Addis Ababa University, Ethiopian Journal of Business and Economics, EJBE Vol.: 12, No.: 2,
Doi: *https://dx.doi.org/10.4314/ejbe/v12i2.1* p-**ISSN:** ***2311-9772*** **e-ISSN:** ***2410-2393***
Available online: http://ejol.aau.edu.et/index.php/ejbe and https://www.ajol.info/index.php/ejbe

Bridging the Gap: How Rural Roads Connect Local Communities to Vital Services and Resources in Aleta-Wondo, Sidama Region, Ethiopia

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Abstract

Poverty is a major issue in Sub-Saharan Africa, and the transportation sector is viewed as a viable tool for promoting economic growth and development. The objective of this research was to analyze the importance of roads in resource mobilization by small-scale farmers, measure their impact on market access and engagement, and quantify their contribution to improving household well-being in two Ethiopian woredas. A multistage sampling process was used to choose 514 households, which were categorized as having or not having road access. The data was analyzed using descriptive and inferential statistics, as well as a treatment effects model. The study discovered that households with road access had better access to markets, schools, and health care services than those without. However, due to selection bias, the observed differences cannot be attributablesimply to road access. To solve this issue, a treatment effects model was used, and the matching exercise's quality was evaluated. The findings show that access to institutions and infrastructure, market access, and input consumption channels all have a major impact on households and their livelihoods. As a result, investment in road infrastructure is critical for fostering rural developmentand improving local communities' livelihoods in Sub-Saharan Africa.

Keywords: Poverty, transport sector, roads, market access, rural development, Ethiopia

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Introduction

Poverty is still a major issue in Sub-Saharan Africa, according to the World Bank, with the region seeing high levels of poverty in 2018. One potential solution to this challenge is to focus on expanding the transportation sector, which can improve market access and encourage economic growth and development (Berge et al., 2017). Since 2010, Ethiopia has recognized the potential of road development and has made major expenditures in this field.

The government has been collaborating with donors to provide all-weather links to rural towns under the Universal Rural Road Access Program (URRAP), and in the 2018/19 fiscal year, the government committed 37.3 billion birrs ($1.1 billion) in road development. Ethiopia had 144,024 kilometers (89,492 miles) of all-weather roads as of 2019/20, accounting for around 41% of the country's required road network. Ethiopia plans to invest 3.0 trillion birrs (about $58 billion) on the road sector over the next ten years, with the goal of constructing an additional 102,000 km and upgrading 28,000 km of federal highways, doubling the rural road network to 109,000 km from the present 56,000 km (JAICA, 2022).

Ethiopia allocated 11% of its budget to road infrastructure and maintenance work in the fiscal year 2021/22, demonstrating the government's strong commitment to road investment (JAICA, 2022). Many studies have been conducted to assess the influence of roads on the livelihoods of populations in developing countries, with variable results. For example, Khandker, Bakht, and Koolwal (2009) discovered that road investment reduced poverty by 8 to 10% in Bangladesh, whereas Dercon et al. (2009) discovered that access to roads reduced poverty by 6.9% in Ethiopian villages. However, Asher and Novasad (2018) discovered no clear impact of roads on household consumption and agricultural productivity in Indian villages, indicating the need for additional research to better understand the causal relationship between road sector development and improved community livelihoods.

Given these conflicting findings, the purpose of this study is to investigate the influence of the Aleta-Wondo road on the livelihoods of adjacent Ethiopian villages. The study intends to provide insight on the ways in which road sector growth can benefit the lives of rural populations by focusing on a specific case study. The Aleta-Wondo road has the potential to boost economic possibilities and alleviate poverty in the region by expanding the road network and enhancing access to markets. Studying the precise effects of this road on the surrounding communities can provide useful insights into the efficacy of road sector development as a poverty reduction strategy in Ethiopia and other developing nations.

Against the backdrop of the aforementioned issues, the objectives of this study are to evaluate the significance of roads in the utilization of resources by small-scale farmers; assess the influence of roads on improving farmers' access to markets; and their level of engagement in market activities, and determine the extent to which roads contribute to enhancing the well-being of households residing in the study area.

Review of Literature

Theoretical Literature

Road construction has been a critical role in the economic and social development of societies. Roads are viewed as a vital economic infrastructure that can cut transportation costs, increase access to markets and services, and promote the movement of products and people (Wachs, 2015). These benefits have been identified in numerous studies. For example, a study in rural Ethiopia found that households with road access had better market access, which could potentially lead to increased economic opportunities and improved livelihoods (Teklewold et al., 2013). Another study in India found that the construction of rural roads led to an increase in the productivity of firms in the manufacturing and service sectors, which in turn led to an increase in employment and income (Mitra and Murayama, 2017).

Social theories, such as the human capital hypothesis, propose that investments in education and training can lead to increased productivity and economic growth (Becker, 1964). Access to education is often hindered by poor road infrastructure, particularly in rural areas, where schools may be far away and difficult to reach. Improved transportation infrastructure, such as roads, can increase access to education and improve human capital, leading to higher productivity and economic growth (Gebreegziabher et al., 2019).

From a social perspective, roads can also have a significant impact on social development. Access to roads can improve access to healthcare, reduce travel time to schools and markets, and increase access to social services such as police and fire departments (Banister and Berechman, 2001). This can lead to increased social inclusion and cohesion as well as improved quality of life. For example, a study in rural Tanzania found that the construction of a road led to improved access to healthcare services, which in turn led to a reduction in child mortality rates (Rockers et al., 2009).

Social theories such as the social capital theory, which contends that social networks and trust can have a favorable impact on economic and social results, also support the relevance of roads in social development (Putnam, 1995). Road access can aid in the development of social capital by facilitating the building of social networks and promoting social engagement (Gebreegziabher et al., 2019). This can result in increased social cohesion and cooperation, which can lead to better economic and social consequences.

To summarize, the relationship between roads and development is complex and varied, with economic and social consequences. Many studies have identified the benefits of road infrastructure, including lower transportation costs, enhanced access to markets and services, improved education and human capital, improved access to healthcare, and increased social inclusion and cohesiveness. Economic and social theories that emphasize the relevance of transportation infrastructure in economic and social growth back up these benefits. As a result, investments in road infrastructure should be prioritized to support economic and social development, especially in rural and disadvantaged areas.

Empirical Literature

Rural roads are crucial for promoting economic development and enhancing social welfare in rural areas by providing access to markets, healthcare, and education, as well as improving mobility for households in remote areas. Numerous empirical studies have investigated the impact of rural roads on households in Africa and elsewhere. This section presents an empirical literature review of the benefits and challenges of rural road infrastructure for households.

One of the key benefits of rural roads is improved market access, which leads to enhanced economic prospects for rural households. According to Kone et al. (2017), rural road building in Cote d'Ivoire enhanced agricultural production and farmer revenue. Similarly, Winters et al. (2016) discovered that improving rural roads in Ethiopia boosted market access and improved household welfare. Another advantage of rural road infrastructure is improved access to social services. For instance, Anang et al. (2018) found that rural road improvements in Ghana led to increased access to healthcare services and improved health outcomes for households. In addition, rural roads can facilitate access to education. Duflo et al. (2006) reported that improvements in rural road infrastructure in Kenya led to increased school enrollment and attendance. However, rural road infrastructure can also have negative impacts on households. For example, the construction of rural roads can lead to land expropriation, resulting in the displacement of households and the loss of property rights (Tao et al., 2014). Additionally, rural road infrastructure can increase traffic accidents, leading to injuries and fatalities (Chen & Li, 2015).

Despite any negative consequences, the benefits of rural road infrastructure are frequently large for households. Alem et al. (2019) discovered that building rural roads in Ethiopia has a beneficial influence on household income and food security. Similarly, Oduro et al. (2019) showed that improvements to rural roads in Ghana enhanced agricultural productivity and income for farmers. Rural roads can have negative consequences as well, such as increased traffic accidents and property expropriation. Governments should invest in rural road infrastructure to improve residents' access to markets, social services, and economic prospects. Simultaneously, efforts to offset the negative impacts of rural roads, such as increasing road safety and preserving the rights of households impacted by road development, should be implemented.

Rural roads play a crucial role in improving household access to markets and economic prospects. They facilitate farmers' access to input and output markets, resulting in enhanced production and income (Deininger & Jin, 2003). Rural roads also improve access to health care and education, all of which are critical for the social welfare of households. Jacoby et al. (1995) discovered that households near rural roads had better access to healthcare services, resulting in better health outcomes. Furthermore, by boosting chances for income-generating businesses and education, rural roads can improve social welfare, particularly for women and children. For example, Gao et al. (2020) discovered that rural roads in China enhanced enrolment rates for girls in primary schools.

Description of the Study Area, Sampling, Data and Methods

Description of the Project and Study Area

The Aleta-Daye road project is located in the Sidama National Regional State, which is south of the capital city of Ethiopia, Addis Ababa. The road crosses 18 kebeles of the Aleta-Wondo, Tentecha, and Hagere-Selam woredas, covering a total length of 51 kilometers. The project was completed within five to seven months at a cost of 3.4 million Ethiopian birr and funded by the federal budget through the Ethiopia Road Administration.

Aleta-Wondo Woreda has a current population of 436,672, of which 223,300 are rural and 194,835 are urban residents. The average altitude of the area is 2100 meters above sea level, and it has three distinct agro-ecological zones: 12% is classified as Dega (highlands), 71% as Woinadega (midlands), and 17% as dry Kolla (lowlands). The main source of income in the area is mixed-type farming, with major crops including maize, haricot bean, root crops (sweet potato and enset), and cash crops such as coffee, chat, and fruit trees. Coffee, enset, and fruit are perennial crops in the area, and their productivity and production depend on the availability of the required amount of rain, in addition to other required inputs. However, this woreda, especially in the lowland areas, has become food insecure due to increasing population pressure, limited land size, and low coffee production.

Tentecha Woreda, established in 2018, is found northeast of Aleta-Wondo Woreda and north of Hula Woreda. It has a wet, cool temperate climate and receives an annual rainfall of 1200 to 1800 mm, with a mean annual temperature of 10 to 15°C. Enset, barley, wheat, cabbage, and potatoes are widely grown in this district.

Sampling, Data and Methods

The study employed a multistage sampling procedure. In the first stage, the team identified two woredas for the study. In the second stage, the team randomly selected two kebeles: Dobe Kebele from Aleta-Wondo Woreda and Debecha Kebele from Tentecha Woreda. This approach aimed to obtain a representative sample of the study population while also reducing any potential biases that could arise from non-random sampling methods. The selection of these kebeles was based on their geographical location, size, and the predominance of smallholder farmers engaged in agriculture.

This selection process ensured that the study was conducted in areas that were relevant to the research objectives and that the results could be generalized to similar settings.

Table 1

Sample Determination of The Selected Kebeles

Sampling procedures	**Dobe Kebele**		**Debecha Kebele**	
	Population	Sample	Population	Sample
Total Population	1338	308	427	206
Reside <= Km	834	191	235	113
Reside >2 Km	504	116	192	93

Source: Own Computation

In this study, the unit of analysis was households. The study employed the sample size determination formula developed by Cochran (1977). This formula was used to ensure that the sample size was adequate to provide accurate and reliable results while minimizing the margin of error. The formula used was presented as follows:

Because the population is infinite, the formula used is:

$$n_0 = \frac{z^2pq}{e^2}$$

Where, $n_0$is sample size, z is the selected value of desired confidence level, p is the estimated proportion of an attribute that is present in the population, q=1-p and e, the desired level of precision.

If the population is finite the sample size is estimated as follows;

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Whereas N is population size. A total of 514 households were considered. Since households are classified as those having access to road and or not, the proportional allocation method is used to get representative households of the strata (Bowley, 1962) but with more samples allocated to the users to reduce the dropouts.

Finally, the number of households from both groups were taken from the list obtained from each *Kebele*. Of the 519 households sampled, 56.45% reside within 2 km radius off the road and the remaining 43.45% are more than 2-kms away from the road. Following Iimi *et al*., (2016), we used 2km radius as a cut-off point whereby less than this cut-off value shows access to road and above the cut-off value as having no access to road. Survey questionnaire was administered to gather data from sample households pertinent to their demographic, socio-economic and institutional factors. With regard to the method of data analysis, inferential statistics and treatment effects models were used to examine mean differences and control for selection bias, respectively.

PSM constructs a statistical comparison group that is based on a model of the probability of participating in the treatment T conditional on observed characteristics X, or the propensity score:

$P(X) = Pr(T = 1|X)$.. 1

Rosenbaum and Rubin (1983) cited in (Shahidur *et al*., 2010), show that, under certain assumptions, matching on P(X) is as good as matching on X. The necessary assumptions for identification of the program effect are (a) conditional independence and (b) presence of a common support. These assumptions are detailed in the following sections. Conditional independence states that given a set of observable covariates X that are not affected by treatment; potential outcomes Y are independent of treatment assignment T. If Y_1 represents outcomes for participants and Y_0 outcomes for nonparticipants, conditional independence implies.

$(Y_1, Y_0) \perp T|X$ ……………………………………………………………........2

A second assumption is the common support or overlap condition: $0 < P(T_i = 1|X_i) < 1$… 3. This condition ensures that treatment observations have comparison observations "nearby" in the propensity score distribution (Heckman, LaLonde, and Smith, 1999 in Shahidur *et al.*, 2010).

Rosenbaum and Rubin (1983) show that if the exposure to treatment is random within cells defined by X, it is also random within cells well-defined by the values of the mono-dimensional variable p(X). As a result, given a population of units denoted i, is the propensity score $p(X_i)$ is known the Average effect of Treatment on the Treated (ATT). In non-experimental studies, the most common approach to evaluate a program effect is to calculate the average effect of the treatment on the treated [ATT]. Shahidur *et al.*, (2010) states that the treatment effect of the program using these methods can either be represented as the average treatment effect (ATE) or the treatment effect on the treated (ATT) and the estimation of the treatment effect is specified as follows:

The average treatment effect (ATE): $E(\Delta_i) = E(Y1i - Y0i) = E(Y1i) - E(Y0i)$ 3

Where $\Delta_i = Y1i - Y0i$.

This is the expected effect of the project for a randomly selected individual. The average treatment effect on the treated (ATT):

$E(\Delta_i = 1) = E(Y1i - Y0i{:}\, Ti = 1)$ 4

$$= E(Y1i{:}\, Ti = 1) - E(Y0i{:}\, Ti = 1)$$

Where the outer expectation is over the distribution of $(p(Xi){:}\, Ti = 1)$and $Y1i$ and $Y0i$ are the potential outcomes in the two counterfactual situations of treatment and control respectively. The PSM technique has been used as a non-parametric method in the impact evaluation literature. Matching methods support in creating a counterfactual from the control group. The basic assumptions when using a counter factual is that the untreated samples approximate the treated samples if they had not been treated, i.e., $(Y_{0i}{:}\ \mathrm{I} = 1)$ (Heckman *et.al.*, 1998 cited in Edenshaw, 2016).

The assumption of conditional independence (CIA) is critical and proper to make the matching valid. This assumption argues that treatment is random and conditional on observed variables(x) specified as in equation (2). This assumption implies that the counterfactual outcome for the treated group is the same as the observed outcome for the non-treated group given the control variables(x). In the present case, this means that the counterfactual livelihood situation is the same as the livelihood situation that would have existed if the household had no access to road, specified as:

$\mathrm{E}(\mathrm{Y}_0 \backslash \mathrm{X}, \mathrm{I} = 1) = \mathrm{E}(\mathrm{Y}_0 \backslash \mathrm{x}, \mathrm{I} = 0) = \mathrm{E}(\mathrm{Y}_0 \backslash \mathrm{x})$ 5

The first term of equation (5) represents the counterfactual livelihood situation of the treated group and is equal to the observed livelihood of the untreated (control) group. This assumption rules of selection into the program and gains from access to road on the basis of running observables. The CIA requires that the set of X's contain all variables that jointly influence the outcome with no treatment, as well as the selection into program. Under conditional independence, therefore, the ATT can be computed as:

$$ATT = E(Y_1 - Y_0 \backslash X, I = 1) = E(Y_1 \backslash x, I = 1) = E(Y_0 \backslash x, I = 1) \quad \text{......................} 6$$

However, matching of households based on observables may be feasible when the dimensions of control variables are large. To overcome this problem of dimensionality, Rosenbaum and Rubin (1983) argued that one can match along a single score variable given by the propensity score, $p(x)$, which summarizes the large variables.

Results and Discussion

This section highlights the major findings of the study. For ease of elucidation, this section is presented in three sub-sections. The first part presents the descriptive statistics followed by results of inferential statistics and treatment effects model, respectively.

Descriptive Statistics

As shown in Table 2, the study found that the average age of the sampled households was approximately 46 years, while about 68 percent of the households were literate. The households had an average size of six members, and their access to roads was limited, with an average access rate of 44 percent. The mean distance to the nearest water source, school, health facility, and market center was 27, 26.6, 35.6, and 34 minutes, respectively. The households also had an average land size of 1.36 hectares.

The study further assessed the food consumption score (FCS) of the households, which was found to be about 36 on average, falling within the acceptable category. In terms of fertilizer usage, the mean household utilization of urea and DAP was found to be 36.9 and 39.3 KG, respectively. These figures indicated that the utilization of urea and DAP was below the national average, which is 43 kg urea and 65 kg DAP.

These findings (Table 2) indicate that the sampled families confront a variety of problems, including restricted access to roads and basic amenities, low literacy rates, and limited usage of agricultural inputs. Yet, the acceptable food consumption score suggests that the households were able to meet their basic food demands despite the problems they experienced.

Table 2

Results of Descriptive Statistics

S. No	*Variables*	*mean*	*min*	*max*
1	Age	45.5	20	90
2	Read & Write (1=yes)	0.68	0	1
3	Household size	6.1	2	15
4	Access to road (1=yes)	0.44	0	1
5	Distance to water	27.1	2	120
6	Distance to school (in minutes)	26.6	1	456
7	distance to a health facility (in minutes)	35.6	3	120
8	Distance to a market center (in minutes)	34	1	180
9	Frequency of visiting markets (count)	2.4	0	25
10	TLU	3.5	0	25.2
11	FCS	35.98	5	120.5
12	Land size	1.36	0	10
13	Urea	36.9	0	300
14	DAP	39.3	0	300

Source: computed June, 2022 field survey data

Inferential Statistics

The results of the study suggest that households with road access have better access to markets, schools, and health facilities compared to those without road access. The mean difference in frequency of visiting markets was statistically significant, with households near the road visiting markets more frequently than those far away (mean difference = -0.49, t = -3.185, p = 0.0019). The mean difference in distance from the market was also statistically significant, with households near the road being closer to the market than those far away (mean difference = 22.81 minutes, t = 15.589, p = 0.0000). Similar findings were observed for distance from health facilities (mean difference = 15.26 minutes, t = 9.983, p = 0.0000) and distance from schools (mean difference = 19.02 minutes, t = 8.454, p = 0.0000).

In addition, households with road access were found to use more chemical fertilizers, including both urea and DAP, than those without road access. The mean difference in amount of DAP used was statistically significant, with households near the road using more DAP than those far away (mean difference = -13.93 kg, t = -4.416, p = 0.0000). The mean difference in amount of urea used was also statistically significant, with households near the road using more urea than those far away (mean difference = -11.27 kg, t = -9.626, p = 0.0000).

These findings are consistent with prior research highlighting the good impact of road development on rural access to services and resources (Khandker, 2007; Yang, Zhang, & Timmer, 2006). Furthermore, the findings show that improved road access can help improve agricultural output by expanding availability to agricultural inputs such as chemical fertilizers. Previous research has demonstrated a good association between road infrastructure and agricultural productivity (Fafchamps & Gubert, 2007; Gollin, Lagakos, & Waugh, 2014).

Overall, the study emphasizes the significance of road infrastructure in rural development initiatives, notably in terms of boosting access to services and resources and increasing agricultural output. Investment in road infrastructure should be prioritized by policymakers and development practitioners in order to eliminate poverty and support economic development in rural areas.

Table 3

Mean Difference Between Households Near the Road and Those Far Away

S. No	*Variables*	*Mean (Control)*	*Mean (Treated)*	*Difference*	*T*	*p-value*
1	Frequency of visiting markets	2.19	2.64	-0.49	-3.185	0.0019
2	Distance from the market (in minutes)	43.95	21.14	22.81	15.589	0.0000
3	Distance from a health facility (in minutes)	42.19	26.93	15.26	9.983	0.0000
4	Distance from school (in minutes)	34.99	16.97	19.02	8.454	0.0000
5	Amount of DAP used (in kg)	33.22	47.15	-13.93	-4.416	0.0000
6	Amount of UREA used (in kg)	32.03	43.29	-11.27	-9.626	0.0000

Source: computed June, 2022 field survey data

Results of the Treatment Effects Model

Due to selection bias, the statistically significant variations in access to institutions and facilities, market access, and input utilization found between the treatment and control groups cannot be attributable exclusively to access to roadways. To address this issue, we used a treatment effects model and used mean bias, standardized mean difference, and variance ratio to measure the quality of the matching exercise (see the Annex for details).

The findings of the study indicate that households with access to roads have better access to institutions and facilities, as well as markets and inputs (Table 4). Roads have a significant impact on households and their livelihoods through three channels: access to institutions and facilities, market access, and input and usage channels. Access to institutions and facilities is critical for rural households, as they often lack basic services such as healthcare and education. The study found that households with road access had better access to healthcare facilities, schools, and other basic services, indicating the importance of road infrastructure in promoting access to these facilities.

The mean distance from a health facility was found to be lower among the treatment group compared to the control group, with a statistically significant difference of -15.46 minutes (t-statistic = -5.77). This suggests that having access to roads reduces the distance from a health facility. This finding goes in tandem with previous studies that have shown a positive relationship between road access and healthcare access (Berdegué et al., 2011; Gakidou et al., 2017).

Market access is also necessary for rural households in order to boost the availability of goods and services. The study discovered that households with road access had better market access, which might lead to more economic opportunities and better livelihoods. Market visits were found to be more frequent in the treatment group than in the control group, with a statistically significant difference of 0.53 (t-statistic=2.96). This shows that having access to highways increases the regularity with which people visit markets. This finding is consistent with earlier research that has found a link between road access and market participation.

The treatment group was found to be closer to the market than the control group, with a statistically significant difference of -22.74 minutes (t-statistic=-11.28). This implies that having access to highways shortens the trip to the market. This finding is consistent with prior research that has demonstrated that improved transportation infrastructure, such as roads, can boost market access and participation. Several studies have shown that rural roads have a positive impact on market access (Munoz et al., 2017; Gebreegziabher et al., 2019; Jalan and Ravallion, 2002; Mu and van de Walle, 2011; Damania et al., 2016).

Furthermore, access to inputs, such as chemical fertilizers, can improve productivity and increase incomes. The study found that households with road access used more chemical fertilizers, indicating the positive impact of roads on agricultural input usage. The mean amount of DAP used was found to be higher among the treatment group compared to the control group, with a statistically significant difference of 11.21 kg (t-statistic = 2.66). This suggests that having access to roads has a positive impact on the amount of DAP used. This finding is consistent with previous studies that have shown a positive relationship between road access and fertilizer use (Kilic et al., 2015; Nkonya et al., 2014). The mean amount of UREA used was found to be higher among the treatment group compared to the control group, with a difference of 8.19 kg, but the difference was not statistically significant (t-statistic = 1.92). This suggests that having access to roads may not have a significant impact on the amount of UREA used. This finding is consistent with previous studies that have shown mixed results regarding the relationship between road access and fertilizer use (Kilic et al., 2015; Nkonya et al., 2014).

The distance from school was found to be lower among the treatment group compared to the control group, with a statistically significant difference of -16.86 minutes (t-statistic=-8.82). This suggests that having access to roads reduces the distance from school. This finding is consistent with previous studies that have shown a positive relationship between road access and education access (Gebreegziabher et al., 2019; Nauges and Strand, 2017). These findings of the study suggest that roads play an important role in enhancing the livelihoods of local communities through these channels. Improving road infrastructure can potentially increase access to institutions and facilities, markets, and inputs, which could have a significant positive impact on rural households and their livelihoods.

Table 4

Impact of Roads on Access to Institutions and Input Use

S. No	***Variables***	***Treated***	***Control***	***Difference***	***T***
1	Frequency of visiting markets	2.63	2.09	0.53	2.96
2	Distance from the market (in minutes)	21.63	44.37	-22.74	-11.28
3	Distance from a health facility (in minutes)	27.63	43.09	-15.46	-5.77
4	Distance from school (in minutes)	16.19	33.05	-16.86	-8.82
5	Amount of DAP used (in kg)	47.76	36.55	11.21	2.66
6	Amount of UREA used (in kg)	43.85	35.66	8.19	1.92

Source: computed June, 2022 field survey data

Conclusions and Policy Implications

According to this study, access to roads has a significant positive impact on the livelihoods of rural households through improved access to institutions and facilities, market participation, and the use of agricultural inputs. Households with access to roads have better access to healthcare facilities, schools, and other basic services and are more likely to participate in markets and use agricultural inputs such as chemical fertilizers. Previous studies have also highlighted the positive impact of road access on market participation and educational access.

Policymakers should prioritize expenditures in rural road development and complementing investments in healthcare, education, and other essential services to maximize the benefits of road infrastructure. Furthermore, for long-term benefits, proper upkeep of existing road infrastructure is critical. Local communities should be included in the planning and implementation of road infrastructure projects to ensure that their needs and priorities are considered, supporting sustainability and alignment with local development goals.

Rural road infrastructure investments can have a substantial positive influence on local economy and help to alleviate poverty. A comprehensive approach to rural development, including the participation of local populations in planning and implementation, can encourage long-term development in rural regions. Policymakers should explore the following policies to encourage rural development: (1) Increase investment in rural road infrastructure: Policymakers should allocate more resources to improve and expand road networks in rural areas. This can be done through funding from government budgets, development assistance, or public-private partnerships. (2) Prioritize maintenance and repair of existing roads: In addition to building new roads, policymakers should ensure that existing roads are well-maintained and repaired regularly to ensure that they remain functional and safe. (3) Use appropriate road construction technologies: Policymakers should use appropriate road construction technologies that are suitable for local conditions and can withstand natural disasters such as floods and landslides. (4) Involve local communities in road planning and construction: Local communities can provide valuable input and help identify the most critical road infrastructure needs in their areas. Policymakers should involve these communities in the planning and construction process to ensure that the roads meet their specific needs.

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Annexes

```
. ttest ELetricEnergy , by( HHDISRoad )

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    >2Km |     291    .2268041    .0245907    .4194863    .1784052     .275203
   <=2km |     224    .2991071    .0313071    .4685624    .2374114    .3608028
---------+--------------------------------------------------------------------
combined |     515    .2582524    .0194997    .4425176    .2199436    .2965613
---------+--------------------------------------------------------------------
    diff |            -.072303    .0392423               -.1493984    .0047923
------------------------------------------------------------------------------
    diff = mean(>2Km) - mean(<=2km)                               t =  -1.8425
Ho: diff = 0                                     degrees of freedom =      513

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0330         Pr(|T| > |t|) = 0.0660          Pr(T > t) = 0.9670
```

```
. ttest Visittomarket , by( HHDISRoad )

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    >2Km |     276    2.195652     .075219    1.249632    2.047574     2.34373
   <=2km |     225    2.644444    .1299844    1.949766    2.388296    2.900593
---------+--------------------------------------------------------------------
combined |     501    2.397206    .0722039    1.616141    2.255345    2.539066
---------+--------------------------------------------------------------------
    diff |           -.4487923    .1439116               -.7315396    -.166045
------------------------------------------------------------------------------
    diff = mean(>2Km) - mean(<=2km)                               t =  -3.1185
Ho: diff = 0                                     degrees of freedom =      499

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0010         Pr(|T| > |t|) = 0.0019          Pr(T > t) = 0.9990
```

```
. ttest HHDISmarket , by( HHDISRoad )

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    >2Km |     293    43.94539     1.03338    17.68862    41.91157    45.97921
   <=2km |     226    21.13717    .9900463    14.88366    19.18622    23.08812
---------+--------------------------------------------------------------------
combined |     519    34.01349    .8787049    20.01828    32.28722    35.73975
---------+--------------------------------------------------------------------
    diff |            22.80822    1.463109                19.93385    25.68259
------------------------------------------------------------------------------
    diff = mean(>2Km) - mean(<=2km)                               t =  15.5889
Ho: diff = 0                                     degrees of freedom =      517

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

```
. ttest HHDIShealth , by( HHDISRoad )

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    >2Km |     293    42.19795    1.073291    18.37178    40.08559    44.31032
   <=2km |     225    26.93333    1.044525    15.66787    24.87498    28.99169
---------+--------------------------------------------------------------------
combined |     518    35.56757    .8270877     18.8242     33.9427    37.19243
---------+--------------------------------------------------------------------
    diff |            15.26462    1.529087                12.26062    18.26862
------------------------------------------------------------------------------
    diff = mean(>2Km) - mean(<=2km)                               t =   9.9828
Ho: diff = 0                                     degrees of freedom =   516

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

```
est HHDISschool , by( HHDISRoad )

sample t test with equal variances
------------------------------------------------------------------------------
roup |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
-----+--------------------------------------------------------------------
>2Km |     266    34.99248     1.84457    30.08403     31.3606    38.62436
=2km |     208    15.97115    .9524147    13.73592    14.09348    17.84883
-----+--------------------------------------------------------------------
ined |     474    26.64557    1.196791    26.05598    24.29388    28.99725
-----+--------------------------------------------------------------------
diff |            19.02133     2.24991                14.60025    23.44241
------------------------------------------------------------------------------
diff = mean(>2Km) - mean(<=2km)                               t =   8.4543
diff = 0                                     degrees of freedom =      472

Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

```
. ttest Fertilizerexpe , by( HHDISRoad )

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    >2Km |     259    230.9073    10.56708     170.061    210.0986     251.716
   <=2km |     208    301.9855    18.90499    272.6517    264.7145    339.2565
---------+--------------------------------------------------------------------
combined |     467    262.5653    10.37667    224.2417    242.1744    282.9561
---------+--------------------------------------------------------------------
    diff |           -71.07814     20.6391               -111.6356   -30.52069
------------------------------------------------------------------------------
    diff = mean(>2Km) - mean(<=2km)                               t =  -3.4439
Ho: diff = 0                                     degrees of freedom =      465

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0003         Pr(|T| > |t|) = 0.0006          Pr(T > t) = 0.9997
```

```
. ttest DAP , by( HHDISRoad )

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    >2Km |     293     33.2227     1.59139    27.24021    30.09065    36.35475
   <=2km |     226    47.15265     2.94015    44.20015     41.3589    52.94641
---------+--------------------------------------------------------------------
combined |     519    39.28854     1.59157    36.25846    36.16181    42.41526
---------+--------------------------------------------------------------------
    diff |           -13.92996    3.154156                -20.1265   -7.733419
------------------------------------------------------------------------------
    diff = mean(>2Km) - mean(<=2km)                               t =  -4.4164
Ho: diff = 0                                     degrees of freedom =      517

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

```
. ttest Urea, by( HHDISRoad )

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
    >2Km |     293    32.02816    1.631301    27.92338    28.81756    35.23876
   <=2km |     226    43.29425    2.960539    44.50666    37.46032    49.12818
---------+--------------------------------------------------------------------
combined |     519    36.93401    1.601539    36.48559     33.7877    40.08032
---------+--------------------------------------------------------------------
    diff |           -11.26609    3.195039               -17.54295   -4.989235
------------------------------------------------------------------------------
    diff = mean(>2Km) - mean(<=2km)                               t =  -3.5261
Ho: diff = 0                                     degrees of freedom =      517

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0002         Pr(|T| > |t|) = 0.0005          Pr(T > t) = 0.9998
```

```
. pstest, graph both
```

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
Age	U	43.784	45.71	-15.9		-1.70	0.091	1.08
	M	43.791	43.77	0.2	98.9	0.02	0.986	1.27
ReWR	U	.78392	.66412	27.0		2.84	0.005	.
	M	.78571	.77551	2.3	91.5	0.24	0.808	.
HHS	U	6.1357	6.3092	-8.4		-0.90	0.371	1.07
	M	6.1276	6.2092	-4.0	52.9	-0.40	0.689	1.18
Bellow15y	U	2.2563	2.2366	1.8		0.19	0.848	1.08
	M	2.2551	2.352	-8.9	-393.6	-0.90	0.367	1.21
Landsize	U	1.4089	1.3453	6.1		0.65	0.513	1.25
	M	1.3463	1.3851	-3.7	39.0	-0.38	0.703	0.62*
TLU	U	3.3556	3.6181	-8.5		-0.89	0.372	0.63*
	M	3.2561	3.0786	5.8	32.4	0.71	0.480	1.02
Save	U	.46734	.39313	15.0		1.60	0.111	.
	M	.46429	.42857	7.2	51.9	0.71	0.478	.
Loan	U	.28643	.22519	14.0		1.50	0.134	.
	M	.28061	.2602	4.7	66.7	0.45	0.650	.

* if variance ratio outside [0.76; 1.32] for U and [0.75; 1.33] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.021	13.23	0.104	12.1	11.3	34.3*	1.11	20
Matched	0.005	2.94	0.938	4.6	4.3	17.3	0.76	20

* if B>25%, R outside [0.5; 2]