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The Effect of Village Road Development on Mobility, Environmental Quality, and Community Economy

Teguh Susilo*, Monica Dewi, Susilowati, Inge Anggitadari
Universitas Kahuripan Kediri, Indonesia
Email: teguh@students.kahuripan.ac.id*

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ABSTRACT

Road infrastructure plays a strategic role in supporting regional development, particularly in rural areas with limited accessibility. Adequate road infrastructure can enhance inter-regional connectivity, facilitate the mobility of residents, and support economic growth as well as environmental quality. This study aims to analyze the influence of village road development on mobility, environmental quality, and the economic conditions of the community in Desa Ceruk, *Kecamatan* Bunguran Timur Laut, *Kabupaten* Natuna, Riau Islands Province. The research employed a qualitative descriptive method, with data collected through observations, interviews, documentation, and questionnaires. The findings indicate that the development of village roads has a significant positive impact on mobility, evidenced by a reduction in travel time to the city center from one hour to 30–45 minutes, as well as easier access to the final disposal site (TPA). In terms of the environment, roads equipped with drainage systems also support waste management and local sanitation. Economically, the majority of respondents reported increased household income and the emergence of new business opportunities. About 70% of respondents strongly agreed that the development of village roads contributed positively to family economic conditions. Overall, the construction of village roads has proven capable of accelerating mobility, supporting environmental management, and promoting the economic growth of the community.

INTRODUCTION

Indonesia's rural areas face persistent challenges in accessibility, with inadequate road infrastructure identified as a primary barrier to socio-economic development (Djajawinata et al., 2023; Nawir et al., 2023). According to the Central Statistics Agency (BPS, 2023), approximately 40% of village roads in remote regions remain in poor condition, significantly limiting community mobility and access to essential services. This infrastructure deficit directly impacts the eight main welfare indicators established by BPS, including income level, housing quality, health accessibility, and transportation facilities (Ezeudu & Fadeyi, 2024; Fan, Chen, & Yang, 2025).

In the context of globalization, the level of progress of a region can be identified through the development of its infrastructure (Noskov, 2020; Zeibote et al., 2019). Infrastructure plays an essential and strategic role in accelerating the development process at regional and national levels (Petrova et al., 2018; Siatan et al., 2024). In addition, infrastructure contributes significantly to economic growth (Brueckner, 2021; Meersman & Nazemzadeh, 2017). The availability of infrastructure as the main foundation for sustainable economic development cannot be separated from the fluctuations and developments in economic growth occurring in a region or country (Pandit et al., 2017; Raicu et al., 2021).

The problem becomes particularly acute in archipelagic provinces such as the Riau Islands, where geographic isolation compounds infrastructure challenges (Narotama, 2022;

Wulandari et al., 2023). Natuna Regency, specifically Ceruk Village in Bunguran Timur Laut Subdistrict, exemplifies this issue. Prior to 2018, the village road spanning 800 meters remained unpaved, with travel time to the city center exceeding one hour—double the time experienced after road construction. This condition restricted market access for agricultural products, limited educational opportunities, and constrained healthcare service utilization (Marion et al., 2024). Thus, infrastructure becomes the basis that supports long-term economic growth (Cigu et al., 2018). Based on a publication from the Central Statistics Agency (BPS), eight main indicators can be identified as a reference in assessing the level of community welfare.

These indicators include income level, expenditure structure and consumption behavior, housing conditions or quality, availability of housing facilities, household health, accessibility to health services, access to education, and ease of using transportation facilities (Moges Tareke & Abraha Baraki, 2024). All of these indicators are closely related to infrastructure development (Lee & Yoon, 2021). The provision of adequate infrastructure has the potential to improve the community's ability to access education, health, and transportation facilities, as well as encourage economic growth through increased income and quality of life (Ezeudu & Fadeyi, 2024; Khanani, Adugbila, Martinez, & Pfeffer, 2021; Manggat, Zain, & Jamaluddin, 2018). Therefore, planned and sustainable infrastructure development is an important instrument in realizing the overall welfare of the community (Adshead et al., 2019; Danilina & Chebotarev, 2017).

Development is essentially a process of change in the structure and patterns of society that serves to drive social dynamics at various levels (Utama, 2021). The presence of technology in this process acts as a catalyst that accelerates economic growth (Zaghdoud, 2025). Through development, significant transformations occur in the economic and social conditions of society (Kvilinskyi et al., 2017). One tangible form of development is the construction of road infrastructure in a region, which is intended to promote the welfare of the community while realizing social equality and justice at various levels of society (Fobosi & Malima, 2025; Franco & Tracey, 2019; Suharto et al., 2025). In its implementation, development requires the right approach to produce balanced and equitable economic growth across all levels of society (Atmaja & Mahalli, 2015). The development of village roads to support smooth transportation plays a very important role in the growth of mobility, environmental quality, and the economy of a region (Kamaludin & Qibthiyyah, 2022; Qin et al., 2020).

Thus, development plays an important role in expanding employment opportunities, reducing poverty rates, and increasing the per capita income capacity of the community (Abisuga-Oyekunle et al., 2020; Zameer et al., 2020). Optimal infrastructure development also contributes to increased economic efficiency, smooth distribution of goods and services, and increased added value of community economic activities (Kadyraliev et al., 2022; Khoshnava et al., 2020). For example, the construction of a village road in Ceruk Village, Bunguran Timur Laut Subdistrict, Natuna Regency, Riau Islands Province, is a concrete example of infrastructure development that can be used to assess its impact on population mobility, environmental quality, and the economic conditions of the local community.

This study addresses the identified research gap by examining the comprehensive impact of village road development on three interconnected dependent variables: community

mobility, environmental quality, and economic conditions. The independent variable, village road infrastructure development, is operationalized through the 800-meter road construction project featuring a 5-meter width with proper drainage systems and CBR-compliant base layer. By investigating these relationships within Ceruk Village's unique geographical and socioeconomic context, this research contributes novel empirical evidence to the discourse on rural infrastructure development in Indonesian archipelagic regions.

The novelty of this research lies in its integrated analytical framework that simultaneously examines mobility, environmental, and economic dimensions of village road development within a remote island community context. Unlike previous studies that examined these aspects in isolation or within mainland contexts, this research provides comprehensive insights into how infrastructure development functions as a catalyst for multifaceted community transformation in geographically isolated areas. Furthermore, the study's focus on Natuna Regency, an understudied region in Indonesia's border areas, contributes valuable empirical data to inform evidence-based policymaking for similar peripheral communities.

This research aims to analyze the influence of village road development on three key aspects: (1) community mobility patterns, measured through travel time reduction and accessibility improvement; (2) environmental quality, assessed through waste management efficiency and drainage system effectiveness; and (3) economic conditions, evaluated through household income changes and business opportunity emergence. The study's benefits extend to multiple stakeholders: providing empirical evidence for local government policy formulation regarding rural infrastructure prioritization, offering practical insights for community development practitioners, and contributing to the theoretical understanding of infrastructure's multidimensional impacts in rural Indonesian contexts. Ultimately, this research seeks to inform more effective, evidence-based approaches to rural development that maximize community welfare outcomes through strategic infrastructure investment.

METHOD

The analysis used in this study was descriptive qualitative. Data were obtained from primary and secondary sources and processed qualitatively. Primary data were collected directly from the village community by administering questionnaires. The research population consisted of economically active residents of Ceruk Village who used the village road infrastructure for mobility. The sample size was determined using the Slovin formula.

$$n = \frac{N}{1 + N(e)^2}$$

Description:

n = number of research subjects

N = population size

e = permissible error rate

In applying the Slovin formula, the value of $e$was set at 0.1 (10%) for large populations and 0.2 (20%) for relatively small populations. According to this technique, the sample size generally ranged from 10% to 20% of the total population, depending on the desired level of accuracy.

This study used questionnaires as research instruments to gather public responses regarding road infrastructure improvements. Data were collected using closed-ended questionnaires with predetermined answer options, which facilitated respondents in selecting answers that best reflected their conditions and experiences (Andriyani, 2018).

An interactive data analysis approach was applied for data processing and interpretation (Rahayu, 2025), involving four main stages: data collection, data reduction, data display, and conclusion drawing or verification (Andriyani, 2018).

Table 1. Questionnaire Statements on the Impact of Infrastructure Development

No	Impact of Infrastructure Development	A (SS)	B (S)	C (KS)	D (TS)
1	Were you informed that a road would be built (road repairs)?				
2	Did you receive information about the construction from the local government?				
3	Do you agree with the road construction plan?				
4	Do you feel that there are any benefits from the construction or widening of the road?				
5	Are there any negative impacts arising from the construction or widening of the road?				
6	Were the procedures carried out appropriately and did no one suffer losses during the construction or widening of the road?				

Table 2. Questionnaire Statements on Community Economy *(Andriyani, 2018)*

No	Community Economy	A (SS)	B (S)	C (KS)	D (TS)
1	Your income increased after the infrastructure development				
2	Your economic situation has improved				
3	You feel that the development has had a positive impact on your family's economy				
4	You feel that your economic situation has benefited from the infrastructure development				

RESULT AND DISCUSSION

The construction of village roads aims to open access to centers of community activity such as markets, schools, and village administrative centers. Good village roads will improve accessibility and economic circulation. In this study, the road construction carried out was a filling project. Filling is the process of filling soil or gravel material to raise the elevation of the road base. This process must take into account the bearing capacity of the subgrade (CBR) to ensure that the road is stable and not easily damaged. The CBR (California Bearing Ratio) classification for village roads is generally used to determine the quality of the subgrade and the required thickness of the road pavement. A good CBR value for village roads is usually above 10%, while a CBR value of less than 10% may require improvement or special treatment of the subgrade. This work includes mobilization, land clearing and stripping, ditch excavation,

and selective filling from excavation sources. The road opening and paving is 800 meters long with a road width of 5 meters.

Table 3. CBR Value Classification

No	Classification	Road Type	CBR (%)	Source & Description
1	Very Good	a. Gravel	25-60	Laboratory data from the Research and Development is suitable for permanent village roads without additional stability measures
		b. Gravel or sand	20-60	
2	Good	a. Coarse sand	10-30	Bina Marga: Suitable for inter-village roads with moderate traffic
		b. Fine sand	6-26	
3	Moderate	Silt and clay	4-15	Results of studies by the PUPR Research AASHTO: Suitable for light villages (with low traffic)
4	Poor	Organic clay	3-8	Directorate of Highways: Soil stability is necessary for village roads (soil replacement/ lime)
5	Very poor	Humus/organic soil	<3	SNI 1732-1989-F and AASHTO Standard) : Very weak and unstable without improvement

(Source: Compiled based on Soedarsono in (Soedarsono, 1985)

Based on the research population of Ceruk Village with a total population of 1,093 people (data from Natuna Regency, 2018) , the sample size of respondents based on the Slovin formula is:

$$n = \frac{N}{1 + N(e)^2}$$

$$n = \frac{1093}{1 + 1093(0{,}2)^2}$$

$$n = 24{,}441$$

So it was rounded up to 24 respondents. However, in this study, the author used the minimum number determined by experts, which is 30 people. Based on the data processing results, the distribution of respondents' answers was divided into several criteria, namely: gender, age, and occupation. From the field questionnaire data, it can be seen that based on the research data processing results, it is known that the majority of respondents, 70%, were male. The results of the questionnaire data processing obtained from the field show that 8 respondents (26.67%) were under 30 years old, while 8 other respondents (26.67%) were in the 31-40 age range. Meanwhile, 12 respondents (40%) were in the 41-50 age group, and 2 respondents (6.67%) were over 50 years old. Based on the field questionnaire data, the majority of people who use this road access are in the "other" category or road users who use road facilities, namely Based on the questionnaire data processing results, the majority of respondents are self-employed, namely 9 people (30%). Meanwhile, 5 respondents (16.7%) worked as farmers, 7 respondents (23.3%) were private employees, 1 respondent (3.3%) was a civil servant, 3 respondents (10%) were students, and 5 respondents (16.7%) were housewives. Road infrastructure development

has proven to have a positive impact on increasing community mobility, which is an important aspect in supporting social and economic activities in the region. The existence of adequate roads makes the mobility process more efficient, so that the community has greater opportunities to access urban areas more easily. The community has experienced an increase in the smoothness and flexibility of their mobility, which was previously hampered by damaged, rocky, and uncomfortable road infrastructure. With wider roads and improved infrastructure quality, travel is now faster, safer, and more comfortable for road users.

Table 4. Average Travel Time from Village to City or Vice Versa

Travel Time from Village to City/Vice Versa		Before Road Construction		After road construction	
		Frequency	Percentage (%)	Frequency	Percentage (%)
< 15	minutes	0	0	0	0
15-30	minutes	0	0	12	40
30-45	minutes	1	3,3	17	56,7
1	hour	23	76,7	1	3,3
>1	hours	6	20	0	0
Total		30	100	30	100

Table 5. Total travel time of the community to the city/week

Total Travel Time/	Before Road Construction		After road construction	
	Frequency	Percentage (%)	Frequency	Percentage (%)
1-2 times	9	30	0	0
3-4 times	8	26,7	12	40
5-6 times	10	33,3	5	16,7
>6 times	3	10	13	43,3
Total	30	100	30	100

Based on the empirical information collected, it can be concluded that before and after the road repairs, the average time taken by the community to reach the city changed significantly. According to the data, 23 respondents or 76.7% of respondents stated that the travel time before the construction or repair of the road took 1 hour. However, after the road construction or improvement, 17 respondents or 56.7% stated that the average travel time was 30-45 minutes. Before the construction of adequate roads, rural communities generally faced limitations in mobility. Damaged, narrow, or muddy roads during the rainy season were often a major obstacle to economic and social activities. Farmers had difficulty transporting their agricultural products to the market, children had difficulty reaching school, and health services were difficult to access. The construction of village roads opened up new opportunities to improve the mobility of residents. Improved accessibility allowed people to travel faster, more efficiently, and more comfortably, thereby encouraging greater participation in economic activities. Farmers could transport their crops to market more easily and efficiently, which ultimately increased their income. Similarly, small traders found that good access to village roads made it easier for them to obtain raw materials and market their products to other areas.

Road construction is one form of infrastructure development that plays an important role in driving regional growth. The availability of an adequate road network can increase community mobility and facilitate the distribution of goods and services. However, road infrastructure development also has a significant impact on the quality of residential areas, especially in areas with landfills and good drainage. On the one hand, road construction near

landfills brings economic and social benefits. Adequate roads facilitate the transport of waste to landfills, thereby improving the operational efficiency of waste management. Better access allows for faster and more effective distribution and handling of waste. This greatly helps reduce the risk of waste accumulation in residential areas, which can cause public health problems.

Table 6. Travel Time to Final Disposal Site

Travel Time to Landfill	Before Road Construction		After road construction	
	Frequency	Percentage (%)	Frequency	Percentage (%)
< 15	0	0,00	6	37,5
15-30	1	6,25	9	56,25
30-45	14	87,50	1	6,25
1	1	6,25	0	0
>1	0	0,00	0	0
Total	16	100	16	100

Based on the table above, it can be concluded that before and after the construction or repair of the road, the travel time experienced by the community has changed significantly. Of the 16 respondents, 14 respondents or 87.50% stated that before the road was repaired, the travel time to the landfill was 30-45 minutes. Meanwhile, after the road was repaired, 9 ts or 56.25% of respondents stated that the travel time was faster, which was only around 15-30 minutes.

In areas with good drainage systems, road construction can minimize the impact of rainwater runoff that carries pollutants into water bodies. Effective drainage helps control surface water flow, preventing puddles and potential flooding that usually occur during the rainy season. A good drainage system also reduces soil erosion around road construction sites, which is often an environmental problem in many areas.

One of the main effects of road construction on the community's economy is increased accessibility. Good roads facilitate the mobility of people and goods, thereby reducing transportation costs and travel time. This has a direct impact on trade and distribution activities, which become faster and more efficient. Business actors, including small traders, farmers, and craftsmen, can reach wider markets and increase their sales volume. Increased accessibility due to road construction also opens up new opportunities for the community to develop business sectors. The emergence of smooth transportation routes encourages the growth of new businesses, such as food stalls, transportation services, lodging, and other informal businesses. This stimulates job growth and increases the income level of the population.

Table 7. Road Infrastructure Development Statement

No	Statement	SS		S		KS		TS		Total	
		F	%	F	%	F	%	F	%		
1	P1	17	56.7	13	43.3	0	0	0	0	30	100
2	P2	17	56.7	13	43.3	0	0	0	0	30	100
3	P3	27	90	3	10	0	0	0	0	30	100
4	P4	27	90	3	10	0	0	0	0	30	100
5	P5	1	0	0	0	0	0	29	96.7	30	100
6	P6	15	50	15	50	0	0	0	0	30	100

Table 8. Increase in Community Income

No	Statement	SS		S		KS		TS		Total	
		F	%	F	%	F	%	F	%		
1	P1	18	60	11	36.7	1	3.3	0	0	30	100
2	P2	18	60	11	36.7	1	3.3	0	0	30	100
3	P3	21	70	9	30	0	0	0	0	30	100
4	P4	19	63.3	11	36.7	0	0	0	0	30	100

The development of village road infrastructure represents a strategic intervention pursued through government-community collaboration aimed at enhancing social welfare in rural areas. These findings align with theoretical frameworks established by Adisasmita, who emphasized that adequate road infrastructure serves as a fundamental prerequisite for encouraging economic activity, facilitating mobility, and creating business opportunities for rural populations. The empirical results from Ceruk Village demonstrate that road infrastructure development impacts not merely the physical and aesthetic dimensions of rural environments, but more significantly influences community economic trajectories.

From a mobility perspective, the data reveals substantial improvements in community accessibility patterns. The reduction in average travel time from 1 hour to 30-45 minutes (56.7% of respondents) represents a 37.5-50% time efficiency gain, corroborating findings by Fajri (2017) regarding infrastructure's role in enhancing rural connectivity. This improvement transcends mere convenience; it fundamentally restructures daily life patterns and economic participation possibilities. Farmers who previously struggled with transporting agricultural products due to damaged or impassable roads can now deliver goods to markets efficiently, reducing post-harvest losses and expanding market reach. This aligns with Prasetyo and Firdaus's assertion that transportation infrastructure directly influences regional economic productivity through enhanced logistical efficiency.

The environmental quality dimension reveals significant improvements in waste management systems. The reduction in travel time to landfill facilities from 30-45 minutes (87.50% pre-construction) to 15-30 minutes (56.25% post-construction) indicates improved environmental service efficiency. This finding supports sustainable development principles outlined in contemporary infrastructure planning literature, demonstrating that well-designed road networks incorporating proper drainage systems can simultaneously serve economic and environmental objectives. The integrated drainage infrastructure has effectively minimized surface water accumulation and reduced soil erosion, addressing common environmental challenges in tropical rural settings. These results parallel findings from similar infrastructure projects documented in regional development studies, where environmental considerations integrated into construction design yield long-term sustainability benefits.

Economically, the research reveals transformative impacts on community livelihoods. The finding that 70% of respondents strongly agreed that village road development positively affected family economic conditions substantiates theoretical propositions regarding infrastructure-economic growth linkages. The improved road access has catalyzed microeconomic activities, enabling MSME (Micro, Small, and Medium Enterprises) expansion and diversification. Village entrepreneurs have successfully developed creative businesses

encompassing handicrafts, culinary specialties, and processed agricultural products—opportunities previously constrained by logistical limitations. This economic diversification phenomenon aligns with Atmaja and Mahalli's (2015) observations regarding infrastructure's multiplier effects on local economic development.

Furthermore, the construction has generated secondary economic opportunities beyond primary production sectors. The improved accessibility has enhanced the village's tourism potential, attracting visitors to natural and cultural attractions previously difficult to reach. This has stimulated ancillary business development including homestay accommodations, traditional food establishments, and souvenir enterprises. Such economic diversification reduces community dependence solely on agricultural income, enhancing household economic resilience—a pattern consistent with broader rural development literature emphasizing infrastructure's role in economic transformation.

However, critical considerations emerge regarding sustainable implementation. The research underscores that village road construction requires comprehensive planning and active community participation throughout project cycles. Roads must be designed and constructed to align with authentic community needs, ensuring equitable benefit distribution. Community involvement in planning and construction supervision proves essential for ensuring projects transcend mere formality and deliver substantive value. Additionally, long-term maintenance and sustainability require prioritization to ensure infrastructure longevity and continued benefit realization—a challenge frequently encountered in rural infrastructure projects as documented in development literature.

Environmental sustainability considerations warrant particular attention. Construction must adhere to sustainable development principles, with environmental impact assessments integral to planning processes. Roads should be designed to minimize ecosystem disruption, avoiding productive agricultural lands and water catchment areas. Adoption of environmentally friendly materials and construction technologies that minimize pollution represents crucial steps in maintaining ecological balance within village environments. These principles reflect contemporary best practices in sustainable infrastructure development, ensuring that short-term economic gains do not compromise long-term environmental integrity.

The Ceruk Village case study thus provides valuable empirical evidence supporting the proposition that strategic village road infrastructure development, when properly planned and executed, serves as a catalyst for multidimensional community transformation. The simultaneous improvements in mobility efficiency, environmental quality, and economic conditions demonstrate infrastructure's potential as an integrated development tool. These findings contribute to the growing body of evidence supporting infrastructure investment prioritization in rural development strategies, particularly in Indonesia's geographically diverse and often isolated rural communities.

CONCLUSION

Village road infrastructure development in Ceruk Village, Bunguran Timur Laut Subdistrict, Natuna Regency, has demonstrably achieved its multifaceted objectives of enhancing community mobility, improving environmental quality, and stimulating economic growth. The empirical evidence reveals significant travel time reductions of 37.5-50% for city access and 42.8% for waste disposal facilities, indicating substantial mobility efficiency gains.

Environmental management improvements through integrated drainage systems have enhanced sanitation and reduced flooding risks, while economic indicators show that 70% of respondents experienced positive household income changes and expanded business opportunities. These findings affirm that strategically designed and properly executed village road infrastructure functions as an effective catalyst for integrated rural development, transcending mere physical connectivity to fundamentally transform community welfare across multiple dimensions. The success of this intervention underscores the critical importance of comprehensive planning, active community participation, and sustainable maintenance frameworks in maximizing infrastructure development outcomes. Future research should investigate the long-term sustainability of these impacts beyond the immediate post-construction period, examine comparative outcomes across diverse geographical and socioeconomic contexts, and explore optimal financing mechanisms for scaling successful village infrastructure models throughout Indonesia's archipelagic rural regions. Additionally, longitudinal studies assessing infrastructure maintenance practices and their correlation with sustained community benefits would provide valuable insights for evidence-based policymaking in rural development.

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