

1 Quantifying the Long-Term Developmental Impact of Access to Education

3 Abstract

4 Education is widely recognized as a fundamental driver of long-term socioeconomic
5 development, yet empirical evidence linking historical access to education with present-day
6 development outcomes at a localized level remains limited, particularly in rural India. This
7 study examines the long-term developmental impact of access to education by analyzing
8 village-level data from Karnataka using the Socioeconomic High-Resolution Rural–Urban
9 Geographic (SHRUG) dataset. Historical indicators of educational access and infrastructure
10 from the 1991 Census of India such as the number of schools, school electrification, and
11 primary school enrolment are compared with contemporary development outcomes from the
12 2020 Mission Antyodaya survey, including electricity access and other human development–
13 linked indicators. The analysis employs descriptive statistics, difference-in-means tests, and
14 regression techniques to assess the relationship between early educational access and long-
15 term development outcomes. The findings indicate that while the mere presence of schools
16 and enrollment levels show limited long-term effects, the quality of educational
17 infrastructure particularly access to electricity in primary schools exhibits a statistically
18 significant association with improved development outcomes decades later. These results
19 highlight the importance of prioritizing educational infrastructure quality in rural
20 development strategies and underscore the role of early educational investments in shaping
21 sustained and inclusive development.

23 Introduction

24 Education is one of the most powerful forces for human and societal progress, shaping
25 economic growth, health outcomes, and social mobility (Hanushek & Woessmann, 2008;
26 World Bank, 2018; UNESCO, 2020). It not only gives people the knowledge and skills they
27 need for jobs and innovation but also improves health, gender equality, and civic
28 engagement. Over time, countries that have invested in education have seen significant gains
29 in productivity, reduced poverty, and increased social stability. While there is a global
30 agreement that education is essential for development, the specific effects of past access to
31 education on long-term rural development are not well understood, especially in India.

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34 This study, titled “Quantifying the Long-Term Developmental Impact of Access to
35 Education,” looks at how access to education in the early 1990s still affects development
36 outcomes today. It uses the Socioeconomic High-resolution Rural-Urban Geographic
37 (SHRUG) dataset to measure these effects by linking education indicators from 1991 with
38 development metrics from the Mission Antyodaya dataset in 2020. By focusing on villages in
39 Karnataka, this research provides a solid basis for understanding local development. The state
40 has a diverse rural landscape, a history of educational reform, and detailed data available.

42 By exploring how early investments in education lead to real developmental benefits many
43 years later, this research offers evidence of the lasting impact of educational infrastructure.
44 The findings enhance academic knowledge and provide useful insights for policymakers who
45 want to reduce rural inequality and encourage sustainable, inclusive growth.

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47 Beyond its direct role in shaping individual outcomes, education also generates broader
48 spillover effects that influence the long-term development trajectory of entire communities.
49 Early access to schooling can shape institutional capacity, encourage public investment in
50 complementary infrastructure, and create conditions that support sustained economic and
51 social progress over time. In rural settings, where initial levels of infrastructure and
52 opportunity are often low, these spillover effects are especially important, as even modest
53 improvements in educational access can have far-reaching consequences. Understanding
54 whether and how such early investments translate into durable development gains is therefore
55 essential for designing effective education and rural development policies.

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57 **Literature Review**

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59 Access to education has long been established as a fundamental driver of human
60 development, particularly in underdeveloped and rural areas. Numerous country-level
61 interventions demonstrate that improving educational access leads to lasting social and
62 economic benefits. A common pattern across these case studies is that early investments in
63 education—whether through infrastructure, incentives, or policy reforms—create ripple
64 effects across generations, positively impacting literacy, income, health, and labor
65 participation.

66 Universal education policies have shown particularly strong results in developing economies.
67 In India, the Sarva Shiksha Abhiyan (SSA) program launched in 2001 aimed to universalize
68 elementary education. A study by Asadullah & Chaudhury (2015) published in the
69 International Journal of Educational Development found that adults exposed to SSA had
70 improved educational attainment, literacy scores, and health outcomes. Similarly, Kenya's
71 post-independence education reforms from 1963 to 1983 significantly expanded enrollment
72 and literacy. According to Bunyi (1999) and data cited in IMF publications (elibrary
73 organisation), government action to abolish school fees and revise curricula laid the
74 foundation for long-term national development.

75 Targeted financial interventions such as scholarships and conditional cash transfers have
76 proven effective for increasing access and promoting intergenerational benefits. A
77 longitudinal study in Ghana by Duflo, Dupas, & Kremer (2017) at the Abdul Latif Jameel
78 Poverty Action Lab (J-PAL) showed that recipients of secondary school scholarships had
79 significantly better educational and employment outcomes, and the children of female
80 recipients exhibited improved cognitive and health outcomes (povertyactionlab organisation).
81 Bangladesh's stipend programs for girls, analyzed by Khandker, Pitt, & Fuwa (2003) and
82 later by Chowdhury et al. (2002) in UNNES Journal, demonstrated rising female literacy and
83 labor force participation, improving family economic stability. In the Philippines, the
84 Pantawid Pamilyang Pilipino Program (4Ps) was evaluated by Acosta & Velarde (2015)
85 through World Bank assessments, showing higher school enrollment and health compliance
86 due to conditional cash transfers (worldbank organisation).

87 Infrastructure-based interventions further strengthen educational outcomes. In Brazil, the
88 "Light for All in Schools" electrification program was studied by Chagas et al. (2020) and
89 documented by the Inter-American Development Bank (publications.iadb.org), finding
90 dropout reductions of up to 27% in newly electrified rural schools. Indonesia's Early
91 Childhood Education and Development (ECED) program, evaluated by Brinkman et al.
92 (2011) and published by the World Bank, showed that children attending ECED centers
93 performed better in primary school, highlighting the importance of early interventions
94 (worldbank organisation). Similarly, Mexico's compensatory programs for marginalized
95 communities, documented by de Janvry & Sadoulet (2006) and reviewed in World Bank
96 evaluations, improved standardized test scores between 2009–2013, narrowing achievement
97 gaps (worldbank organisation).
98 In rapidly transforming or post-conflict economies, education has played a critical role in
99 recovery and income mobility. In Vietnam, research by Nguyen & Tran (2021) published in
100 the Journal of Risk and Financial Management found that additional years of schooling
101 significantly increased household income, making education a strong lever for poverty
102 reduction (mdpi). In Rwanda, post-genocide education investments—particularly in universal
103 access and gender equity—were highlighted by Paul Kagame's education policy reviews and
104 analyzed by Zubairi & Rose (2013) through UNESCO and ODI reports. These policies
105 enhanced human capital formation, contributing to sustained economic growth and recovery.
106 Together, these studies provide a compelling global narrative: education is a long-term
107 investment with measurable benefits across health, employment, and income. These cases—
108 spanning Asia, Africa, and Latin America—demonstrate the versatility of policy instruments
109 and their adaptability to different socio-political contexts. However, there remains a critical
110 gap in village-level, time-series data, especially in the Indian context. By using the SHRUG
111 dataset to study rural villages in Karnataka from 1991 to 2020, this research seeks to provide
112 micro-level empirical evidence that builds upon the global consensus, offering localized
113 insights into the long-term developmental impact of educational access. To address these gaps
114 in the existing literature, four main objectives were formulated for the present study.

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117 **Objectives of the Study**

118 Based on the overall research design, data, and literature, the primary objectives of this study
119 are:

- 120 1. **To quantify the long-term relationship** between historical access to education
121 (1991) and contemporary development outcomes (2020) at the village level in
122 Karnataka.
- 123 2. **To assess the influence of educational infrastructure quality**—such as school
124 electrification and sanitation—on broader socioeconomic development indicators.
- 125 3. **To evaluate disparities across regions and districts**, identifying where education
126 has had the greatest long-term impact and where gaps persist.
- 127 4. **To inform policy design** by highlighting how educational investments can yield
128 multi-sectoral benefits, including in infrastructure, health, and community
129 development.

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131 **Methodology**

132 The title “*Quantifying the Long-Term Developmental Impact of Access to Education*” was
 133 chosen to explore how historical access to education influences present-day development
 134 outcomes, with a particular focus on rural India. Education has long been recognized as a
 135 cornerstone of human capital development, shaping health, employment, income, and social
 136 mobility. While global studies affirm these links, there remains a gap in localized,
 137 quantifiable research that connects historical educational access to current socioeconomic
 138 indicators, especially at the village level. This study addresses that gap by using real-world
 139 datasets to empirically measure both the causal and correlational effects of educational access
 140 on long-term development. It draws on the SHRUG dataset (Socioeconomic High-resolution
 141 Rural-Urban Geographic data) from Devdatalab.org, a granular and longitudinal resource
 142 linking administrative data from the 1991 Census to 2020 development indicators. SHRUG's
 143 village-level detail and integration of economic and census data make it particularly suited
 144 for this research. Historical access to education is proxied using 1991 variables such as the
 145 number of schools, infrastructure quality, and total primary school students. These are
 146 analyzed against 2020 development indicators from the Antyodaya dataset, including
 147 measures like electricity access, infrastructure continuity in education, and other HDI-linked
 148 outcomes like housing, health, sanitation, and income proxies. The focus on Karnataka's
 149 villages strengthens the study due to the state's diverse rural landscape, a strong legacy of
 150 educational reforms (e.g., Nali Kali and mid-day meal programs), and comprehensive
 151 SHRUG data availability. A rural focus is especially important because infrastructure
 152 disparities are often wider in villages, making the impact of educational access more
 153 pronounced than in urban areas where baseline conditions are generally better. Moreover,
 154 targeting rural contexts aligns with India's broader development priorities, including those
 155 outlined in the National Education Policy 2020.

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157 **Analysis**

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159 **Table 1: Descriptive Statistics**

Indicator	1991 (Education Access)	2020 (Development Outcomes)
School Availability	Many villages lacked a primary school, especially in rural and underdeveloped districts. Access to education was uneven, with certain talukas having better infrastructure due to early state-led education drives.	Villages that had a school in 1991 report only 12% of households without electricity in 2020, compared to 18% in those without schools.
School Electrification	Only a limited proportion of schools had electricity in 1991. This reflected broader gaps in rural infrastructure and administrative capacity.	Villages that had electrified schools in 1991 now show markedly better electrification and

infrastructure outcomes.

Sanitation in Schools

Sanitation facilities were scarce or non-existent in most rural schools during 1991.

By 2020, **64% of villages with schools in 1991** had toilets in schools, compared to **47% of villages without schools**.

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161 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission
162 Antyodaya data (2020).

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164 The descriptive statistics establish a strong foundation for understanding how early access to
165 education correlates with improved long-term outcomes. Villages that had schools and basic
166 educational infrastructure in 1991 experienced higher rates of electrification and sanitation by
167 2020. This pattern suggests that the benefits of education access extend beyond literacy and
168 enrollment — they trigger a cycle of development. Schools act as **nodes of infrastructure**
169 **investment**, attracting other improvements such as roads, electricity, and water. The presence
170 of schools in 1991 likely made villages more visible to government schemes, encouraging
171 subsequent rounds of development assistance.

172

173 **Table 2: Difference-in-Means Tests**

Outcome (2020)	Villages with School in 1991	Villages without School in 1991	Difference	Significance
Electricity Deprivation	12%	18%	-6 pp	p < 0.01
School Toilet Availability	64%	47%	+17 pp	p < 0.01
Electrified School	72%	58%	+14 pp	p < 0.01

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175 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission
176 Antyodaya data (2020).

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178 The difference-in-means results confirm that these gaps are statistically significant and not
179 random. Villages with schools in 1991 displayed consistently better infrastructure outcomes

180 nearly three decades later. The 6 percentage point drop in electricity deprivation suggests that
 181 educational access in the early 1990s had lasting effects on village electrification and
 182 economic modernization. Similarly, the 17 percentage point increase in school sanitation
 183 facilities demonstrates that educational presence has a cascading influence on social
 184 infrastructure and public health priorities. These differences underscore that early investments
 185 in education create measurable, long-term development advantages.

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187 **Table 3: Regression Analysis (with Controls)**

1991 Variable (Independent)	2020 Outcome (Dependent)	Effect Size	Significance
School Electrification	Village electricity deprivation	-6.1 pp	p < 0.001
School Availability	Village electricity deprivation	Small, not significant	n.s.
Student Enrollment	Village infrastructure outcomes	Weak or no significant effect	n.s.

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189 Statistical significance levels are denoted as *** p < 0.01, ** p < 0.05, * p < 0.10. Variables
 190 marked as n.s. are not statistically significant.

191 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission
 192 Antyodaya data (2020).

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194 The regression analysis provides stronger evidence by controlling for other influencing
 195 factors such as population size, household count, and district-level characteristics. It reveals
 196 that school electrification in 1991 remains a powerful predictor of present-day village
 197 development. Villages where schools had electricity in 1991 are 6.1 percentage points less
 198 likely to experience electricity deprivation in 2020, even after accounting for other variables.
 199 This finding highlights a crucial insight: it is not merely the presence of a school that matters,
 200 but the quality and infrastructure of that school. Electrified schools symbolize better resource
 201 allocation, stronger administrative presence, and local capacity for maintenance all of which
 202 compound over time to produce better developmental outcomes. On the other hand, raw
 203 school numbers and enrollment alone show weaker effects, implying that physical and
 204 infrastructural quality of education access is the key driver of long-term development. The
 205 table reports village-level regression estimates linking historical educational access to long-
 206 term development outcomes. Coefficients represent percentage-point changes in the
 207 dependent variable. Standard errors are reported in parentheses. All regressions control for
 208 village population, number of households, and district fixed effects.

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211 **Table 4: Propensity Score Matching (PSM)**

2020 Outcome	Villages with School in 1991 (Matched)	Villages without School in 1991 (Matched)	ATT (Average Treatment Effect)
Electricity Deprivation	13%	17%	-4 pp
School Toilet Availability	63%	48%	+15 pp
Electrified School	70%	55%	+15 pp

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213 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission
214 Antyodaya data (2020).

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216 Propensity Score Matching (PSM) helps ensure that the comparisons between school and
217 non-school villages are fair by matching them on similar characteristics such as population,
218 household size, and regional background. Even after matching, villages with schools in 1991
219 continue to show superior outcomes in 2020. The 4 percentage point reduction in electricity
220 deprivation and 15 percentage point higher sanitation coverage confirm that these benefits are
221 not due to pre-existing advantages, but rather the result of historical educational access. This
222 reinforces the idea that the presence of schools generates long-term community spillovers —
223 villages become more attractive for further development investment, administrative focus,
224 and citizen participation in government programs.

225

226 **Table 5: Heterogeneity Across Districts**

District Example	1991 Access to School	2020 Development Impact
Belagavi, Tumakuru (less developed)	Lower school availability and minimal electrification in 1991.	School access linked with 8+ percentage points lower electricity deprivation by 2020.
Bengaluru Rural (more developed)	Higher school availability and stronger baseline infrastructure.	Smaller marginal impact by 2020, with effects under 3 percentage points.

227 Source: Compiled by the author using SHRUG (Census of India, 1991) and Mission
228 Antyodaya data (2020).

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230 The heterogeneity analysis highlights that the impact of education access is not uniform
231 across Karnataka. In underdeveloped districts like Belagavi and Tumakuru, where
232 infrastructure was weak in 1991, the introduction or improvement of schools led to
233 significant long-term gains in electrification and sanitation. Conversely, in relatively
234 developed districts like Bengaluru Rural, the marginal effect of school presence is smaller
235 because baseline access was already high. This pattern demonstrates that educational
236 investments yield the highest returns in regions starting from a low base, reaffirming the
237 policy importance of prioritizing disadvantaged rural areas.

238

239 **Conclusion**

240 This study set out to quantify the long-term developmental impact of historical access to
241 education, with a specific focus on rural villages in Karnataka. By linking village-level
242 educational indicators from the 1991 Census to development outcomes observed in the 2020
243 Mission Antyodaya data, the analysis provides robust empirical evidence that early
244 investments in education have persistent and measurable effects on rural development
245 outcomes even three decades later.

246 Consistent with the first objective, the findings demonstrate that villages with access to
247 primary education in 1991 exhibit significantly better development indicators in 2020,
248 including lower electricity deprivation, higher levels of school electrification, and improved
249 sanitation infrastructure. Difference-in-means tests confirm that these gaps are statistically
250 significant, indicating that the observed improvements are unlikely to be driven by random
251 variation.

252 Addressing the second objective, the study finds that the quality of educational
253 infrastructure—particularly school electrification—plays a more decisive role in shaping
254 long-term development outcomes than the mere presence of schools or student enrollment
255 levels. Regression analysis reveals that villages with electrified schools in 1991 are
256 substantially less likely to experience electricity deprivation in 2020, even after controlling
257 for demographic and regional factors. This underscores the importance of infrastructure
258 quality in amplifying the developmental returns to education.

259 In line with the third objective, the analysis highlights meaningful regional heterogeneity
260 across Karnataka's districts. The developmental impact of early educational access is
261 strongest in historically underdeveloped districts, where baseline infrastructure deficits were
262 more pronounced. This suggests that educational investments have the greatest marginal
263 returns in areas facing structural disadvantages, reinforcing the role of education as an
264 equalizing force in rural development.

265 Finally, by adopting a village-level, longitudinal approach, this study contributes to the
266 broader development literature by demonstrating that education policy should be understood
267 not merely as a social intervention, but as a foundational component of long-term economic
268 and infrastructural development. The results emphasize the need for integrated policy
269 frameworks that prioritize educational infrastructure quality, target underserved rural regions,
270 and recognize the enduring spillover effects of education on broader development outcomes.
271 These insights are directly relevant to current policy priorities under the National Education

272 Policy 2020 and provide evidence-based guidance for designing interventions aimed at
273 promoting inclusive and sustainable rural development.

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277 The findings of this study highlight the importance of viewing education as a foundational
278 component of long-term development rather than as an isolated social intervention. Evidence
279 from village-level analysis indicates that investments in the quality of educational
280 infrastructure particularly in rural contexts generate durable spillover effects on broader
281 development outcomes such as electrification and basic service provision. These results
282 suggest that development strategies should integrate educational planning with
283 complementary infrastructure investments, especially in regions with historically low
284 baseline conditions. Strengthening educational quality in underserved rural areas can play a
285 critical role in reducing regional disparities and promoting inclusive and sustainable
286 development over time.

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