# Sustainable Transportation Planning in Ecologically Sensitive Areas: Evaluating the Environmental Impacts of the Bangem–Nguti Road Project.

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## ABSTRACT

Transportation infrastructure development is a key driver of economic growth and social integration, particularly in remote and underdeveloped regions. However, in ecologically sensitive areas, such as the Kupe Muanenguba Division in Cameroon, infrastructure projects like the Bangem–Nguti road pose significant environmental and social challenges. This study provides a comprehensive evaluation of the environmental impacts associated with the Bangem–Nguti road project, integrating findings from Environmental and Social Impact Assessments (ESIAs), communal development plans, and comparative analyses of similar projects worldwide. The paper highlights the trade-offs between socio-economic benefits and ecological risks, discusses mitigation strategies, and offers recommendations for sustainable transportation planning in biodiversity-rich landscapes.

**Keywords:** Sustainable transportation, environmental impact assessment, road construction, biodiversity conservation, Cameroon

## INTRODUCTION

Road infrastructure is widely acknowledged as a fundamental catalyst for economic and social development, particularly in low and middle-income countries where rural isolation hinders access to essential services and markets (Foster & Briceño-Garmendia, 2010; World Bank, 2024). In Cameroon, the government has prioritized road construction as a strategy to stimulate economic growth, enhance market integration, and reduce poverty, recognizing that improved connectivity is crucial for unlocking the agricultural and commercial potential of rural regions (PNDP, 2012; World Bank, 2024). The Bangem–Nguti road project, currently under accelerated construction in the Kupe Muanenguba Division of the Southwest Region, exemplifies this national commitment. By linking the towns of Bangem and Nguti, the project aims to disenclave historically marginalized communities, facilitate cross-border trade with Nigeria, and promote regional development through improved access to markets, healthcare, education, and administrative services (Ultimate Media Cameroon, 2025).

However, the route of the Bangem–Nguti road traverses some of Cameroon's most ecologically sensitive landscapes, including dense tropical forests, the Bayang Mbo Wildlife Sanctuary, and the Bakossi Mountains. These areas are part of the Guineo-Congolian forest region, renowned for its exceptional biodiversity and high levels of endemism, supporting critical habitats for endangered species such as forest elephants, chimpanzees, and pangolins (PNDP, 2012; SGSOC, 2011). The region's forests not only harbor unique flora and fauna but also provide vital ecosystem services-such as carbon sequestration, water regulation, and non-timber forest products-that underpin local livelihoods and contribute to global environmental stability (FAO, 2015; Laurance et al., 2014).

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The construction and operation of the Bangem–Nguti road present complex challenges. Direct impacts include habitat loss and fragmentation, soil erosion, and changes to local hydrology, while indirect effects may involve increased human access leading to illegal logging, poaching, and agricultural expansion (Laurance et al., 2014; Wilkie et al., 2000). These risks are exacerbated by the area's rugged topography, high rainfall, and the dependence of local communities on natural resources for subsistence (PNDP, 2012; SGSOC, 2011). Experience from similar projects in Cameroon and other tropical regions underscores the importance of integrating environmental safeguards into infrastructure planning. For example, sustainable road design in tropical forests requires careful harvest planning, avoidance of sensitive habitats, and adoption of best practices to minimize ecological disturbance (FAO, 2015; Laurance et al., 2014).

This paper provides a comprehensive evaluation of the environmental and socio-economic impacts of the Bangem–Nguti road project. Drawing on primary project documents, Environmental and Social Impact Assessments (ESIAs), communal development plans, and comparative literature, the study situates the project within the broader context of sustainable transportation planning in tropical forest regions. By analyzing both the opportunities for regional development and the risks to biodiversity and ecosystem services, the paper aims to inform policy and practice to achieve a balance between infrastructure-driven growth and the imperative of conserving Cameroon's unique natural heritage.

## LITERATURE REVIEW

### Environmental Impacts of Road Construction in Tropical Forests

Road construction is widely recognized as a primary driver of landscape transformation in tropical forests, often initiating a cascade of environmental changes with both immediate and long-term consequences. The direct effects of road building include habitat clearance, fragmentation of continuous forest cover, alteration of hydrological regimes, and increased edge effects that degrade habitat quality by exposing forest interiors to sunlight, wind, and invasive species, thereby reducing biodiversity (Barlow et al., 2016; Laurance et al., 2014).

Recent research underscores that not only primary roads but also the proliferation of secondary and informal "ghost" roads dramatically accelerate deforestation and forest degradation. For example, secondary roads branching from main arteries have been shown to cause far more forest loss than the original roads themselves, with deforestation associated with secondary roads in the Congo Basin being over 30 times greater than that caused by primary roads. Similarly, in the Asia-Pacific region, the density of both mapped and unmapped roads is the strongest correlate of forest loss, often preceding and predicting patterns of deforestation (Hughes et al., 2024; Mongabay, 2025).

In addition to direct forest loss, roads fragment habitats, breaking large tracts into smaller, isolated patches. This fragmentation alters microclimates, increases vulnerability to fire and invasive species, and impedes the movement and genetic exchange of wildlife, which can lead to local extinctions. Even narrow, unpaved roads have been shown to significantly reduce or halt the movement of forest-dependent species, including birds, mammals, and amphibians (Gülçi, 2013; Sloan, 2012). The construction process itself can cause soil erosion, sedimentation of waterways, and disruption of natural drainage patterns, particularly in wet tropical environments (Mamoní Valley Preserve, 2023).

Moreover, roads act as conduits for human access, facilitating illegal logging, poaching, and agricultural expansion, which further amplify deforestation and biodiversity loss (Wilkie et al., 2000). The cumulative effect of these pressures can lead to rapid forest degradation and the loss of ecosystem services critical for local communities and global biodiversity. The environmental toll is often compounded by inadequate institutional capacity and resources for effective management and enforcement in many tropical nations (Laurance et al., 2014).

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### Socio-Economic Dimensions of Road Development

Despite the significant environmental risks, road infrastructure is often justified by its potential to generate substantial socio-economic benefits. Improved accessibility can enhance market integration, reduce transportation costs, and increase employment opportunities, which are particularly vital in rural and remote areas (Foster & Briceño-Garmendia, 2010). In Cameroon, poor road infrastructure has long been a major constraint to agricultural productivity and access to essential services such as health and education (PNDP, 2012).

However, the distribution of benefits from road development is not always equitable. Marginalized groups may be excluded from decision-making processes, and environmental degradation can disproportionately affect subsistence livelihoods, exacerbating social inequalities (Cernea, 1997). Furthermore, the influx of new settlers and commercial interests facilitated by roads can lead to land conflicts and undermine traditional land tenure systems. Therefore, integrating social considerations and participatory planning into transportation projects is essential to ensure that development is both inclusive and sustainable.

### Case Studies of Transportation Projects in Ecologically Sensitive Areas

The Chad-Cameroon Pipeline Project incorporated extensive Environmental and Social Impact Assessment (ESIA) procedures and introduced mitigation measures such as wildlife crossings and dust suppression. However, despite these efforts, challenges related to enforcement and cumulative impacts persisted, illustrating the limitations of technical solutions without robust institutional support (World Bank, 2002).

Similarly, the Kumba-Mamfe Road project in Cameroon facilitated economic growth and market integration but also increased pressure on adjacent protected areas. The project attempted to mitigate environmental impacts through erosion control and community engagement, yet the expansion of secondary roads and associated activities continued to threaten local ecosystems (AfDB, 2012).

The SGSOC Palm Oil Project in Nguti involved large-scale land clearing that resulted in permanent habitat loss and social conflicts, underscoring the importance of transparent impact assessments and participatory planning. This project demonstrated how infrastructure can catalyze land conversion and resource extraction, often with insufficient regard for environmental and social safeguards (Greenpeace Africa, 2018).

These case studies collectively highlight the need for comprehensive, participatory, and adaptive approaches to transportation planning in ecologically sensitive regions. Effective mitigation requires not only technical measures but also strong governance, community involvement, and continuous monitoring to address both direct and indirect impacts.

## STUDY AREA

Bangem and Nguti are two subdivisions located in the Kupe Muanenguba Division of Cameroon's Southwest Region, an area renowned for its rugged terrain, rich biodiversity, and significant conservation value.

Bangem serves as the capital of Kupe Muanenguba Division and is situated at approximately 5°04′60″N latitude and 9°45′60″E longitude (Bangem, 2025). Nestled halfway up Mount Manenguba and its famous twin lakes, Bangem enjoys a cool, rainy climate and is considered the heartland of the Bakossi tribe. The town is surrounded by lush rainforests and sits near the Bakossi National Park and the Bayang-Mbo Wildlife Sanctuary, both of which are home to a remarkable diversity of plant and animal species, including chimpanzees, mandrills, and forest elephants. The area is also notable for its unique geological features, such as the crater lakes of Mount Manenguba and Lake Bermin, which boasts one of the highest species diversities of fish relative to its size anywhere in the world. The elevation and proximity to Mount Kupe and the Bakossi Mountains contribute to the area's high rainfall and the presence of numerous streams and watersheds, making it a critical water catchment for the region (Bangem, 2025; ERuDeF, 2024).

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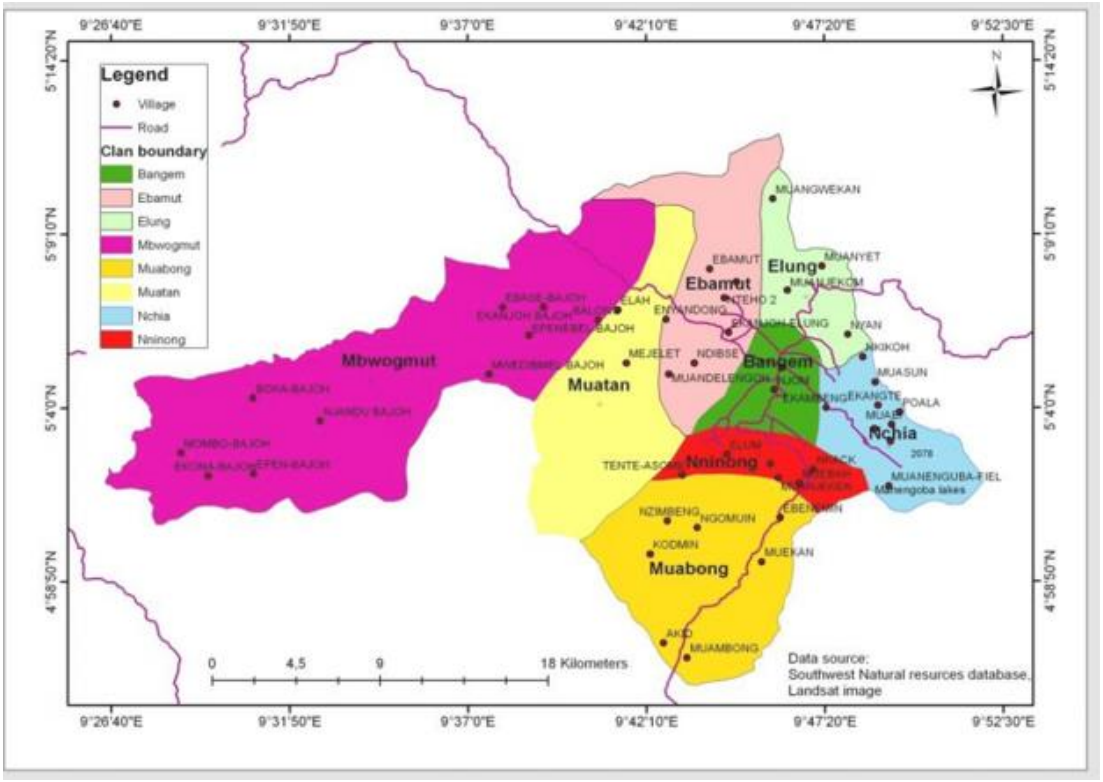


Figure 1: shows the location of Bangem

Nguti on the otherhand is located northeast of Bangem at approximately 5°19′48″N latitude and 9°25′07″E longitude (Nguti, 2025). It covers an area of about 1,851 km² and sits at an elevation of 1,289 meters above sea level. Nguti is a sub-divisional headquarters comprising 54 villages and is home to several principal ethnic groups, including the Mbo, Belong, Bassosi, and Bakossi. The commune extends over the northern part of Kupe Muanenguba Division and borders eight other Cameroonian communes, including Mamfé, Tinto, Fontem, Santchou, Melong, Bangem, and Konye. The landscape is characterized by dense forests, rolling hills, and proximity to protected areas, with a climate and ecological profile similar to that of Bangem. Nguti also once had an airstrip, reflecting its historical significance as a regional hub (Nguti, 2025).

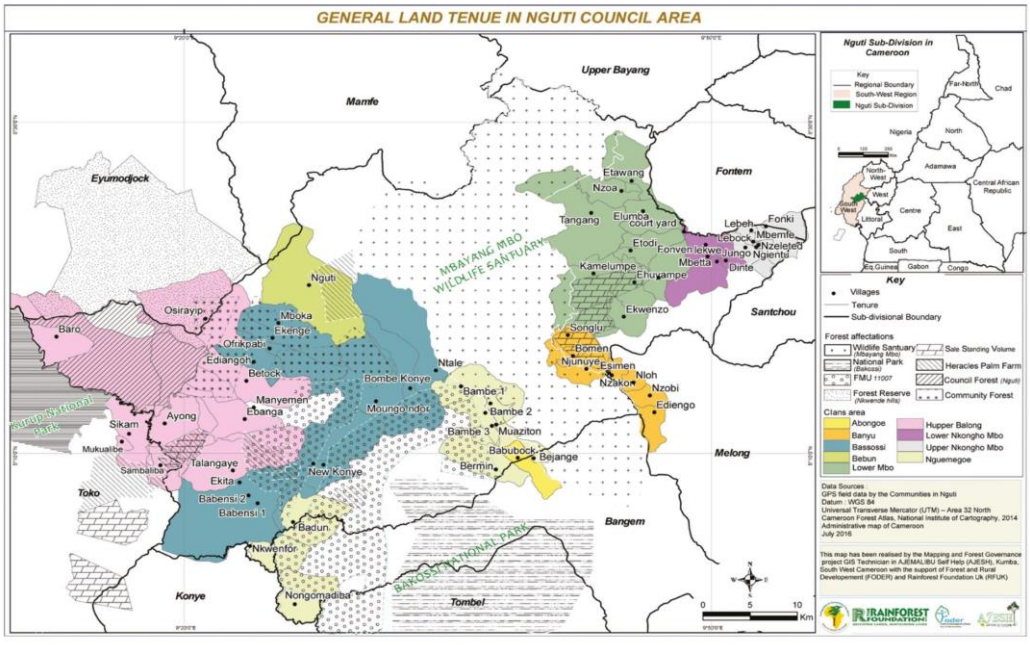


Figure 2: shows the location of Nguti

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The Bangem–Nguti road is a 53-kilometer stretch currently under construction in Cameroon's Kupe Muanenguba Division, intended to connect the towns of Bangem and Nguti. The project is being implemented by the Rapid Intervention Battalion (BIR), an elite engineering and security unit of the Cameroonian military, which has established a base near Bangem to facilitate the construction process (Eco Outlook News, 2025; Ultimate Media Cameroon, 2025). Construction activities began in late 2024, with significant progress reported in early 2025, including completed topographic and geotechnical studies and the deployment of heavy machinery along the route (Eco Outlook News, 2025).

The road is expected to transform the region by opening up isolated communities, improving the transport of agricultural products, and stimulating local trade and economic activities. The BIR's involvement ensures not only technical execution but also security and community engagement throughout the project (Ultimate Media Cameroon, 2025). Upon completion, the Bangem–Nguti road will provide a critical link for residents and businesses, enhancing access to markets, services, and the broader Southwest Region.

Figure 3: Construction Work

Figure 4: Equipments

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Figure 5: BIR transporting equipments to project site

## METHODOLOGY

This study employed a qualitative approach, synthesizing data from multiple sources:

### Document Analysis

The research reviewed Environmental and Social Impact Assessment (ESIA) reports, communal development plans, and project documentation related to the Bangem–Nguti road (SGSOC, 2011; PNDP, 2012).

### Comparative Literature Review

It also examined similar transportation projects in tropical forest regions globally to identify best practices and lessons learned.

### Stakeholder Perspectives

Analysed consultation outcomes documented in project reports and academic studies.

### Spatial Analysis

Interpreted maps and satellite imagery from project documents to assess spatial relationships between the road and ecologically sensitive areas.

## RESULTS

### Socio-Economic Benefits

The Bangem–Nguti road project is expected to significantly improve transport efficiency, reducing travel time and costs for local farmers and traders (Ultimate Media Cameroon, 2025). Enhanced access to markets is likely to increase agricultural productivity and household incomes. The construction phase has generated employment opportunities for local labor, contributing to poverty alleviation.

Improved road access also facilitates better delivery of health and education services, which are critical for human development. Furthermore, the road may promote eco-tourism by improving access to natural attractions within the Bakossi Mountains and Bayang Mbo Sanctuary.

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**Environmental Impacts**

**Habitat Loss and Fragmentation**

Road construction necessitates clearing vegetation along the corridor, leading to direct loss of forest cover. The linear nature of roads fragments habitats, creating edge habitats vulnerable to invasive species and microclimatic changes (Laurance et al., 2014). Fragmentation disrupts animal movement patterns, breeding, and foraging behavior, especially for wide-ranging species like elephants and primates.

**Increased Human Access and Resource Exploitation**

The new road facilitates easier access for hunters, loggers, and agricultural settlers, increasing pressure on forest resources. Illegal logging and poaching are major concerns, as documented in similar projects (Wilkie et al., 2000). The influx of people may also introduce invasive species and increase waste and pollution.

**Soil Erosion and Water Quality Degradation**

The region's high rainfall and steep slopes make it susceptible to erosion. Road construction disturbs soil and vegetation, increasing sediment runoff into rivers and streams, which can degrade water quality and aquatic habitats (SGSOC, 2011). Uncontrolled erosion may also undermine road stability, increasing maintenance costs.

**Air and Noise Pollution**

Heavy machinery and increased traffic generate dust and noise pollution, disturbing both wildlife and local communities. Noise can disrupt animal communication and breeding behaviors (AfDB, 2012).

**Cumulative and Long-Term Impacts**

The road project adds to existing pressures from agricultural expansion, plantations, and other infrastructure developments. Cumulative impacts may exceed the capacity of ecosystems to recover, leading to long-term degradation and loss of ecosystem services vital for local livelihoods and biodiversity conservation.

## DISCUSSION

**Balancing Development and Conservation**

The Bangem–Nguti road project encapsulates the classic dilemma of infrastructure development in biodiversity hotspots. While socio-economic benefits are tangible and urgently needed, the ecological costs could be severe if not properly managed. This necessitates a holistic approach that integrates environmental safeguards with community development.

**Mitigation Measures and Best Practices**

Drawing on the ESIA and lessons from comparable projects, key mitigation strategies include:

Minimizing Vegetation Clearance**:** Restricting the road footprint and restoring disturbed areas post-construction.

Wildlife Crossings: Designing underpasses or overpasses to maintain habitat connectivity.

Erosion Control: Implementing engineering solutions such as retaining walls, riprap, and rapid re-vegetation.

Community Engagement: Continuous sensitization and involvement in monitoring to reduce illegal activities.

Monitoring and Adaptive Management: Establishing long-term ecological and social monitoring programs to inform adaptive responses.

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### Challenges to Implementation

Despite well-designed mitigation plans, enforcement remains a major challenge due to limited institutional capacity and funding. Cumulative impacts from multiple projects complicate management, requiring coordinated regional planning and governance.

## CONCLUSION

The Bangem–Nguti road project is a critical development initiative with the potential to transform livelihoods in the Kupe Muanenguba Division. However, its location in an ecologically sensitive area demands stringent environmental management. Sustainable transportation planning must balance infrastructure benefits with conservation priorities through rigorous impact assessments, participatory approaches, effective mitigation, and long-term monitoring.

## RECOMMENDATION

Strengthen ESIA Enforcement: Ensure mitigation measures are implemented fully with independent oversight.

Enhance Stakeholder Participation: Engage local communities and indigenous groups throughout the project lifecycle.

Promote Sustainable Livelihoods: Develop alternatives to reduce dependence on forest exploitation.

Establish Regional Coordination: Integrate road planning with broader land use and conservation policies.

Secure Funding for Monitoring: Allocate resources for continuous environmental and social monitoring.

### Ethical Approval

This study did not involve direct research with human participants or animals. All data used were obtained from publicly available documents, secondary sources, and published literature. Therefore, ethical approval was not required.

### Conflict of Interest:

The authors declare that there are no conflicts of interest regarding the publication of this paper.

### Data Availability Statement

All data supporting the findings of this study are available within the article and its cited references. Additional information or materials can be provided by the corresponding author upon reasonable request. No new datasets were generated during the current study.

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