IUBAT Review—A Multidisciplinary Academic Journal, 8(2): 130-153
https://doi.org/10.3329/iubatr.v8i2.86884

Assessing the Socio-Economic Effects of Improved Rural Accessibility: A Case Study of Keraniganj Upazila

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Keywords:

Economic Development; Income; Poverty; LGED; Rural Connectivity; Social-transformation; Women-employment.

Abstract

Rural road development plays a transformative role in improving livelihoods in developing countries like Bangladesh. This study evaluates the socio-economic effects of enhanced rural accessibility in two unions of Keraniganj Upazila named Jinjira and Kalindi through structured household surveys, interviews, and field observations. Results reveal that improved connectivity significantly increased household income (by 33% in Jinjira and 17% in Kalindi) and savings (by 111.6% and 86.9%, respectively). Local businesses experienced higher customer flow and income, while better roads encouraged school attendance and improved healthcare access for 53% of respondents in Jinjira and 40% in Kalindi. A paired t-test ($p = 0.001$) confirmed a statistically significant rise in income levels, emphasizing the role of rural connectivity in poverty reduction. However, 24% reported congestion, 22% noted rising accidents, and 20% mentioned environmental issues, underscoring emerging sustainability challenges. The study concludes that while improved accessibility enhances income, mobility, and quality of life, long-term planning should integrate safety, environmental protection, and equitable infrastructure coverage to achieve sustainable rural transformation.

1. Introduction

Rural road development has long been recognized as a cornerstone of economic and social transformation, particularly in developing countries. Improved connectivity enhances access to markets, schools, healthcare, and employment opportunities, helping to reduce poverty and improve living standards (Khandker, Bakht, & Koolwal, 2009; Sloman, Hopkinson, & Taylor, 2017). In Bangladesh, where nearly 76% of people live in rural areas (Trading Economics, 2016; World Bank, 2014); limited infrastructure remains a major barrier to progress. Poor road conditions constrain mobility, raise transport costs, and hinder access to essential services, reinforcing cycles of poverty and inequality (Oraboune, 2008; Oosterhaven & Knaap, 2000). Against this backdrop, this study examines the tangible socio-economic outcomes of rural accessibility improvements in Keraniganj Upazila. It focuses on measurable indicators such as household income, savings, education, healthcare, and land-use changes following LGED

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Article received: April 2025 Revised and accepted: December 2025 Published: December 2025

interventions; aiming to provide evidence of how improved connectivity can drive inclusive rural growth in Bangladesh.

Poor road conditions in rural Bangladesh not only increase the cost of daily mobility but also limit access to essential services, agricultural markets, and income-generating opportunities (Oraboune, 2008; Oosterhaven & Knaap, 2000). Decades of research have emphasized that investments in rural roads can yield substantial returns by enabling farmers and small businesses to access inputs and sell products more efficiently (Binswanger *et al*., 1993; Patarusak, 2013; Dercon *et al*., 2008). Additionally, well-connected rural areas tend to show improvements in education and healthcare outcomes, as families are better able to reach schools and health facilities (BIDS, 2004; Asian Development Bank, 2023).

The Local Government Engineering Department (LGED) has played a crucial role in expanding rural infrastructure in Bangladesh. Initially focused on rural development, LGED has gradually expanded its scope to include urban and water resource management projects, contributing to poverty reduction, employment generation, and economic diversification (Asian Development Bank, 2016; LightCastle Partners, 2024). While significant progress has been made, challenges such as increased traffic congestion, environmental concerns, and disparities in infrastructure quality persist, necessitating continuous policy interventions and investment (Sengupta, Coondoo, & Route, 2007).

Keraniganj Upazila, located near the capital city of Dhaka, offers a unique setting to evaluate such impacts. Though technically close to urban hubs, parts of this upazila remain underserved. While some unions, such as Jinjira, enjoy relatively good connectivity, others like Kalindi are still developing. This contrast provides a valuable opportunity to examine how rural road development affects income levels, business activity, education, healthcare & land use and to what extent these benefits are equitably distributed.

While national studies have demonstrated the positive outcomes of rural infrastructure development, localized analyses capturing on-the-ground realities remain limited. This study seeks to fill that gap by systematically evaluating the socio-economic impacts of improved rural accessibility in two contrasting unions; Jinjira and Kalindi within Keraniganj Upazila. The research specifically investigates measurable parameters such as household income, savings, access to education and healthcare, and changes in land use resulting from LGED interventions. Grounded in field-based data and community-level observations, the study aims to generate practical insights for policymakers to design and implement rural connectivity initiatives that are economically productive, socially inclusive, and environmentally sustainable.

2. Literature Review

Access to reliable rural transportation has long been recognized as a cornerstone of development, particularly in low and middle-income countries where large populations depend on agriculture and informal livelihoods. Improved rural roads reduce travel time and costs, connect remote communities to markets, and unlock access to health, education, and employment opportunities (Chambers, 1980; Edmonds, 1998; Njenga & Davis, 2003; Fan *et al.*, 2007). In Bangladesh, where rural connectivity directly affects both economic and social well-being, poor road conditions often mean higher prices for goods, limited access to quality education and healthcare, and constrained agricultural productivity (Binswanger *et al.*, 1993; Dercon *et al.*, 2008; World Bank, 2014). Studies have shown that better transportation infrastructure is positively linked with increased household income, reduced poverty, and improved overall resilience (Khandker, Bakht, & Koolwal, 2009; Oraboune, 2008). LGED has been at the forefront of addressing these challenges, with targeted road development initiatives aimed at integrating rural areas into broader economic systems (Asian Development Bank, 2016, 2023).

Several studies support the claim that road development plays a significant role in improving household earnings, diversifying occupations, and facilitating access to markets and non-farm employment opportunities (Patarasuk, 2013; Lokshin & Yemtsov, 2005). For instance, better rural roads have been associated with higher farm productivity and wages, largely due to easier access to agricultural inputs and transportation services (Dercon *et al.*, 2008). Connectivity also promotes small business growth and the establishment of local enterprises by enabling the smoother flow of goods and services (LightCastle Partners, 2024; Sloman, Hopkinson, & Taylor, 2017). In Bangladesh, where the rural economy is highly sensitive to mobility constraints, such improvements can be transformative. However, while the economic benefits are clear, researchers have also pointed to accompanying risks including land use changes, rising traffic, and environmental degradation particularly in areas experiencing rapid development (Sengupta, Coondoo, & Route, 2007; Oosterhaven & Knaap, 2000). Road expansions can alter settlement patterns and accelerate urban sprawl, creating new challenges for planners and local governments (Patarasuk, 2013).

Beyond economics, improved rural roads also lead to measurable gains in education and public health. Children are more likely to attend school when they can travel safely and affordably, and families can more readily access medical facilities, improving outcomes in maternal and child health (BIDS, 2004; Asomani-Boateng *et al.*, 2015; Asian Development Bank, 2023). However, these benefits are not always equitably distributed. Vulnerable groups, particularly women, the elderly, and the disabled, may still face barriers due to safety issues or a lack of inclusive infrastructure design (Tarefder, 2015). Furthermore, while national-level statistics highlight LGED's success in bringing most rural households within two kilometers of paved roads (World Bank, 2014), many communities still remain underserved. The challenge, therefore, is not only to

build roads but to build smartly but ensuring that connectivity translates into meaningful and lasting socio-economic transformation. This study responds to that challenge by focusing on the localized effects of rural road development in Keraniganj Upazila, aiming to provide context-specific insights into both the benefits and the trade-offs of infrastructure-led development.

3. Methodology

3.1 Research Design and Approach

This study employs a quantitative research approach to assess the socio-economic impacts of rural road development in Keraniganj Upazila, Dhaka, focusing on Jinjira and Kalindi unions. The research investigates income variations, business growth, school attendance, healthcare access, and land-use transformations due to improved road connectivity. Given the structured nature of the study, primary data collection was conducted using household surveys, structured interviews on open ended questionnaire and observational assessments, ensuring a comprehensive evaluation of rural connectivity impacts.

A paired sample t-test was used to determine the statistical significance of changes in income levels, allowing for a robust before-and-after impact assessment. Additionally, descriptive statistical tools such as percentage distributions and frequency analysis were employed to evaluate changes in household income, savings, and overall living standards.

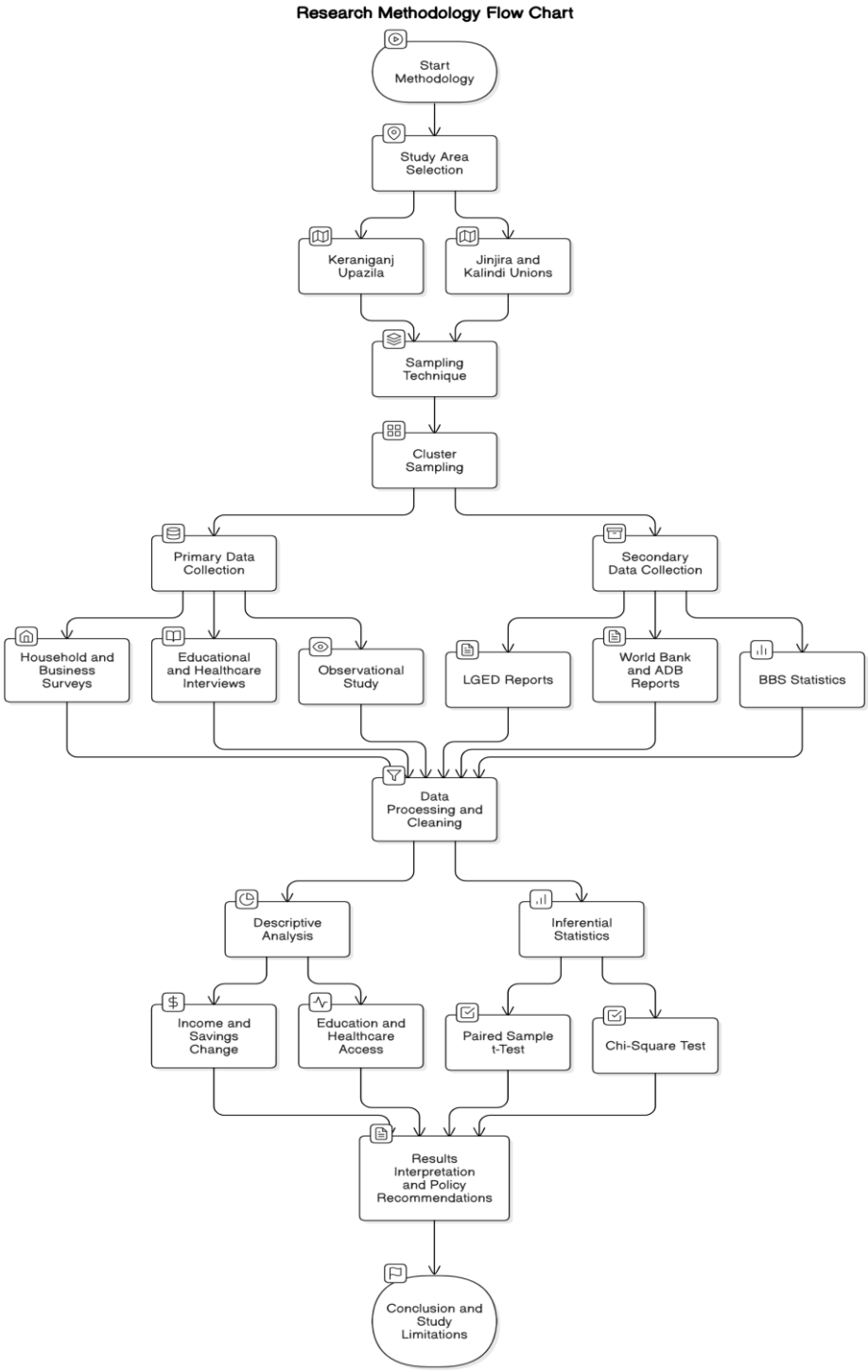

Figure 1: Research methodology Flow-Chart.

3.2 Study Area and Sampling Framework

Keraniganj Upazila, located southwest of Dhaka, provides a meaningful setting for assessing how rural connectivity influences everyday socio-economic conditions. Although it lies close to the capital, accessibility varies widely across its twelve unions. To capture this variation, the unions of Jinjira and Kalindi were purposively selected. Jinjira benefits from several Upazila and Union Roads and has long enjoyed better transport links, while Kalindi remains comparatively underserved. This contrast allowed the study to explore how different levels of rural accessibility shape income, mobility, access to services, and broader social outcomes, consistent with comparative rural development studies (Khandker *et al.*, 2009; Dercon et al., 2008; World Bank, 2014).

Figure 2: Study Area (Keraniganj, Dhaka)

3.3. Sample Frame and Eligibility

The sampling frame consisted of permanently residing households within the selected clusters of each union. Household lists were collected from the respective Union Parishad offices and were refined through field verification to ensure that no settlement pockets were overlooked. Because rural connectivity affects households in different ways through mobility, access to markets, or changes in daily travel patterns; all households located within the study clusters were considered eligible.

To ensure that the sample represented the population directly influenced by road development, the following eligibility conditions were applied:

- Households must have resided in the union for at least five years, allowing a reliable capture of “before” and “after” conditions.
- Households needed at least one income-earning member, making income comparison meaningful.

- Seasonal or temporary dwellings, as well as households unable to provide information on income or mobility patterns, were excluded.

This process aligns with common practice in rural socio-economic impact studies, where households closest to infrastructure interventions form the basis for understanding local welfare changes (Oraboune, 2008; Dercon *et al.*, 2008).

3.4. Cluster Sampling and Household Selection Procedure

A two-stage cluster sampling approach was used to ensure that the sample captured diverse accessibility conditions within each union.

Stage 1: Cluster Identification

Each union was divided into small geographic clusters based on settlement density, proximity to LGED-improved roads, and natural boundaries. Clusters were categorized into:

- High-accessibility clusters, located close to improved or paved roads; and
- Moderate-to-low-accessibility clusters, located farther from LGED interventions.

One cluster from each category was selected using simple random selection, ensuring that both well-connected and less-connected areas were represented.

Stage 2: Household Selection Within Clusters

Within each selected cluster, enumerators followed a systematic household selection method. After randomly choosing a starting point, every third household along the primary settlement path was approached. This method ensured fairness, reduced intentional bias, and remained practical for rural fieldwork, where formal household numbering is often limited.

If a chosen household was unavailable or declined participation, the next adjacent household was approached. This ensured completeness of the sample without compromising the systematic process. Such structured yet flexible methods are widely recommended for socio-economic field research in rural areas with variable accessibility (World Bank, 2014).

3.5. Sample Size

A total of 30 households (15 from each union) were surveyed. While modest, this sample size is appropriate for the study's exploratory objectives and aligns with rural development assessments conducted in data-constrained settings (Khandker *et al.*, 2009). The focus was on generating localized, household-level insights rather than population-wide generalizations, consistent with case-study methodologies using small but information-rich samples. The relative homogeneity within clusters further supports the adequacy of the sample for detecting shifts in income, savings, and service access. In addition, the paired sample t-test applied to income data remains statistically valid for small samples when observations are matched and approximately normally distributed, as

demonstrated in similar before–after rural infrastructure studies (Dercon *et al.*, 2008; Khandker *et al.*, 2009).

3.6. Data Collection

Structured face-to-face interviews were conducted between 10:00 AM and 2:00 PM to ensure participants were engaged in their day-to-day activities, providing spontaneous and unbiased responses. The survey covered employment status, income levels, living costs, and satisfaction levels before and after the LGED led road development. Changes in profession, net income, and access to healthcare were also documented, ensuring a comprehensive understanding of socio-economic transformations.

A separate close ended questionnaire purposive survey was conducted to examine land use changes and school participation rates. Attendance records from local primary schools were collected to compare student participation before and after the road infrastructure improvements, assessing the impact on educational accessibility. To inform future planning, respondents were asked about their evolving needs, infrastructural expectations, and socio-economic aspirations. This data provides insights into potential areas for further rural connectivity expansion. All surveys followed a structured questionnaire format, ensuring consistency and reliability in data collection while minimizing response bias.

3.7. Data Analysis Techniques & Hypothesis

The study employs both descriptive and inferential statistical methods to evaluate the impact of road connectivity.

Descriptive Statistics

- Percentage analysis for changes in income, savings, and employment rates.
- Frequency distributions for household access to healthcare and education.

Inferential Statistics

- Paired Sample t-Test was conducted to assess whether income levels before and after road development significantly differed.
- Chi-Square Test was used to evaluate changes in categorical socio-economic variables.

The null hypothesis (H_0) assumes that rural road development has not resulted in a significant change in household income, while the alternative hypothesis (H_1) suggests a statistically significant improvement in economic conditions post-development:

$$H_0 : \mu 1 = \mu 2$$

$$H_1 : \mu 1 \neq \mu 2$$

where,

- μ_1 = Mean household income before road development
- μ_2 = Mean household income after road development

3.8. Ethical Considerations

Informed consent was obtained from all participants before data collection. All responses were kept confidential and anonymous to ensure privacy. This study adhered to the ethical guidelines of human research participation, ensuring voluntary participation without coercion.

4. Data Analysis and Findings

This section presents a comparative analysis between Jinjira and Kalindi unions. In Jinjira, enhanced accessibility has resulted in greater income growth and business activity due to proximity to major upazila roads and markets. Kalindi, with limited connectivity, shows moderate yet positive socio-economic change. Analytical commentary has been added throughout to link observed outcomes with relevant literature (Khandker *et al.*, 2009; Dercon *et al*., 2008; ADB, 2023).

4.1 Analysis of Jinjira Union

Age distribution among respondents in Jinjira Union ranged from 18 to over 50 years, with the majority belonging to the working-age group below 50. Most participants were concentrated in the 30–35-year range, reflecting an economically active population engaged in diverse occupations. This demographic structure indicates that road development primarily benefits a productive age group that contributes significantly to household income and local commerce. The dominance of younger and middle-aged respondents also highlights the role of improved connectivity in supporting employment mobility and livelihood diversification within rural communities.

Net incomes of family in Jinjira union represent a noticeable distribution. Table 1 shows that significant rise in income after the implementation of rural connectivity measures such as construction of roads and maintenance of existing road networks. Almost a hike of 33% has been shown in the net income of families indicating overall development of the area. Still, it can be seen that 7 of 15 participants have status of poor having income (dollar)/day/person less than $1.90 (World Bank, 2015) which indicates development works should further be carried on and road network and other infrastructures should be given emphasis for poverty reduction of the whole area.

Table 1: Poverty status based on poverty line of Jinjira Union

Tag	Family's Net income (Before)	Family's Net income (After)	Family Member (Nos.)	Daily Income (BDT/Day/ Person)	Daily Income (Dollar/Day/Person)	Status (Poor if <$1.90)
P-1	18240	22240	5	121.6	1.43059	Poor

P-2	19000	23200	5	126.667	1.4902	Poor
P-3	19760	24260	6	109.778	1.2915	Poor
P-4	12160	15160	3	135.111	1.58954	Poor
P-5	22800	27800	5	152	1.78824	Poor
P-6	24624	30324	5	164.16	1.93129	Not Poor
P-7	27360	33360	5	182.4	2.14588	Not Poor
P-8	30400	37000	6	168.889	1.98693	Not Poor
P-9	30704	38904	5	204.693	2.40816	Not Poor
P-10	27360	34360	5	182.4	2.14588	Not Poor
P-11	10640	10640	4	88.6667	1.04314	Poor
P-12	16720	20720	4	139.333	1.63922	Poor
P-13	22800	27800	4	190	2.23529	Not Poor
P-14	33440	41440	5	222.933	2.62275	Not Poor
P-15	22040	27540	4	183.667	2.16078	Not Poor

Figure-3 tells us about the scenario that rural connectivity development by LGED has overall positive impact among 93% cases. Some evidence showed unchanged scenario that might be due to not enough coverage. So, emphasis has to be given to increase accessibility.

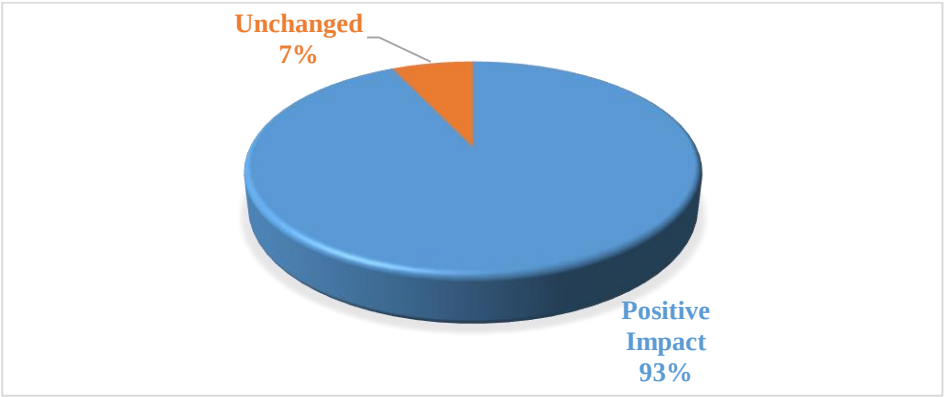

Figure 3: Impact of Rural Connectivity at Jinjira Union

As shown in Table 2, approximately 93% of the surveyed households in Jinjira Union reported a notable rise in both savings and living costs following

improved connectivity, while only 7% experienced no change due to limited coverage. On average, household net income increased by about 25–30%, reflecting the positive economic impact of enhanced accessibility. Correspondingly, family savings exhibited a substantial growth of 111.6%, indicating stronger financial resilience and improved income management. However, this progress was accompanied by a 45% rise in living expenses, suggesting that while overall economic conditions improved, the cost of living also escalated alongside increased economic activity.

Table 2: Savings and increase of living cost in Jinjira union

Tag	Family's Net income (Before)	Family's Net income (After)	Savings (Before)	Savings (After)	Saving (%) Increase	Increase in Living Cost (%)
P-1	18240	22240	800	1750	118.8	42.36
P-2	19000	23200	830	1800	116.9	43.24
P-3	19760	24260	850	1800	111.8	46.41
P-4	12160	15160	500	1200	140.0	51.11
P-5	22800	27800	1000	2200	120.0	42.22
P-6	24624	30324	1050	2300	119.0	47.09
P-7	27360	33360	1200	2500	108.3	43.52
P-8	30400	37000	1340	2800	109.0	42.62
P-9	30704	38904	1200	2900	141.7	60.19
P-10	27360	34360	1100	2550	131.8	56.06
P-11	10640	10640	700	700	0.0	0.00
P-12	16720	20720	700	1500	114.3	50.79
P-13	22800	27800	1000	2100	110.0	43.33
P-14	33440	41440	1400	3100	121.4	50.00
P-15	22040	27540	900	1900	111.1	55.56

Residential status also has been changed among the people after the development of rural network. Figure-4 shows trends that almost 40% people have much improved residential status where almost 40% have improved status resulting in construction of modern buildings and RCC structures in that area. Moreover, it can be seen also that almost 40% has unchanged condition regarding

residential status and 7% have deteriorated condition due to lack of connectivity at some areas within Jinjira Union.

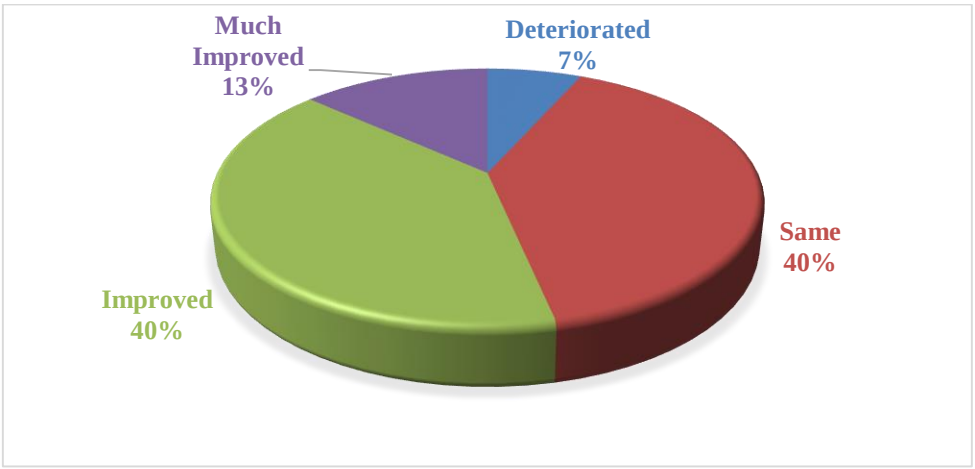

Figure 4: Residential Status at Jinjira union

Access to medical services also increased by the overall development of the rural connectivity by the LGED. Figure-5 Shows 53% of participants think that access to medical services increased due to the connectivity of rural network whereas 27% of them think more development is required.

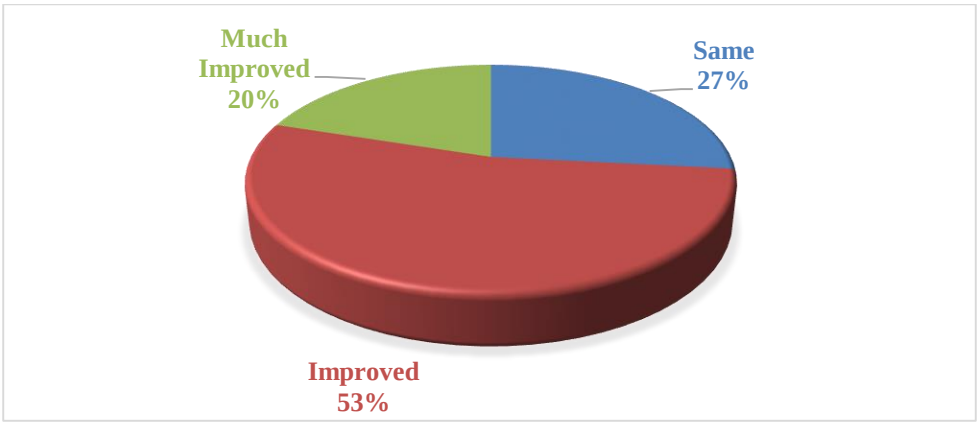

Figure 5: Access to Medical Services at Jinjira Union

The overall satisfaction level, as illustrated in Figure 6, indicates a positive public perception of rural connectivity improvements implemented by LGED. Nearly 60% of respondents expressed satisfaction with the overall connectivity, acknowledging its contribution to enhanced accessibility and mobility. Furthermore, about 27% of respondents reported being highly benefited, citing noticeable improvements in income levels and overall living standards as direct outcomes of the enhanced road infrastructure. However, approximately 13% of participants emphasized the need for further expansion and improvement,

suggesting that greater network coverage and connectivity to remote areas are essential to ensure more inclusive and equitable development across all parts of the union.

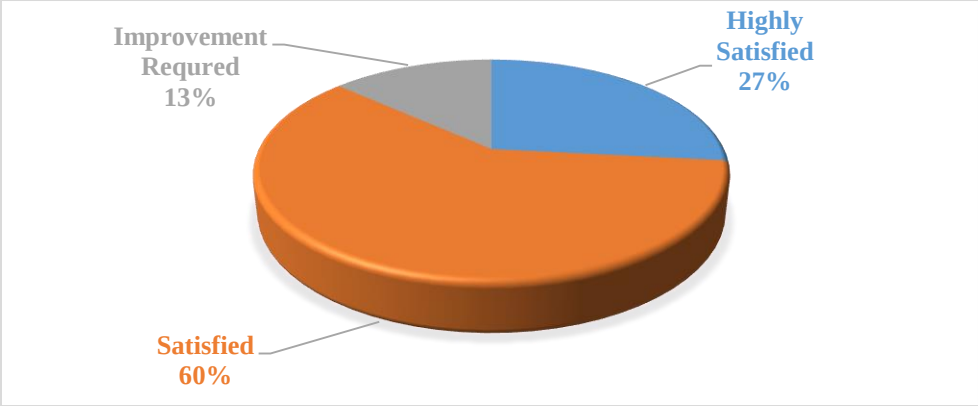

Figure 6: Overall satisfaction of people at Jinjira union

4.2 Analysis of Kalindi Union

In Kalindi Union, the age of respondents similarly ranged from 18 to above 50 years, with the majority belonging to the younger and middle-aged groups between 25 and 40 years. This pattern reflects a population that is economically active yet still developing in terms of income stability and access to opportunities. The concentration of respondents within this working-age bracket suggests that improvements in rural connectivity have the potential to enhance employment prospects and small-scale enterprise activities. The findings imply that younger residents, in particular, are likely to benefit from increased mobility, access to markets, and participation in emerging local economic activities resulting from improved road infrastructure.

Again, net incomes of family in Kalindi union represent a noticeable distribution. Table 3 shows that significant rise in income after the implementation of rural connectivity measures such as construction of roads and maintenance of existing road networks. Almost a hike of 17% has been shown in the net income of families indicating overall development of the area. Still, it can be seen that 10 of 15 participants have status of poor having income (dollar)/day/person less than $1.90 (World Bank, 2015) which indicates development works should further be carried on and road network and other infrastructures should be given emphasis for poverty reduction of the whole area.

Table 3: Poverty status based on poverty line of Kalindi Union

Tag	Family's Net income (Before)	Family's Net income (After)	Family Members	Daily Income (BDT/Day/ Person)	Daily Income (Dollar/Day/Person)	Status (Poor if <$1.90)

P-16	12616	14316	5	95.44	1.193	Poor
P-17	13832	15732	5	104.88	1.311	Poor
P-18	14440	16440	6	91.3333	1.14167	Poor
P-19	8360	9860	3	109.556	1.36944	Poor
P-20	16720	19220	5	128.133	1.60167	Poor
P-21	18240	19740	5	131.6	1.645	Poor
P-22	20520	23520	5	156.8	1.96	Not Poor
P-23	22800	26300	6	146.111	1.82639	Poor
P-24	22800	26500	5	176.667	2.20833	Not Poor
P-25	19760	22260	5	148.4	1.855	Poor
P-26	8360	9360	4	78	0.975	Poor
P-27	12160	13660	4	113.833	1.42292	Poor
P-28	16720	19220	4	160.167	2.00208	Not Poor
P-29	25840	29840	5	198.933	2.48667	Not Poor
P-30	16720	18720	4	156	1.95	Not Poor

Figure-7 tells us about the scenario that rural connectivity development works by LGED has overall positive impact among 70% cases. Some evidence showed unchanged scenario that might be due to not enough coverage. So emphasis has to be given to increase accessibility.

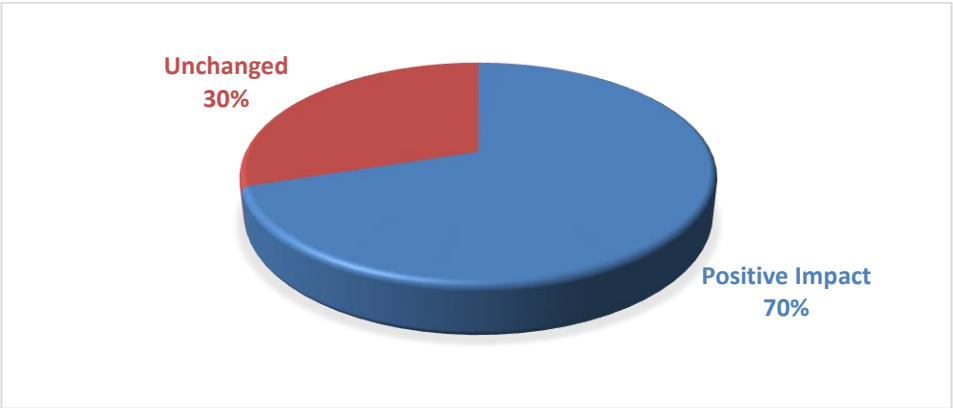

Figure 7: Impact of rural Connectivity of at Kalindi union

As presented in Table 4, approximately 70% of the surveyed households in Kalindi Union reported an upward trend in both savings and living expenses, reflecting the positive but moderate economic effects of improved rural connectivity. In contrast, about 30% of respondents experienced no significant change, primarily due to limited infrastructural coverage, as the area remains relatively remote compared to Jinjira Union. On average, household net income increased by 15–20%, accompanied by an 86.9% rise in savings, indicating gradual economic strengthening among connected households. However, this progress was coupled with a 13.8% increase in living costs, suggesting that while financial conditions have improved, the overall cost of living has also risen moderately in response to enhanced accessibility and local economic activity.

Table 4: Savings and increase of living cost in Kalindi Union

Tag	Family's Net income (Before)	Family's Net income (After)	Savings (Before)	Savings (After)	Saving (%) Increase	Increase in Living Cost (%)
P-16	12616	14316	830	1750	110.8	10.44
P-17	13832	15732	910	1800	97.8	12.33
P-18	14440	16440	950	1800	89.5	13.45
P-19	8360	9860	550	1200	118.2	17.17
P-20	16720	19220	1100	2200	100.0	14.14
P-21	18240	19740	1200	2300	91.7	3.70
P-22	20520	23520	1350	2500	85.2	15.23
P-23	22800	26300	1500	2800	86.7	16.30
P-24	22800	26500	1500	2900	93.3	17.04
P-25	19760	22260	1300	2550	96.2	10.68
P-26	8360	9360	550	700	27.3	17.17
P-27	12160	13660	800	1500	87.5	11.11
P-28	16720	19220	1100	1800	63.6	18.18
P-29	25840	29840	1700	3100	82.4	16.99
P-30	16720	18720	1100	1900	72.7	12.12

Residential status also has been changed among the people after the development of rural network. Figure-8 shows trends that almost 15% people have much improved residential status where almost 25% have improved status

resulting in construction of modern buildings and RCC structures in that area. Moreover, it can be seen also that almost 48% has unchanged condition regarding residential status and 12% have deteriorated condition due to lack of connectivity at some areas within Kalindi Union.

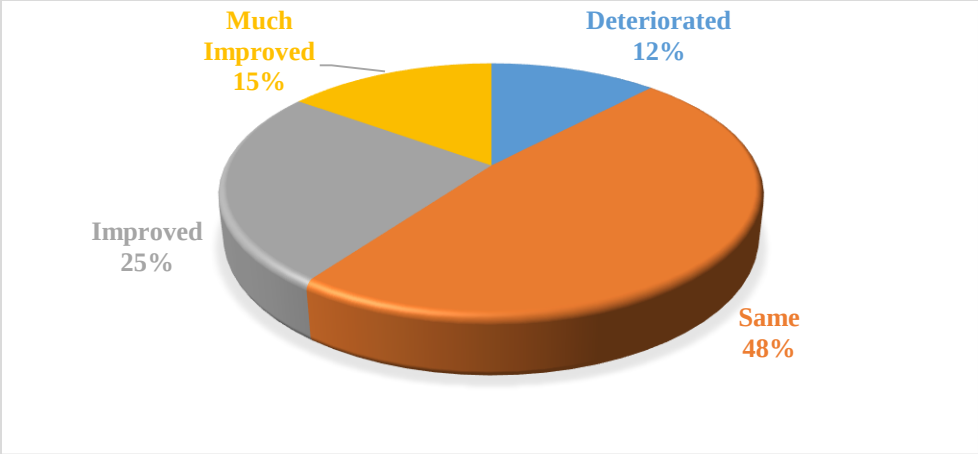

Figure 8: Residential Status of at Kalindi union

Access to medical services also increased due to the overall development of the rural connectivity by the LGED. Figure-9 Shows 40% of participants think that access to medical services increased due to the connectivity of rural network whereas 37% of them think more development is required.

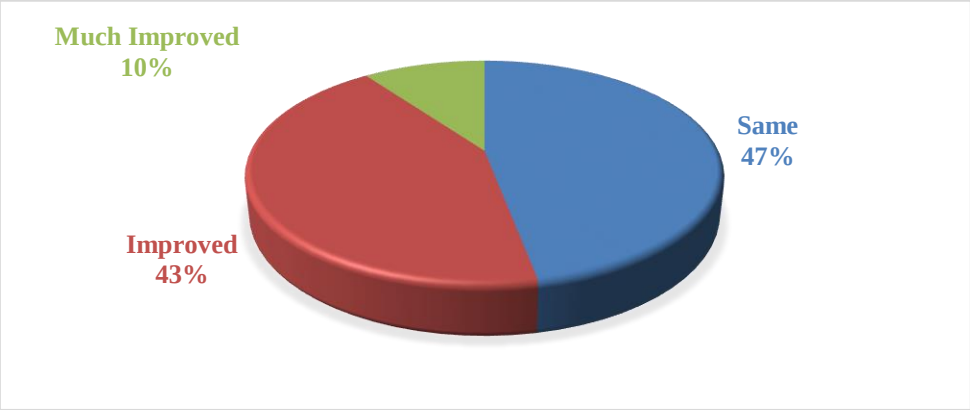

Figure 9: Access to medical Services at Kalindi Union

The overall satisfaction level of residents in Kalindi Union, as illustrated in Figure 10, reflects a more varied perception of the rural connectivity initiatives undertaken by LGED. Approximately 33% of respondents reported being highly benefited, citing noticeable improvements in income levels and living standards as direct outcomes of enhanced accessibility. Around 20% expressed general satisfaction with the existing level of rural connectivity, acknowledging its positive but limited impact. However, a significant 47% of participants emphasized the

need for further improvement and wider coverage, underscoring that connectivity should be expanded to more remote areas of the union to ensure equitable access and maximize the developmental benefits of the infrastructure investments.

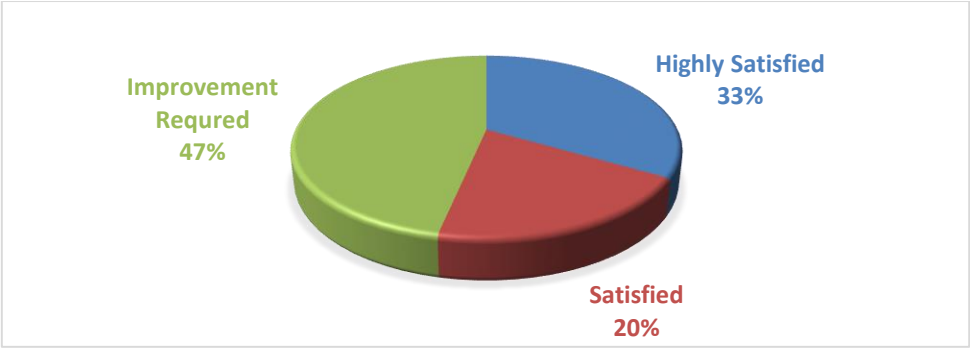

Figure 10: Overall Satisfaction of People at Kalindi Union

After analyzing Kalindi union, some differences with Jinjira union have been obtained. But the overall scenario of the socio-economic development due to Rural Connectivity by LGED is found satisfactory. Also, the poverty conditions including satisfaction improved but more comprehensive poverty alleviation program is required with more coverage of rural connectivity. Combined analysis of these two unions might depict the overall scenario in comprehensive manner.

4.3 Comparison Scenario

Figure 11 represents the net income comparison between two unions. It is found that, participants of Jinjira Union generate more income per person compared to the Kalindi Union. It is quite anticipated as the Jinjira Union has more connectivity.

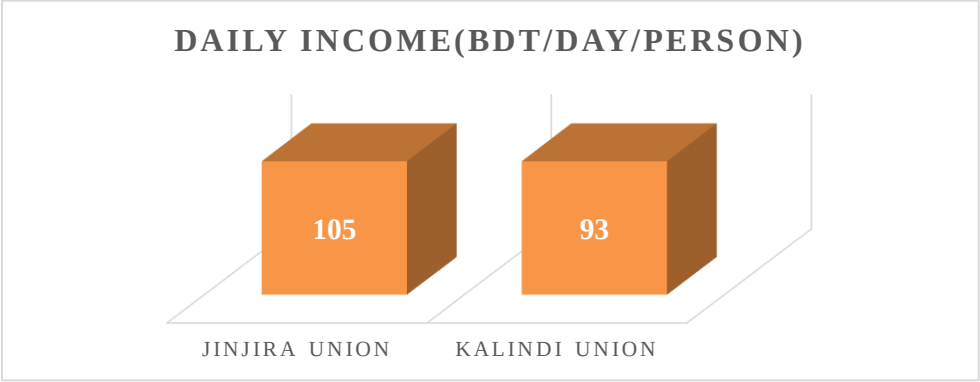

Figure 11: Daily Income Variation of the Two Unions

Four (4) out of Ten (10) Upazila roads are connected with this union. As a result, greater communication helps this union to have more per capita income and less poverty-stricken people compared to Kalindi Union. It has the biggest growth

center named Jinzira Bazar. Moreover, it has greater number of Rural markets. Almost Six (6) Rural markets are situated there as shown in Table 5.

Table 5: Growth Centers of Keraniganj (Source: LGED)

Growth Centre ID	Name of the Growth Centre
32638024	Amin Bazar
32638023	Bibir Bazar
32638025	Dholeswer Bazar
32638020	Kalatia Hat
32638021	Ruhitpur Hat
32638022	Zinzira Bazar

Also, poverty status is found more improved in Jinjira Union than Kalindi Union for the same reason. Per capita daily income is greater in Jinjira Union about by almost 13%.

Figure-12 Shows the satisfactory increase in daily income of these two unions. Both unions show a rapid hike of daily income within a few years. Specially after the adverse effect of COVID-19 pandemic the increase of income among the grass root people shows the importance of rural connectivity throughout the Upzilla. Moreover, participants' response also shows this rural connectivity developed by LGED also helped to access the medical services in due time causing great help to the COVID-19 patients.

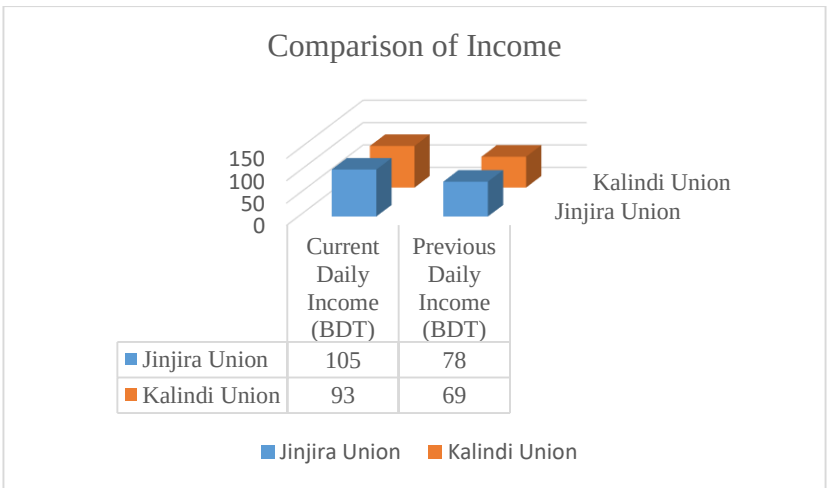

Figure 12: Comparison of Income Variation (Per Person) of the Two Unions within 2 years (2022-24)

Whether the Rural connectivity developed by the LGED actually aided rural people in reducing poverty thereby ensuring empowerment or not, can be obtained from the paired sample statistics. Paired sample t-test is performed for the determination of significance of change in income level. Table 6 shows a significance of 0.001 which is clearly below 0.050 and represents that the improvement of income level is satisfactory. Thus, the poverty reduction and socio-economic development due to the rural connectivity by the LGED is referred obvious from statistical point of view.

Table 6: Paired sample t-test statistics of previous and present income of the participants

Income Comparison	Mean	Standard Deviation	95% Confidence Level		t-test	df	Sig.
			Upper Level	Lower Level			(2-tailed)
	3716.6	2108.78	2962.05	4471.28	0.064	17	0.001

Successful indication of the poverty reduction obtained from the data analysis from findings in Keraniganj Upazila. It can be concluded that the status of poverty has been changed and null hypothesis of no change in income level is rejected thereby.

4.4 Other Impacts

4.4.1 School Attendance

Keraniganj Upazila hosts 128 primary schools, where students represent a major share of local travel demand, particularly during morning hours. The improvement of rural roads by LGED has transformed school accessibility by upgrading previously earthen and flood-prone roads into durable bituminous surfaces. This enhancement has not only increased the availability of safe and affordable motorized transport but also reduced travel time and seasonal disruptions that once hindered attendance. As a result, school participation rates have risen noticeably, especially in areas previously isolated during the rainy season as shown in Figure-13. These outcomes reaffirm that reliable road infrastructure is a key enabler of educational access and social development in rural Bangladesh, warranting sustained investment in inclusive connectivity.

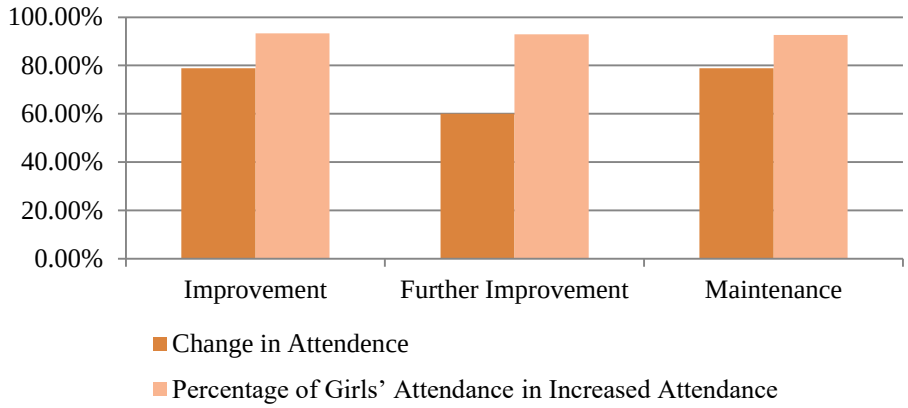

Figure 13: Attendance Percentage Increased Due to Good Accessibility

4.4.2 Changes in Land Use

Road infrastructure improvements significantly influence land use patterns, leading to increased commercial activity and urbanization. As depicted in Figure 14, the most notable change post-development is the rise in local shops across all surveyed areas. Improved accessibility and consumer demand have driven commercial expansion, with new shops predominantly emerging along upgraded roads. Additionally, the number of semi-paved and paved residential buildings has increased, facilitated by enhanced road widening and surfacing. Previously, transporting construction materials to rural areas was challenging; however, improved road conditions have eased logistics, enabling rapid residential development. These land use transformations contribute to increased traffic volumes and shifts in transportation modes, necessitating strategic planning for sustainable urban growth.

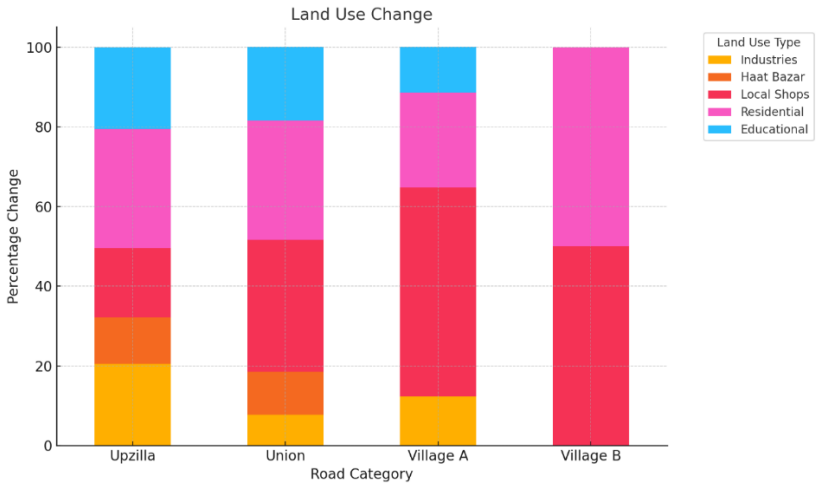

Figure 14: Land Use Change Due to Good Accessibility

4.4.3 Road Usability

Despite road development efforts, 19% of roads in Keraniganj villages remain unusable year-round, particularly during the rainy season. Among these, 2.7% are Union Roads, 23.7% are Village Road A, and 29.4% are Village Road B, indicating persistent accessibility challenges. Improved connectivity has significantly boosted local commerce, with 77.3% of shopkeepers reporting increased customer flow, as newly developed roads facilitate better access. Additionally, 78.5% of roads now support new transportation modes, previously absent due to poor conditions. Table 7 presents the distribution of these new transport modes across road types, though no significant correlation is found between intervention type and modal shifts.

Table 7: Introduction to New Modes due to Road Connectivity Development by LGED

Intervention Type	Road Type	New Modes
Improvement	Union Road	Truck, Auto-rickshaw, Auto-van
	Village Road A	Truck, Auto-rickshaw, Auto-van, Car, CNG
	Village Road B	Auto-rickshaw, Auto-van
Rehabilitation	Union Road	Truck, Auto-rickshaw, Auto-van, CNG
	Village Road A	Truck, Auto-rickshaw, Auto-van
	Village Road B	Auto-rickshaw
Maintenance	Union Road	Bus, Auto-rickshaw, Auto-van, CNG
	Village Road A	Truck, Auto-rickshaw, Auto-van, CNG
	Village Road B	Auto-rickshaw

4.5 Challenges Encountered

Road development in Keraniganj has significantly improved connectivity, but it has also introduced new challenges. Heavy traffic has emerged as the most severe issue, as narrow roads that once accommodated only small vehicles now face an influx of trucks transporting construction materials. The expansion of local shops and residential buildings along these roads has further intensified congestion. Another major concern is the rise in accidents. Previously, non-motorized vehicles like rickshaws and vans dominated the roads, posing minimal safety risks. However, the increased use of motorized vehicles such as auto-rickshaws and auto-vans has led to a notable surge in accidents. Traffic congestion is another

growing issue, driven by increased motorization and changes in land use. The construction of new commercial and residential structures along the roads has restricted movement, causing frequent bottlenecks. Addressing these challenges requires better traffic management and infrastructure planning to balance accessibility with safety.

5. Conclusion and Recommendation

This study reaffirms that improved rural road connectivity can drive substantial socio-economic progress when implemented thoughtfully and inclusively. In Keraniganj Upazila, household income rose by 33% in Jinjira and 17% in Kalindi, while household savings increased by 111.6% and 86.9%, respectively. Social benefits were also evident that school attendance and healthcare access improved by 53% in Jinjira and 40% in Kalindi, demonstrating the broader human impact of better accessibility.

Although the majority of beneficiaries reported improved livelihoods, gender and occupational patterns revealed nuanced dynamics. Women, particularly those engaged in small-scale trading and household-based income activities, reported enhanced mobility and participation in local markets, while men in transport and construction sectors benefited from expanded job opportunities. However, given the modest sample size (n = 30) and the design of the instrument, the analysis permits indicator-level insights rather than fully powered subgroup modelling. Therefore, these gender and occupation-specific findings should be viewed as indicative rather than conclusive, warranting deeper investigation in future research.

Furthermore, emerging challenges such as: 24% citing congestion, 22% increased accidents, and 20% environmental concerns highlight the need for integrated rural planning that signifies infrastructure expansion with safety and environmental safeguards. Future studies should adopt larger, gender-disaggregated datasets to better capture the differentiated impacts of rural connectivity and to design targeted interventions.

In summary, the findings underscore that rural accessibility not only enhances income and mobility but also empowers communities when supported by inclusive planning and continuous monitoring.

Acknowledgement

The authors would like to thank the Upazila Nirbahi Officer (UNO) and Upazila Engineer (UE) of Keraniganj Upazila Parishad for their kind and cordial support and help for collecting the data and required information.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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