

Electricity Consumption, Roads and Their Infrastructure; Strategies to Increase Per Capita Income and Reduce Poverty in East Nusa Tenggara

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ABSTRACT

Low electricity consumption, restricted road length, and insufficient road infrastructure are believed to contribute to low per capita income and high poverty rates in East Nusa Tenggara. To substantiate this hypothesis, a study was undertaken in that province and the population are 21 districts and one city. This study analyzed data from 2019 to 2023 and utilized the Panel Data Regression analysis method. The findings of this study indicate that electricity consumption significantly impacts the increase in per capita income. Conversely, to alleviate poverty, the variable of road length exerts a significant influence. However, road infrastructure variables have shown no effect on boosting per capita income or reducing poverty. Formulation of strategies to diminish poverty while augmenting per capita income was conducted through the Analytical Network Process (ANP) analysis tool, involving nine stakeholders and decision-makers within the region. ANP is a supportive tool in decision-making processes that has many criterias and sub criterias. The agreed-upon strategy focuses on three primary priorities: enhancing community electricity consumption, extending road lengths, and enhancing road infrastructure.

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1. Introduction

Poverty is defined as the inability to fulfil fundamental human needs (Yani et al., 2022). It primarily arises from the community's low per capita income in meeting these basic necessities (E. (Ned) Hill, 2023). These necessities include food, education, healthcare, clean water, land, employment, housing, natural resources, and environmental sustainability (Tackie, 2021). Additionally, there's a need for a sense of security against threats or acts of violence, as well as access to participate in socio-political life. High poverty levels have significant repercussions on a region, including increased dropout rates, poor health outcomes, elevated unemployment, alarming crime rates, and social unrest within society (Curto et al., 2023). Moreover, poverty often leads to the depletion of natural resources (Rahma et al., 2019).

The issue of increasing per capita income and alleviating poverty is a significant concern for the Indonesian government. Efforts have been and will continue to be made to address these challenges, with a focus on pro-growth, pro-job, and pro-poor strategies (Anam et al., 2023),(Anderson et al., 2018), (Taruno, 2019). However, despite these efforts, several provinces in Indonesia still struggle with acute poverty, including the province of East Nusa Tenggara (NTT). In NTT, the main challenges revolve around uneven economic growth distribution and low incomes among the populace, leading to widespread poverty in the region. This is evident from the considerable income disparity between different areas (Figure 1). Throughout the period from 2019 to 2023, Kupang City emerged with the highest per capita income, while other regions experienced relatively low per capita incomes. Sabu Raijua, Manggarai, and Malacca consistently remained among the areas with the lowest per capita incomes.

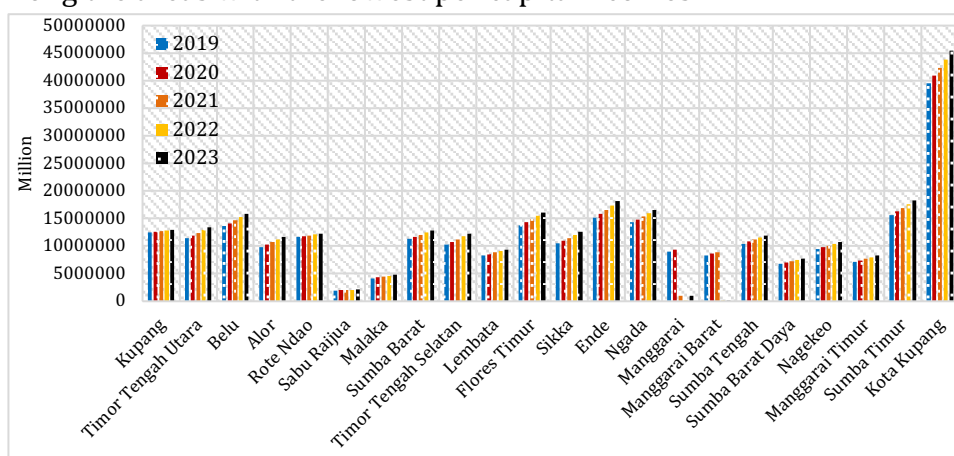


Figure 1. Spread per capita income in NTT

Source : BPS, 2024

The disparity in per capita income levels contributes significantly to high poverty rates. Notably, East Nusa Tenggara (NTT) is recognised as one of the most impoverished provinces in Indonesia. Data from the Central Statistics Agency (BPS) illustrates that poverty in NTT surpasses the national average by a significant margin. From 2019 to 2023, while Indonesia's poverty rate fluctuated around 10%, NTT consistently reported a poverty rate of approximately 50% of its population. Interestingly, despite a substantial

increase in per capita income nearing 52% in 2023, this surge has not led to a reduction in the poverty rate in NTT (Figure 2). Poverty persists as a pressing issue within the province.

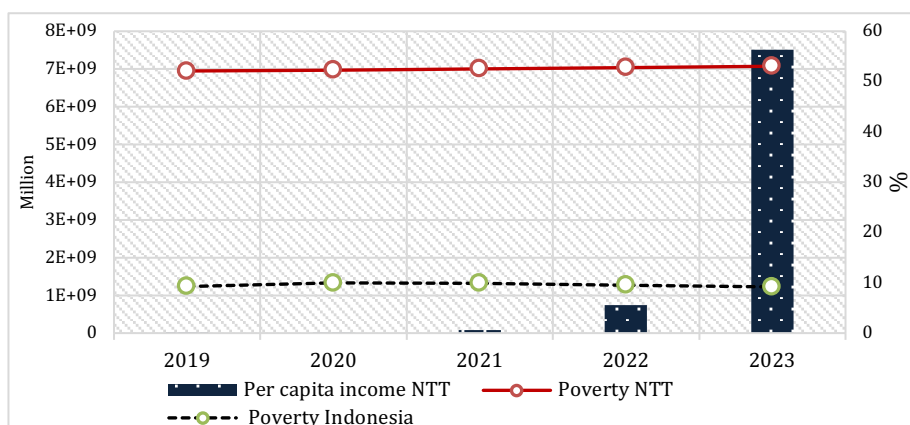


Figure 2. Per capita income, poverty in NTT and poverty in Indonesia

Source : BPS, 2024

There are multiple factors contributing to poverty in the region. Some of the factors are including inadequate income to sustain livelihoods, limited access to quality education, and insufficient supporting infrastructure for a decent standard of living (Meilvidiri et al., 2020). However, it is suspected that the lack of road infrastructure and low electricity consumption are significant contributors to the low income and high poverty rates in the province (Asiedu et al., 2021),(Nalle et al., 2022). As is well-known, road infrastructure and access to electricity play crucial roles in facilitating economic and industrial activities in an area. Increased economic activity and industrial development naturally attract labour, thereby reducing unemployment rates (Eka Puspitawati, 2021). One of the government's key approaches to alleviating poverty in NTT, guided by a pro-growth stance, involves initiatives to expand road networks, allocate funds for road infrastructure projects (such as bridge construction, road improvements, and increasing road capacity), and boost electricity consumption annually. The objective is to enhance accessibility to the province, thereby unlocking its economic potential and reducing poverty levels.

Throughout the period from 2019 to 2023, the government implemented a substantial electricity policy targeting residential and industrial sectors (Arif, 2023), resulting in a 120% increase in electricity usage by the community and industries in NTT. Additionally, road length saw a marginal increase of 0.03% during the same period, while road infrastructure improvements surged by 59%. However, despite the government's extensive efforts to enhance per capita income and alleviate poverty through infrastructure development and increased electricity consumption, satisfactory results have not been achieved. Therefore, this study aims to assess the impact of road infrastructure and electricity usage on per capita income growth and poverty reduction in NTT, as well as to propose effective government strategies to address these challenges.

2. Literature Review

Percapita Income and Poverty

Development is fundamentally a continuous process aimed at advancing society in a positive direction (H. Hill, 2021). A key measure of development success is the increase in per capita income among the population (Adrangi & Kerr, 2022), (Coscieme et al., 2020). Per capita income not only serves as an indicator of developmental progress but also reflects the overall welfare of a region (Cohen Kaminitz, 2023), (Kurnia et al., 2022). Similarly, poverty serves as another indicator of successful development. There are three main causes of low per capita income and high poverty rates. Firstly, at the micro-level, an unequal distribution of resources leads to disparities in income, resulting in low and uneven income distribution (Panzera & Postiglione, 2022). Limited and poor-quality ownership of natural resources further exacerbates this issue. Secondly, differences in the quality of human resources contribute to variations in per capita income and poverty levels. Poor-quality human resources lead to low productivity, which consequently affects earnings (Rahim, 2023), (Lefebvre, 2023). Factors such as low education levels, disadvantaged circumstances, discrimination, or inherited disadvantages contribute to this phenomenon. Lastly, differences in access to capital also play a significant role in determining per capita income and poverty levels (Salgotra et al., 2021), (Omar & Inaba, 2020).

Driven by a strong commitment to advancing development, the government has implemented various programs and policies in NTT. Some of these initiatives include the President's directive aimed at uplifting disadvantaged villages, regional empowerment programs designed to address economic crises, and poverty reduction strategies focused on enhancing income, production, and food security (Pulinggomang & J Fanggidae, 2019), (Mahpudin, 2020). Notably, these governmental efforts have yielded results, particularly in the form of increased per capita income. Between 2020 and 2023, there was a notable 10% growth in the per capita income of NTT residents. However, despite this positive economic trend, poverty levels have shown an upward trajectory, increasing by 0.3% annually. Regrettably, the rise in per capita income has not been accompanied by a reduction in poverty rates (Figure 3).

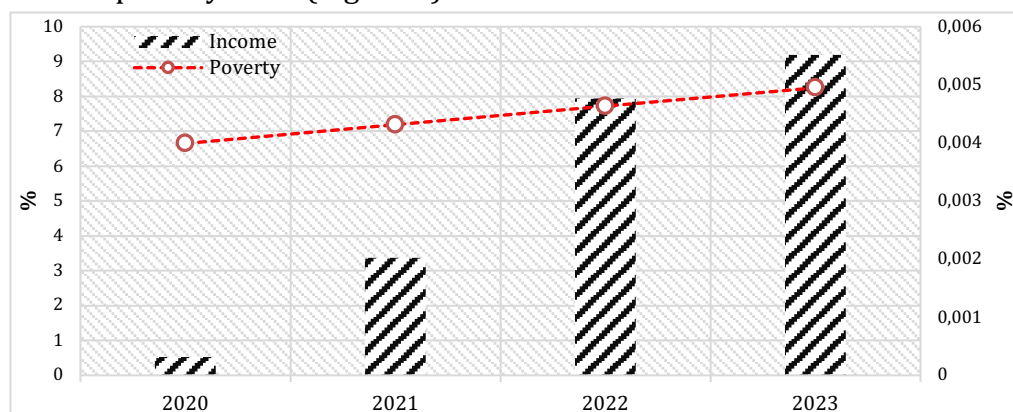


Figure 3. Percentage growth in per capita income and poverty in NTT

Source : BPS, 2024

The existence of road infrastructure as an opening for economic activities

While road infrastructure development plays a crucial role in the advancement of a region (Rahim, 2023). Its significance as a catalyst for various economic sectors endows road infrastructure with a substantial multiplier effect (Lestari et al., 2022),(Aderogba & Adegboye, 2019). Moreover, aside from serving as a driver for economic sector development, road infrastructure significantly contributes to the Gross Domestic Product (GDP). The impact of road infrastructure on the economy operates through two main channels: direct and indirect (Sianturi et al., 2023). Directly, this infrastructure boosts output within the region. Indirectly, it fosters increased economic activity, which in turn augments capital for both the private and public sectors, facilitates employment, and consequently enhances output (Wang et al., 2023).

Between 2019 and 2023, there was a notable increase in funding for road infrastructure in NTT, amounting to 0.6%. These funds were allocated for various purposes such as constructing bridges to connect different areas, road maintenance, and enhancing road capacity. Concurrently, the length of roads also saw a marginal increase of 0.03% during this period (Figure 4). However, this situation highlights that the funds allocated for infrastructure maintenance still fall short compared to the length of existing roads. Prior to 2023, it's evident that the length of roads did not match the level of road infrastructure construction. This suggests that many roads in NTT were not adequately maintained, remained impassable, or had limited capacity. Beginning in 2023, with the increase in funds for road infrastructure, the length of roads is also set to increase, leading to improved road conditions in NTT. This development further reduces the region's isolation and facilitates the flow of goods and services.

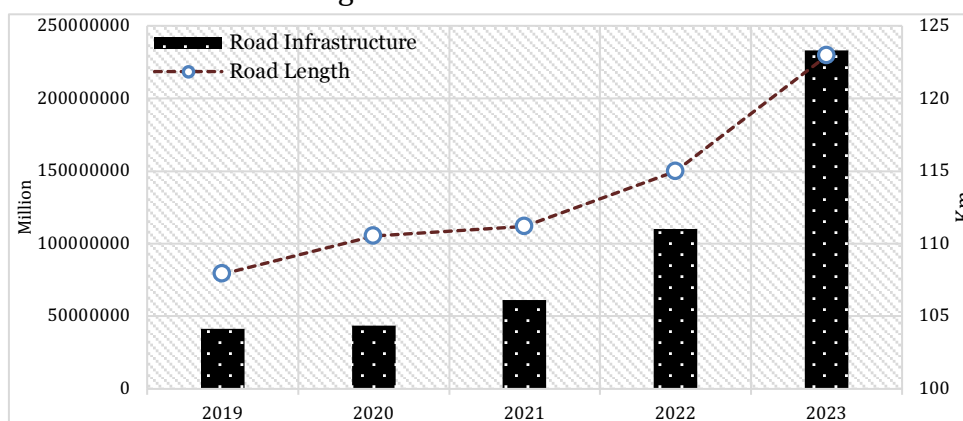


Figure 4. Improved infrastructure and road length

Source : BPS, 2024

Electricity as a basic need of the community

On the other hand, electricity stands as a cornerstone in the establishment of modern industries and serves as a vital component in renewable energy alternatives. Many production and manufacturing processes rely heavily on a consistent and dependable supply of electricity (Burke et al., 2018),(Hasid et al., 2023). Adequate electricity availability empowers industries to operate machinery and equipment

efficiently, leading to enhanced productivity, reduced production costs, and increased competitiveness in the global market (Hossin & AlShehhi, 2024),(Song et al., 2023). Moreover, the reliability of electricity enables the provision of essential services such as street lighting, modern healthcare facilities, and efficient water treatment systems. These amenities collectively contribute to enhancing the quality of life for communities and bolster the success of renewable energy initiatives, thereby mitigating poverty and rendering the region more appealing to investors (Kusumawardani & Agusti, 2024),(Shyu, 2014). Thus, electricity not only satisfies daily necessities but also plays a pivotal role in fostering sustainable development.

Throughout the years 2019 to 2023, the population of households in NTT Province ranged from approximately 54 to 55 million people, with an average growth rate of about 0.005%. In contrast, the growth of electricity supply to households during this period increased by 0.2% (Figure 5). However, despite this relatively faster growth in electricity availability, not all households in the province have been able to access electricity. This situation highlights a significant challenge as lack of access to electricity remains a contributing factor to poverty, given its essential role as a basic necessity.

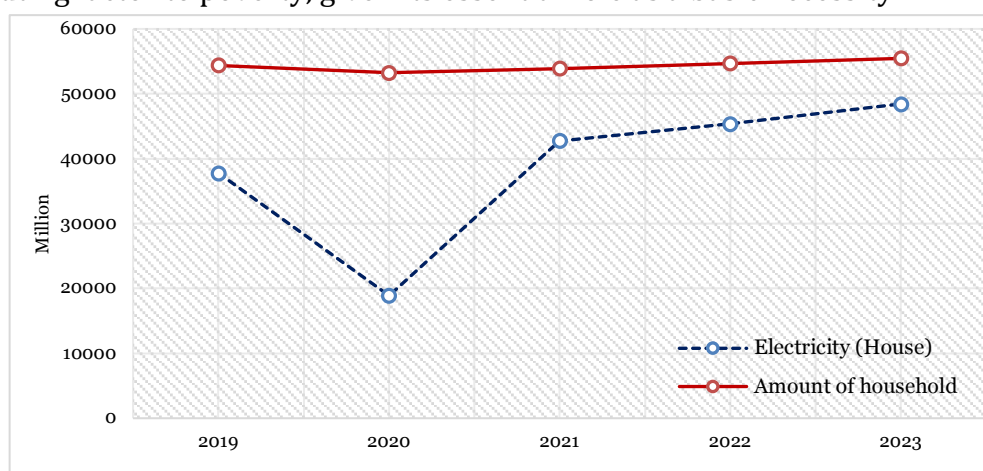


Figure 5. Comparison of the number of houses electrified and the number of households
Source : BPS, 2024

3. Research Method

The research was conducted in NTT province, encompassing 21 districts and one city. Secondary data from the years 2019 to 2023 were utilised and analysed employing the Panel Data Regression method and sourced from Central Statistical Agency (BPS). The Panel Data Regression combines cross-sectional data and time-series data. Cross-sectional data involves observing multiple subjects simultaneously (Yani et al., 2022), while time-series data pertains to observations of a single subject over several time periods (Hallin et al., 2023). The use of panel data regression offers several advantages, notably yielding more precise estimation results. This is attributed to the increased number of observations, which in turn leads to augmented degrees of freedom and helps mitigate potential errors stemming from variable omissions (Hsiao, 2014), (Brüderl &

Ludwig, 2014),(Maulid et al., 2021). The general equation of panel data regression is as follows.

$$Y = \beta_0 + \sum_{n=1}^n \beta_1 x_{nit} + \epsilon_{it} \dots\dots\dots (1)$$

Where :

- Y = Response variables in observation units to - i and time to - t
- β_0 = Intercept regression models in observation units to - i and time to - t
- β_1 = Coefficient slopes
- x_{it} = Predictor variables for observation units to - i time period to - t
- ϵ_{it} = Error in observation units to - i and time to - t
- n = Number of predictor variables
- i = Unit cross section
- t = Unit time series

The equations in this study are:

1. The effect of independent variables on GDP per capita

$$LnGDP_1 = \beta_0 + \beta_1 LnX_{1it} + \beta_2 LnX_{2it} + \beta_3 LnX_{3it} + \epsilon_{it} \dots\dots\dots (2)$$

2. The effect of independent variables on poverty

$$LnPov_1 = \beta_0 + \beta_1 LnX_{1it} + \beta_2 LnX_{2it} + \beta_3 LnX_{3it} + \epsilon_{it} \dots\dots\dots (3)$$

The variables used in this study are as listed in the table below.

Table 1 Research variables and descriptions

No	Variables	Unit	Descriptions
Dependent Variables			
1	GDP per capita (GDP)	IDR	Per capita, the income of people NTT based on economic activity
2	Poverty (Pov)	%	Percentage of poor people in NTT
Independent Variables			
1	Electricity (X ₁)	unit	The number of households supplied with electricity
2	Road Length (X ₂)	km	The length of roads that are asphalted and can be used by cars or other heavy vehicles
3	Road Infrastructure (X ₃)	million	The expenditure incurred for road maintenance and the construction of road infrastructure
	β		Constanta
	i		Locations of the study : 21 districts, 1 city
	t		Years of study : 2019 -2023

To formulate strategies aimed at increasing income and alleviating poverty in NTT through the development of road infrastructure and enhanced electricity consumption, the Analytical Network Process (ANP) analysis method was employed. ANP serves as a supportive tool in decision-making processes, facilitating stakeholders in ranking policy alternatives (Kheybari et al., 2020),(X. Chen et al., 2018). This method proves valuable as it addresses decision-making challenges by integrating perspectives among stakeholders,

who often rely on subjective judgments based on assumptions, alongside data or regulations set forth by governmental bodies or regulators (Taherdoost & Madanchian, 2023). The respondents in this study comprised three distinct groups: community representatives (3 respondents), central government officials (3 respondents), and local government representatives (3 respondents), totalling nine respondents. All the respondents are stakeholders in NTT.

The consistency index (CI) in ANP simulations is an evaluation of whether respondents' answers are consistent. The consistency index of a comparison matrix is calculated using the following formula:

$$CI = \frac{\lambda_{max} - n}{n - 1} \dots\dots\dots (4)$$

Furthermore, the consistency ratio (CR) obtained is calculated by comparing the consistency index with the value of the random consistency index number, using the following formula:

$$CR = \frac{CI}{RI} \dots\dots\dots (5)$$

Where :

- CI = consistency index
- λ_{max} = The largest eigenvalue of the pairwise comparison matrix $n \times n$
- n = Number of items compared
- CR = consistency ratio
- RI = random consistency index

A matrix comparison is considered consistent when the CR value is not greater than 10%. A lower consistency ratio indicates better consistency of the comparison matrix (Gonzalez-Urango et al., 2024). Additionally, there is a rater agreement, which is a measurement tool indicating the level of agreement or concordance of answers. The rater agreement value is represented by Kendall's Coefficient of Concordance, which ranges between 0 and 1. A value closer to 1 signifies better agreement among raters. While getting Kendall's Coefficient of Concordance using the equations :

$$RI_i = \sum_{i=1}^n r_{ij} \dots\dots\dots (6)$$

$$RI = \frac{m(n+1)}{2} \dots\dots\dots (7)$$

$$S = \sum_{i=1}^n (RI_i - RI)^2 \dots\dots\dots (8)$$

$$W = \frac{12 \sum_{i=0}^n d_i^2}{m^2 n (n^2 - 1)} \dots\dots\dots (9)$$

Where:

- RI_i = The aggregated ranking of criterion i
- RI = The mean of the RI_i values

- r_{ij} = The rank given to criterion i by the evaluator group j
 m = The number of rater groups rating n factors
 S = A sum-of-squares statistic deviation over the row sums of ranking R_i
 W = Kendall's Coefficient of Concordance; $0 \leq W \leq 1$

Table 2. Kendall's Coefficient of Concordance Interpretation

W	Interpretation (D.-C. Chen et al., 2021)
0	No agreement
0.1	Weak agreement
0.3	Moderate agreement
0.6	Strong agreement
1	Perfect agreement

4. Results and Discussion

The effect of roads and electricity on GDP per capita

The findings of this study reveal that electricity consumption has a significant impact on increasing per capita income in NTT, with a coefficient of determination of 0.10 (R^2 of 10.11%). Specifically, every 1% increase in electricity consumption for the community's benefit correlates with a 63.7% increase in GDP per capita (Table 3). This underscores the critical role of electricity in driving economic development in the region. However, the government has identified several limitations in electricity development, including a lack of private investment, limited costs for building power plants, and a growing public demand that exceeds the government's supply capacity. In line with these observations, research conducted by Navarro also supports the notion that electricity can directly or indirectly boost per capita income (Bazán Navarro et al., 2023). Similarly, in India, increased electricity consumption has been linked to higher per capita income (Aneja & Mathpal, 2021),(Tiwari et al., 2021). Unfortunately, simultaneous increases in road length and improvements to road infrastructure have not yielded a significant increase in per capita income (Table 3).

Table 3. The effect of independent variables on per capita income

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.18085	2.543662	4.788707	0.0000
Electricity	0.637080	0.205269	3.103630	0.0025*
RoadLength	0.141000	0.163928	-0.860131	0.3917
RoadInf	0.098020	0.094366	-1.038724	0.3013
R-squared	0.101120	Mean dependent var		16.50887
F-statistic	3.974843	Durbin-Watson stat		2.355398
Prob(F-statistic)	0.009963			

* = 0.05

** = 0.001

Source : process data 2024

The effect of roads and electricity on poverty

Through the effect of roads and electricity on poverty, this study elucidates that an increase in road length can lead to a reduction in poverty. Specifically, each additional 1% increase in road length is associated with a 25.1% reduction in poverty, with a coefficient of determination of 0.163 (R^2 of 16.3%). Expanding road networks has implications for facilitating economic activities, enhancing the movement of goods and services, and elevating living standards (Luu et al., 2019),(Ng et al., 2019). The Asian Development Bank (ADB) has underscored the significant role of expanding road networks in mitigating regional isolation and improving people's living standards. Drawing from Africa's experience, poverty reduction has been achieved by expanding road networks to counter regional isolation (Safitri, 2018),(Osman Gaal et al., 2017). While higher increases in electricity usage may also contribute to poverty reduction, it appears that their impact is not as significant. However, this study indicates that only road infrastructure development has a discernible influence on poverty reduction, whereas other variables do not exhibit the same effect.

Table 4. The effect of independent variables on poverty reduction

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.894792	0.961179	3.011708	0.0032
Electricity	-0.032262	0.077566	-0.415926	0.6783
RoadLength	-0.251208	0.061944	4.055423	0.0001**
RoadInf	0.009270	0.035658	0.259970	0.7954
R-squared	0.163222	Mean dependent var		3.830169
F-statistic	6.892147	Durbin-Watson stat		2.717477
Prob(F-statistic)	0.000276			

* = 0.05

** = 0.001

Source : process data 2024

Strategies to increase the income and reduce poverty in NTT through roads and electricity consumption

The next, the increasing income and reducing poverty in a region is perceived as a multifaceted process that necessitates improvements from various fronts and requires contributions from diverse stakeholders. This research endeavours to formulate strategies aimed at augmenting per capita income and mitigating poverty through the enhancement of electricity consumption and the development of roads and infrastructure. The findings of this study reveal that the foremost priority is to boost electricity consumption in the community (0.415 points), followed by a focus on expanding the length of roads that are still feasible for development (0.315 points), and lastly, adding infrastructure to existing road networks (0.269 points) (Table 5).

Table 5. Strategies to increase per capita income and reduce poverty using ANP

Purpose	Criteria	Point	Program	Point
Increasing per capita income	Increasing electricity consumption	0.415	Increasing the number of households receiving electricity	0.463

Purpose	Criteria	Point	Program	Point
and reducing poverty			Increasing the electricity capacity (kWh) per household	0.316
			Improving / adding electricity infrastructure for the community	0,219
	Road length	0.315	Increasing road length	0.531
			Upgrading road status (from village road to regional road)	0.469
	Adding road infrastructure and facilities	0.269	Increasing road capacity (tonnage)	0.387
			Increasing road maintenance funds	0.315
		Increasing the number of connecting bridges between areas	0.275	

Source : process data 2024

In each priority, several exemplary programs have been developed (Table 5). In the first priority, the flagship program focuses on increasing the number of households with access to electricity (0.463 points). This program is deemed crucial as not all individuals/households currently have access to electricity. The subsequent program aims to enhance electricity consumption per household (0.316 points), followed by initiatives to improve and expand electricity infrastructure within communities (0.219 points).

For the second priority, the primary program entails expanding existing road networks (0.531 points). This initiative is pivotal as it addresses concerns regarding regional isolation. Additionally, efforts to elevate the status of village roads to regional roads (0.469 points) are highlighted. This elevation in status is anticipated to alleviate regional isolation by facilitating mass transportation to urban centres.

In the third priority, the main program involves increasing road capacity (tonnage) (0.293 points), which would enable small roads to accommodate large vehicles for transporting community agricultural products. Subsequently, there are programs aimed at augmenting funds for road maintenance (0.315 points), and enhancing connectivity through the construction of additional bridges between areas (0.275 points).

Each respondent demonstrated a consistency index ranging between 0.01 and 0.09, indicating that each qualified respondent was consistent in their responses (Table 6). Kendall's coefficient of 38 percent signifies the level of agreement among all respondents regarding the simulated poverty reduction strategy. This agreement is considered moderately substantial.

Tabel 6. Consistency index dan Kendall's Coefficient of Concordance

Response	Consistenci Index	Kendall's Coefficient	Interpretation
Resp 1	0.01 – 0.08	0.3807	Moderate Agreement
Resp 2	0.02 – 0.07		
Resp 3	0.01 – 0.09		
Resp 4	0.03 – 0.08		

Responsdence	Consistenci Index	Kendall's Coefficient	Interpretation
Resp 5	0.02 – 0.09		
Resp 6	0.03 – 0.09		
Resp 7	0.04 – 0.09		
Resp 8	0.01 – 0.07		
Resp 9	0.02 – 0.08		

Source : process data 2024

5. Conclusion

The issue of poverty in NTT stems from various factors, including low electricity consumption within communities and constraints in road infrastructure. The study findings elucidate that augmenting electricity consumption in communities can lead to an increase in per capita income. This is attributed to electricity serving as a gateway for industrialization and fostering economic activities with a significant multiplier effect. Regrettably, not all households in NTT have access to electricity. Conversely, the expansion of road networks and infrastructure appears to have limited impact on boosting per capita income. However, adding roads in the NTT region has shown a notable effect in poverty reduction, whereas road infrastructure alone has not demonstrated significant impact.

To address these challenges, the government's strategy to enhance revenue and alleviate poverty entails three priorities. Firstly, priority is given to increasing electricity consumption. This involves initiatives such as expanding the number of electricity users, enhancing electricity power per household, and bolstering electricity infrastructure within communities. Secondly, emphasis is placed on road length, with programs aimed at extending road networks and elevating the status of roads from village roads to regional roads. Lastly, the third priority focuses on augmenting facilities and infrastructure within road networks. Programs within this priority include enhancing road capacity, increasing maintenance funds for road infrastructure, and augmenting the number of bridges connecting different regions. This agreed strategy is considered moderate in terms of consensus among stakeholders.

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