

Community Socio-Economic Model for Environmental Conservation in Post-Coal Mining Fragmented Forests

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Abstract

Coal mining causes significant environmental degradation and socio-economic impacts, necessitating a sustainable approach to post-mining conservation. This study develops a community-based socio-economic model for environmental conservation in fragmented post-mining forests using Structural Equation Modeling (SEM). The results show that perceptions of environmental conservation have a significant positive impact on socio-economic conditions (+0.740, $p = 0.000$), while expectations for area management and socio-economic challenges are not significant (-0.013, $p = 0.886$). The model explains 54.2% of the variation in socio-economic conditions, with external factors such as education and environmental experiences also playing a role. Aligning policies with local community interests is crucial for successful conservation. This study highlights the importance of a multisectoral approach integrating environmental and socio-economic policies to support sustainable community well-being.

Keywords: Post mining conservation; Socio-Economic Model; SEM

Introduction

Coal mining severely impacts forest ecosystems through environmental degradation and socio-economic consequences. Mountaintop mining and valley fill (MTM/VF) disrupt stream integrity, while mining-induced geophysical changes reduce biodiversity and often cause irreversible damage (Zhang, Wei, and Dong 2021). Ecosystem service values decline as vulnerability increases, with a 53% drop in sensitive macroinvertebrates. Although restoration efforts like the Forestry Reclamation Approach (FRA) aim to recover ecosystems, challenges persist (Belmer and Wright 2019). Additionally, mining waste pollutes soil and water, exacerbating land degradation despite economic benefits. Sustainable policies must balance energy needs with ecosystem conservation (Zipper, Skousen, and Welsch 2011). Coal mining also alters post-mining landscapes, affecting water quality, biodiversity, and hydrology. Waste rock weathering introduces selenium, while wastewater reduces macroinvertebrate populations. Mining disrupts water flow and groundwater levels, necessitating effective reclamation, such as integrating the DPSIR framework with ecosystem services (Rouhani, Skousen, and Tack 2023). Despite economic benefits, coal mining's environmental impact demands a sustainability-focused approach (Asmin et al. 2019). Immediate and long-term rehabilitation strategies incorporating ecological, hydrological, and socio-economic perspectives are essential. Socio-economic approaches are crucial for balancing conservation and community welfare. Community Economic Development (CED) supports local economies through micro-financing and sustainable resource management, while community-based ecotourism (CBE) fosters economic empowerment and conservation (Johnson, Cox, and Yang 2019). In Indonesia, an integrated empowerment program supports sustainable forest

management. Effective ecotourism requires active community participation, and recognizing communities as key conservation stakeholders strengthens ecological and economic outcomes (Amalia Rezeki et al. 2023). This study develops a socio-economic model for environmental conservation in post-coal mining fragmented forests by analyzing key socio-economic and ecological factors to achieve sustainability.

Research Method

This study employs a quantitative approach using Structural Equation Modeling (SEM) to develop a community-based socio-economic model for environmental conservation in post-coal mining fragmented forests (Maigret, Cox, and Yang 2019). The research targets 100 community members with direct experience in environmental and socio-economic challenges, using purposive sampling to ensure relevant participation. Data is collected through structured Likert-scale questionnaires (Sudarmadji and Hartati 2021) (1–5) measuring two latent variables: (1) Perceptions of Environmental Conservation, covering awareness, attitudes, and willingness to participate; and (2) Expectations for Area Management and Socio-Economic Challenges, addressing post-mining land use, alternative livelihoods, and institutional support. SEM is applied to analyze complex relationships between these variables, with loading factor analysis (≥ 0.5) assessing indicator contributions and path analysis examining direct and indirect effects. Correlation analysis determines relationship strength, while composite reliability ($\rho_c \geq 0.7$) ensures measurement validity. The results will guide policy recommendations for strengthening community-driven conservation in post-mining areas. The hypotheses in this study are: 1. Perceptions of Environmental Conservation has a positive influence on Community Socio-Economic 2. Expectations for Area Management and Socio-Economic Challenges has a positive influence on Community Socio-Economic This study was conducted in the villages of Barunang and Buhut Jaya, Central Kalimantan, Indonesia. The study site map is shown in Figure 1.

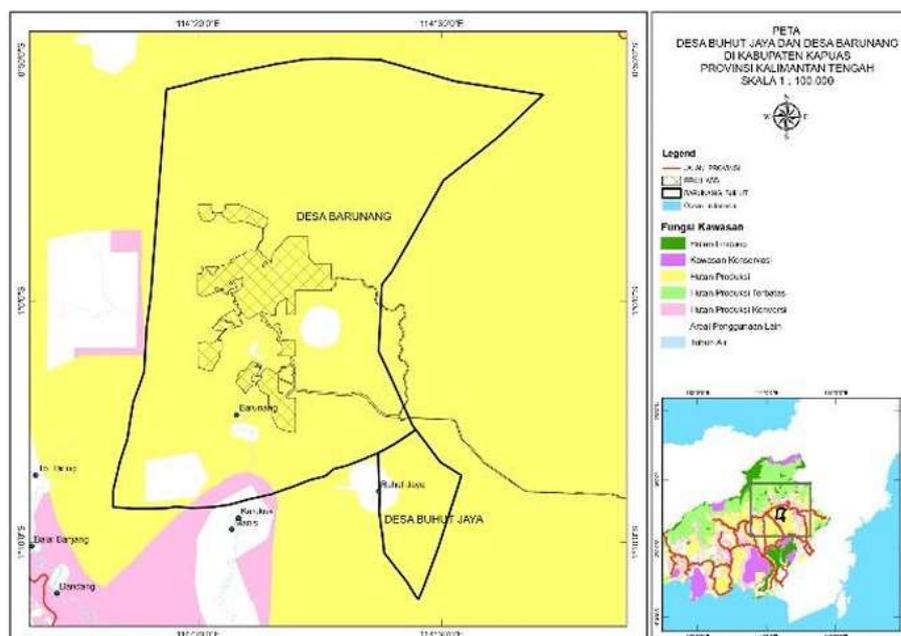


Figure 1. Map of Research Location

A description of the sample is as follows: In the village of Baronang and Buhut Jaya, both villages represent 50% of the sample. Gender distribution is 58% male and 42% female in both villages. The age groups for both villages include 10% under 20 years, 44% between 20-30 years, 25% between 31-40 years, 13% between 41-50 years, and 8% over 50 years. Marital status is split with 29% single, 63% married, and 8% widowed or widower. In terms of family size, 50% have 1-3 members, 39% have 4-6 members, and 11% have more than 6 members. Education levels show 3% have no schooling, 9% attended elementary school, 19% completed junior high school, 48% finished high school, and 21% went to college. Employment distribution includes 5% farmers, 42% miners, 20% civil servants, 18% self-employed, and 6% not working. Income is distributed as 9% earning less than 1 million, 26% earning between 1-3 million, 31% earning between 3-5 million, and 34% earning more than 5 million. Regarding additional income, 25% have extra income, while 75% do not. 82% of the sample lives around post-mining forest areas. The longevity of residence in the area shows 34% have lived there for less than 5 years, 39% for 5-10 years, and 27% for more than 10 years. Involvement in the mining sector is reported by 32%, while 68% have not worked in mining. Regarding environmental conservation or rehabilitation programs, 30% are involved, while 70% are not. 32% participate in local community groups, while 68% do not. Lastly, frequency of attendance at community meetings or activities shows that 38% never attend, 46% attend rarely (1-2 times a year), 14% attend sometimes (3-5 times a year), and 2% attend often (more than 5 times a year).

Results and Discussion

Perceptions of Environmental Conservation in Post-Coal Mining Fragmented Forest Areas

Perceptions of environmental conservation in post-coal mining forests depend on ecological impacts, socio-economic conditions, and reclamation effectiveness (da Silva Espinoza et al. 2022). Biodiversity loss and landscape homogenization create skepticism about reclamation, while pollution and degradation erode trust in mining companies (Gadekar et al. 2023). Though post-mining areas offer ecotourism potential, poor integration of environmental and economic needs hinders success. Community-centered assessments are essential to align reclamation with local values. Transparent engagement, ecological restoration, and economic sustainability are key to improving conservation perceptions (Munysi A., Jauhari, and Faisal 2024).

Expectations for Area Management and Socio- Economic Challenges in Post-Coal Mining Fragmented Forest Areas

Post-coal mining forests face environmental degradation, livelihood loss, and poor management. Land subsidence, pollution, and displacement disrupt communities (Halder, Bandyopadhyay, and Banik 2021). Science-based reforestation restores ecosystems and supports local economies (Mar et al. 2022). UAV monitoring and traditional ecological knowledge enhance revegetation (KHAN and JAVED 2022). Governance and policies must align with sustainability goals to ensure effective reclamation. An integrated approach is crucial for resilient post-mining communities (Adinugroho et al. 2019).

Community Socio-Economic Model for Environmental Conservation in Post-Coal Mining Fragmented Forests

The Community Socio-Economic Model for Environmental Conservation in Post-Coal Mining Fragmented Forests examines perceptions of environmental conservation and expectations for area management and socio-economic challenges through 17 questions. Table 1 summarizes the measurement model's validity and reliability.

Table.1 Summary of measurement models

Construct	Item	Loading Factor	Composite Reliability (Rho-C)
Community Socio-Economic	PKE 2	0,580	0,827
	PKE 3	0,590	
	KM1	0,684	
	KM2	0,512	
	KM3	0,687	
	ATPP1	0,614	
Perceptions Of Environmental Conservation	ATPP2	0,610	0,861
	ATPP3	0,612	
	PM1	0,660	
Expectations for Area Management and Socio-Economic Challenges	PM2	0,859	0,709
	PM3	0,728	
	PPSD1	0,794	
	PPSD3	0,664	
	HTPK2	0,596	
	HTPK3	0,749	
	TSE1	0,603	
	TSE 3	0,506	

The table summarizes measurement models validating "Community Socio-Economic," "Perceptions of Environmental Conservation," and "Expectations for Area Management and Socio- Economic Challenges," with all constructs meeting validity (loading factor >0.5) and reliability (Rho-C>0.7) standards, aligning with prior studies highlighting the importance of robust psychometric properties for accurate assessments (Dharmasyah 2023). Correlation between Perceptions of nvironmental Conservation and Expectations for Area Management and Socio-Economic Challenges on Community Socio-Economic listed in Table 2.

Table 2. Correlation between local wisdom on environmental education

Variable	Community Socio-Economic
Perceptions of Environmental Conservation	0,736
Expectations for Area Management and Socio-Economic Challenges	0,204

The SEM analysis indicates that perceptions of environmental conservation strongly correlate with socio-economic status (0.736), while expectations for area management and socio-economic challenges show a weaker correlation (0.204), underscoring the role of conservation perceptions in community well-being. The weak link between management expectations and conservation perceptions highlights the need for participatory approaches integrating local knowledge. Financial incentives, such as payments for environmental services, can align economic benefits with conservation goals, emphasizing inclusive strategies for strengthening community support and ecological resilience. The Community Socio-Economic Model for Environmental Conservation in Post-Coal Mining Fragmented Forests is shown in Figure 2.

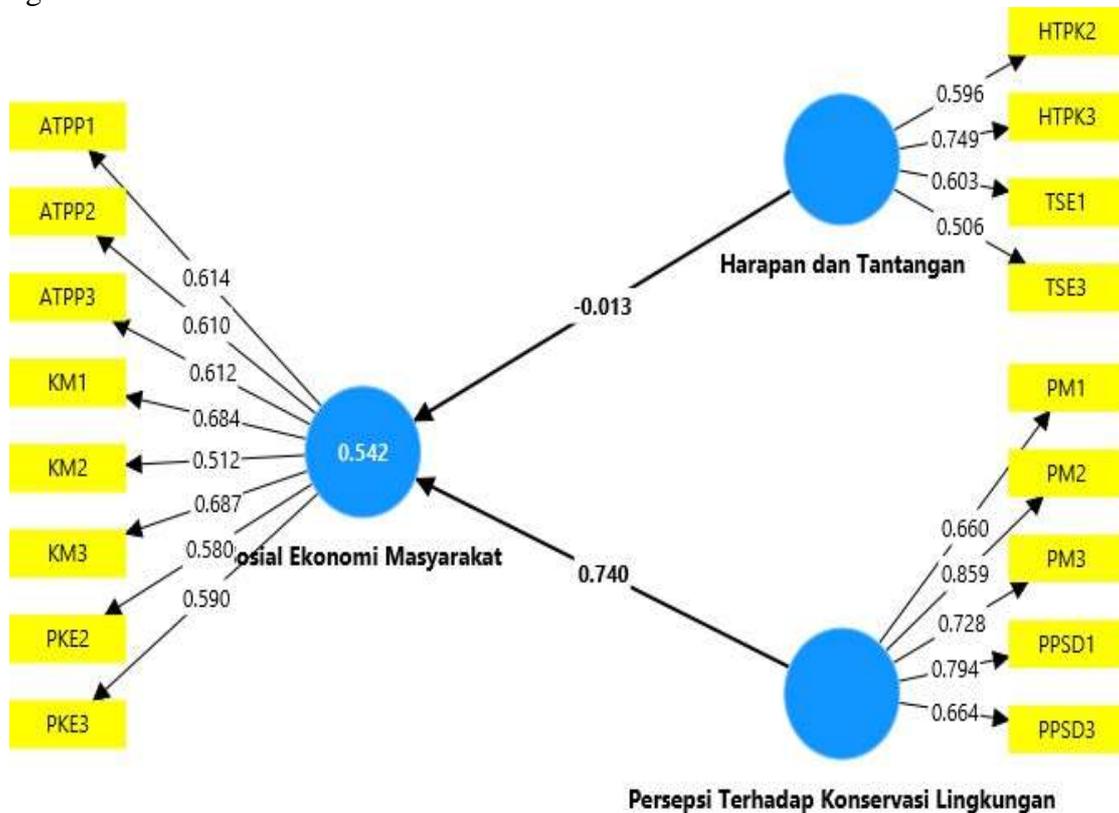


Figure 2. Community Socio-Economic Model for Environmental Conservation in Post-Coal Mining Fragmented Forests

The SEM analysis reveals that perceptions of environmental conservation significantly enhance socio-economic status (0.740), while community expectations and challenges have minimal impact (- 0.013), explaining 54.2% of the variation. External factors like education and environmental experiences also shape conservation perceptions. Misalignment between management expectations and community priorities may hinder conservation efforts, highlighting the need for inclusive strategies that integrate local interests with sustainability goals. Model summary listed in Table 3.

Table 3. Model Summary

Model Summary	P Values	Conclusion
Perceptions of environmental conservation -> Community Socio- Economic	0,000	Significant
Expectations for Area Management and Socio-Economic Challenges -> Community Socio- Economic	0,886	Not Significant

Perceptions of environmental conservation significantly enhance socio-economic conditions (+0.740, $p = 0.000$), while weak and insignificant governance expectations (-0.013, $p = 0.886$) indicate policy misalignment. Socioeconomic challenges, including limited education and poverty, further influence this relationship, emphasizing the need for a multisectoral approach integrating environmental and socio-economic policies for sustainable development.

Conclusion

This study finds that perceptions of environmental conservation significantly improve socio-economic conditions, highlighting the need for awareness-driven strategies and integrated policies for sustainable community welfare.

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