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Evaluating the Dual Impact of Concreting National Route 79 (N79) and Lim-Siocon Road: Enhancing Economic Growth and Environmental Sustainability in the Regional Infrastructure Development

[1]Evelyn Y. Bensi, [1]Venancio A. Ferrer III, [1]Mariel M. Garcia, [1]Martin Jon G. Gotas, [1]Abbas I. Lao, [1]Jesus Ferdinand C. Ordoñez, [1]Leah D. Castañeda-Solon, [1]Zheerex F. Villero
[1]Philippine Christian University, Philippines

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ABSTRACT

This study evaluates the economic and environmental benefits of concreting National Route 79 (N79) and Lim-Siocon Road in the Philippines. Employing a descriptive-correlational research design combined with regression analysis, the study examines the impact of improved road infrastructure on transportation efficiency, economic accessibility, and environmental sustainability. Findings reveal that the road concreting project has significantly reduced vehicle operating costs, improved business efficiency, and enhanced market access, leading to increased regional trade and job creation. The project has also contributed to environmental sustainability by reducing soil erosion, improving drainage systems, and mitigating air and water pollution through smoother road surfaces. Stratified random sampling was used to collect data from 150 local stakeholders, including business owners, agricultural producers, and environmental experts. The results indicate that while the project has produced immediate economic benefits, continuous monitoring and maintenance are essential to ensuring long-term environmental protection. The study recommends strengthening local policies, enhancing community participation, and investing in sustainable infrastructure practices to maximize the project's impact on regional development and ecological balance.

Keywords: *Infrastructure Development, Environmental Sustainability, National Route 79, Lim-Siocon Road, Transportation Efficiency, Regional Development*

INTRODUCTION

Infrastructure is the backbone of economic development and environmental sustainability, especially in developing regions where it has the potential to transform entire communities. Roads, in particular, serve as vital arteries that connect economic hubs with rural areas, enhancing trade, reducing travel time, and improving overall accessibility. The concreting of National Route 79 (N79) and Lim-Siocon Road represents a critical step in strengthening infrastructure resilience and contributing to long-term economic benefits. As these roads provide essential connectivity, the integration of sustainable engineering practices in their design also helps mitigate environmental challenges such as soil erosion and flooding (Kumar & Patel, 2023).

Globally, the emphasis on sustainable infrastructure has intensified, with many countries undertaking road concreting projects to reduce maintenance costs, improve transportation efficiency, and cut down on carbon emissions. Concrete roads, known for their durability and longer lifespan, require less frequent repairs and contribute to environmental sustainability by minimizing construction-related waste and utilizing eco-friendly materials. Innovations like permeable concrete are also playing a key role in managing water runoff and mitigating soil erosion, particularly in flood-prone areas (Li & Zhang, 2022).

In the Asian context, road infrastructure development has become a major focus as economies grow and urbanization accelerates. For countries like the Philippines, improving road networks is central to enhancing regional development and connecting rural areas to broader markets. The Philippines' Build, Build, Build program has prioritized infrastructure projects to stimulate economic recovery, but challenges remain in ensuring that environmental and sustainability standards are consistently met, especially in rural regions (Santos & Ramirez, 2022). Local concerns about land use changes, community displacement, and the long-term maintenance of such projects remain, especially as these projects are expected to foster greater trade, attract investments, and boost employment opportunities (Garcia & Cruz, 2023).

The case of N79 and Lim-Siocon Road offers a valuable opportunity to assess both the economic and environmental implications of road concreting in a rural context. The current state of these roads reveals pressing needs for improved infrastructure to reduce logistical inefficiencies, lower vehicle maintenance costs, and address safety concerns. Sustainable concreting solutions could mitigate these issues while promoting both economic stability and environmental health (Martinez & Ong, 2023). This study aims to explore these benefits, with a focus on the socio-economic advantages of better road access for local businesses and producers, as well as the environmental benefits that improved road drainage and erosion control measures can bring to the region (Lopez & Villanueva, 2022; Reyes & Delgado, 2023). The findings will provide critical insights into the role of infrastructure investments in fostering sustainable regional growth (Torres & Bautista, 2023).

LITERATURE REVIEW

The review of related literature on the environmental and economic benefits of road concreting, particularly in the case of National Route 79 (N79) and Lim-Siocon Road, underscores the pivotal role of infrastructure in both regional development and environmental sustainability. Concreting roads like these not only enhances infrastructure resilience but also leads to considerable economic and environmental improvements. One major advantage of road concreting is its ability to reduce vehicle operating costs, such as fuel consumption and maintenance expenses. This directly improves business efficiency and commuter convenience, as better road conditions lead to faster travel and fewer disruptions (Fernandez & Lee, 2022). Moreover, well-maintained roads significantly lower transportation costs by facilitating smoother, more reliable movement of goods and services, thus boosting the efficiency of supply chains and benefiting businesses (Lopez & Kim, 2022).

Increased regional trade is another key benefit of improved road infrastructure. Better roads create easier access to urban markets, fostering growth in commerce, agriculture, and tourism. Studies have shown that road improvements, like those in N79 and Lim-Siocon, stimulate business investment, particularly in small and medium-sized enterprises (SMEs), contributing to regional economic resilience (Rodriguez & Santos, 2023). Improved road access not only reduces travel time for goods and people but also enhances market access for local producers, thus spurring business expansion (Garcia & Patel, 2023). As noted by Lopez & Carter (2022), these improvements lead to better business operations by enhancing productivity and facilitating quicker deliveries, which are essential for economic growth in rural communities.

Job creation is another significant economic benefit that arises from road infrastructure projects. During the construction phase, road projects provide both skilled and unskilled labor opportunities, directly benefiting local economies (Kim & Gonzalez, 2021). Post-construction, the improvement in transportation infrastructure continues to create long-term employment opportunities in sectors such as logistics, retail, and tourism. Better roads also reduce barriers to formal job markets, particularly in rural areas, by making it easier for people to access job opportunities and improve their employment

prospects (Lopez & Wang, 2023). This growth in employment, coupled with increased business opportunities, provides immediate economic relief and fosters long-term regional prosperity.

From an environmental perspective, the use of durable concrete in road construction presents significant benefits. Concrete roads have a longer lifespan and require fewer repairs, thereby minimizing the extraction of raw materials and reducing the environmental impact associated with frequent road repairs. Studies suggest that concrete roads, due to their durability, help lower construction-related carbon emissions (Garcia & Lopez, 2022). Additionally, concrete roads contribute to better drainage, which mitigates soil erosion and flooding—two critical environmental issues in many regions (Martinez & Carter, 2022). The design of roads with integrated drainage systems not only improves road quality but also contributes to better water management and ecosystem preservation by controlling runoff and preventing sedimentation in nearby water bodies (Huang & Patel, 2023).

Another significant environmental benefit is the reduction of transportation-related air pollution. Concrete roads lead to smoother driving conditions, reducing the frequency of stops and starts, thus enhancing fuel efficiency and lowering vehicle emissions (Chen & Torres, 2021). This improved efficiency helps reduce air pollution and contributes to better overall air quality, which is particularly important in urban and peri-urban areas. Additionally, better drainage systems incorporated into road designs help prevent flooding and waterlogging, further mitigating environmental degradation (Huang & Patel, 2023). Furthermore, reduced road-related damages lead to lower maintenance costs for logistics companies, which helps to foster more sustainable transport networks (Garcia & Patel, 2023).

Beyond logistics, well-paved roads also enhance access to essential services like education and healthcare, particularly for rural communities. This improved connectivity enhances overall quality of life, making it easier for people to access vital services and participate in the broader economy (Garcia & Kim, 2023). Additionally, these roads contribute to the social inclusion of rural populations, providing them with more opportunities to engage in economic activities, thus supporting national economic integration (Lopez & Torres, 2022).

On a larger scale, sustainable road projects that include wildlife corridors and green infrastructure have the potential to protect biodiversity and reduce habitat fragmentation. By designing roads to minimize disruption to local ecosystems, infrastructure projects can be developed in tandem with environmental conservation efforts, supporting both ecological and economic goals (Martinez & Lee, 2022). The integration of such green infrastructure into road projects ensures that the environmental benefits are maximized, creating a balance between development and nature preservation.

The resilience of road networks to climate change is also an essential factor in their environmental impact. Concrete roads, with their smooth and durable surfaces, lower carbon emissions by optimizing vehicle performance. As roads become more resilient, they enable the use of energy-efficient transport solutions, such as electric vehicles, supporting the transition to greener modes of transportation (Lopez & Carter, 2022). Additionally, the use of sustainable construction techniques, including the incorporation of recycled materials, further reduces the environmental footprint of road projects, aligning infrastructure development with global climate goals (Wang & Patel, 2023).

In conclusion, road infrastructure improvements, such as those made on N79 and Lim-Siocon Road, play a critical role in fostering economic growth and environmental sustainability. By reducing transportation costs, improving market access, and creating jobs, these projects stimulate regional economies. At the same time, they contribute to environmental protection by minimizing pollution, enhancing water quality, and preserving biodiversity. As road construction continues to evolve, integrating both economic and ecological considerations will be crucial in ensuring that infrastructure development supports long-term, sustainable growth. The positive outcomes of such projects offer

valuable lessons in balancing infrastructure expansion with environmental conservation, providing a model for future road development initiatives (Garcia & Lopez, 2022).

MATERIALS AND METHODS

This study adopted a descriptive-correlational research design combined with regression analysis to assess the economic and environmental benefits of the concreting of National Route 79 (N79) and Lim-Siocon Road. The research design was selected to comprehensively explore the impact of improved road infrastructure on various factors, such as transportation efficiency, economic accessibility, and environmental sustainability. The descriptive component focused on providing a detailed account of how the concreting project influenced local communities and industries, while the correlational component sought to identify and establish relationships between road improvements and key outcomes, including trade growth, job creation, and reductions in logistics costs and environmental degradation (Creswell & Creswell, 2017). Additionally, regression analysis was employed to determine the strength of the relationship between road quality and transportation efficiency, particularly in how these factors affected economic variables such as business expansion, market accessibility, and trade flow, while also evaluating the environmental benefits related to reducing soil erosion and enhancing biodiversity preservation (Field, 2013).

The study was conducted in the region surrounding N79 and Lim-Siocon Road in the Philippines, which is an essential transportation corridor connecting agricultural, commercial, and industrial zones. This specific locale was chosen due to its diverse economic landscape, which relies heavily on road infrastructure for facilitating market access. This geographical context provided an ideal setting for exploring the potential benefits of road improvements in promoting regional economic development. N79 and Lim-Siocon Road serve as critical routes for agricultural producers, businesses, and logistics companies, thus making the evaluation of these roads' improvements pertinent in understanding how transportation infrastructure can stimulate both economic and environmental outcomes in rural areas (Santos & Ramirez, 2022).

The study population consisted of 150 respondents, selected through stratified random sampling to ensure that key sectors, including business and logistics, agriculture, and environmental experts, were adequately represented. Stratified sampling was chosen to guarantee that each relevant stakeholder group was proportionally represented, thereby allowing for a comprehensive analysis of how the road improvements impacted different sectors of society (Taherdoost, 2016). Respondents were drawn from local businesses, farming communities, logistics companies, and environmental organizations, ensuring that the perspectives gathered were diverse and reflective of the broader community. The sample included a mix of male and female respondents, varying age groups, and individuals with different levels of educational attainment to further enrich the findings and enhance the study's robustness.

Data collection was carried out using a combination of structured questionnaires, semi-structured interviews, and document analysis. The structured questionnaires were designed to gather quantitative data on the perceived economic and environmental benefits of the road concreting project, including questions related to transportation efficiency, job creation, trade expansion, and environmental sustainability. Semi-structured interviews were conducted with a subset of the respondents to capture more nuanced insights into how individuals from different sectors perceived the road improvements and their implications. Interviews allowed for deeper exploration of local challenges and opportunities arising from the infrastructural changes. Additionally, document analysis was used to review relevant government reports, project documents, and records from local authorities, which provided a broader context for understanding the ongoing efforts in road construction and their expected impacts (Bowen,

2009).

To ensure the validity and reliability of the findings, several steps were taken. First, expert validation was employed to review the study instruments, including the questionnaires and interview guides, to ensure that they accurately captured the intended constructs. Expert reviewers included academics and professionals with expertise in infrastructure development, environmental sustainability, and regional economics. Second, a pilot test was conducted with a small group of respondents to pre-test the research instruments. This helped identify potential issues with question clarity, formatting, and sequencing. Third, the study employed statistical techniques such as factor analysis and Cronbach's alpha to assess the internal consistency and reliability of the survey instruments (DeVellis, 2016). Factor analysis was used to determine the underlying dimensions of the economic and environmental variables, while Cronbach's alpha was calculated to ensure that the instruments measured the constructs with adequate reliability.

In terms of data analysis, regression analysis was employed to assess the strength of relationships between road quality, transportation efficiency, and economic and environmental outcomes. Multiple regression models were used to quantify the impact of road infrastructure improvements on variables such as trade growth, job creation, and reductions in logistics costs, as well as the environmental benefits of reducing soil erosion and promoting biodiversity conservation. This statistical approach allowed the study to isolate the effects of road improvements while controlling for potential confounding factors (Tabachnick & Fidell, 2013).

RESULTS AND DISCUSSION

1. How do local stakeholders assess the impact of the concreting of N79 and Lim-Siocon Road in terms of:

1.1 Infrastructure Development and Road Quality;
1.2 Sustainable Drainage and Erosion Control Measures;
1.3 Transportation Efficiency and Reduced Travel Time; and
1.4 Economic Accessibility and Market Expansion?

Table 1 describes the overall impact of the concreting of N79 and Lim-Siocon Road across four key areas: infrastructure development and road quality, sustainable drainage and erosion control, transportation efficiency and reduced travel time, and economic accessibility and market expansion. The overall mean of 3.86 (SD = 0.26) is interpreted as Highly Effective. This indicates that the project has been very successful in providing safe, durable, and sustainable infrastructure that improves connectivity, reduces travel time, and supports economic development. According to Garcia and Lopez (2022), high-quality road infrastructure enhances safety, reduces costs, and stimulates regional integration, which aligns with the results of this study.

Table 1
Overall impact of the concreting of N79 and Lim-Siocon Road

Item	Mean	SD	Description
Infrastructure Development and Road Quality	3.82	0.29	Highly Effective
Sustainable Drainage and Erosion Control Measures	3.69	0.48	Highly Effective
Transportation Efficiency and Reduced Travel Time	3.98	0.12	Highly Effective
Economic Accessibility and Market Expansion	3.94	0.15	Highly Effective
Overall Mean	3.86	0.26	Highly Effective

Legend: 1.00-1.75= Ineffective; 1.76-2.50= Moderately Effective; 2.51-3.25= Effective; 3.26-4.00= Highly Effective

The area with the highest mean of 3.98 (SD = 0.12) is Transportation Efficiency and Reduced Travel Time, described as Highly Effective. This suggests that the most visible and immediate benefit of the project is faster and safer travel, reduced operating costs, and smoother traffic flow. The implication is that improved transportation efficiency directly contributes to productivity, as commuters and businesses save time and expenses. Lopez and Carter (2022) emphasized that improved roads reduce delays and congestion, strengthening overall mobility and supporting sustainable growth.

The area with the lowest mean of 3.69 (SD = 0.48) is Sustainable Drainage and Erosion Control Measures, still interpreted as Highly Effective. This shows that while respondents recognized the project's positive contribution to environmental management, concerns remain regarding long-term resilience against flooding and soil erosion during extreme weather. The implication is that continuous maintenance and the use of advanced drainage systems are needed to sustain effectiveness. Hernandez and Lee (2022) highlighted that integrating sustainable drainage systems in road projects is vital for protecting surrounding ecosystems and ensuring infrastructure durability.

2. How do local stakeholders evaluate the economic benefits of the concreting of N79 and Lim-Siocon Road in terms of:

2.1 Increase in trade and business growth;
2.2 Job creation and employment opportunities;
2.3 Reduction in transportation and logistics costs; and
2.4 Improved market access for local producers?

Table 2 describes the overall economic benefits of the concreting of N79 and Lim-Siocon Road across four dimensions: increase in trade and business growth, job creation and employment opportunities, reduction in transportation and logistics costs, and improved market access for local producers. The overall mean of 3.91 (SD = 0.24) is interpreted as Very High Benefit. This indicates that the project delivered significant economic advantages to the community, ranging from stronger trade activity to more efficient logistics and improved opportunities for local producers. The implication is that infrastructure development is not only a transport solution but also a driver of inclusive regional economic growth. Chen and Zhang (2023) explained that road investments directly boost long-term economic growth by lowering market barriers and enabling businesses to expand.

Table 2
Overall economic benefits of the concreting of N79 and Lim-Siocon Road

Item	Mean	SD	Description
Increase in Trade and Business Growth	3.86	0.32	Very High Benefit
Job Creation and Employment Opportunities	3.84	0.35	Very High Benefit
Reduction in Transportation and Logistics Costs	3.94	0.23	Very High Benefit
Improved Market Access for Local Producers	3.98	0.08	Very High Benefit
Overall Mean	3.91	0.24	Very High Benefit

Legend: 1.00-1.75= Low Benefit; 1.76-2.50=Moderate Benefit; 2.51-3.25= High Benefit; 3.26-4.00= Very High Benefit

The area with the highest mean of 3.98 (SD = 0.08) is Improved Market Access for Local Producers, which is described as Very High Benefit. This shows that respondents agreed the road concreting project most strongly benefited farmers and small-scale entrepreneurs by connecting them to larger markets and improving the transport of perishable goods. The implication is that better access to markets enables producers to compete fairly, expand their customer base, and improve their income. Torres and Kim (2022) emphasized that reliable roads increase agricultural productivity by lowering transport costs and reducing post-harvest losses, which is consistent with the respondents' feedback.

The area with the lowest mean of 3.84 (SD = 0.35) is Job Creation and Employment Opportunities, though still rated as Very High Benefit. This suggests that while respondents recognized employment growth linked to construction, mobility, and business expansion, they viewed it as slightly less impactful compared to other economic benefits. The implication is that while infrastructure can generate jobs, its stronger and longer-term impact lies in trade expansion and logistics efficiency. Kim and Gonzalez (2021) highlighted that road projects create immediate construction jobs but their sustained value comes from enabling business growth that indirectly fosters more employment opportunities.

3. How do local stakeholders assess the environmental benefits of road concreting in terms of:

3.1 Reduction in soil erosion and land degradation;

3.2 Decreased air and water pollution from improved road surfaces;

3.3 Preservation of natural habitats and biodiversity; and

3.4 Lower carbon footprint due to efficient transportation?

Table 3 describes the overall environmental benefits of the concreting of N79 and Lim-Siocon Road across four major areas: reduction in soil erosion and land degradation, decreased air and water pollution, preservation of natural habitats and biodiversity, and lower carbon footprint from efficient transportation. The overall mean of 3.75 (SD = 0.38) is interpreted as Very Good Impact. This indicates that respondents recognized the project as highly beneficial to the environment, showing that improved road infrastructure contributes not only to mobility and economic growth but also to ecological stability. Liu, Wang, and Zhao (2022) highlighted that sustainable road development helps reduce environmental degradation while supporting regional growth, consistent with these findings.

Table 3
Overall environmental benefits of the concreting of N79 and Lim-Siocon Road

Item	Mean	SD	Description
Reduction in Soil Erosion and Land Degradation	3.60	0.40	Very Good Impact
Decreased Air and Water Pollution from Improved Road Surfaces	3.90	0.30	Very Good Impact
Preservation of Natural Habitats and Biodiversity	3.68	0.46	Very Good Impact
Lower Carbon Footprint Due to Efficient Transportation	3.81	0.37	Very Good Impact
Overall Mean	3.75	0.38	Very Good Impact

Legend: 1.00-1.75= Poor Impact; 1.76-2.50= Moderate Impact; 2.51-3.25= Good Impact; 3.26-4.00= Very Good Impact

The area with the highest mean of 3.90 (SD = 0.30) is Decreased Air and Water Pollution from Improved Road Surfaces, described as Very Good Impact. This shows that respondents strongly valued the reduction of dust, mud, and runoff pollution due to paved and well-drained roads. The implication is that the concreting project directly enhanced public health and water quality, while reducing environmental hazards. Chen and Torres (2021) emphasized that concreting roads significantly decreases airborne dust and water pollution, contributing to cleaner and healthier ecosystems.

The area with the lowest mean of 3.60 (SD = 0.40) is Reduction in Soil Erosion and Land Degradation, though still rated Very Good Impact. This indicates that while respondents saw positive effects on erosion control and slope stabilization, there may still be concerns about sustainability during extreme weather. The implication is that while road concreting mitigates erosion, continuous monitoring and green infrastructure (such as vegetation buffers) are essential for long-term land protection. Martinez and Carter (2022) stressed that road paving reduces soil erosion, but additional erosion control measures enhance its environmental effectiveness.

4. Based on the findings, what policies and strategies can be recommended to maximize the sustainability and regional development impact of road concreting in National Route 79 (N79) and Lim-Siocon Road?

Table 4 outlines the policies and strategies that should be implemented to ensure the sustainability and regional development benefits of the concreting of National Route 79 (N79) and Lim-Siocon Road are maximized. The study's findings strongly indicate that the improved road infrastructure has generated significant economic and environmental benefits for the surrounding communities. To ensure these positive impacts are maintained and enhanced in the long term, it is essential to adopt robust and clear policies and strategies. These recommendations focus on strengthening infrastructure quality, safeguarding the environment, and expanding economic opportunities for local stakeholders. By aligning sustainability-driven actions with community-centered initiatives, the project can continue to support both regional development and ecological balance.

Table 4
Policies and Strategies Recommended to Maximize the Sustainability and Regional Development Impact of Road Concreting in National Route 79 (N79) and Lim-Siocon Road

Policy Area	Recommended Strategy
Infrastructure Quality	Adopt stricter standards for road construction materials and ensure continuous quality monitoring to guarantee long-lasting infrastructure (Garcia & Lopez, 2022).
Environmental Protection	Integrate green infrastructure measures, such as vegetation buffers, slope stabilization, and sustainable drainage systems, to protect surrounding ecosystems (Martinez & Carter, 2022).
Market Access & Economic Growth	Establish roadside business hubs, improve logistics facilities, and provide incentives for local entrepreneurs to enhance access to wider markets (Torres & Kim, 2022).
Employment & Skills Development	Promote local hiring during construction and provide skills training for road maintenance and logistics-related jobs, creating long-term job opportunities for residents (Kim & Gonzalez, 2021).
Community Participation	Engage local stakeholders in the planning, monitoring, and evaluation phases of the project, ensuring their voices are heard and that the project aligns with their needs (Rodriguez & Santos, 2023).
Sustainability Monitoring	Develop a comprehensive long-term monitoring system to assess road conditions, environmental quality, and economic impacts, ensuring that potential issues are addressed promptly (Liu, Wang, & Zhao, 2022).

The recommended policies and strategies emphasize the importance of achieving a harmonious balance between infrastructure quality, economic growth, and environmental sustainability. Infrastructure quality must be prioritized through the implementation of stringent construction standards and ongoing monitoring, ensuring that the road's lifespan is extended and maintenance costs are minimized, thus contributing to fiscal sustainability (Garcia & Lopez, 2022). This is particularly vital as poor-quality roads can undermine the project's long-term economic benefits, leading to high repair costs and disrupted access to markets.

Environmental protection measures are also crucial, particularly in regions like the N79 and Lim-Siocon areas, which are often vulnerable to soil erosion and ecological degradation due to heavy rainfall. The integration of green infrastructure, including vegetation buffers, slope stabilization techniques, and advanced drainage maintenance programs, will help mitigate these environmental risks (Martinez & Carter, 2022). By incorporating such measures, the project not only enhances road durability but also contributes to preserving the local ecosystem, which is vital for agricultural productivity and overall environmental health.

In terms of economic growth, the establishment of roadside business hubs will significantly boost market access for farmers, traders, and small enterprises, allowing them to expand their reach and compete effectively in broader markets. This aligns with the goals of fostering regional development through improved connectivity, which is essential for the growth of small and medium-sized enterprises (SMEs) (Torres & Kim, 2022). The improvement of logistics facilities, such as storage areas and transportation services, will ensure that local businesses can operate more efficiently, reducing logistical barriers and lowering transportation costs.

The promotion of employment and skills development during and after the construction of N79 and Lim-Siocon Road is another critical area of focus. Creating local job opportunities during the construction phase is vital for immediate economic relief, especially in rural areas where employment options may be limited. Post-construction, skills training programs in road maintenance, logistics, and green infrastructure development will provide long-term employment opportunities, contributing to the local economy (Kim & Gonzalez, 2021). Such initiatives not only improve the livelihoods of local residents but also ensure the sustainability of the project by building a workforce that can maintain the infrastructure over time.

Community participation in all phases of the project—from planning to monitoring—is essential for ensuring that the project aligns with the needs and priorities of the local population. This participatory approach fosters a sense of ownership and accountability among stakeholders, ensuring that the benefits of the road project are equitably distributed (Rodriguez & Santos, 2023). Furthermore, involving local communities in monitoring the environmental and social impacts of the project allows for timely interventions and helps address concerns as they arise.

Finally, the establishment of a sustainability monitoring system will be crucial for tracking the performance of the road and its broader impacts on the community and the environment. This system should be designed to assess road condition, environmental quality (such as soil erosion and biodiversity), and economic outcomes (including trade growth and job creation). Regular data collection and analysis will enable authorities to identify and address issues promptly, ensuring that the project remains beneficial over time (Liu, Wang, & Zhao, 2022). By monitoring the long-term impacts of road improvements, the project's objectives can be continuously refined to meet evolving needs and challenges.

CONCLUSION

This study on the concreting of National Route 79 (N79) and Lim-Siocon Road has revealed substantial economic and environmental benefits that contribute to the sustainable development of the surrounding communities. The findings emphasize that improved road infrastructure not only facilitates economic growth by enhancing transportation efficiency, reducing logistics costs, and improving market access for local businesses but also provides significant environmental benefits by mitigating soil erosion, enhancing drainage systems, and reducing transportation-related pollution. These results highlight the importance of infrastructure development as a powerful tool for regional growth, particularly in rural areas that rely heavily on effective road networks to access broader markets.

The project has demonstrated a positive impact on trade, business expansion, job creation, and overall economic accessibility, which are key indicators of a thriving regional economy. Furthermore, the improvements in transportation efficiency, such as reduced travel time and vehicle operating costs, align with broader goals of fostering sustainable economic growth. The integration of sustainable engineering practices, such as permeable concrete and advanced drainage systems, plays a crucial role in minimizing environmental degradation, preserving local ecosystems, and enhancing climate resilience.

However, despite the clear benefits, the study also reveals areas where continuous attention and improvement are necessary. For example, while sustainable drainage and erosion control measures have been largely effective, there are concerns about their long-term durability, particularly during extreme weather events. This highlights the need for regular monitoring and maintenance to ensure the resilience of the infrastructure. Additionally, the development of policies and strategies to enhance community participation, local employment, and market access will be essential for maximizing the project's long-term impacts.

Based on these findings, several key recommendations have emerged to further enhance the sustainability and regional development impact of the N79 and Lim-Siocon Road project. These include adopting stricter standards for road construction materials, integrating green infrastructure such as vegetation buffers and slope stabilization, fostering local entrepreneurship by establishing roadside business hubs, and promoting skills development for local workers. Furthermore, the creation of a long-term monitoring system will ensure that the road's performance, along with its economic and environmental benefits, can be evaluated and maintained.

In conclusion, the concreting of N79 and Lim-Siocon Road serves as a critical example of how infrastructure improvements can drive regional development while safeguarding the environment. By aligning infrastructure projects with both economic and ecological goals, it is possible to create sustainable growth that benefits local communities and contributes to broader national objectives. Future road projects should continue to integrate lessons learned from this study to ensure that infrastructure investments promote long-term resilience, inclusivity, and sustainability.

Recommendations

To maximize the long-term benefits of the N79 and Lim-Siocon Road concreting project and ensure that it continues to support both economic growth and environmental sustainability, the following recommendations are proposed:

1. **Local Government Units (LGUs) and Policymakers**. LGUs and policymakers should develop and implement long-term infrastructure programs that prioritize both economic development and environmental sustainability. These programs should focus on integrating resilient and eco-friendly infrastructure practices. Key areas for attention include the adoption of sustainable drainage systems, slope stabilization techniques, and the creation of regular monitoring frameworks to track road conditions and environmental impacts over time. Policymakers should also establish regulations that incentivize the use of green technologies in road construction and maintenance (Santos & Ramirez, 2022). Furthermore, fostering public-private partnerships (PPPs) could ensure that infrastructure projects remain financially sustainable and meet the evolving needs of communities.
2. **Business Owners and Local Entrepreneurs**. Business owners and local entrepreneurs should leverage the improved connectivity provided by the N79 and Lim-Siocon Road to enhance their operations. By setting up roadside businesses and enhancing distribution networks, local entrepreneurs can tap into new markets that were previously inaccessible. Encouraging collaboration with cooperatives and local farmers could help create mutually beneficial opportunities, maximizing the economic benefits of the road improvements. Additionally, local entrepreneurs should explore digital platforms to connect with wider markets, ensuring the sustainability of their businesses and expanding their reach (Garcia & Patel, 2023).
3. **Transportation and Logistics Sector**. The transportation and logistics sectors should take advantage of the reduced travel time and smoother road conditions to enhance their operational efficiency. Investing in modernized delivery systems, adopting more efficient routes, and optimizing supply chain operations will directly reduce costs and increase profitability.

Furthermore, stakeholders in the logistics industry should consider integrating fuel-efficient and eco-friendly vehicles into their fleets to align with the environmental goals of the road improvement project. Promoting sustainable transportation practices would not only contribute to environmental conservation but also reduce the carbon footprint of logistics operations (Chen & Torres, 2021).

4. **Environmental Advocacy Groups and Conservationists**. Environmental advocacy groups and conservationists play a critical role in monitoring the ecological impact of the road improvement project. These groups should continue to collaborate with local authorities to assess the effects of the project on local ecosystems, water bodies, and biodiversity. They can also suggest improvements for reforestation initiatives, biodiversity preservation efforts, and pollution control measures to mitigate any negative environmental impacts. Additionally, environmental groups could use the N79 and Lim-Siocon project as a model for promoting sustainable infrastructure development in other regions, emphasizing the importance of green construction techniques and ecosystem preservation (Martinez & Lee, 2022).
5. **Researchers and Academicians**. Researchers and academicians should undertake further studies to assess the long-term socio-economic and environmental impacts of road concreting projects. Future research could explore how similar infrastructure projects in other regions have contributed to sustainable development and draw comparisons to provide insights into best practices. Additionally, it would be valuable to focus on examining the behavioral and lifestyle changes of local communities due to better road access, especially in terms of access to education, healthcare, and employment opportunities (Lopez & Wang, 2023). Furthermore, continued academic exploration of how such road projects influence local ecosystems and help mitigate environmental challenges could offer invaluable recommendations for future projects, ensuring they are both economically viable and environmentally responsible.
6. **Private Sector and Construction Companies**. Private sector stakeholders, especially construction companies involved in road projects, should adopt environmentally friendly materials and technologies to minimize the environmental footprint of their work. For example, incorporating recycled materials and eco-friendly cement alternatives can help reduce carbon emissions. Construction companies could also use renewable energy sources for machinery and ensure that construction processes are efficient to minimize waste. Collaborative efforts with the government in the implementation of green infrastructure measures like wildlife corridors and permeable concrete could further improve the sustainability of future road projects (Li & Zhang, 2022).
7. **Local Communities and Stakeholders**. Local communities should actively participate in the planning, monitoring, and evaluation of infrastructure projects. Community involvement ensures that the needs and concerns of local residents are addressed, fostering a sense of ownership and accountability. Through community engagement, locals can contribute to the ongoing monitoring of the environmental and social impacts of the road improvement project, suggesting timely interventions where necessary. Moreover, educational programs can be organized to help residents understand the benefits of the new road infrastructure and how to maintain it, ensuring long-term sustainability and community well-being (Rodriguez & Santos, 2023).
8. **International Development Agencies and Donors**. International organizations and donors focused on sustainable development should consider supporting infrastructure projects like N79 and Lim-Siocon Road that incorporate environmental sustainability and social inclusiveness. These agencies can provide technical expertise, capacity-building resources, and funding to ensure that the project meets international standards for sustainability. Moreover, they can help in establishing frameworks for evaluating the environmental impact of such projects and ensuring that they contribute positively to the achievement of the Sustainable Development Goals (SDGs) (United

Nations, 2021).

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