

Rural Infrastructure Development and Its Contribution to Sustainable Development Goals (SDGs)

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Abstract:

Rural infrastructure constitutes the physical foundation upon which the Sustainable Development Goals must be built in a country where the majority of the population lives in villages. This paper examines the contribution of rural infrastructure development to the achievement of the SDGs in India, drawing upon secondary data from official programme dashboards, the NITI Aayog SDG India Index and the empirical literature of the past decade and a half. The paper first maps the principal rural infrastructure programmes, roads, electrification, drinking water, sanitation, housing and digital connectivity, onto the goals and targets they serve; it then documents the transformation of rural infrastructure stocks across the period 2014 to 2025; and it tests, through correlation and regression analysis on an illustrative inter-state dataset, the association between composite rural infrastructure attainment and SDG Index performance. The analysis finds a strong positive and statistically significant association between rural infrastructure attainment and SDG scores, consistent with the causal evidence of the programme evaluation literature that roads, power, water, sanitation and connectivity raise incomes, schooling, health and gender outcomes. The paper concludes that rural infrastructure is not one sector among many but the delivery platform of the 2030 Agenda in rural India, and offers suggestions on convergence, maintenance, quality and last-mile equity through which its contribution can be deepened.

Keywords: Rural infrastructure, Sustainable Development Goals, rural roads, electrification, drinking water, sanitation, digital connectivity, India.

1. Introduction

Development arrives in a village on a road. It is carried on electric wires and water pipes, sheltered in permanent housing, connected through optical fibre, and made usable by the schools, health centres and markets that these networks reach. The 2030 Agenda for Sustainable Development, with its seventeen goals and one hundred and sixty-nine targets, names the outcomes, the end of poverty and hunger, health, education, gender equality, clean water, modern energy, decent work and sustainable communities, but every one of these outcomes presumes, in a rural context, an infrastructural precondition: the child cannot attend the school the road does not reach; the clinic cannot refrigerate

vaccines without power; the girl cannot be spared the water walk without a tap; the farmer cannot sell where no road, market or network connects. Rural infrastructure is thus not merely one of the goals, though Goal 9 names infrastructure expressly, but the platform on which the rural achievement of nearly all the goals rests.

India presents this proposition at the world's largest scale. Nearly two-thirds of India's population, over sixty crore rural inhabitants across some six lakh villages, depends on rural infrastructure for its access to every service the goals enumerate, and the period since 2014 has witnessed the most concentrated rural infrastructure expansion in the country's history: the completion of village road connectivity under the Pradhan Mantri Gram Sadak Yojana, the electrification of every inhabited village and the near-universal household electrification drive, the sanitation transformation of the Swachh Bharat Mission, the tap water mission of Jal Jeevan, the rural housing programme, and the extension of digital connectivity toward every panchayat. Each of these programmes was conceived before the SDG era or independently of it, yet together they constitute India's largest de facto SDG investment, and their assessment against the goals is therefore both natural and necessary.

The present paper undertakes this assessment. It asks three questions: through what pathways does rural infrastructure contribute to the goals, and what does the empirical literature establish about these pathways; what has actually been built across the recent decade, and with what recorded change in rural conditions; and is the inter-state pattern of infrastructure attainment associated with the inter-state pattern of SDG performance as the pathway logic predicts? The paper proceeds through a review of literature (Section 2), objectives and methodology (Sections 3 and 4), a mapping of programmes to goals and a documentation of the infrastructure decade (Sections 5 and 6), an empirical analysis of the infrastructure-SDG association (Section 7), a goal-wise discussion (Section 8), and challenges, findings, suggestions and conclusion (Sections 9 to 11).

2. Review of Literature

Duflo and Pande (2007) studied the distributional effects of large dam infrastructure in India, finding agricultural gains downstream against costs in the districts of construction, and establishing the methodological template, exploiting geography for identification, that the modern infrastructure evaluation literature follows. The study's lesson that infrastructure's benefits and burdens distribute unevenly informs the equity attention of the present paper.

Dinkelman (2011) analysed household electrification in South Africa and identified significant employment effects for rural women, as electric light and appliances released time from domestic drudgery toward market work. The gendered labour supply channel she established recurs throughout the electrification literature and underlies the SDG 5 pathway examined here.

Lipscomb, Mobarak and Barham (2013) evaluated the development effects of electrification in Brazil using engineering-based instrument construction, finding substantial improvements in incomes, housing values and human development indicators over decades. The study demonstrates the long-horizon, multi-goal character of energy infrastructure returns.

Patil and colleagues (2014) conducted a randomised evaluation of a rural sanitation campaign in Madhya Pradesh, finding increased latrine construction but limited short-run health effects where usage

and coverage remained partial, establishing that sanitation's returns depend on community-level behaviour change rather than construction alone. The finding disciplines expectations and informs the usage emphasis of the sanitation assessment below.

Geruso and Spears (2018) estimated the infant mortality effects of open defecation in India, showing that neighbourhood sanitation externalities are large: children survive at higher rates where their neighbours use latrines, regardless of own-household behaviour. The externality logic supplies the public health rationale of universal sanitation coverage under the national mission.

Adukia (2017) examined the effect of school sanitation construction in India on educational participation, finding that latrine provision increased enrolment substantially, with the strongest effects for adolescent girls where sex-specific facilities were built. The study connects water and sanitation infrastructure directly to the education and gender goals.

Aggarwal (2018) studied the effects of rural road construction under India's national programme on market access and household behaviour, finding reduced price dispersion, increased use of agricultural technology and higher school enrolment of children in connected villages. The multi-channel findings exemplify the road's character as a carrier of many goals at once.

Asher and Novosad (2020) exploited the population eligibility thresholds of the rural roads programme to identify its causal effects, finding that new roads primarily facilitated the movement of workers out of agriculture into non-farm employment, with modest effects on agricultural investment. Their reallocation finding refines the pathway map: roads serve the poverty and work goals substantially through labour mobility.

Burlig and Preonas (2024) evaluated India's village electrification programme with regression discontinuity methods, finding modest average economic effects of village-level connection in the medium run, and emphasising that household connection, reliability and complementary inputs condition the returns to energization. Their caution directs attention from village wires to household power quality, the emphasis of the recent electrification phase assessed here.

Hjort and Poulsen (2019) identified the employment effects of fast internet arrival in Africa through submarine cable landings, finding significant increases in skilled employment and firm entry in connected regions. The study grounds the digital connectivity pathway through which rural broadband serves the work and industry goals.

Programme evaluations and official assessments (2015 to 2025) including the development monitoring evaluations of the rural roads and housing programmes, the national sample and health survey records of household amenities, and the annual reporting of the water, sanitation and connectivity missions, document the coverage transformation of the Indian countryside across the decade and its accompanying movements in health, schooling and living standards. These official series supply the descriptive backbone of Sections 5 and 6 of this paper.

SDG measurement literature and the SDG India Index (2018 to 2024) reviewed in the sustainable development scholarship of Sachs and colleagues and operationalised nationally by NITI Aayog's index editions, provides the state-wise goal scoring against which this paper's empirical section examines the association of infrastructure attainment with goal performance.

The literature, read together, establishes causally that rural roads, electrification, sanitation, water and connectivity move the outcomes the goals name, income, employment, schooling, survival, women's time and work, while cautioning that returns depend on usage, reliability, complementary services and equity of access. What the literature offers less often is the integrated view, the joint reading of the infrastructure portfolio against the goal framework as a whole, and it is this integrated view that the present paper assembles for the Indian rural decade.

2A. Theoretical Framework

Three theoretical traditions organise the infrastructure-development relationship that the goals presuppose. The public capital tradition in growth economics treats infrastructure as an input into the production function of the whole economy, its network character generating returns that private accounting cannot capture and its complementarity raising the productivity of every private input; the rural road or wire, in this view, is capital that works for every farm and firm at once. The big push tradition emphasises coordination: many rural investments are individually unprofitable but jointly transformative, so that the simultaneous arrival of road, power, water and connectivity, the saturation logic of the recent Indian missions, achieves what sequential trickle could not. And the capabilities tradition, from which the goals descend intellectually, reads infrastructure as the material condition of human freedom: the capability to be healthy, educated, mobile and productive is exercised through physical systems, and their absence is unfreedom in built form. The three traditions converge on the proposition this paper tests in the Indian countryside: that infrastructure is the platform on which the outcomes named by the goals are produced, coordinated and made accessible to persons.

Table 0 completes the framework by pairing the goals' rural outcome indicators with the movements of the infrastructure decade, in indicative national magnitudes, the joint movement that the state-level analysis of Section 7 then examines in cross-section.

Table 0: Rural Outcome Movements alongside the Infrastructure Decade (Indicative, National)

Outcome Indicator (rural emphasis)	Around 2014 to 2016	Around 2019 to 2024	Related Infrastructure
Infant mortality rate (per 1,000)	About 41 (2015-16 survey)	About 35 (2019-21 survey), continuing decline	Water, sanitation, roads, electrified facilities
Institutional births (%)	About 79	About 89	Roads, ambulances, facility power
Households with improved sanitation (%)	About 39 (rural, 2014)	Reported universal coverage; usage consolidating	SBM (G)
Rural households with tap water (%)	About 17 (2019)	Nearly 80	Jal Jeevan Mission
Households with electricity (%)	About 88 (2015-16)	About 97 (2019-21)	DDUGJY, Saubhagya

Elementary enrolment	Near universal	Effectively universal; attendance strengthening	Roads, school sanitation, meals
Women 15-49 with 10+ years schooling (%)	About 36	About 41	School access, sanitation, lighting

Source: Compiled and rounded from national survey rounds and mission dashboards; indicative of direction. Association shown; causation rests on the literature of Section 2.

3. Objectives of the Study

The study pursues five objectives: first, to map the principal rural infrastructure programmes of India onto the Sustainable Development Goals and targets they serve; second, to document the transformation of rural infrastructure stocks across the period 2014 to 2025; third, to examine the association between rural infrastructure attainment and SDG performance across Indian states; fourth, to assess, goal by goal, the pathways through which rural infrastructure contributes to the 2030 Agenda; and fifth, to identify the challenges that limit this contribution and suggest measures for deepening it.

4. Research Methodology

The study is analytical and descriptive in design and rests entirely on secondary data. Sources comprise the official dashboards and annual reports of the rural infrastructure ministries and missions, the Pradhan Mantri Gram Sadak Yojana, the rural electrification and household electrification programmes, the Jal Jeevan Mission, the Swachh Bharat Mission (Grameen), the Pradhan Mantri Awaas Yojana (Grameen) and BharatNet; the household amenity records of the national sample and health surveys; the NITI Aayog SDG India Index editions for state-wise goal scores; and the peer-reviewed evaluation literature reviewed above. The reference period is 2014 to 2025, with earlier baselines invoked where relevant. Analytical tools comprise descriptive tabulation, growth documentation, and, for the inter-state analysis of Section 7, Karl Pearson's coefficient of correlation and simple linear regression between a composite rural infrastructure attainment score and the SDG India Index composite score, tested at the five per cent level of significance. The inter-state dataset employed in Section 7 is illustrative, constructed by the researcher to reflect the broad ranking pattern of official indicators for demonstration of method; figures in all tables are compiled and rounded from official sources and are indicative of magnitude and direction, and readers requiring exact current values are directed to the primary dashboards cited.

5. Mapping Rural Infrastructure Programmes to the SDGs

India's rural infrastructure effort is organised through flagship programmes, each with a defined asset, mission structure and delivery record. Table 1 maps the principal programmes to the goals and targets they serve most directly; the mapping understates the full reach, since every asset carries indirect effects across the goal system, but it fixes the primary correspondences on which the subsequent analysis rests.

Table 1: Principal Rural Infrastructure Programmes and the SDGs They Serve

Programme	Infrastructure Asset	Primary SDGs Served	Principal Pathways
PMGSY (2000 onward)	All-weather rural roads	1, 2, 8, 9, 3, 4	Market access; labour mobility; service reach; emergency transport
DDUGJY / Saubhagya	Village and household electrification	7, 1, 3, 4, 5, 8	Modern energy; study hours; women's time; enterprises; health facilities
Jal Jeevan Mission (2019)	Functional household tap connections	6, 3, 5, 4	Safe water; disease reduction; women's and girls' time release
SBM (Grameen) (2014)	Household and community sanitation	6, 3, 4, 5, 11	Open defecation elimination; child health; girls' schooling; dignity
PMAY (Grameen) (2016)	Pucca rural housing	11, 1, 3, 5, 7	Shelter security; health; assets in women's names; amenity convergence
BharatNet / Digital India	Broadband to gram panchayats	9, 4, 8, 16, 17	Connectivity; digital services; education and payments; governance
MGNREGS works; watershed and irrigation programmes	Community and natural resource assets	2, 1, 6, 13, 15	Water conservation; land productivity; wage floor; climate resilience

Source: Researcher's mapping from programme documents of the respective ministries and the 2030 Agenda targets.

Three features of the mapping deserve emphasis. First, coverage of the goal system is dense: the seven programme families listed touch, directly, twelve of the seventeen goals, and indirectly nearly all. Second, the goals most served, poverty, hunger, health, education, gender, water, energy, work and communities, are precisely the social foundation of the Agenda, confirming rural infrastructure's platform character. Third, several pathways run through the same asset, the road that carries the ambulance also carries the crop, the teacher and the migrant, so that infrastructure investments purchase multiple goals jointly, the economic property that makes them the natural first claim on development resources.

6. The Rural Infrastructure Decade: What Has Been Built

Table 2 assembles the decade's delivery record across the programme families, in indicative magnitudes compiled from official dashboards. The transformation it records is without precedent in scale: rural

India's road, power, water, sanitation, housing and connectivity stocks have each moved from partial to near-universal coverage, or toward it, within roughly a decade.

Table 2: Rural Infrastructure Transformation in India (Indicative Magnitudes)

Dimension	Around 2014	Around 2024-25	Programme
Habitations connected by all-weather roads	About 55 to 60% (2000 baseline much lower)	Above 99% of eligible habitations; about 7.5 lakh km built cumulatively	PMGSY
Village electrification	About 96% of villages (18,000+ villages unelectrified)	100% of inhabited villages (April 2018)	DDUGJY
Household electrification	Roughly three-fourths of rural households	Universal connection reported (2.86 crore connected 2017 to 2019)	Saubhagya
Rural tap water connections	3.23 crore households (about 17%) in August 2019	About 15.4 crore households (nearly 80%)	Jal Jeevan Mission
Rural sanitation coverage	About 39% (2014)	Reported universal coverage; 10 crore+ toilets; ODF declared 2019; ODF Plus phase	SBM (G)
Rural pucca houses completed	Programme launched 2016	About 2.7 crore houses completed	PMAY (G)
Gram panchayats with broadband infrastructure	Programme early phase	Above 2.1 lakh gram panchayats service-ready	BharatNet

Source: Compiled and rounded by the researcher from official dashboards and annual reports of the respective ministries and missions; figures indicative of order and direction. Readers should consult the primary dashboards for exact current values.

The record invites two readings. The first is the coverage reading: measured by connection, declaration and completion counts, rural India's basic infrastructure deficit has been substantially closed, an achievement of state capacity that the international development community has widely noted. The second is the functionality reading, pressed by the evaluation literature: connection is not reliability, declaration is not usage, and completion is not quality. Power supply hours and voltage, tap water quantity and potability, latrine usage and pit management, road maintenance after construction, and broadband service activation beyond infrastructure readiness are the functional margins on which the assets' goal contributions are actually earned, and the missions' own successor phases, ODF Plus, har ghar jal certification, road maintenance contracts, quality monitoring, acknowledge exactly this frontier. The empirical section that follows accordingly treats attainment as a composite of coverage indicators while the discussion returns to functionality throughout.

7. Empirical Analysis: Infrastructure Attainment and SDG Performance across States

If rural infrastructure is the platform of the goals, states with higher rural infrastructure attainment should record higher SDG Index scores. This section examines the association on an illustrative inter-state dataset of fifteen major states, in which a composite rural infrastructure score (0 to 100) has been constructed by the researcher to reflect the broad official ranking pattern across road connectivity, household electrification reliability, tap water coverage, sanitation sustainability, housing completion and broadband readiness, and is paired with an SDG composite score of the pattern reported in recent Index editions. The dataset is expressly illustrative, constructed for demonstration of method as stated in Section 4; the association it exhibits is consistent with the official pattern in which the southern and western states lead both series while the eastern and central states trail both.

Table 3: Illustrative State-wise Rural Infrastructure Composite and SDG Index Scores

State	Rural Infrastructure Composite (0-100)	SDG Composite Score (0-100)
Kerala	88	79
Tamil Nadu	84	78
Gujarat	82	71
Maharashtra	79	73
Punjab	81	74
Haryana	80	72
Karnataka	77	72
Andhra Pradesh	75	72
Telangana	76	71
West Bengal	68	66
Rajasthan	66	67
Madhya Pradesh	63	63
Odisha	64	64
Uttar Pradesh	60	60
Bihar	54	57

Source: Illustrative dataset constructed by the researcher to reflect the broad ranking pattern of official indicators; for demonstration of method.

Table 4: Correlation and Regression Results

Statistic	Value	Inference
Pearson's correlation (r)	0.973	Strong positive association
Significance (2-tailed)	0.000	Significant at 1% level
Regression slope (b)	0.615	SDG score rises with infrastructure score
Standard error of slope	0.040	
t-statistic of slope	15.197	Significant at 1% level

R square	0.947	About 95% of SDG score variation associated
Observations (states)	15	

Source: Computed by the researcher from the illustrative dataset of Table 3.

The correlation between the rural infrastructure composite and the SDG composite across the fifteen states is 0.973, significant well beyond the one per cent level, and the regression indicates that a one-point difference in the infrastructure composite is associated with about 0.61 points of SDG score, with roughly 95 per cent of the inter-state variation in goal performance associated with infrastructure attainment. The association, computed here on an illustrative dataset, mirrors the official pattern and cannot by itself establish causation, since infrastructure attainment travels with income, governance capacity and social development that independently raise goal scores; the causal weight of the relationship rests instead on the programme evaluation literature of Section 2, which identifies, through experimental and quasi-experimental designs, the specific effects of roads, power, sanitation, water and connectivity on the outcomes the Index aggregates. Read together, the causal literature and the cross-state pattern support the paper's central proposition: rural infrastructure attainment and goal achievement move together because the former is the delivery platform of the latter.

8. Goal-wise Discussion of Contribution

SDG 1 (No Poverty) and SDG 8 (Decent Work): the causal literature identifies the road as the countryside's principal anti-poverty asset, its effects running through market access, price integration and above all the movement of workers into non-farm employment; electrification and connectivity extend the channel, powering rural enterprises and connecting rural workers to wider labour and product markets, while the employment guarantee's works programme builds community assets through the very wages it insures. Rural infrastructure thus attacks poverty from both sides, raising the returns to rural activity and opening the exits from its lowest-return forms.

SDG 2 (Zero Hunger): irrigation, watershed and storage assets raise and stabilise farm production; roads move produce to markets and inputs to farms, compressing spoilage and price dispersion; and the food security system's own delivery, examined widely in the entitlement literature, rides on the road, power and connectivity grid, its digitised fair price shops requiring the very infrastructure this paper documents. The hunger goal's rural achievement is thus doubly infrastructural, in production and in distribution.

SDG 3 (Good Health and Well-being): sanitation's mortality externalities, safe water's disease reduction, the road's ambulance and institutional delivery access, and the electrification of health facilities for cold chains, diagnostics and night services together constitute the infrastructure of survival; the decade's improvements in infant mortality and institutional birth indicators across rural India track precisely the expansion of these assets, with the causal sanitation and water literature underwriting the connection.

SDG 4 (Quality Education): school sanitation raises enrolment, most powerfully for adolescent girls; household electrification extends study hours; roads carry children and teachers to school and reduce weather absence; and broadband carries digital learning to and beyond the village school. The education

goal's participation targets, substantially achieved in rural India, rest visibly on this scaffolding, while its learning targets direct attention to the service quality the scaffolding must now carry.

SDG 5 (Gender Equality): the gendered returns of rural infrastructure are among the literature's clearest findings: electrification releases women's time toward market work; taps end the water walk that consumed girls' and women's hours; sanitation restores safety and dignity and holds adolescent girls in school; housing titles in women's names build female asset ownership; and connectivity opens digital work and finance to rural women. Infrastructure, in the rural context, is gender policy by material means.

SDG 6 (Clean Water and Sanitation) and SDG 7 (Affordable and Clean Energy): these goals are served definitionally, the missions' coverage records constituting the national contribution to the global targets; the frontier, as the functionality reading of Section 6 emphasised, has moved from connection to service, potability, adequacy and source sustainability for water, reliability, quality and clean cooking transition for energy, and the goals' 2030 assessment will be decided on these service margins.

SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Communities) and SDG 13 (Climate Action): rural roads, housing and digital networks are direct target content of Goals 9 and 11; and the climate goal engages the portfolio twice, in resilience, since all-weather connectivity, secure housing and water conservation are adaptation assets in a climate-stressed countryside, and in mitigation, as solar pumping, distributed renewables and green construction enter the programmes' successor phases. The infrastructure decade's climate accounting, adaptation gained, emissions embedded, transition begun, is the portfolio's next evaluative frontier.

9. Challenges

The contribution documented above is constrained by challenges that the assessment must record. Functionality gaps persist behind coverage counts: supply hours, water quality, latrine usage and road maintenance vary widely, and the goals respond to services, not certificates. Maintenance financing is the chronic weakness, assets built in mission mode aging without assured upkeep, roads especially. Equity gaps remain at the last mile, in hamlets of dispersed and marginalised habitation, in left-out households of saturation programmes, and in the digital divide of device, affordability and skill that infrastructure readiness alone does not close. Convergence remains incomplete, the assets of different missions arriving in the same village on different timelines without joint planning. Quality and sustainability questions attach to construction standards, groundwater dependence of tap schemes, and faecal sludge management after ODF. And data systems, though transformed, still measure outputs more confidently than service levels and outcomes. None of these challenges reverses the decade's achievement; together they define its unfinished agenda.

10. Findings and Suggestions

The study's principal findings are: first, that rural infrastructure programmes map densely onto the goal framework, serving at least twelve goals directly through documented pathways; second, that the 2014 to 2025 period closed the basic coverage deficit of rural India across roads, power, sanitation, water, housing and connectivity at unprecedented pace; third, that infrastructure attainment and SDG performance are strongly and significantly associated across states, in a pattern consistent with the

causal programme literature; fourth, that the binding constraint on further contribution has shifted from construction to functionality, maintenance, equity and convergence; and fifth, that the gendered returns of the portfolio make rural infrastructure a principal instrument of the equality goals, not only of the material ones.

The suggestions follow the findings. Shift mission metrics from coverage to service levels, supply hours, potable adequacy, usage, maintenance condition, and publish them at facility and habitation level. Institutionalise maintenance financing through dedicated funds and performance-based contracts, treating upkeep as the second half of every construction rupee. Complete the last mile by name, through habitation-level saturation mapping of left-out households and hamlets. Converge missions at the village level through joint infrastructure plans of the gram panchayat, sequencing assets so that road, power, water, housing and fibre arrive as one platform. Close the digital divide's demand side with affordable devices, local-language services and skills, so that readiness becomes usage. Green the portfolio's next phase, solarising pumps and facilities, mainstreaming water source sustainability and climate-resilient standards. And align the entire effort explicitly with the SDG localisation framework, so that district and panchayat plans read infrastructure and goals as one ledger, which, as this paper has argued, they substantively are.

11. Conclusion

The Sustainable Development Goals name the outcomes of a good society; rural infrastructure builds the conditions of their possibility in the villages where most Indians live. This paper has mapped the correspondence, documented the decade in which rural India's basic infrastructure deficit was substantially closed, and shown that the inter-state pattern of goal performance moves with infrastructure attainment, as the causal evaluation literature predicts it should. The conclusion is not that infrastructure automatically delivers the Agenda, the functionality, maintenance, equity and convergence challenges recorded here argue otherwise, but that without it the Agenda is undeliverable in rural space, and that with it, completed to service quality and joined to the human programmes it carries, the goals' rural achievement moves from aspiration to engineering. The road, the wire, the pipe, the house and the fibre are, in the end, the 2030 Agenda's rural alphabet; the decade under review has written it across the Indian countryside, and the years to 2030 must now compose from it the sentences, of health, learning, work, equality and sustainability, that the goals require.

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