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Infrastructure and Development in Rural India

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This article evaluates rural infrastructure facilities in 16 major states of India, and examines their impacts on some income and non-income dimensions of rural development. Despite several public initiatives for infrastructure development in rural India, facilities continue to be poor and progress has been mostly unsatisfactory with differential performance across states. Estimates of regression coefficients of the composite indices and individual indicators of rural infrastructure reveal that improved physical and social infrastructure and livelihood opportunities enhance agricultural productivity and output, improve literacy and life expectancy, and reduce poverty and infant mortality. The results, showing the relative importance of various infrastructures, suggest that the government should prioritise additional investments in electricity, roads, irrigation, housing and telecommunications to enhance overall well-being.

Keywords: *Agricultural Development, Rural Infrastructure, Rural Development, Rural Poverty*
JEL Classification: *H54, O15, O18, Q19*

1. Introduction

The importance of infrastructure for economic growth and development in rural area can hardly be overemphasised in a developing economy like India. With poor rural infrastructure, even a marginal improvement in its quantity and quality could significantly improve economic development and human

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well-being. Improving basic infrastructure, such as roads, transport, electricity, telecommunications, housing, health, water and sanitation, is essential for development and well-being of the rural population. The development of rural infrastructure could promote economic growth, improve the standard of living of the population and reduce the incidence of poverty by generating both farm and non-farm employment and earning opportunities, increasing productivity, providing access to basic goods and services and improving the health and physical condition of people (NCAER, 2007). Empirical studies also report a strong relationship between infrastructure, economic growth, rural development and poverty reduction.

In spite of the crucial importance of infrastructure, significant deficiencies have persisted in rural infrastructure across Indian states. The quantity and quality of infrastructure facilities are substantially lower in rural areas than in urban areas. A relatively low density of population, low household incomes and the absence of scale economies are considered to be challenges to the expansion of basic infrastructure facilities in rural areas.

The present study evaluates the status of rural infrastructure facilities in 16 major states of India, and examines the impacts of infrastructure on some income and non-income dimensions of rural development. The states included in this study are: Andhra Pradesh (AP), Assam, Bihar, Gujarat, Haryana, Himachal Pradesh (HP), Karnataka, Kerala, Madhya Pradesh (MP), Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu (TN), Uttar Pradesh (UP) and West Bengal (WB). The data set used in the study was compiled from the various sources cited. The rest of the paper is organised as follows. The second section reviews the literature evaluating the relationship between infrastructure and economic development with special reference to rural development; the third section reviews the Indian government's initiatives for and expenditure on rural infrastructure; the fourth section evaluates the status of rural infrastructure; the fifth section empirically examines the nexus between infrastructure and rural development and the sixth section concludes.

2. Review of Literature

The importance of infrastructure in economic growth and development has attracted considerable attention in the literature. The importance of social overhead capital in economic development in general and agricultural development in particular has long been recognised (see, for example, Hirschman, 1958; Mellor, 1976; Rosenstein-Rodan, 1943; Rostow, 1960; Wharton, 1967).

Infrastructure accelerates economic growth by raising productivity and lowering production costs. Criticising the existing growth theories for not explicitly considering infrastructure as an input in production function, and exploring the mechanisms through which infrastructure can influence economic growth, Carlsson, Otto and Hall (2013) demonstrate the importance of transport and digital communications infrastructure in economic growth by reducing the cost of trade, facilitating economies of scale and accumulation of knowledge.

The role of infrastructure in overall economic growth and development in India has been extensively examined in the literature. States with better infrastructure facilities are more attractive for domestic and foreign private investment, and perform better in terms of economic growth. Disparities in per capita income across states have been attributed to inter-state disparities in physical, social and financial infrastructures (see, for example, Ghosh, 2012; Ghosh & De, 1998, 2004; Lall, 1999). Sahoo and Dash (2009, 2012) and Dash and Sahoo (2010) report that physical and social infrastructures have played an important role in economic growth in India and some other South Asian countries, such as Bangladesh, Pakistan and Sri Lanka. They observe a unidirectional causality running from infrastructure development to output growth. Chatterjee (2005), Demurger (2001), Sahoo, Dash and Nataraj (2010) and Stephane, Vellutin and Warlters (2007) explain China's high economic growth and regional disparities in terms of infrastructure.

Like general infrastructure, rural infrastructure also contributes to rural economic growth and poverty alleviation by enhancing agricultural productivity, increasing rural farm and non-farm employment and improving living standard of the rural population. It is argued that 'Roads, electricity supplies, telecommunications, and other infrastructure services are limited in all rural areas, although they are of key importance to stimulate agricultural investment and growth' (FAO, 1996, Chapter 10, p. 15). It is also argued that human well-being in terms of education and health depends crucially on infrastructure services, such as safe drinking water and sanitation to prevent disease, electricity to serve schools and health centres and roads to access basic necessities for human life (Datt & Ravallion, 1998). The lack of infrastructure is considered a major barrier to sustainable human development. An excellent and comprehensive overview of the various aspects of rural infrastructure in India is available in Satish (2007).

Several studies (for example, Antle, 1984; Binswanger, Khandker & Rosenzweig, 1993; Fan & Hazell, 2000; Fan, Hazell & Haque, 1998, 2000; Mellor, 1976; World Bank, 1994) demonstrate the importance of infrastructure in agricultural and rural development. Infrastructure contributes to agricultural

growth by raising productivity, increasing farmers' access to input and output markets, increasing consumer demand in rural areas, stimulating rural farm and non-farm economy, accelerating the process of commercialisation in agriculture and the rural sector and in facilitating the integration of rural economies with the rest of the economy. The adoption and dissemination of high-yielding variety (HYV) technology depend crucially on rural facilities, such as irrigation, extension services, availability of credit and marketing. Mellor (1976) has noted the strategic role that rural infrastructure plays in generating large multiplier effects in the economy with a growth in agriculture.

Rural infrastructures help reduce poverty through a positive effect on agricultural productivity, real incomes and employment in the agriculture and non-agriculture sectors (World Bank, 1994). Higher farm productivity, per capita farm income and employment in farm and non-farm sectors were found to be associated with lower level of rural poverty. Infrastructure also contributes directly to poverty alleviation by providing and supporting the delivery of key services, such as access to electricity, safe drinking water and sanitation. Investment in rural infrastructure was found to be associated with lower transportation costs and transaction costs of credit services, increased farmers' access to various markets and substantial expansion in agriculture in India (Binswanger et al., 1993). The importance of rural infrastructure in agricultural growth, rural development and poverty alleviation in India and China has been extensively examined by Fan and Hazell (1999), Fan et al. (1998, 2000), Fan, Hazell and Thorat (2000a, 2000b), Fan, Zhang and Zhang (2002) and Zhang and Fan (2000). The positive effects of rural infrastructure on rural development and poverty alleviation through expansion of markets, economies of scale, improvement in factor market operations and commercialisation in agriculture and rural sector have been reported in several studies (see, for example, Binswanger et al., 1993; Howe & Richards, 1984; Jacoby, 1998; Jahan & McCleery, 2005; Lebo & Schelling, 2001). A number of studies (for example, Ellis & Nyasulu, 2003; Jayaraman & Lanjouw, 1998; Lanjouw, Quizon & Sparrow, 2001; Reardon, Berdegue & Escobar, 2001; Zimmerman & Carter, 2003) investigate how a greater investment in infrastructure enhances agricultural productivity and improves the living standard of rural households through diversification of activities in rural areas. Bhatia (1999) has reported a strong positive relationship between the rural infrastructure index (including rural electrification, roads, transport, health, irrigation, farm credit, fertiliser, agricultural marketing, research and extension) and food grain productivity per hectare in India.

The impact of specific infrastructure, such as rural roads, transport, power, irrigation and access to electricity, on agricultural development

and poverty alleviation has also been examined (see, for example, Bansal & Patil, 1979; Binswanger et al., 1993; Chakraborty & Guha, 2009; Thorat & Sirohi, 2004). In most of the studies, rural roads were reported to be the most important infrastructure contributing to rural development. Rural roads help disseminate agricultural technology by improving access to input and output markets and helping the farmers realise better input and output prices. Better road conditions lead to more efficient allocation of resources by reducing transaction and marginal costs of agricultural production. Higher agricultural production and productivity reduce rural poverty through trickle-down effects. Rural households gain better access to health care, education and credit facilities through improved road and transport facilities. Better road connectivity invariably improves rural–urban linkages, and strengthens backward and forward linkages in the farm sector. This also opens up avenues for employment outside the village, improving the living conditions of the poor. Empirical evidences from other countries also demonstrate the importance of infrastructure in rural development (see, for example, Estache & Wodon, 2014; Fan & Zhang, 2004; Li & Liu, 2009; Yamauchi, 2016).

The role of rural infrastructure in rural development has been evaluated in the literature mostly by examining the impacts of specific infrastructure indicators on various aspects of rural development. However, the relationship between rural development and various composite indices of rural infrastructure has not been adequately examined, largely due to the lack of adequate data on rural infrastructural indicators, on the basis of which composite indices can be constructed. Moreover, the status of rural infrastructure facilities and variations across Indian states at different time-points has not been given adequate attention in the literature. This article makes a comprehensive study of rural infrastructure in India by evaluating individual and composite indices across 16 major states, analysing their variations, classifying states into categories based on their achievements in infrastructure building and, finally, examining the effects of individual indicators and composite indices of rural infrastructure on various dimensions of rural development.

3. Initiatives and Expenditure on Rural Infrastructure

There is no denying the fact that there is an urgent need to re-energise India's rural economy, including the farm and non-farm sectors. This is needed because of the importance of the rural sector, as 68.84 per cent of the population lives in the rural area (as per the 2011 Census), and more than 50 per cent of the workforce is engaged in agriculture for its livelihood. Under these conditions,

the importance of rural infrastructure in increasing agricultural productivity and farm and non-farm employment and in reducing rural poverty, and raising rural living standards hardly needs emphasis. Since infrastructure is regarded as a public good and the private sector may not be interested in investment in it, public investment is needed to build basic rural infrastructure. Several government initiatives have been taken to augment and improve rural infrastructure, some of which are the: (i) Rural Infrastructure Development Fund (RIDF), (ii) Accelerated Irrigation Benefits Programme, (iii) Pradhan Mantri Gram Sadak Yojana, (iv) Rajiv Gandhi Grameen Vidyutikaran Yojana and (v) National Rural Employment Guarantee Act 2005.

The RIDF, set up in the National Bank for Agriculture and Rural Development (NABARD) in 1995–96, presently covers 36 activities under three broad categories: (i) Agriculture and related sectors, (ii) Rural connectivity and (iii) Social sector. The assistance under the RIDF constitutes about 20 per cent of the investments by the various state governments in the rural infrastructure sector. As on 31 March 2016 since its inception, around 0.582 million projects and a cumulative RIDF (RIDF-I–XXI) assistance of ₹2,601,585.5 million (including Bharat Nirman) were sanctioned. Rural connectivity (roads and bridges) cumulatively accounted for the highest share (42 per cent) followed by agriculture and related sectors (40 per cent) and social sector projects (15 per cent) (NABARD, 2016). A review of the performance of RIDF scheme is available in Dadhich (2014). Under the Accelerated Irrigation Benefits Programme (AIBP) for accelerating the implementation of major/medium irrigation projects, a cumulative amount of ₹663,670.9 million was allocated of which ₹638,112.6 million (96.14 per cent) was released during 1996/97–2014/15, and irrigation potential on 7,247.69 thousand hectares of land was created up to 1 March 2013.

Pradhan Mantri Gram Sadak Yojana (PMGSY) was launched in December 2000 to provide all-weather road connectivity to eligible unconnected habitations. A total amount of ₹1,193,770.7 million was released during 2006/07–2015/16, and a total amount of ₹1,160,006 million was spent on road works during 2007/08–2015/16. As on 31 January 2012, 220,612 km of road length was constructed during 2007–12, and 222,035.49 km of road length was completed, connecting 46,221 habitations during 2009/10–2014/15. Moreover, as on 10 March 2016, 190,413.9 km of road length was completed and 258,189.88 km of road was upgraded under the rural road component of the Bharat Nirman programme. Under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), which was launched to (i) electrify all the villages, (ii) provide electricity to all rural households and (iii) provide electricity connection to all the households below poverty line (BPL) free of charge, a total amount ₹138,698.3 million was disbursed during 2010/11–2014/15.

The National Rural Employment Guarantee Act 2005 (NREGA), later renamed Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), was brought into force on 2 February 2006 in order to legally guarantee 100 days of unskilled jobs per rural household, thereby protecting the households against economic insecurity. It is a self-targeting and demand-driven poverty alleviation scheme, providing the rural poor the right to 100 days of employment at the minimum wages prevailing in the states. During 2008/09–2014/15, a total amount of ₹2,451,242.6 million (79.32 per cent) was spent out of the total available fund of ₹3,090,462.8 million, providing employment to 328.4 million households and generating 14,554.1 million person-days employment for scheduled caste (SC), scheduled tribe (ST) and other households. However, the performance of the scheme in terms of employment generation was largely unsatisfactory, as employment provided to households was far below 100 days; the average number of days of employment per household was 48 in 2008–09 which declined to 40 in 2014–15. The performance of the scheme in terms of completion of works was also very poor during 2008/09–2012/13, the percentage of works completed being lying between 19.1 and 50.8. There were considerable inter-state variations in the performance of the scheme.

Most of the rural infrastructure services (roads, water supply including drinking water, minor irrigation, water management and watershed development, health and sanitation and housing) are under the control of state governments, while the central government manages rural electricity and telecommunications. Nevertheless, the central government has been contributing significantly to the development of rural infrastructure. Its spending on rural infrastructure has increased tremendously since 2000–01, particularly after 2005, when the rural infrastructure programme, Bharat Nirman, was launched to improve roads, electricity, irrigation, drinking water, telecommunications and housing in rural areas. Table 1 reveals a four-fold increase in total expenditure on rural infrastructure between 2000/01 and 2010/11, but a subsequent decline in 2011–12 from the previous year. During the entire period (2000–12), rural roads received the highest share, followed by drinking water and sanitation, rural housing and irrigation; the lowest expenditure was on the provision of urban amenities to rural areas programme (PURA).

4. Status of Rural Infrastructure

This section reviews the status and trends in the progress of rural infrastructure facilities, such as roads, telecommunications, power and housing, water and sanitation and education and health. Progress has been evaluated for various

Table 1 Central Government Expenditure on Rural Infrastructure at Constant (2006–07) Prices

Infrastructure	*2000–01 (₹ Million)*	*2005–06 (₹ Million)*	*2010–11 (₹ Million)*	*2011–12 (₹ Million)*	*Total (2000–12) (₹ Million)*
Rural roads	32,660	40,810	168,820	134,630	905,170 (29.8)
Rural drinking water and sanitation	27,450	50,680	79,630	69,560	623,420 (20.5)
Rural housing	19,470	26,340	77,910	68,710	485,110 (16.0)
Irrigation	24,250	22,680	59,040	14,690	481,840 (15.9)
Rural electrification	9,330	11,710	37,680	17,090	241,000 (7.9)
Telecommunication	0	18,620	23,360	11,750	138,510 (4.6)
Watershed	6,280	4830	18,620	16,090	105,570 (3.5)
Integrated Action Plan (IAP)	0	0	11,300	25,230	36,540 (1.2)
Storage	1,500	1,730	1,390	1,850	19,720 (0.6)
PURA	0	0	500	630	2,060 (0.1)
Actual expenditure on rural infrastructure (Total)	**120,940**	**177,400**	**478,250**	**360,230**	**3,038,940 (100.0)**

Source: IDFC (2013).

Notes: Figures in parentheses are the shares of total expenditure during 2000–12. PURA = provision of urban amenities to rural areas.

indicators of each category of infrastructure, as well as for various composite infrastructure indices constructed by combining multiple indicators of rural infrastructure. The following indicators are chosen for each category:

1. **Roads**: road density (rural road length per 100 sq. km); proportion of surfaced road to total.
2. **Telecommunications**: tele-density (number of telephone lines per 100 people).
3. **Power and housing**: proportion of households with access to electricity; proportion of villages electrified; proportion of households with *pucca* (concrete structure) houses.
4. **Water and sanitation**: percentage of gross cropped area irrigated; proportion of households with access to safe drinking water; proportion of households with access to toilets.
5. **Education and health**: The educational opportunity index (EOI) was estimated as a weighted geometric average of: the number of secondary schools per 1,000 people in the age group 9–14 years (NSS); the female-to-male literacy ratios for ages 7 years and above (FML); and the intensity of school education (ISE) (i.e., gross enrolment ratio for classes I–XII). The weighting of different indicators was primarily guided by normative consideration (see Malhotra, 2014, for details). Thus, the EOI was constructed as follows:

$$EOI = Exp[0.3\ ln(NSS) + 0.3\ ln(FML) + 0.4\ ln(ISE)]$$

The health opportunity index (HOI) was estimated as a weighted geometric mean of: the population per bed in government hospitals (PGH); rural health personnel index (HPI) comprising health staff per rural health centre (sub-centres, primary health centres and community health centres); and the inverse of the infant mortality rate (IMR). The HOI is given by:

$$HOI = Exp[0.3\ ln(PGH) + 0.3\ ln(HPI) + 0.4\ ln(IMR)]$$

Based on Malhotra (2014), the following composite indices were constructed as the weighted geometric average of their respective indicators and attributes:

1. **Physical Infrastructure Development Index (PIDI)** was constructed by combining: the proportion of households with access to electricity, safe drinking water and toilets (EWT); the proportion of households with *pucca* houses (HPH); and the index of road connectivity (IRC) estimated as a product of (*a*) the proportion of surfaced roads to total roads, and

(*b*) the increase in road coverage per 100 sq. km relative to the national average. The PIDI is given by:

$$PIDI = \{Exp[0.4\ ln(EWT) + 0.3\ ln(HPH) + 0.3\ ln(IRC)]\}/100$$

2. **Social Opportunity Index (SOI)** was constructed by combining: the educational opportunity index (EOI), health opportunity index (HOI), and real per capita monthly expenditure adjusted for inequality (PCE). The SOI is given by:

$$SOI = \{Exp[0.3\ ln(EOI) + 0.3\ ln(HOI) + 0.4\ ln(PCE)]\}/100$$

3. **Livelihood Opportunity Index (LOI)** was constructed by combining: the employment rate for usual principal activity status for all ages (ERP) [derived from the (*a*) workforce participation rate for usual principal activity status for all ages, and (*b*) labour force participation rate for usual principal activity status for all ages]; inverse of the unemployment rate for current daily activity status for casual workers for all ages (URC); and the proportion of non-farm employment to the total employment (NFE). The LOI is given by:

$$LOI = \{Exp[0.3\ ln(ERP) + 0.4\ ln(URC) + 0.3\ ln(NFE)]\}/100$$

4.1 Progress on Rural Infrastructure

At the national level, rural infrastructure facilities are found to have improved significantly, though from a low base, across all dimensions except water and sanitation (Table 2). There is, however, no reason for complacency, as the current status of almost all the indicators of rural infrastructure is far from satisfactory. As of the year for which the latest data are available, only 19.2 per cent of the rural households had access to electricity, safe drinking water and toilets; 55.3 per cent of the households had access to electricity, 82.7 per cent had access to safe drinking water, 30.7 per cent to toilets and 51.4 per cent possessed *pucca* houses. As of 2013, 94.5 per cent of the villages were electrified. With 59.8 per cent of surfaced road, rural India had the road density of 92.04 km per 100 sq. km, and tele-density of 39.9 per 100 people. As of 2007–08, only 44.6 per cent of the gross cropped area was irrigated.

4.1.1 Rural Roads

The state of road infrastructure is represented in terms of (i) road density as a quantitative measure, and (ii) proportion of surfaced road to the total, representing the qualitative aspect. At the national level, road density improved from 57.04 km in 1991 to 92.04 km in 2008; and the proportion of surfaced road to total road increased from 42.4 per cent in 1981 to 59.8 per cent in 2011

Table 2 Progress on Rural Infrastructure (National)

Infrastructure	*1981*	*1991*	*2001*	*2011*
A. Rural Roads				
1. Road density (road length per 100 sq. km)	na	57.04 (1991)	73.91 (2003)	92.04 (2008)
2. Proportion of surfaced road to total (per cent)	42.4	48.0	53.9	59.8
B. Telecommunications				
1. Rural tele-density (number of telephone lines per 100 people)	na	0.84 (1993)	2.00 (1999)	39.90 (2012)
C. Power and Housing				
1. Proportion of households with access to electricity	14.7	30.5	43.5	55.3
2. Proportion of villages electrified	na	88.05 (1991)	92.3 (1999)	94.5 (2013)
3. Proportion of households with *pucca* houses	22.5	30.6	41.1	51.4
D. Water and Sanitation				
1. Percentage of gross cropped area irrigated	29.0 (1980–83)	36.0 (1990–93)	44.0 (2005)	44.6 (2007–08)
2. Proportion of households with access to safe drinking water	26.5	55.5	73.2	82.7
3. Proportion of households with access to toilets	na	9.5	22.8	30.7
4. Proportion of households with access to electricity, safe drinking water and toilets	na	3.9	10.2	19.2
E. Education and Health				
1. Education Opportunity Index	21.73	26.38	26.77	49.00
2. Health Opportunity Index	17.14	15.80	17.29	20.04
Composite Indices				
1. Physical Infrastructure Development Index (PIDI)	0.092	0.154	0.255	0.363
2. Social Opportunity Index (SOI)	0.208	0.225	0.244	0.317
3. Livelihood Opportunity Index (LOI)	0.273 (1983)	0.321 (1993–94)	0.296 (2004–05)	0.332 (2009–10)

Sources: Bhalla and Singh (2012), Government of India (2010, 2013), IDFC (2013), Malhotra (2014) and NCAER (2007).
Note: 'na' stands for Not Available.

Table 3 Progress on Rural Roads in India

	Road Density (rural road length per 100 sq. km) (km)				*Proportion of Surfaced Road to Total (%)*			
State	*1991*	*1997*	*2003*	*2008*	*1981*	*1991*	*2001*	*2011*
AP	34.34	39.16	69.69	122.53	85.8	47.8	59.5	63.8
Assam	na	na	201.49	289.87	***8.0***	9.6	***7.4***	***13.0***
Bihar	27.63	27.63	74.89	119.39	31.1	33.3	37.1	41.8
Gujarat	23.08	22.48	66.62	66.73	68.8	85.1	91.4	92.6
Haryana	na	na	55.00	57.53	**86.6**	**92.1**	**96.2**	**98.0**
HP	***0.70***	***4.78***	54.50	61.57	17.6	44.1	46.7	67.8
Karnataka	43.91	40.96	93.18	124.00	56.0	63.2	68.3	62.9
Kerala	**295.62**	**304.21**	**348.18**	**537.66**	19.5	23.2	28.4	52.6
MP	14.56	10.83	49.74	50.16	48.4	53.3	44.6	58.9
Maharashtra	43.30	42.90	83.71	67.56	42.5	69.9	77.5	83.0
Odisha	104.52	123.71	128.26	128.99	10.8	***6.9***	17.8	18.5
Punjab	na	na	66.03	76.85	75.9	74.7	84.8	91.9
Rajasthan	13.13	13.13	***38.08***	***47.18***	50.2	48.9	63.2	80.1
Tamil Nadu	104.02	104.02	130.64	139.24	75.5	64.7	73.7	81.7
UP	8.54	14.79	89.26	101.21	40.4	46.1	61.6	78.4
WB	28.14	35.46	72.22	216.46	37.6	39.7	45.5	23.3
India	57.04	60.31	73.91	92.04	42.4	48.0	53.9	59.8
CV (%)	138.02	134.94	76.04	90.40	55.14	48.99	45.68	42.72
L/H	0.002	0.016	0.109	0.088	0.092	0.075	0.077	0.133

Sources: Government of India (2010), Malhotra (2014) and NCAER (2007).

Notes: Rural roads include state highways, rural and other roads; H = highest value (bold) and L = lowest value (italics bold). 'na' stands for Not Available.

(Table 2). The situation improved across all states (Table 3), but there were wide inter-state variations in both indicators in all the years. Even though the disparities across states declined with time, the difference in the level of the two indicators between the best and worst-performing states is very high. In terms of road density, HP, the worst-performing state in 1991 and 1997, had only 0.2 and 1.6 per cent of the level of the best-performing state (Kerala), respectively. It improved its position in 2003 and 2008 when Rajasthan became the worst-performing state, and constituted only 10.9 and 8.8 per cent of the best-performing state (Kerala). Similarly, in terms of the proportion of surfaced road to total road length, Assam was the worst-performing state in 1981, 2001 and 2011, constituting only 9.2, 7.7 and 13.3 per cent of the best-performing state (Haryana). In 1991, Odisha was the worst performing state in this regard with only 7.5 per cent of the level in the best performing state (Haryana). The inter-state variations in road density and in the proportion of surfaced roads, measured in terms of the coefficient of variation (CV), were quite high, but declined over the years. This has serious implications for balanced regional development in India, as rural roads play a significant role in rural development.

4.1.2 Telecommunications

The level of tele-density was very low till 2006 after which there has been a remarkable improvement. At the national level, tele-density was as low as 0.18 in 1993, increased marginally to 2.0 in 2006, but jumped to 39.9 in 2012 (Table 2). A similar trend is observed across all the states, though there were wide inter-state variations in tele-density in all the years (Table 4). The variations increased till 2006 after which it declined significantly. The inter-state variations in tele-density, measured in terms of CV, increased from 89.07 per cent in 1993 to 99.56 per cent in 2006, after which it declined to 30.2 per cent in 2012.

This is also reflected in the wide gap in tele-density between the best and worst-performing states. In 1993, the worst-performing state (Rajasthan) constituted only 1.6 per cent of the level of tele-density attained by the best-performing state (Kerala). The gap remained large till 2006 as the worst-performing state (Bihar) achieved only 5.9 per cent of the level of tele-density of the best-performing state (Kerala). The gap narrowed remarkably in 2012, as the worst-performing state (Bihar) attained 36.8 per cent of the level of the best-performing state (HP) that overtook Kerala.

4.1.3 Power and Housing

Rural power and housing is measured in terms of the (i) proportion of households with access to electricity; (ii) proportion of villages electrified; and (iii) proportion of households with *pucca* houses. The proportion of rural households connected with electricity (penetration rate of electricity) in India

Table 4 Progress on Telecommunications in Rural India

	Tele-density (number of telephone lines per 100 people)			
State	*1993*	*1999*	*2006*	*2012*
AP	0.18	0.62	2.39	41.04
Assam	na	na	0.88	30.18
Bihar	0.03	***0.11***	***0.69***	***26.90***
Gujarat	0.24	0.94	2.68	51.64
Haryana	0.19	0.70	3.18	55.76
HP	0.37	2.13	7.53	**73.08**
Karnataka	0.26	0.99	2.03	42.92
Kerala	**0.63**	**3.04**	**11.63**	62.59
MP	0.14	0.35	0.97	29.51
Maharashtra	0.17	0.78	2.91	51.19
Odisha	0.07	0.27	1.21	37.43
Punjab	0.17	1.24	3.10	64.82
Rajasthan	***0.01***	0.50	1.31	42.81
Tamil Nadu	0.20	0.45	3.58	60.46
UP	0.02	0.20	0.90	31.79
WB	0.03	0.28	1.24	41.19
India	0.18	0.84	2.00	39.90
CV (%)	89.07	94.69	99.56	30.20
L/H	0.016	0.036	0.059	0.368

Sources: Government of India (2007, 2013) and NCAER (2007).
Notes: H = highest value (bold) and L = lowest value (italics bold). 'na' stands for Not Available.

increased significantly from 14.7 per cent in 1981 to 55.3 per cent in 2011 (Table 5). However, even though 94.5 per cent of villages were electrified, about 45 per cent of the rural households were not connected with electricity. This could be due to lack of purchasing power of the unconnected households or to poor quality/inadequacy of supply (NCAER, 2007). The target of achieving universal access of rural households to electricity appears to be far from reality.

The condition appears to be more disappointing at the regional level, as in many states the proportion of households with access to electricity was far below the national average, and the difference between the connected and unconnected households was substantially greater than the national average, though the gap declined marginally over the years. While HP had the highest penetration rate of 51.1 per cent in 1981 followed by Punjab and Haryana, Bihar had the lowest penetration rate of only 3.5 per cent followed by UP, MP and WB. Thus, the worst-performing state (Bihar) achieved only 6.8 per cent of the level of the best-performing state (HP). The situation improved marginally in 2011,

Table 5 State of Electricity and Housing in Rural India

	Percentage of Households with Access to Electricity				*Percentage of Villages Electrified*			*Percentage of Households with Pucca Houses*			
State	*1981*	*1991*	*2001*	*2011*	*1991*	*1999*	*2013*	*1981*	*1991*	*2001*	*2011*
AP	12.5	37.5	59.7	89.7	**100.00**	99.92	**100.0**	18.6	29.8	47.0	66.0
Assam	na	12.4	16.5	28.4	na	na	96.1	na	***10.5***	***14.2***	***21.1***
Bihar	***3.5***	***5.6***	***5.1***	***10.4***	69.21	***70.87***	95.3	17.8	24.1	37.2	45.0
Gujarat	30.8	58.4	72.1	85.0	99.25	99.51	99.8	36.4	43.4	51.0	61.7
Haryana	41.0	63.2	78.5	87.2	99.79	**100.00**	**100.0**	31.1	41.5	58.2	70.9
HP	**51.1**	**85.9**	**94.5**	**96.6**	98.61	98.95	99.9	41.0	49.8	61.8	75.0
Karnataka	21.4	43.8	72.2	86.7	97.85	98.56	99.95	19.2	30.5	42.6	55.1
Kerala	23.2	42.0	65.5	92.1	88.08	**100.00**	**100.0**	35.1	51.6	64.6	79.2
MP	6.9	34.5	62.3	58.3	88.09	95.43	97.6	17.0	20.9	31.2	33.4
Maharashtra	24.1	53.5	65.2	73.8	96.77	100.00	99.9	25.8	35.4	40.3	53.4
Odisha	13.0	17.5	19.4	35.6	***66.98***	73.30	***78.9***	***8.3***	13.0	21.8	36.7
Punjab	50.6	77.0	89.5	95.5	99.31	**100.00**	**100.0**	**49.6**	**72.1**	**83.3**	**85.8**
Rajasthan	8.7	32.4	44.0	58.3	71.31	92.21	97.6	40.4	47.0	57.1	64.8
Tamil Nadu	26.0	44.5	71.2	90.8	99.58	99.62	**100.0**	25.6	34.6	47.3	60.3
UP	4.0	11.0	19.8	23.8	73.19	78.58	88.9	21.6	32.7	46.1	59.2
WB	7.0	17.8	20.3	40.3	72.76	77.56	99.99	12.0	15.7	24.9	36.0
India	14.7	30.5	43.5	55.3	88.05	92.30	94.5	22.5	30.6	41.1	51.4
CV (%)	74.18	59.62	53.34	44.67	15.12	12.01	5.85	44.63	47.00	38.73	31.92
L/H	0.068	0.065	0.054	0.108	0.669	0.709	0.789	0.167	0.146	0.170	0.246

Sources: IDFC (2013), Malhotra (2014) and NCAER (2007).

Notes: H = highest value (bold) and L = lowest value (italics bold). 'na' stands for Not Available.

as the gap between the best and worst-performing states declined marginally: while 96.6 per cent of the households were connected with electricity in HP followed by Punjab and Kerala, a mere 10.4 per cent of the households were connected with electricity in Bihar followed by UP and Odisha, implying that Bihar achieved 10.8 per cent of the level achieved by the best performer (HP). However, inter-state variation in the penetration rate declined, as the CV in the proportion of connected households declined from 74.18 per cent in 1981 to 44.67 per cent in 2011.

The performance of the states in terms of electrification of villages was better than in terms of the penetration rate, and inter-state variation in the proportion of villages electrified was significantly lower than for the penetration rate during 1991–2013. In 1991, while Odisha was the worst performer with 66.98 per cent of villages electrified followed by Bihar with 69.21 per cent, AP was best performer with 100 per cent of its villages electrified. The situation improved over the years. In 2013, there were as many as 10 states with either 100 per cent or almost 100 per cent of their villages electrified, and the gap between the best and worst performers declined significantly, as the ratio between the worst and best performers increased from 0.669 in 1991 to 0.789 in 2013. The inter-state variation in the proportion of villages electrified, measured in terms of CV, declined from 15.12 per cent in 1991 to 5.85 per cent in 2013. A remarkably higher inter-state variation in the proportion of households connected with electricity than that in the proportion of villages electrified signifies that the disparity in electricity connection across households has been wider than those across villages.

The performance in terms of the proportion of households having *pucca* houses was also far from satisfactory, as 44.63 per cent of households had *pucca* houses in 1981 which went up marginally to 51.4 per cent in 2011. Moreover, inter-state disparity in the proportion of households with *pucca* houses and the gap between the best and worst-performing states was large, though it declined over the years. While Punjab was the best performer in all the years with 49.6, 72.1, 83.3 and 85.8 per cent of households having *pucca* houses in 1981, 1991, 2001 and 2011, respectively, Odisha was the worst performer in 1981 with only 8.3 per cent of households having such houses, and Bihar was the worst performer in 1991, 2001 and 2011 followed by Odisha in 1991 and 2001 and by MP in 2011. While Odisha achieved 16.7 per cent of the level achieved by the best performer in 1981, Bihar achieved 24.6 per cent of the level of the best performer in 2011. The coefficient of variation in the proportion of households with *pucca* houses across states declined from 44.63 per cent in 1981 to 31.92 per cent in 2011 (Table 5).

4.1.4 Water and Sanitation

The following indicators were considered to assess the progress of rural infrastructure related to water and sanitation: (i) percentage of gross cropped area (GCA) irrigated; (ii) proportion of households with access to safe drinking water; and (iii) proportion of households with access to toilets within their premises. While irrigation is essential for agricultural production, access to drinking water and sanitation is essential for human survival.

In spite of its crucial importance for agricultural development, irrigation has expanded at a slow rate. The proportion of irrigated gross cropped area in India increased from 29 per cent in 1980–83 to 44 per cent in 2007–08 (Table 6). There were also wide variations in irrigated area across the states. While Punjab had the highest percentage of irrigated GCA (86.84 per cent) in 1980–83 followed by Haryana (62.21 per cent), MP had the lowest level of irrigation with 11.79 per cent of irrigated GCA; MP attained 13.6 per cent of the level attained by Punjab. In the remaining years, Kerala was the worst performer with the percentage of irrigated GCA varying between 12.34 and 16.5 per cent, and Punjab was the best performer with irrigated GCA varying between 94.58 and 98.0 per cent; Kerala achieved 17.0 per cent of what Punjab achieved in 2007–08. The CV in the proportion of irrigated GCA, however, declined from 68.0 per cent in 1980–83 to 51.5 per cent in 2007–08.

While the supply of safe drinking water was impressive with 82.7 per cent of households having access to it, sanitation conditions were rather dismal with only 30.7 per cent of households having access to toilets within their premises even in 2011. There were, however, large inter-state variations in the provisions of both drinking water and sanitation. Punjab was the best performer and Kerala was the worst in providing safe drinking water to households in all the years. Whereas the proportion of households with safe drinking water was 81.8 per cent in Punjab in 1981, it was just 6.3 per cent in Kerala, constituting only 13.2 per cent of the former. Similarly, in 2011, while the percentage was 96.7 per cent in Punjab, it was 28.3 per cent in Kerala, constituting 29.3 per cent of the level attained by the former. Inter-state variation in the provision of safe drinking water has declined over the years, as the CV declined substantially from 73.1 per cent in 1981 to 20.9 per cent 2011. Despite this decline in inter-state variation due to impressive progress in the provision of safe drinking water facilities in the rural areas of most states, there are concerns about both quality and sustainability. More than 0.2 million habitations in India have poor water quality, such as excess fluoride, arsenic, nitrate, iron and salinity, which are health hazards (NCAER, 2007).

The provision of sanitation has been far from satisfactory, unlike in the case of safe drinking water. More than 69 per cent of rural households had no access to

Table 6 State of Irrigation, Drinking Water and Sanitation in Rural India

	Percentage of Gross Cropped Area Irrigated				*Proportion of Households with Access to Safe Drinking Water*				*Proportion of Households with Access to Toilets*		
State	*1980–83*	*1990–93*	*2005*	*2007–08*	*1981*	*1991*	*2001*	*2011*	*1991*	*2001*	*2011*
AP	35.43	39.87	46.0	46.3	15.1	49.0	76.9	88.6	6.6	18.1	32.2
Assam	16.96	20.21	24.0	24.4	na	43.3	56.8	68.3	30.5	59.5	59.6
Bihar	33.67	43.18	49.0	60.6	33.8	56.6	86.1	93.9	5.0	14.0	17.6
Gujarat	22.93	29.33	41.0	41.7	36.2	60.0	76.9	84.9	11.2	21.7	33.0
Haryana	62.21	77.14	85.0	86.0	42.9	67.1	81.2	92.0	6.5	28.7	56.1
HP	17.00	18.00	19.0	19.2	39.6	75.5	87.6	93.2	6.4	27.8	66.6
Karnataka	15.95	22.58	29.0	29.4	17.6	67.3	80.5	84.4	6.9	17.5	28.4
Kerala	13.36	***12.34***	***16.0***	***16.5***	***6.3***	***12.2***	***16.8***	***28.3***	**44.1**	**81.4**	**93.2**
MP	***11.79***	20.66	30.0	32.2	8.1	45.6	61.5	73.1	***3.6***	8.9	***13.1***
Maharashtra	12.66	15.38	19.0	19.6	18.3	54.0	68.4	73.2	6.6	18.2	38.0
Odisha	22.90	26.24	35.0	36.7	9.5	35.3	62.9	74.4	***3.6***	***7.7***	14.1
Punjab	**86.84**	**94.58**	**98.0**	**97.0**	**81.8**	**92.1**	**96.9**	**96.7**	15.8	41.0	70.4
Rajasthan	21.27	27.20	36.0	36.4	13.0	50.6	60.5	72.8	6.7	14.6	19.6
Tamil Nadu	48.70	47.90	56.0	55.9	31.0	64.3	85.3	92.2	7.2	14.4	23.2
UP	47.42	62.29	74.0	75.5	25.3	56.6	85.5	94.3	6.4	19.1	21.8
WB	24.57	54.27	56.0	56.9	65.8	80.3	86.9	91.4	12.3	26.9	46.7
India	29.00	36.00	44.0	44.6	26.5	55.5	73.2	82.7	9.5	22.8	30.7
CV (%)	68.0	62.2	54.4	51.5	73.1	33.1	26.0	20.9	97.6	74.5	59.8
L/H	0.136	0.131	0.163	0.170	0.077	0.132	0.173	0.293	0.082	0.095	0.141

Sources: Bhalla and Singh (2012), IDFC (2013) and Malhotra (2014).

Notes: H = highest value (bold) and L = lowest value (italics bold). 'na' stands for Not Available.

toilet facilities in India even in 2011. This was the status of sanitation even after an improvement from a situation when more than 90 per cent of households had no toilet facilities within their premises in 1991 (Table 6). The situation in the states was more alarming. While Kerala was the best performer in all the three years with the proportion of households having toilet facilities ranging from 44.1 to 93.2 per cent, Odisha was the worst with 3.6 and 7.7 per cent of households having access to toilets in 1991 and 2001, respectively. MP—another worst performer in 1991 with only 3.6 per cent of households with access to toilets—had the lowest percentage of households with toilet facilities in 2011. Inter-state variation in the proportion of households with toilet facilities was also quite large, though it declined over the years.

The performance, judged in terms of the proportion of households with access to all three facilities, such as electricity, safe drinking water and sanitation, was even more appalling. Table 7 reveals that only 3.9 per cent of households had

Table 7 Households with Access to Electricity, Drinking Water and Sanitation

	Proportion of Households with Access to Electricity, Safe Drinking Water and Toilet		
State	*1991*	*2001*	*2011*
AP	3.3	12.8	28.4
Assam	4.5	9.7	18.0
Bihar	2.0	***2.7***	***4.9***
Gujarat	8.8	18.6	29.7
Haryana	5.0	22.1	50.3
HP	5.3	25.2	62.4
Karnataka	3.7	11.5	20.9
Kerala	3.4	10.0	24.9
MP	2.1	5.9	9.3
Maharashtra	4.2	12.1	27.4
Odisha	***1.0***	3.1	7.8
Punjab	**13.9**	**38.5**	**67.6**
Rajasthan	3.7	9.1	14.4
Tamil Nadu	4.0	10.4	20.7
UP	2.9	7.0	10.0
WB	5.5	11.2	25.5
India	3.9	10.2	19.2
CV (%)	66.62	69.63	70.77
L/H	0.072	0.070	0.072

Source: Malhotra (2014).
Notes: H = highest value (bold) and L = lowest value (italics bold).

access to all three facilities in rural India in 1991, and the situation improved only marginally over the years, as 19.2 per cent of households got access to these facilities in 2011. While Punjab was the best performer in this respect in all three years with the percentage ranging from 13.9 in 1991 to 67.6 in 2011, Odisha was the worst performer in 1991 with just 1 per cent of households having access to all the three facilities, and Bihar was the worst performer in 2001 and 2011 with percentages as low as 2.7 and 4.9, respectively. Overall, inter-state variation in the access to all three facilities was very large and increasing over the years, as the CV increased from 66.62 per cent in 1991 to 70.77 per cent in 2011. The worst-performing state achieved around 7 per cent of the level achieved by the best performer.

The variations in the level of infrastructure facilities across states may, in general, be attributed to the inter-state variations in the amount of funds disbursed and utilised under the various schemes for rural infrastructure development, and in the physical outcomes of the schemes. State-wise data (available from www.indiastat.com, but not reported here to save space) on the amount of funds allocated/disbursed and actually used for infrastructure building demonstrate considerable inter-state variations. This could be one possible reason for the observed inter-state variations in the level of various infrastructures. The underlying reasons for the inter-state differences in the level of various infrastructures may be discussed in a separate article.

4.1.5 Education and Health Infrastructure

The status of education and health infrastructures is evaluated in terms of the Education Opportunity Index (EOI) and the Health Opportunity Index (HOI), respectively, as outlined in fourth section. Table 8 reveals that in terms of the EOI, Gujarat was the best performer in 1981 and 1991, Karnataka in 2001 and MP in 2011. West Bengal was the worst performer in 1981, 2001 and 2011, and Bihar in 1991. In terms of the HOI, Kerala was the best performer in all the years, and UP was the worst performer in 1981, Odisha in 1991 and 2011 and Bihar in 2001. The gaps in EOI and HOI between the best and worst-performing states, and the inter-state variations in both the indices increased over the years.

4.2 Composite Rural Infrastructure Index

The composite indices (viz., the PIDI, SOI and LOI) were constructed by combining various indicators and attributes of each type of index, as outlined in fourth section. Table 9 reveals that all the indices improved between 1981 and 2011 at the national and state levels. However, there were wide variations across states in the magnitude of improvement in the indices, though the extent of variations and the gap between the best and worst-performing states in PIDI

Table 8 State of Education and Health Infrastructure in Rural India

	Education Opportunity Index (EOI)				*Health Opportunity Index (HOI)*			
State	*1981*	*1991*	*2001*	*2011*	*1981*	*1991*	*2001*	*2011*
AP	16.33	20.90	26.62	40.92	18.00	17.50	15.64	20.93
Assam	23.18	28.53	31.30	46.35	14.84	13.54	13.79	18.63
Bihar	16.02	***18.68***	15.74	34.10	12.60	9.47	***10.37***	16.18
Gujarat	**32.00**	**39.37**	36.98	62.44	18.46	19.84	20.50	22.51
Haryana	16.21	21.19	20.44	36.15	15.02	16.27	18.06	18.67
HP	29.03	34.76	34.65	73.35	21.08	21.21	21.50	23.42
Karnataka	27.94	34.92	**38.75**	58.51	23.64	16.77	18.73	25.09
Kerala	27.74	31.11	27.23	40.32	**38.27**	**48.24**	**56.39**	**49.16**
MP	19.24	27.19	32.87	**73.74**	13.98	12.10	11.13	13.23
Maharashtra	26.84	33.86	33.16	46.69	20.10	28.94	27.25	33.15
Odisha	22.29	31.72	29.93	53.70	10.21	***8.22***	12.75	***10.55***
Punjab	22.19	22.63	22.98	40.80	22.14	16.32	19.63	21.47
Rajasthan	16.04	21.07	28.25	49.32	13.72	14.02	12.51	15.34
Tamil Nadu	23.02	27.76	25.39	45.21	20.68	24.19	26.00	25.99
UP	17.42	18.72	25.39	43.47	***9.77***	9.23	11.20	11.54
WB	***14.78***	19.09	***15.39***	***24.17***	17.47	19.21	21.74	23.57
India	21.73	26.38	26.77	49.00	17.14	15.80	17.29	20.04
CV (%)	25.33	25.16	24.78	28.18	37.48	52.53	55.84	42.81
L/H	0.462	0.474	0.397	0.328	0.255	0.170	0.184	0.215

Source: Malhotra (2014).

Notes: H = highest value (bold) and L = lowest value (italics bold).

Table 9 Composite Indices of PIDI, LOI and SOI in Rural India

	Physical Infrastructure Development Index (PIDI)				*Social Opportunity Index (SOI)*				*Livelihood Opportunity Index (LOI)*			
State	*1981*	*1991*	*2001*	*2011*	*1981*	*1991*	*2001*	*2011*	*1983*	*1993–94*	*2004–05*	*2009–10*
AP	0.071	0.141	0.299	0.442	0.195	0.215	0.236	0.309	0.255	0.299	0.262	0.313
Assam	0.048	0.070	0.111	0.189	0.209	0.219	0.248	0.304	0.340	0.271	0.322	0.325
Bihar	0.077	0.089	0.120	0.186	0.162	***0.163***	***0.168***	***0.243***	0.249	0.283	0.299	0.367
Gujarat	0.185	0.286	0.454	0.470	0.252	0.284	0.303	0.378	0.306	0.325	0.374	0.314
Haryana	0.112	0.220	0.428	0.658	0.203	0.224	0.245	0.293	0.350	0.347	0.377	0.382
HP	0.057	0.194	0.403	0.666	0.270	0.273	0.303	0.413	**0.471**	0.527	0.357	0.419
Karnataka	0.087	0.159	0.286	0.409	0.252	0.248	0.278	0.352	0.260	0.338	0.280	0.375
Kerala	0.075	0.136	0.230	0.427	**0.301**	**0.361**	**0.405**	**0.471**	***0.202***	0.266	***0.225***	0.275
MP	0.067	0.111	0.172	0.224	0.181	0.199	0.211	0.291	0.385	0.350	0.300	0.277
Maharashtra	0.095	0.181	0.302	0.475	0.242	0.298	0.302	0.379	0.261	0.333	0.253	0.294
Odisha	***0.025***	***0.041***	***0.093***	***0.144***	0.170	0.193	0.219	0.259	0.250	0.284	0.277	0.310
Punjab	**0.225**	**0.363**	**0.600**	**0.772**	0.260	0.242	0.271	0.333	0.284	0.476	0.313	0.385
Rajasthan	0.116	0.193	0.279	0.391	0.180	0.202	0.218	0.278	0.388	**0.621**	0.387	**0.469**
Tamil Nadu	0.115	0.187	0.260	0.396	0.223	0.268	0.291	0.363	0.205	***0.256***	0.245	***0.254***
UP	0.082	0.137	0.234	0.321	***0.157***	*0.163*	0.215	0.268	0.380	0.402	**0.417**	0.373
WB	0.093	0.125	0.228	0.341	0.185	0.227	0.235	0.279	0.208	0.307	0.280	0.350
India	0.092	0.154	0.255	0.363	0.208	0.225	0.244	0.317	0.273	0.321	0.296	0.332
CV (%)	51.9	48.7	48.5	44.2	20.1	22.0	21.3	19.2	26.2	29.0	18.3	16.8
L/H	0.111	0.113	0.155	0.187	0.522	0.452	0.415	0.516	0.429	0.412	0.54	0.542

Source: Malhotra (2014).

Notes: H = highest value (bold) and L = lowest value (italics bold).

and LOI declined to some extent during this period. The inter-state variation in the SOI declined marginally, but the gap between the best and worst-performing states increased over the years.

4.2.1 Classification of States

Based on performance on the composite infrastructure indices, the states are classified into three categories: the top five states with top five infrastructure levels; the bottom five states with the lowest last five levels; and the six middle-level states with infrastructure levels between the top five and bottom five states. Table 10 classifies the states into these categories, based on the ranking of states in terms of their score in each infrastructure index, reported in Table 9.

Punjab had the highest PIDI level and Odisha had the lowest across all the years. HP was among the bottom five states in 1981, but improved its position remarkably in 1991 to move to the top-five category, and retained its position thereafter. Maharashtra improved its position from the middle-level category in 1981 and 1991 to the top-five category in 2001, and retained its position in 2011. Rajasthan was among in the top-five category in 1981 and 1991, but fell to the middle-level category in 2001 and 2011. The top five states in PIDI are those with a high level of per capita income from agriculture and low level of rural poverty. On the other hand, among the bottom five states in 1981, AP and HP improved their position significantly to move to a higher category—HP moved to the top-level category and AP to the middle-level one. West Bengal, which was in the middle-level category in 1981 fell to the bottom-five in 1991 and 2001, but managed to come back to the middle-level category in 2011. The states in the bottom-five category are those with a low level of per capita income from agriculture and high level of rural poverty.

Kerala had the highest level of SOI and Bihar the lowest across all the years. Among the top five states in 1981, Punjab and Karnataka fell to the middle-level in 1991 and have remained there thereafter. The remaining three states maintained their position in the top-five category in all the years. Maharashtra and Tamil Nadu, which were in the middle-level category in 1981, managed to improve their position to the top-level category in 1991 and have remained there since. On the other hand, all the BIMARU states (Bihar, MP, Rajasthan and UP) including Odisha which were in the bottom-five category in all the years, with the exception that MP, managed to move to the middle-level category in 2011; West Bengal was in the middle-level category till 2001, but fell to the lowest level in 2011.

In terms of LOI, some of the poor states, such as Rajasthan, MP and UP, were in the top-five category along with some agriculturally developed states such as Haryana and Punjab. However, MP fell to the middle level in 2004–05

Table 10 Classification of States According to Infrastructure Level

Infrastructure Indicator/Year	*Top Five States*	*Six Middle-level States*	*Bottom Five States*
Physical Infrastructure Development Index (PIDI)			
1981	Punjab, Gujarat, Rajasthan, Tamil Nadu, Haryana	Maharashtra, WB, Karnataka, UP, Bihar, Kerala	AP, MP, HP, Assam, Odisha
1991	Punjab, Gujarat, Haryana, HP, Rajasthan	Tamil Nadu, Maharashtra, Karnataka, AP, UP, Kerala	WB, MP, Bihar, Assam, Odisha
2001	Punjab, Gujarat, Haryana, HP, Maharashtra	AP, Karnataka, Rajasthan, Tamil Nadu, UP, Kerala	WB, MP, Bihar, Assam, Odisha
2011	Punjab, HP, Haryana, Maharashtra, Gujarat	AP, Kerala, Karnataka, Tamil Nadu, Rajasthan, WB	UP, MP, Assam, Bihar, Odisha
Social Opportunity Index (SOI)			
1981	Kerala, HP, Punjab, Karnataka, Gujarat	Maharashtra, Tamil Nadu, Assam, Haryana, AP, WB	MP, Rajasthan, Odisha, Bihar, UP
1991	Kerala, Maharashtra, Gujarat, HP, Tamil Nadu	Karnataka, Punjab, WB, Haryana, Assam, AP	Rajasthan, MP, Odisha, UP, Bihar
2001	Kerala, Gujarat, HP, Maharashtra, Tamil Nadu	Karnataka, Punjab, Assam, Haryana, AP, WB	Odisha, Rajasthan, UP, MP, Bihar
2011	Kerala, HP, Maharashtra, Gujarat, Tamil Nadu	Karnataka, Punjab, AP, Assam, Haryana, MP	WB, Rajasthan, UP, Odisha, Bihar
Livelihood Opportunity Index (LOI)			
1983	HP, Rajasthan, MP, UP, Haryana	Assam, Gujarat, Punjab, Maharashtra, Karnataka, AP	Odisha, Bihar, WB, Tamil Nadu, Kerala
1993–94	Rajasthan, HP, Punjab, UP, MP	Haryana, Karnataka, Maharashtra, Gujarat, WB, AP	Odisha, Bihar, Assam, Kerala, Tamil Nadu
2004–05	UP, Rajasthan, Haryana, Gujarat, HP	Assam, Punjab, MP, Bihar, Karnataka, WB	Odisha, AP, Maharashtra, Tamil Nadu
2009–10	Rajasthan, HP, Punjab, Haryana, Karnataka	UP, Bihar, WB, Assam, Gujarat, AP	Odisha, Maharashtra, MP, Kerala, Tamil Nadu

Source: Based on the score of composite indices reported in Table 9.

and to the lowest level in 2009–10, and UP fell to the middle-level category in 2009–10. Odisha and Bihar, the two states consistently at the lowest levels in the PIDI and SOI, were also in this category in terms of the LOI, along with some states belonging to the top-level category in PIDI and SOI.

5. The Infrastructure–Development Nexus

It is argued that rural infrastructures, such as roads, electricity, telecommunications and irrigation, are crucially important for rural development and poverty alleviation through improved agricultural productivity, increased rural farm and non-farm employment and improved human well-being. It is also argued that human development in terms of education and health depends crucially on infrastructure services, such as roads, electricity, safe drinking water and sanitation. The role of infrastructure in rural development has been evaluated in the literature mostly by examining the impacts of specific infrastructure indicators on rural development. However, the relationship between rural development and various composite indices of rural infrastructure has not been given adequate attention. This section examines the relationship between infrastructure and rural development by estimating the effects of both individual indicators as well as composite indices of rural infrastructure on various dimensions of rural development.

As a background to understanding the nexus between infrastructure and development, we have reviewed the trends in some income and non-income dimensions of development. This exercise along with the observed trends in various indicators of rural infrastructure would throw light on the nature of relationship between infrastructure and development. Table 11 reveals that the magnitude of all the development indicators except rural poverty and infant mortality rate has increased over time. This is expected in the process of development. When this observation is taken in conjunction with the increasing trend in the indicators of rural infrastructure, one can expect a positive relationship between infrastructure and all the development indicators except rural poverty and infant mortality, for which a negative relationship is expected.

This is confirmed by the results of the estimated relationship between the composite indices/individual indicators of rural infrastructure and various dimensions of rural development. First, we have examined the effects of the composite indices of infrastructure, and then the impacts of the individual indicators of infrastructure on rural development. As dependent variables, we have chosen the PCIA, APH and APW as indicators of agricultural development, the RPOV as the incidence of rural poverty, and RLIT, RELB and RIMR as

Table 11 Trends in the Development Indicators in Rural India

Development Indicator	*1981*	*1991*	*2001*	*2011*
Income dimension				
1. Per capita income from agriculture & allied activities (three-year average) at 1993–94 prices (₹) (PCIA)	2234 (1980–83)	2534 (1990–93)	2656 (2000–03)	3146 (2009–12)
2. Value of agricultural output per hectare (three-year average) at 1990–93 prices (₹) (APH)	5090 (1980–83)	6957 (1990–93)	9285 (1999–2002)	9050 (2005–08)
3. Value of agricultural output per worker (three-year average) at 1990–93 prices (₹) (APW)	5086 (1980–83)	5993 (1990–93)	7651 (1999–2002)	7091 (2005–08)
Non-income dimension				
4. Head count ratio of rural poverty (%) (RPOV)	45.65 (1983)	37.27 (1993)	28.30 (2004–05)	23.65 (2009–10)
5. Literacy rate (%) (RLIT)	36.01	44.69	59.21	68.91
6. Expectation of life at birth (Years) (RELB)	53.7 (1981–85)	58.9 (1991–95)	61.2 (1998–2002)	62.1 (2002–06)
7. Infant mortality rate (Number of deaths by age 1 per 1000 live births) (RIMR)	114.0	87.0	72.0	48.0

Sources: Bhalla and Singh (2012), Government of India (2002), Malhotra (2014) and Reserve Bank of India (2007, 2013).
Note: The years in parentheses below the figures are the reference years. For the other figures these are noted at the top of the table.

indicators of human development. Drawing insights from the literature, while APH and APW are specified as functions of the PIDI and SOI, the remaining developmental variables are specified as functions of all the composite indices (PIDI, SOI and LOI). The regression equations were estimated by the ordinary least squares (OLS) method using pooled cross-sectional data for 16 states corresponding to four time-points, as mentioned in the relevant tables in the fourth section, and in Table 11. The data for the infrastructure indices and developmental variables were used in such a manner as to avoid possible simultaneity bias. There was also no serious multicollinearity problem. The equations seem to be well specified as indicated by the estimated values of R^2 and the significant coefficients of the explanatory variables with expected sign (Table 12).

The results unambiguously establish the crucial importance of the physical and social infrastructure indices and the livelihood opportunity index in rural development. The coefficients of the indices bear the expected sign and turn out to be statistically significant in all but two cases; while the coefficient of PIDI is significant in all the equations, the coefficient of the SOI is significant in all the cases except for PCIA and the coefficient of the LOI is significant in all cases except for RLIT. Overall, the indices are positively associated with PCIA, APH, APW, RLIT and RELB, but negatively with RPOV and RIMR, implying that better infrastructure facilities and livelihood opportunities reduce rural poverty and infant mortality, and improve rural literacy and life expectancy by raising agricultural productivity and output.

This is corroborated by the results of the estimated relationship between the individual infrastructure indicators and various dimensions of rural development. Drawing inferences from the literature, the agricultural development variables (PCIA, APH and APW) are specified as functions of all the selected infrastructure variables except for PHPH and PHDW; the remaining developmental variables are specified as functions of all the infrastructure variables except for IRRI (see Table 13 for the infrastructure variables). The regression equations were estimated by the OLS method using pooled cross-sectional data for 16 states corresponding to four time-points, as mentioned in the relevant tables in the fourth section and in Table 11. As far as possible, subject to their availability, data for the developmental and infrastructure variables were used in such a way as to avoid possible simultaneity bias. There was also no serious multicollinearity problem among the explanatory variables. The equations appear to be well specified as indicated by the estimated values of R^2 (ranging from 0.51 to 0.83) and the significant coefficients of the infrastructure variables with expected sign (Table 13).

Table 12 Log-linear Relations between Infrastructure Indices and Rural Development

Independent Variables	*Dependent Variable (in natural logarithms)*						
	PCIA	*APH*	*APW*	*RPOV*	*RLIT*	*RELB*	*RIMR*
Constant	8.79	10.14	9.93	0.85	5.21	4.35	2.50
	(25.78)*	(34.61)*	(22.71)*	(2.09)**	(26.28)*	(73.73)*	(6.84)*
ln *PIDI*	0.22	0.17	0.37	−0.38	0.08	0.05	−0.19
	(2.97)*	(1.94)**	(2.79)*	(−4.26)*	(1.97)**	(3.69)*	(−2.73)*
ln *SOI*	0.09	0.66	0.30	−0.94	0.94	0.18	−1.28
	(0.40)	(2.47)**	(1.82)***	(−3.64)*	(7.44)*	(4.80)*	(−5.49)*
ln *LOI*	0.40	–	–	−0.37	0.17	0.07	−0.32
	(2.17)**			(−1.68)***	(1.55)	(2.18)*	(−1.69)***
R^2	0.37	0.33	0.27	0.67	0.74	0.69	0.66
$\overline{R}^2$	0.34	0.31	0.25	0.66	0.72	0.67	0.64
F-statistic	11.71[a]	15.17[a]	10.34[a]	41.03[a]	55.93[a]	43.59[a]	38.30[a]
N	64	64	64	64	64	64	64

Source: Author's estimate.

Notes:
- *PCIA* = per capita income from agriculture and allied activities at 1993–94 prices; *APH* = agricultural productivity per hectare at 1990–93 prices; *APW* = agricultural output per worker at 1990–93 prices; *RPOV* = rural poverty (head count ratio); *RLIT* = rural literacy; *RELB* = expectation of life at birth in rural area; *RIMR* = infant mortality rate in rural area; *PIDI* = Physical Infrastructure Development Index; *SOI* = Social Opportunity Index and *LOI* = Livelihood Opportunity Index.
- The figures in parentheses are *t*-statistics. *, ** and *** indicate significance at the 1, 5 and 10 per cent levels, respectively; [a] indicates significance of the *F*-statistics at the 1 per cent level; *N* = number of observations; and ln = natural logarithm.

Table 13 Log-linear Relations between Infrastructure Indicators and Rural Development

Infrastructure Variables	*Developmental (dependent) Variables (in natural logarithms)*						
	PCIA	*APH*	*APW*	*RPOV*	*RLIT*	*RELB*	*RIMR*
Constant	6.48	6.55	4.68	5.79	3.29	3.59	5.10
	(19.73)*	(17.70)*	(8.47)*	(9.81)*	(13.98)*	(47.44)*	(9.94)*
ln *PSR*	−0.07	−0.09	−0.05	0.11	0.14	−0.01	0.09
	(−1.14)	(−1.17)	(−0.46)	(1.17)	(3.68)*	(−0.93)	(1.07)
ln *PHE*	0.31	0.19	0.54	−0.26	0.13	0.04	0.03
	(5.39)*	(2.88)*	(5.55)*	(−3.31)*	(4.11)*	(3.49)*	(0.47)
ln *TELD*	−0.02	−0.01	0.14	−0.01	0.06	−0.004	−0.13
	(−1.02)	(−0.27)	(3.64)*	(−0.38)	(3.96)*	(−0.88)	(−4.18)*
ln *RODEN*	0.05	0.21	0.27	−002	0.08	0.01	−0.10
	(1.94)**	(4.94)*	(4.25)*	(−1.93)**	(3.91)*	(5.58)*	(−2.11)**
ln *IRRI*	0.22	0.34	0.42	–	–	–	–
	(3.39)*	(4.60)*	(3.78)*				
ln *PHPH*	–	–	–	−0.57	0.09	0.08	−0.33
				(−3.77)*	(1.46)	(4.33)*	(−2.51)**
ln *PHDW*	–	–	–	−0.01	0.02	−0.01	−0.08
				(−0.12)	(0.63)	(−0.51)	(−1.08)
R^2	0.51	0.62	0.58	0.69	0.83	0.77	0.70
$\overline{R}^2$	0.47	0.59	0.54	0.65	0.82	0.74	0.66
F-statistic	11.99[a]	18.97[a]	15.73[a]	20.88[a]	47.02[a]	31.01[a]	21.66[a]
N	64	64	64	64	64	64	64

Source: Author's estimate.

Notes: • *PCIA* = per capita income from agriculture and allied activities at 1993–94 prices; *APH* = agricultural productivity per hectare at 1990–93 prices; *APW* = agricultural output per worker at 1990–93 prices; *RPOV* = rural poverty (head count ratio); *RLIT* = rural literacy; *RELB* = expectation of life at birth in rural area; *RIMR* = infant mortality rate in rural area; *PSR* = proportion of surfaced road to total; *PHE* = proportion of households with access to electricity; *TELD* = tele-density (number of telephone lines per 100 people); *RODEN* = road density (rural road length per 100 sq. km); *IRRI* = percentage of gross cropped area irrigated; *PHPH* = proportion of households with *pucca* houses and *PHDW* = proportion of households with access to safe drinking water.

• The figures in parentheses are *t*-statistics; *, ** and *** indicate significance at the 1, 5 and 10% levels, respectively; [a] indicates significance of the *F*-statistics at the 1 per cent level; *N* = number of observations; and ln = natural logarithm.

The results convincingly establish the importance of electricity, irrigation and roads for growth in agricultural output and productivity, the coefficients of these infrastructure variables being positive and significant in all the equations for agricultural development. Roads turn out to be significant also for poverty reduction and human development in terms of improvements in education and health; electricity is found to play a significant role in reducing rural poverty and improving literacy and life expectancy; tele-density turns out to be significant in increasing per worker productivity and rural literacy and in reducing infant mortality; *pucca* houses are found to be significant in reducing poverty and infant mortality and in improving life expectancy. While accessibility by roads is important for agricultural growth, poverty alleviation and human development, the quality of the road (surfaced road) turns out to be significant in improving rural literacy only but for the other developmental variables. Access to safe drinking water appears to play no significant role in rural development, the coefficient of PHDW being statistically insignificant in all the equations.

As the regression equations are specified in the double-log form, the coefficients of the explanatory variables are estimates of the infrastructure elasticity of development, measuring responsiveness of the developmental variables to additional investment in various infrastructures. Judged by the magnitude of the absolute values of the significant coefficients, electricity, irrigation and roads are found to be most important for agricultural development. Similarly, housing, electricity and roads turn out to be most important for improving literacy and life expectancy, and reducing poverty and infant mortality; telecommunications turns out to be the next important variable for improving worker productivity and literacy, and reducing infant mortality, while the quality of roads appears to be most significant for rural literacy only. These results suggest that the government should prioritise additional investments in electricity, roads, irrigation, housing and telecommunications for enhancing agricultural productivity, improving rural literacy and life expectancy, and reducing rural poverty and infant mortality.

6. Summary and Conclusions

We have evaluated the status of rural infrastructure facilities in 16 major states of India, and examined their impacts on some income and non-income dimensions of rural development. In spite of several public initiatives for infrastructure development in rural India, infrastructure facilities are still inadequate and progress has been mostly unsatisfactory with differential performance across states. Variations in the level of infrastructure facilities across states may be

attributed, in general, to inter-state variations in the amount of funds disbursed and utilised under various schemes for infrastructure building, and in the extent of implementation of programmes and their physical outcomes. The inadequacy of infrastructure has serious implications for agricultural productivity, rural poverty and human development.

Estimating the effects of the composite indices/individual indicators of rural infrastructure on various dimensions of rural development, we have found that better physical and social infrastructure facilities and livelihood opportunities improve rural literacy and life expectancy, and reduce rural poverty and infant mortality, by raising agricultural productivity and output. Among various infrastructure indicators, electricity, irrigation and roads have been most important for agricultural productivity and output growth, poverty reduction and human development in terms of improvements in health and education. Accessibility through roads turns out to be more important than the quality of roads in bringing about socio-economic changes in rural areas. Telecommunications have been significant in raising workers' productivity and rural literacy, and in reducing infant mortality; housing has been important for reducing poverty and infant mortality, and improving life expectancy.

The estimates of infrastructure elasticity of rural development, indicating the relative importance of various infrastructure indicators in rural development, suggest that the government should prioritise additional investments in infrastructure towards electricity, roads, irrigation, housing and telecommunications for achieving growth in agricultural productivity and output, improvements in literacy and life expectancy and reductions in poverty and infant mortality. In view of the prevailing inadequacy of various infrastructure facilities, in spite of their proven importance in rural development, this study advocates appropriate policies and programmes with effective implementation to ensure universal coverage and access to basic infrastructure facilities for all villages and households in rural India. Needless to say, the developmental outcomes of various infrastructures depend on their quality, maintenance and management, apart from their levels. Appropriate steps should be taken for improving governance, delivery mechanisms and efficiency of local level institutions to ensure various infrastructure services to the rural people.

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