number of observations, mean and standard deviation. The table 2 presents the summary statistics of the developmental indicators of agriculture, infrastructure availability and utilisation variables used in the study. Except HYV area (%) and rainfall variability which are taken in their ratio forms, the other variables are in their logarithmic forms in the analysis.

Table 2: Summary Statistics

Sl No	Variable	Definition	No. of Observations	Mean	Std Dev
a	**Dependent variable**				
1	Agricultural Land productivity	Agricultural NSDP (Constant Prices 1999-00) in Rs per hectare of net sown area	570	9.67	0.73
b	**Independent variables**				
2	Infrastructure Availability index	Index measure from PCA using all measures of infrastructure availability indicators	570	1.68	0.54
3	Infrastructure Utilization index	Index measure from PCA using all measures of infrastructure utilisation indicators	570	1.37	0.51
4	Overall Infrastructure index	Index measure from PCA using all measures of rural infrastructure indicators	570	1.71	0.43
5	Input	Fertiliser consumption per lakh hectare of Net Sown Area	570	11.35	0.74
6	Machinery	Number of tractors and tillers per lakh Net Sown Area	570	3.89	0.90
7	Technology	Area under HYV as a percentage of Net Sown Area	570	37.02	16.57
8	Rainfall Variability	Deviation in actual average rainfall (mms) from district specific normal rainfall (mms)	570	43.17	316.92

Note: Except rainfall variability and area under HYV, all the other variables are in their logarithmic form.

Source: Author's compilation

Stationary Test Results

Since the variables used in the analysis are of thirty-year period, we test for stationary as these time series variables could exhibit trending behaviour. If the variables are not stationary, then the assumption of asymptotic property will not hold good. Therefore, to check for the unit root property of the variables, the paper uses Hadri LM Panel root test (Hadri, 2000). The null hypothesis of Hadri LM panel unit-root states that all panels are stationary in nature. Its alternate hypothesis states that some panel may contain unit root. Table 3 presents the stationary test of the variables using Hadri LM panel unit tests

Table 3: Hadri LM Panel Unit Root Test

Variable	Z Statistic	p value	Order of Integration
Land Productivity	-0.94	0.826	I (0)
Infrastructure Availability Index	-1.60	0.946	I (0)
Infrastructure Utilisation Index	-1.63	0.949	I (0)
Overall Rural Infrastructure Index	-0.48	0.683	I (0)
Fertiliser consumption	-2.21	0.986	I (0)
HYV area %	1.57	0.058	I (0)
Tractor use	-3.40	1.000	I (0)
Rainfall variability	-1.15	0.875	I (0)

Source: Author's Compilation

The results of the panel unit root test show that the variables are stationary at level form. Variables such as infrastructure availability index, infrastructure utilisation index, overall infrastructure index, fertiliser consumption, tractor use, and rainfall variability are stationary in level form at 5 per cent level of significance. HVY area (%) is stationary at 10 level of significance in its level form. Therefore, we do not reject the null hypothesis and conclude that all the variables exhibit stationary property in its level form. We then proceed to estimate the random effects model to establish the determinants of agricultural productivity in Karnataka.

Results of Empirical Estimation

Determinants of Agricultural land productivity using infrastructure indices

For the present analysis, the paper uses agricultural land productivity as the dependent variable measured by agricultural net state district domestic income Rs per hectare of net sown area. The explanatory variables in the model include indices of overall availability and utilisation of rural infrastructure, fertiliser consumption, tractors and tillers, area under HYV, and rainfall variability. We also introduce a regional dummy distinguishing the Southern and Northern districts of Karnataka so as to capture the regional differences in land productivity.

In table 4, we present the results of the estimation of the relationship between land productivity and infrastructure by using availability and utilisation indicators of rural infrastructure. Infrastructure availability and infrastructure utilisation index have high positive correlation of 0.94. Therefore, we have estimated two different models as seen in the table 4.

Table 4: Panel model of Land Productivity with Rural Infrastructure Indices

Variables	Pooled OLS	Random effects I	Pooled OLS	Random effects II
Infrastructure Availability index	0.24*** (4.41)	0.26*** (6.35)	-----	-----
Infrastructure Utilisation index	-----	-----	0.27*** (5.34)	0.35*** (9.38)
Fertiliser consumption	0.23*** (4.34)	0.16*** (4.08)	0.24*** (4.45)	0.16*** (4.25)
Tractor use	0.11** (2.88)	0.11* (3.18)	0.13* (3.29)	0.09** (0.005)
HYV Area (%)	0.00001 (0.01)	0.001 (1.23)	0.0002 (0.25)	0.001 (1.24)
Rainfall variability	-0.00002 (-0.58)	-0.00002 (-0.8)	-0.00002 (-0.60)	-0.00002 (-0.59)
Regional Dummy	0.16*** (6.06)	0.16*** (8.81)	0.17*** (6.91)	0.18*** (10.31)
Constant	2.58*** (11.88)	2.90*** (16.94)	2.54*** (11.76)	2.89*** (17.58)
No. of observations	570	570	570	570
R square Within Between Overall	 0.38	 0.52 0.17 0.38	 0.38	 0.56 0.12 0.38
Breusch-Pagan LM test, chi2 (p-value)	1383.12 (0.000)		1525.84 (0.000)	
F value	F(6, 563)= 56.7 Prob>F=0.00	Wald chi2(6)=591.5 Prob > chi2=0.00	F(6, 563)=59.1 Prob>F=0.00	Wald chi2(6)=683.1 Prob>Chi2=0.00

Note: Figures in parentheses indicate t value, ***Significant at 1%, ** Significant at 5 %, * Significant at 10%

Source: Author's Calculation

The regression results of random effects Model 1 indicate a positive and significant relationship of agricultural land productivity with availability of rural infrastructure (0.16***). A 1-unit increase in the provisions of infrastructure in rural areas is associated with an increase of around 0.24 units in land productivity. The estimated coefficient value for fertiliser use is highly significant and has a positive association with land productivity. Tractor use representing machinery is positive and significant at 10 per cent. HYV area (%), which is used as a proxy to capture technology, shows a positive sign, though not significant.

The coefficient of the regional dummy variable is positive and significant at 1% level suggesting that productivity of land is relatively higher in Southern districts than their Northern counterparts. The model is fit as seen by the Wald chi square value of 591.5. The Breusch-Pagan statistic clearly establishes that panel regressions are better suited than the pooled linear regressions. The model seems to provide a good explanatory framework, explaining around 38 per cent of the variance in the dependent variable.

Similarly, the regression output according to random effects Model II, where infrastructure utilisation index has been used as one of the explanatory variables shows high and significant relationship with land productivity. It is important to note here that the coefficient value of utilisation index is higher than that of availability index in determining improvements in land productivity thereby indicating that along with provisioning of infrastructures, the existing infrastructures need to be fully used to their potential to reap their benefits.

Fertiliser input continues to be an important indicator of agricultural productivity. A 1% increase in the fertiliser input usage increases the land productivity by 24 per cent. Variations in rainfall as captured by the rainfall variability have negative though insignificant relationship with land productivity. The growth in adoption of mechanisation in agriculture as indicated by usage of tractors and tillers also shows a positive relationship with land productivity. The overall R^2 of 38 per cent shows that the explanatory power of the model is good.

Determinants of land productivity using overall rural infrastructure index

We regress overall rural infrastructure index which includes both availability and utilisation infrastructure indicators, and other variables such as fertiliser consumption, tractors and tillers, area under HYV, rainfall variability and regional dummy on land productivity.

Table 5 presents the estimation results of land productivity with overall rural infrastructure index where the combined effect of availability and utilisation of infrastructures are being captured in the model. Panel regressions are appropriate than pooled linear regression as shown by the Breusch-Pagan statistic. The model has a good overall fit and the explanatory power of the model is around 33 per cent.

The random effects model III shows that overall infrastructure has positive and highly significant impact on land productivity. A significant coefficient value of 0.41 for overall index of rural infrastructure implies that a 1% improvement in provisioning and utilisation of infrastructure facilities could induce increases in land productivity by almost 0.4%. The coefficient of fertiliser usage is positive and highly significant. The coefficient of regional dummy is positive and significant suggesting that districts lying in the Northern parts have relatively lower land productivity. Therefore, the results of the model show that improvement in provisions and usage of rural infrastructures along with increased use fertiliser use, adoption of mechanisation bring about increases in overall productivity in agriculture.

Table 5: Panel Model of Land Productivity with Overall Rural Infrastructure Index

Variables	Pooled OLS III	Random effects III
Overall Index	0.36*** (5.40)	0.41*** (8.72)
Fertiliser consumption	0.23*** (4.24)	0.16*** (3.99)
Tractor use	0.10 (2.44)	0.07** (2.10)
HYV Area (%)	0.001 (0.45)	0.001** (0.02)
Rainfall variability	-0.00002 (-0.44)	-0.00001 (-0.46)
Region Dummy	0.16*** (6.20)	0.16*** (9.09)
Constant	2.54*** (11.74)	2.86*** (17.20)
No of observations	570	570
R square Within Between Overall	 0.39	 0.55 0.15 0.38
Breusch and Pagan LM test, chi2 (p-value)		1480.61 (0.000)
F value	F (6, 563) = 59.18 Prob > F = 0.000	Wald chi2(6)=658.6 Prob > F = 0.000

Note: Figures in parentheses indicate t value, ***Significant at 1%, ** Significant at 5 %, * Significant at 10%

Source: Author's Calculation

Conclusion

Considering the importance that agricultural sector holds for Karnataka economy, the present paper assesses the relationship between agricultural productivity and infrastructure development across the districts of Karnataka. The foregoing analysis provides insights into understanding the main drivers of agricultural productivity in Karnataka using land productivity as the dependent variable. In order to examine the relationship between rural infrastructure and agricultural productivity, the paper focused on different classifications of rural infrastructure and estimated the influences of infrastructure on agricultural productivity using district level data for the period between 1980 and 2010 in Karnataka.

In contrast to the earlier studies, the present analysis develops infrastructure availability and utilisation indices to examine the impact of rural infrastructure on agricultural productivity. We employed a random effects model to estimate the relationship between rural infrastructure and agriculture using a panel of 19 cross-section units spanning over 30 years. The random effect estimations showed the importance of rural infrastructure in boosting agricultural productivity. The study emphasises the role of making the infrastructures available in rural areas as significantly contributing to agricultural productivity. Infrastructure utilisation index has turned out to be significant and positive, indicating that utilisation of infrastructure can also influence productivity in agriculture positively. Also, more developed districts have better infrastructure facilities while the lagging regions are inadequate both in terms of infrastructure availability and utilisation. Along with infrastructures, the use of traditional inputs such as fertiliser application and the mechanisation of agriculture as indicated by tractor use are also responsible for significant differences in land productivity across the districts.

There is a need to introduce new infrastructures and efficient use of existing ones in rural areas. Resolving regional disparities does not call for equalising provisions of every infrastructure, but provision of those that are region specific. Improvements in institutional mechanisms can go a long way in improving agricultural productivity. Utilisation infrastructure index of economic indicators turns out to be a positive determinant of agricultural productivity. Optimal utilisation of existing infrastructure is a result of a combination of factors. Utilisation of some infrastructure is conditional on the availability and quality of other infrastructure and it is possible that the lowest common denominator determines the overall utilisation of infrastructure.

Thus, rural infrastructure affects agricultural productivity directly through improvements in infrastructures. Therefore, assessing the importance of utilisation of the infrastructure brings to fore several key points that may be ignored if focus remains only on addition to the stock of infrastructure. Further, strengthening human capital and augmenting information awareness enables better usage of existing structures. Thus, the study throws up evidence in support of greater investment in infrastructures in rural areas while at the same time calling for steps to be taken to maximise the utilisation of existing resources.

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