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The Impact of Production Pocket Road Damage on Social, Economic, and Environmental Conditions in Tanampedagi Village, Ampibabo District, Parigi Moutong Regency

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ABSTRACT

This study aims to measure the proportion of damaged production pocket roads out of the total existing routes and to analyze the impact of production pocket road damage on the social, economic, and environmental conditions of the community in Tanampedagi Village, Ampibabo District, Parigi Moutong Regency. The study uses a descriptive quantitative approach with analytical methods comprising Road Damage Ratio Analysis, the Analytical Hierarchy Process (AHP), and the Leopold Matrix. The results show that of the total length of production pocket roads of 4,600 meters, about 1,270 meters or 27.60 percent is damaged and categorized as lightly damaged; nevertheless, this condition is already sufficient to disrupt farmers' activities in accessing their land and transporting their harvests. The AHP analysis reveals that the economic aspect is the top priority with a weight of 0.581, followed by the environmental aspect at 0.309 and the social aspect at 0.110, with the most influential sub-criteria being income in the economic aspect, soil erosion in the environmental aspect, and health in the social aspect. Of the three alternative solutions examined, road repair is the main choice with a weight of 0.542 because it is considered the most effective in supporting economic, social, and environmental recovery. The Leopold Matrix analysis confirms that road damage contributes to increased soil erosion, disaster risk, and water pollution, which overall worsen the environmental quality around the agricultural land. These findings affirm that the improvement of agricultural road infrastructure is an urgent need in sustainable regional development.

Keywords: *AHP, Economic impact, Environmental impact, Leopold Matrix, Production pocket road, Social impact*

INTRODUCTION

The availability of roads is very important for the performance of a region. Road infrastructure has a very important role and function, both in the distribution of goods and services and in increasing the economic growth of the community in meeting its needs (Mangidi et al., 2021). Infrastructure is a physical facility developed or required by public bodies for governmental functions in the provision of water, electricity, waste processing, transportation, and services, as well as in facilitating social and economic goals (Vitri & Herman, 2018). The availability of infrastructure is viewed not only from an economic standpoint but also in terms of the sustainability of development at the central and regional government levels (Prapti et al., 2015).

Several studies based on the new growth theory show the importance of infrastructure in driving the economy. This theory posits that infrastructure serves as an input factor affecting aggregate output and can be a potential source for raising the frontier of technological progress arising from externalities in infrastructure development (Windyarto, 2024). Thus, road

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infrastructure functions not only as a connector between regions but also as a driver of the economic and social activities of the community.

Infrastructure is also greatly needed in agricultural development, which has always been an important agenda in Indonesia's development plans. According to Dumasari (2020), there are five basic requirements for agricultural development, namely a market for farm produce, modern technology, the local availability of production facilities and equipment, incentives for farmers to produce, and transportation. These basic requirements cannot run smoothly without adequate transportation facilities, as affirmed in Law Number 38 of 2004 on Roads, which states that roads are transportation infrastructure that plays an important role in the economic, socio-cultural, environmental, political, and national defense and security fields.

As economic activity increases, road conditions traversed by high and repeated traffic volumes affect the road construction and reduce its quality (Ichsan & Isya, 2014). In general, road damage is caused by the exceeded design life, water pooling due to poor drainage, excessive vehicle loads, inaccurate initial planning, and inadequate supervision and implementation that do not meet standards. This condition is aggravated by minimal maintenance funds, delays in budget disbursement, and inaccurate handling priorities (Farhan, 2022).

Tanampedagi Village is a village in Ampibabo District, Parigi Moutong Regency, whose population is predominantly employed as farmers, with their main source of livelihood derived from agricultural produce. The village is located in the highlands with a fairly extensive land area and good soil fertility, so that many farmers cultivate land in mountainous areas that are quite far from the settlement. To reach that land, the community relies on production pocket roads, namely farm access roads that connect the settlement with the centers of agricultural production.

Damage to production pocket roads in Tanampedagi Village gives rise to complex problems that affect social, economic, and environmental aspects. The damage makes it difficult for farmers to transport production inputs and harvests, lengthens travel time, increases transportation costs, and even poses accident risks, which ultimately reduce farmers' income and welfare. Road damage also affects the environment in the form of soil erosion, disruption of rainwater flow, and an increased risk of landslides. This phenomenon calls for a comprehensive study to measure the level of damage and to map the priority of impacts and their solutions.

The research gap in this study stems from the still limited number of studies that specifically measure and prioritize the impact of farm road damage at the village level by combining a quantitative approach and multi-criteria decision-making. The novelty of this study lies in the combination of three methods, namely Road Damage Ratio Analysis to measure the level of damage, the Analytical Hierarchy Process (AHP) to map the priority of social and economic impacts while formulating alternative solutions, and the Leopold Matrix to assess environmental impacts. To fill this gap, this study aims to measure the proportion of damaged production pocket roads, to analyze their impact on the social and economic conditions of the community, and to analyze their impact on the environment in Tanampedagi Village.

LITERATURE REVIEW

Infrastructure is a physical system required to meet basic human needs in the social and economic fields. Within the framework of the new growth theory, infrastructure serves as an input factor affecting aggregate output and becomes a source of positive externalities for technological progress (Windyarto, 2024). Roads, as one form of transportation infrastructure, function to connect regions, facilitate the distribution of goods and services, and lower logistics costs, so that their availability becomes an important prerequisite for regional economic development, particularly in rural areas based on agriculture.

Road damage is defined as a decline in the quality of road construction that reduces the comfort and smoothness of traffic. Ichsan and Isya (2014) explain that road damage is influenced by traffic volume, vehicle loads, the drainage system, and the quality of planning and maintenance. The level of road damage can be measured through the damage ratio, namely the ratio of the

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length of damaged road to the total length of road, which is commonly classified into good condition, lightly damaged, and heavily damaged according to certain percentage thresholds.

The impact of road damage is multidimensional. From a microeconomic perspective, an increase in transportation cost as an input cost lowers the profit margin and affects the welfare of farm operators. Riwibowo (2022) found that road damage has a significant impact on the distribution of agricultural produce and farmers' income and hinders community economic activity. From the perspective of environmental economics theory, road damage that worsens environmental degradation such as soil erosion and water pollution generates externality costs that depress the sustainability of agricultural activity (Danhas & Muchtar, 2021).

The Analytical Hierarchy Process (AHP) is a multi-criteria decision-making approach developed by Thomas L. Saaty to decompose complex problems into a hierarchical structure of goals, criteria, sub-criteria, and alternatives (Saaty, 2012). AHP establishes priority weights through pairwise comparisons using the Saaty scale, then computes the eigen vector as the priority weight and assesses its reliability through the Consistency Ratio (CR); an assessment is considered consistent if the CR is less than 0.1 (Makkasau, 2013). Meanwhile, the Leopold Matrix is an environmental impact assessment method that maps the interaction between activities and environmental components through magnitude and importance values, so that it can identify the environmental components most affected (Sadler, 2017).

This foundation is supported by a number of empirical findings. Agustina et al. (2022) and Ahmad et al. (2024) show that road development and damage have a real impact on the socio-economic conditions of the community, while Ariyanto and Supriyanto (2022) demonstrate the application of the AHP method in determining the priority of infrastructure handling. These various findings affirm that the combination of damage measurement, multi-criteria priority mapping, and environmental impact assessment is a relevant approach for formulating comprehensive solutions for handling farm roads.

METHOD

This study uses a descriptive research type with a mixed methods approach, namely research that combines quantitative and qualitative methods within a single study to obtain a more complete and in-depth understanding of the phenomenon under study (Creswell et al., 2018). Descriptive research is used to describe the road conditions quantitatively and qualitatively and to analyze the impact of production pocket road damage on the social, economic, and environmental aspects of the community. The research location is Tanampedagi Village, Ampibabo District, Parigi Moutong Regency, with the research object being the damage to production pocket roads in that village.

The types of data consist of primary and secondary data. Primary data were obtained directly through observation, interviews, and questionnaires with relevant informants, especially farmers and stakeholders in Tanampedagi Village, while secondary data were obtained from documents, reports, and publications relevant to the research topic (Sugiyono, 2022). Data collection was carried out through direct observation at the location, interviews, the distribution of pairwise comparison questionnaires for AHP purposes, and documentation (Suharsimi, 2010).

The analytical methods used comprise three complementary approaches. First, Road Damage Ratio Analysis is used to measure the level of road damage, calculated as the ratio of the length of damaged road to the total length of road multiplied by one hundred percent, with the following interpretation criteria: a ratio of less than 10 percent is classified as good condition, a ratio of less than 30 percent is classified as lightly damaged, and a ratio of more than 30 percent is classified as heavily damaged.

Second, the Analytical Hierarchy Process (AHP) is used to analyze and prioritize the impact of road damage on the social and economic aspects and to formulate alternative solutions. The AHP procedure comprises constructing the hierarchical structure, assigning pairwise comparison values among criteria using the Saaty scale, computing the priority weights through

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the eigen vector, and testing consistency through the Consistency Ratio (CR) with the formula CR = (λmax − n)/((n − 1) × RI), where the assessment is considered consistent if the CR is less than 0.1. Third, the Leopold Matrix is used to assess the impact of road damage on the environment by comparing the magnitude and importance values of environmental components before and after road damage, focused on three components, namely soil erosion, disaster risk, and water pollution.

RESULTS AND DISCUSSION

Research Results

The production pocket roads in Tanampedagi Village consist of six routes opened by the village government with a total length of 4,600 meters. Field observation shows that four routes are damaged, namely the Likumbeli route of 700 meters, Lontouwe of 180 meters, Sirosafu of 200 meters, and Sikatelo of 190 meters, so that the total length of damaged road reaches 1,270 meters. The details of the road conditions are presented in Table 1.

Table 1. Condition of Production Pocket Roads in Tanampedagi Village

Road Route	Condition	Route Length	Damaged Length
Likumbeli	Lightly damaged	1,100 m	700 m
Lontouwe	Lightly damaged	300 m	180 m
Sirosafu	Lightly damaged	300 m	200 m
Sikatelo	Lightly damaged	300 m	190 m
Other routes	Good	2,600 m	-
Total		4,600 m	1,270 m

Source: Processed primary data (2025)

Based on these data, the road damage ratio is calculated as the ratio of the length of damaged road (1,270 meters) to the total length of road (4,600 meters) multiplied by one hundred percent, yielding a damage ratio of 27.60 percent. Because this value is below 30 percent, the condition of the production pocket roads in Tanampedagi Village is classified as lightly damaged. Nevertheless, the damage is already sufficient to disrupt farmers' activities in accessing their land and distributing their harvests, because damage in the form of cracks, uneven surfaces, and potholes lengthens travel time and increases transportation costs.

The analysis of social and economic impacts was carried out using the AHP method on three main criteria, namely social, economic, and environmental. The priority weighting results show that the economic aspect is the highest priority with a weight of 0.581, followed by the environmental aspect at 0.309, and the social aspect at 0.110. These calculations have a very good level of consistency with a Consistency Ratio (CR) of 0.0042 or 0.42 percent, well below the 0.1 threshold, so that the pairwise comparison assessment is declared consistent and reliable. The priority weights of the three main criteria are presented in Table 2.

Table 2. Priority Weights of the Main Criteria (AHP)

Criterion	Priority Weight	Rank
Economic	0.581	1
Environmental	0.309	2
Social	0.110	3
Consistency Ratio (CR) = 0.0042 (consistent)		

Source: Processed primary data (2025)

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The analysis of sub-criteria within each aspect reinforces this finding. In the economic aspect, the income sub-criterion has the highest weight at 0.568, followed by production cost at 0.218, agricultural productivity, and distribution cost, which shows that farm road damage most affects the income of the community. In the environmental aspect, the soil erosion sub-criterion has the highest weight at 0.589, followed by water pollution at 0.252 and disaster risk at 0.159. In the social aspect, the health sub-criterion has the highest weight at 0.608, followed by education and security. All sub-criteria calculations have CR values below 0.1 and are therefore consistent.

Based on the combination of the weights of all aspects and sub-criteria, three alternative actions were formulated, namely road repair, environmental management, and local economic development. The alternative weighting results show that road repair occupies the top priority with a total score of 0.542, followed by environmental management at 0.271, and local economic development at 0.145, as presented in Table 3. Road repair is considered the most strategic because it provides the most significant impact on improving the community's economy, reducing environmental impacts, and improving social quality of life.

Table 3. Priority Weights of Alternative Actions (AHP)

Alternative Action	Total Score	Rank
Road repair	0.542	1
Environmental management	0.271	2
Local economic development	0.145	3

Source: Processed primary data (2025)

The environmental impact analysis using the Leopold Matrix is focused on three components, namely soil erosion, disaster risk, and water pollution, by comparing the magnitude and importance values before and after road damage. The analysis shows that before road damage the environmental condition was relatively stable with a low level of impact, but after road damage all values increased. The comparison of these values is presented in Table 4.

Table 4. Leopold Matrix Analysis Results of Environmental Impacts

Environmental Component	Before (M/I)	After (M/I)	Score
Soil erosion	+2 / 2	+4 / 5	0.284
Disaster risk	+2 / 2	+4 / 4	0.135
Water pollution	+1 / 2	+3 / 4	0.070

Source: Processed primary data (2025); M = magnitude, I = importance

Based on Table 4, soil erosion has the highest total score of 0.284, which shows that soil erosion is the most significant environmental impact of farm road damage, followed by disaster risk at 0.135 and water pollution at 0.070. The increase in magnitude and importance values across all components shows that road damage in the form of potholes and uneven surfaces obstructs water flow, accelerates soil erosion, increases the potential for floods and landslides in high-slope areas, and carries sediment and residue to the nearest water sources, thereby reducing water quality.

Discussion

The road damage ratio of the production pocket roads in Tanampedagi Village of 27.60 percent, classified as lightly damaged, shows that although the roads can still be traversed, the damage already noticeably disrupts community mobility, particularly for farmers. This condition

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aligns with the view that good road infrastructure facilitates the distribution of agricultural produce and drives the economic growth of rural areas, so that a decline in road quality lengthens travel time, increases transportation and vehicle maintenance costs, and reduces the efficiency of agricultural activity. This finding reinforces the results of Riwibowo (2022), which show that road damage has a significant impact on the distribution of agricultural produce and farmers' income.

The AHP result that places the economic aspect as the highest priority affirms that road damage is felt most in the economic dimension. From a microeconomic perspective, an increase in input costs such as transportation lowers the profit margin and thus affects the welfare of farm operators. Farmers' income becomes the indicator most sensitive to road conditions, followed by production cost and agricultural productivity, which reflects the direct link between infrastructure conditions and the stability of the local economy in the agrarian sector. This finding is consistent with Agustina et al. (2022) and Ahmad et al. (2024), which show the real impact of roads on the socio-economic conditions of the community.

The environmental aspect, which occupies second priority, shows that road damage also worsens environmental degradation, especially through soil erosion as the most influential sub-criterion. Within the framework of environmental economics theory, this degradation generates externality costs in the form of declining land productivity and rising environmental recovery costs, so that the impact of road damage does not stop at the direct economic aspect but spreads to the sustainability of the agricultural ecosystem. This reinforces the argument that the handling of farm road infrastructure needs to integrate environmental considerations.

The social aspect received the lowest weight, but the health sub-criterion was recorded as the most significant within it. The disruption of access to health services due to poor road infrastructure affirms that roads are not only an economic facility but also a support for access to basic services in rural areas. Thus, although in aggregate the social aspect is deemed less of a priority than the economic and environmental aspects, the health dimension still demands attention in the formulation of road-handling policy.

The alternative weighting result that places road repair as the top priority with the highest score affirms that intervention at the root of the problem, namely the physical condition of the road, is considered the most effective in reducing social, economic, and environmental impacts simultaneously. This choice aligns with regional economics theory and the new growth theory that infrastructure improvement enhances connectivity, lowers logistics costs, and increases regional competitiveness. The alternatives of environmental management and local economic development remain relevant as complementary actions, but both would be more optimal if preceded by road repair as the foundation.

The Leopold Matrix result reinforces the AHP finding by showing an increase in magnitude and importance values across all environmental components after road damage, with soil erosion as the most significant impact. The consistency between the two methods affirms that farm road damage generates layered and interrelated impacts: declining economic accessibility, increasing environmental degradation, and disrupted social access. Therefore, sustainable maintenance of farm roads becomes an urgent need to preserve the balance of the ecosystem while supporting environmentally friendly agricultural development.

Overall, the findings of this study indicate that the handling of production pocket road damage cannot be regarded as merely a technical problem, but as a regional development issue that touches the economic, environmental, and social dimensions simultaneously. The multi-criteria approach through AHP and the environmental impact assessment through the Leopold Matrix provide a more objective basis for formulating policy priorities, so that village and regional governments can allocate resources in a more targeted manner, with road repair as the priority step that has cross-dimensional impacts.

CONCLUSION AND SUGGESTIONS

Based on the research results, the damage ratio analysis shows that part of the production pocket roads in Tanampedagi Village is damaged, classified in the lightly damaged category, yet noticeably disrupts farmers' activities in accessing their land and distributing their harvests. The Analytical Hierarchy Process analysis places the economic aspect as the highest priority, followed by the environmental aspect and then the social aspect, with the most important sub-criteria being income in the economic aspect, soil erosion in the environmental aspect, and health in the social aspect; all calculations show a good level of consistency so that the assessment is declared reliable. Of the three alternative actions formulated, road repair is the top priority because it is considered the most effective in supporting economic, social, and environmental recovery simultaneously.

The evaluation using the Leopold Matrix shows that road damage in agricultural areas has a major impact on the environment, especially on the soil erosion aspect. The environmental condition, which was initially relatively stable, declined after the road damage occurred, marked by an increase in the magnitude and importance of impacts across all analyzed components. The damaged road surface obstructs water flow, thereby accelerating soil erosion and increasing the potential for floods and landslides. Thus, farm road damage not only affects infrastructure but also causes environmental damage that demands sustainable handling.

Based on these findings, the regional government together with relevant agencies is expected to take concrete steps in rehabilitating and periodically maintaining the damaged production pocket roads by involving the active participation of the community, especially farmer groups, from the planning stage through to maintenance, including through the formation of self-help groups for road maintenance. The negative impacts of road damage also need to become a shared concern of the village government and the community through periodic evaluation. This study has limitations because it focuses only on Tanampedagi Village and has not examined external factors such as government policy or the contribution of the private sector, so that future research is advised to expand the scope of the area and consider these factors.

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