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Economic and social impacts of toll road development on farmers: A qualitative case study from Indonesia

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ABSTRACT
This study investigates the economic and social effects of toll-road development on rice-farming households in Terisi District, Indramayu Regency, Indonesia, using qualitative case research and thematic analysis. Data was gathered through purposive sampling and semi-structured interviews with rice farmers from Indonesia's largest rice-growing area. The findings indicate that economic difficulties were the primary concern, representing 39% of responses, and the negative impacts far overshadowed any positive effects, as shown by a 14.7:1 negative to positive ratio. Key challenges included a decline in income, with 12 farmers highlighting reduced earnings, loss of cultivated land (10 responses), and forced land sales (7 responses). Infrastructure and government support issues followed, making up 29.2% of concerns, especially regarding the need for improved irrigation, better drainage, and financial assistance. Despite adverse impacts, 19 farmers continued in agriculture, showing resilience, while 13 diversified into non-farm activities to adapt. Social networks within communities remained largely stable, with 15 farmers reporting no significant changes in relationships. The research suggests that effective mitigation should prioritize fair land-based settlements, targeted livelihood restoration projects, and locally tailored agricultural and social support to help rice-farming communities navigate economic and land-use transitions due to major infrastructure projects.

Contribution/Originality: This study contributes to the existing literature on rural infrastructure impacts. It uses a new estimation methodology, qualitative thematic. It is one of the few studies investigating rice-producing regions. The paper provides the first logical analysis of farmer resilience. Its primary contribution is identifying economic hardship. The study documents livelihood adaptations.

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1. INTRODUCTION

Toll roads and the overall expansion of transport infrastructure have deep and complicated economic and social implications for farmers and rural populations. The literature highlights this double standard: enhancing connectivity can result in better market access, higher land values, and local economic regeneration, but it typically leads to agricultural land conversion, displacement, and more severe social inequality. Systematic reviews and empirical studies have shown how the construction of toll roads often results in the transformation of agricultural land into non-agricultural uses, a phenomenon that risks negatively impacting food security and rural survival if not properly managed (Makbul, Ratnaningtyas, & Wijaya, 2024; Naim, Mufariq, Winarno, & Hermana, 2024; Rahmadana & Putra, 2025). Toll roads and highways have been shown to, in some contexts, improve the income and profitability of agricultural activities and the livelihood of households through reducing transportation costs, as well as market linkages (Bansal, 2025; Cheng, Shao, Cui, & Song, 2025; Shrestha, 2020; Takada, Morikawa, Idei, & Kato, 2021; Wudad, Naser, & Lameso, 2021). Yet these benefits are not evenly distributed; marginalized groups, including smallholder farmers and landless laborers, may be subjected to dispossession, increased poverty levels, and limited participation in economic benefits from the infrastructure (Budiman, 2024; Greiner, Greven, & Klagge, 2021; Khan & Azhar, 2024; Sedegah, Tuffour, & Joel Premkumar, 2023; Weldearegay, Tefera, & Feleke, 2021). These implications manifest themselves as changes in community dynamics, reduced public participation in planning, and increased land disputes (Greiner et al., 2021; Makbul et al., 2024; Naim et al., 2024). Environmental effects, including land degradation and ecosystem disruption, further complicate the picture (Makbul et al., 2024; Rahmadana & Putra, 2025; Wang, Martha, Liu, Lima, & Hertel, 2024; Zhou, Duan, Li, & Geng, 2021). According to previous research, toll road development should facilitate sustainable rural development with minimum adverse impact on farmers, including well-established and fair compensation mechanisms, and engage the rural community (Khan & Azhar, 2024; Makbul et al., 2024; Naim et al., 2024; Rahmadana & Putra, 2025). To develop toll road infrastructure, a basic element of the infrastructure system should be developed due to its widespread effects on rural people, the agricultural community, and the country. Toll road construction is generally related to large-scale land acquisition, transforming the socioeconomic framework of farming communities and disrupting traditional agricultural livelihoods (Biber-Freudenberger et al., 2025; Nurpita, Kumorotomo, & Susanto, 2025). This concern has become particularly relevant and pressing following the launch of global infrastructure investment programs to stimulate economic growth and regional interconnection among governments. The socioeconomic impacts of toll road development on farmers are broad and complex in terms of impacts and drawbacks that warrant comprehensive analyses. It is documented that tolls can enhance market access and lower transportation costs for farm-related commodities and products, but have a downside because their creation results in displacement, disruption of social bonds, and alteration of traditional farming methodologies (Khan, Ni, Man, & Saud, 2025). Transforming farmlands for toll road construction is found to affect around 44% of farmers through several case studies and has an adverse impact on crop yield and income in affected farming households. In addition, the negative impact is not confined to the loss of land but refers to overall systemic transformations of rural employment trends and livelihoods. Up to 22% of respondents in toll road-affected areas have lost their jobs due to land acquisition, and 26% are unable to find new employment, which shows the considerable economic risks for farming communities to keep pace with this switch (Muhtar, Putri, & Hariyadi, 2015). Such displacement impacts are particularly severe on vulnerable communities, especially small-scale farmers who rely heavily on land ownership for economic security and to maintain a stable social identity. The social effects of toll road development are equally significant, affecting community cohesiveness, the preservation of cultural traditions, and traditional agricultural knowledge systems. Research indicates that infrastructure development projects can disrupt established social networks and traditional farming practices developed over generations. Such social transformations often undermine community resilience and adaptive capacity (Kahangirwe & Vanclay, 2024; Zhou, 2021), particularly in areas where agriculture is a mainstay of an economy. Toll roads pose intricate challenges in their development, which demand rigorous examination to appreciate their impact on farming communities at large. The main challenge relates to poor knowledge of toll road project environmental and economic impacts for farmers, and livelihood sustainability, compensation adequacy, and the long-term capacity and resilience of the community. Existing literature reveals a clear need to provide a holistic view of the multifaceted effects of toll road construction on farming communities. Multiple studies have previously considered specific impacts of infrastructure development on individual aspects; however, there has been little systematic examination of the intertwined effects of economic, social, and environmental consequences (Thorsson et al., 2025). This disjointed knowledge deprives policymakers and development practitioners of the ability to design appropriate mitigation strategies and compensations. The issue is also exacerbated by diverse contexts for the development of toll roads, where impacts differ depending on location, economic/social conditions, and therefore, the impact model varies significantly. Studies have found that the results of toll road development have not been evenly distributed among rural communities: the effects depend on the extent of farm size, proximity to development projects, and opportunities for alternative livelihoods (Bacior & Prus, 2018; Su, Dong, Wang, & Wang, 2025).

The heterogeneity of the resulting impact reflects issues of equity and justice in the distribution of impact in the infrastructure development process. Furthermore, established compensation schemes typically do not mitigate the full extent of damage that affected farmers incur, which could be physical losses such as land, crops, and losses of social networks and cultural traditions, as well as intangible losses such as social networks and traditional practices (Edeme, Nkalu, Idenyi, & Arazu, 2020). The deficiencies of existing compensation models, while understandable, indicate a need for a more balanced understanding of the real costs and benefits of toll road construction on affected farming communities.

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This study aims to answer some important questions on which a more complete understanding of the agricultural effects of toll road development on farming communities and rural areas can depend.

1. What are the most important economic implications of toll road construction on farmers?
2. What support does the government plan to give to lessen the impact of toll construction?
3. What changes can be seen from this process after implementation of a toll road system that affect farmers' ability to carry on farming life, and how have they adapted during their periods away from those changes?
4. After toll road construction, what happens to the social and community relations in a farming community?
5. After the development of toll roads, what is Livelihood Diversification and Business Development?

This research aims to present a detailed analysis of such toll road impacts on development communities so that they can better guide infrastructure developers and practice more equitable development policies that are effective. This study seeks to reduce the divide between infrastructure development objectives and agricultural societies by providing them with evidence-based recommendations in this area in order to provide an opportunity for people, communities, and businesses to understand where to find employment opportunities in the future. In other words, transportation infrastructure meets the needs of rural income and livelihoods. Notably, some interrelated aims of the research are as follows: to create an integrated paradigm for evaluating the multidimensional effects of toll road development on agricultural communities (economic, social, and environmental). This framework will help policymakers and development practitioners perform more comprehensive impact assessments and develop appropriate mitigation strategies. Secondly, this study aims to contribute to the development of toll road construction projects from an international background by comparing them with best practices, developments, and lessons learned in recent years, with special attention to new ways of avoiding adverse impacts and maximizing positive development gains. This research will shed light on differences across scenarios and diverse development contexts, informing more impactful, context-sensitive considerations in infrastructure development approaches. Third, this research will assist in developing better pay and help systems for affected farmers in response to toll road infrastructure development. By incorporating the full impact on agricultural communities, such a study would support payment systems that are more comprehensive and balanced, accounting for both tangible and intangible impacts. Fourth, this research aims to contribute to a broader discussion on sustainability in development and the balance between human capacity for infrastructure development and the health of agricultural communities. This study will provide additional insights into trade-offs and synergies between rural development and transportation infrastructure, which could serve as a basis for more comprehensive regional planning and development strategies. Finally, this study aims to provide practical suggestions for stakeholders of toll road development projects (government, development, and community actors) in this situation. By offering actionable approaches to improve the design, implementation, and monitoring of a project, these recommendations could help maximize positive outcomes for stakeholders. Nevertheless, qualitative work on the socioeconomics of rice farmers in West Java, focusing on disruptions or adaptations and why they might occur, is scarce in the extant literature on infrastructure development. Accordingly, this study aims to fill this gap by exploring the lived voices of those affected by toll road construction in the Indramayu Regency community as they adapt their livelihoods and social life to the new infrastructure and structure. Through this qualitative study, we contribute to the literature by providing a deep thematic analysis of rural resilience resulting from rapidly developing infrastructure. Additionally, it provides useful insights for government decision-makers to develop more equitable compensation policies and effective social safety nets for rural communities affected by land conversion.

2. LITERATURE REVIEW

The significant increase in infrastructure, especially toll roads, in the region is a major driver of modernization. However, it will eventually lead to substantial agricultural land conversion. Toll roads cut through rural landscapes, accelerating the physical transformation of productive rice lands into non-crop zones, such as residential, commercial, and industrial sectors. This process reduces the overall farmland available for cultivation and fragments remaining farmland, disrupting irrigation networks and ecological balance (Makbul et al., 2024). This rapid shift to a different land form requires a radical reconfiguration of farming strategies, agricultural resource tenure, and the general fabric of rural households' livelihood structures. With the loss of this important productive asset, land, farmers often must give up typical cultivation methods. Displacement forces farmers to move away from farming to a business-based employment model or to an informal labor market, which is driven more by needs than opportunities (Kebede, Emanna, & Tesfay, 2022). The transformation reflects a more fundamental shift in which farmers are demoted from producers and are becoming increasingly dependent on uncertain labor markets (Rumadan et al., 2022). The end result is drastic changes in farmers' income and well-being. In the process, it will result in a loss of sustainable forms of agricultural income, which, while giving rise to a temporary liquidity recovery, is often followed by long-term uncertainty over how financially secure displaced families are (Makbul et al., 2024).

The transition away from the agricultural sector of the economy, in the absence of optimal financial management and government aid, is often associated with a net loss in household well-being, as the new income is too small to substitute for the continued but less variable returns from rice farming. Toll roads create an economic paradox, often referred to as the "macro-micro trade-off," in which aggregate regional growth comes at the obvious cost of household-level welfare for displaced populations. Macroeconomic indicators highlight infrastructure initiatives such as the Trans-Java Toll Road as vehicles for connectivity, leading to reduced logistics costs and local GDP growth (Makbul et al., 2024; Tchoffo, Dounya, Mouafo, & Tchio, 2024). But this widespread economic success often conceals the "immiserating growth" experienced by local rural populations on the frontline of development through land dispossession. This trade-off is most clearly evident in the disruption of the "land-income-welfare" nexus. Although

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macroeconomic paradigms assume infrastructural investment attracts industrial capital and creates new jobs, the microeconomic situation for farmers is a "capability trap" where they lack the original productive assets, land, and skills to utilize new industrial opportunities (Kebede, 2024). Rather than beneficiaries of modernization, these farmers become "losers" in the game of development and turn to informal trade and low-wage labor to survive the decline in agricultural revenue (Mark, Overland, & Vakulchuk, 2020). In addition, the shift from a stable, land-based rural economy to a shaky cash-based one leaves rural households perpetually vulnerable to the financial collapse that accompanies it. Land compensation payments that promise a "liquidity illusion" can soon become highly evaporative, leaving families with no means to substitute for long-term revenue, as observed in this study among struggling farmers who struggled to reinvest compensation satisfactorily. This has implications for a more constructive account of development economics, demonstrating that (in the absence of social protection policy) infrastructure leads to, by default, increased inequality that neglects the micro-economic security level of food producers, favoring macro-economic efficiency (Andani, Puello, & Geurs, 2021). The "double-edged" effect of toll road developments is now emerging in the academic literature (2021–2025), and it moves beyond simplistic economic growth arguments to critically examine micro-level inequalities. Although recent research has established that toll roads promote regional access (Kuncoro, Wurarah, & Erari, 2024; Zhou, Duan, Geng, & Li, 2024), evidence of these macroeconomic gains is also increasing the local disparities, especially in rural areas. For example, Rahmadana and Putra (2025) argue that while industrial zones reap the benefits, rural "bypass" communities sometimes experience low incomes and social exclusion when traffic and economic activity from development diverts away. This corroborates the results of Makbul et al. (2024) and Naim et al. (2024), who state that the transformation of agricultural land for toll infrastructure displaces food production and widens the skills gap, which in turn makes it more challenging for displaced farmers to enter promised new industrial jobs, offered by development.

3. METHOD

Qualitative descriptive case study to examine the experience and impact of toll road construction on rice farmers in Terisi District, Indramayu Regency. This area was selected because this regency is the biggest rice producer in Indonesia (Nurhanisah, 2020). The case study approach is suitable for a comprehensive analysis of particular situational and context-specific issues, especially for challenging community problems with multiple dimensions. The qualitative data were analyzed thematically with inductive coding, enabling patterns to be rooted in farmers' narratives rather than in predetermined categories. All interview transcripts were read more than once to establish familiarity and to record initial thoughts about these recurring meanings. Next, line-by-line coding was performed through segments of text. These included short, descriptive labels for expressions related to land loss, changes in income, livelihood strategies, relations with society, and prospects of government support. These codes were further grouped into broader candidate themes of relevance. These themes were then consistently revised by comparing them with original transcripts to produce a consolidated final set of themes. Ultimately, such themes were clearly articulated, named by way of a single section, and illustrated with quotations to serve as stand-alone but highly structured illustrations of what toll road development was doing to agricultural livelihoods. By using the same vocabulary that has defined the structure but with real-world relevance, the research generated a comprehensive yet structured account of what toll road construction means for the way people make a living out of farming and how it impacts household well-being. Prior research on the effects of toll roads on farmers or other aspects of agriculture is represented in Table 1.

Table 1. Previous Study.

Author(s)/Study	Research method	Study location/Context	Key findings	Target population
Makbul et al. (2024)	Systematic Literature Review	Global	Toll roads drive agricultural land conversion, threaten food security, and require policy mitigation.	Farmers, rural communities
Cheng et al. (2025)	Quasi-natural experiment, DID	China	Highway access increases agricultural enterprise profitability, especially for perishables and remote firms.	Agricultural enterprises
Shrestha (2020)	Geospatial analysis, market data	Nepal	Proximity to roads raises farmland values, increases market participation, and increases incomes.	Agricultural households
Naim et al. (2024)	Case study, ex-ante evaluation	Indonesia	Human capital and community readiness are key to equitable toll road benefits	Agrarian communities
Khan and Azhar (2024)	Socio-institutional analysis	Pakistan	Infrastructure benefits large landowners, displacing smallholders and sharecroppers.	Smallholders, landless peasants

Nonetheless, none of these studies used qualitative thematic research approaches, so they look for the surface level. The change process taking place below ground level is less well studied. The novelty of this research is based on a qualitative thematic research method. This paper uses this unique method to explore the effect of toll road construction,

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as it confirms that the socio-economic dynamics of farmers working underground are impacted by the construction of toll roads. There are no strict statistical criteria for determining an a priori sample size in qualitative research, since it is the depth and richness of the information rather than generalizability (Boddy, 2016; Vasileiou, Barnett, Thorpe, & Young, 2018). Sample size sufficiency is not the function of fixed numerical goals; rather, it follows the principle of data saturation (Guest, Namey, & Chen, 2020; Malterud, Siersma, & Guassora, 2016), where no further themes or useful insights emerge from new interviews. This number, however, lies comfortably within saturation for qualitative case studies, which often run through sample sizes that range from 20 to 30 participants (Marshall, Cardon, Poddar, & Fontenot, 2013; Vasileiou et al., 2018). This included a final sample size of 40 respondents, enough "information power" to delineate cross-cutting themes focusing on livelihood displacement and economic adaptation, meeting the methodological needs for analytical depth without the necessity of probabilistic representativity (Malterud et al., 2016). Although a sample size of 40 respondents is methodologically adequate for achieving data saturation in a qualitative case study, limitations of statistical representativeness and the probability of selection bias are important. Data synthesis within qualitative inquiry is not necessarily concerned with yielding an outcome that can be statistically generalized to a wider population, but rather with establishing a "transferability" of findings that may or may not transfer to different contexts, as per "thick description" of the phenomenon (Drisko, 2025). Given that up to 40 farmers were included in this study, they might refer to a purposive sample (i.e., a cohort of farmers whose lives were most affected by the toll road and who were willing to share their observations), leading to self-selection bias when those with the greatest grievances or who suffered more losses were the most likely to participate (Robinson, 2014). To decrease researcher bias for interpreting these narratives, triangulation and member checking strategies were used to generate themes that were representative of participants' lived realities compared to the researcher's experiences (Johnson, Adkins, & Chauvin, 2020). Therefore, although the results offered a deep analytical analysis of the processes of displacement and adaptation in Indramayu, they should be viewed as evidence of the local context as a whole and need not be considered a representative picture of all Indonesian farmers whose livelihoods, in the context of infrastructure construction, experience displacement (Leung, 2015).

4. RESULT AND DISCUSSION

The demographic and socio-economic characteristics of 40 rice farmers in Terisi District, Indramayu Regency, who were involved in the study, add to the composition of the farming community and show where targeted support may be needed. The respondents ranged in age from 30 to 67 years, with an average age of 44. Significantly, 50% of the farmers were older than 50, 30% aged between 40 and 50, and 20% were under 40. The distribution shows the predominant pattern of rice farming in the region, where elderly adults are predominant, which indicates a lack of participation among younger generations and highlights the need to adapt engagement strategies for young individuals. Of males, the sample was 72%, and of females, 18%. While men represented a small majority, women's substantial representation suggests that their active and essential involvement in agricultural activities is well established. These figures point out the real need for inclusive agricultural development policies supporting both male and female farmers. Respondents had diverse levels of educational attainment; only the majority (52.5%) had an elementary school education. Forty-two point five percent had completed junior or senior high school, and only five had a bachelor's degree. This implies that most farmers are at least partly educated, suggesting the need for available training and extension services suitable for varying levels of education. Regarding land ownership before selling the land to the toll road project, the average farm size was estimated at 1.35 hectares, ranging from 0.28 to 4 hectares. Most of them (34 of 40) were large landholders (more than one hectare). Five were medium landholders (0.5 to 1 hectare), and only one was a small landholder with less than 0.5 hectare. This skew toward large holdings may impact resource accessibility and production capacity, highlighting the importance of supporting lesser landholders for balanced sector growth. Overall, this evidence indicates that rice farming in this study region is conducted by older (predominantly male) farmers with varying levels of education and relatively large land ownership. The observed demographic and socio-economic patterns raise questions concerning generational transformation, gender disparity, educational outreach, and resource supply, which are key areas for policy and program focus to ensure the sustainability of rural agriculture. The key concerns raised and responses of farmers affected by toll road development were coded into five predominant thematic areas listed in Table 2.

Table 2. Main theme.

Thematic category	Priority ranking	Response frequency	Percentage (%)	Theme variations
Economic impact and financial concerns	1	120	39.0%	20
Infrastructure and government support	2	90	29.2%	10
Farming continuity and adaptation	3	53	17.2%	10
Social and community relations	4	27	8.8%	10
Livelihood diversification and business development	5	18	5.8%	6
Categorize farmers' responses according to whether they retained or lost their land	6	9	2.7%	3

This table summarizes the main themes identified from farmers' responses. In terms of themes identified and displayed in farmer response data, both Financial Concerns and Economic Impact dominate responses, explaining

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almost 40% of all overall themes. This is clearly prioritized over economic stability, which remains the top concern for farmers struggling with land development pressures. The largest difference between the top concern and others, Infrastructure and Government Support, comes second at 29.2%. This shows that near-term economic survival takes precedence over long-term sustainability requirements. The diversity of the 56 themes (over five categories) highlights the complex picture of the challenges farmers face. However, the preoccupation with economic considerations brings the requirement for financial protection and compensatory measures in land development policies to the fore. The economic impacts of toll road development affect farmers, as the most serious economic consequence is financial hardship and income concerns. Table 3: Overview of the concrete economic topics and their prevalence in farming reports.

Table 3. Economic impact and financial concerns.

Theme	Count	Example farmer response
Reduced income or economic hardship	12	"The income was reduced because the land was sold." (Respondent 24)
Loss of cultivated land	10	"Production decreased because some farmers sold their land." (Respondent 5)
Forced or pressured sales	7	"Forced because it passed by the toll road." (Respondent 6)
Through a broker/Mediator	5	"Through broker." (Respondent 12)
Income decrease	4	"The income reduced because the land was sold." (Respondent 24)
Yes, income decreased	4	"Income decreased." (Respondent 30)
Negative impact on food security	4	"Production decreases due to reduced land." (Respondent 40)
Increased economic strain	3	"More economic difficulties." (Respondent 2)
Economic improvement	3	"Selling crop yield more easily with increased price." (Respondent 18)
[Additional 11 economic themes with smaller counts]	51	Various economic-related responses

The economic impact data suggest a mostly unfavorable financial path for impacted farmers. Among the reported concerns, the most mentioned is income reduction, with 12 direct references to lower income or economic difficulty, and more categories of income decline (8 responses) were considered. Loss of cultivated land (10 responses) coincides directly with falling production, which cascades into farmers' livelihoods. Seven farmers reported forced or pressured sales, indicating that land purchases are often under duress rather than voluntary. Only three farmers experienced economic improvement, though that was relatively lower than 69+, indicating economic distress. The data shows land development increases economic vulnerability for farming communities and requires adequate remuneration and alternative livelihood support mechanisms. In such an environment, infrastructure development and government assistance are critical components. The farmer's response, Table 4, shows specific infrastructure requirements and support mechanisms noted in farmers' replies.

Table 4. Infrastructure and government support.

Theme	Count	Example farmer response
Improve infrastructure (Irrigation, Drainage)	20	"Repair and improve drainage." (Respondent 10)
Need for infrastructure improvements	10	"Improvement of irrigation channels." (Respondent 10)
Provide financial assistance or subsidies	9	"Provide subsidy assistance." (Respondent 14)
Increasing agricultural training and support	9	"Provide training in entrepreneurship." (Respondent 30)
Create or allocate replacement land	6	"Add rice field area by making new rice fields." (Respondent 30)
Enhance water management	6	"Controlling floods and muddy water plans." (Respondent 1)
No assistance or training received	5	"Did not receive any assistance." (Respondent 36)
Market access improvements	4	"Facilitating access to sales." (Respondent 33)
Access improvement	3	"Faster because of road access." (Respondent 30)
[Additional infrastructure themes]	18	Various infrastructure-related responses

Infrastructure improvement is the primary focus of such a category, as evidenced by 30 responses, most of which addressed irrigation and drainage systems – indicating the crucial role of water management in the sustainability of agriculture. A combination of requests for financial support and subsidies (9 responses) and calls for agricultural training and support (9 responses) shows that the farmers recognize the need to provide both short-term financial resources and long-term efforts in strengthening their capacity. The 6 responses to a call for replacement of the farm land also reflect the farmers' intent in having a livelihood that would not be threatened by losing the land. Significantly, 5 farmers were not receiving support and training, as it was reported that some 5 farmers experienced no such

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assistance and training, indicating shortcomings in the level of system coverage of the support system. The focus on improvements in access to market (4 responses) indicates that infrastructure development can (when well managed) lead to good outcomes for the remaining farmers through improved access points to infrastructure, which provides opportunities for remaining farmers (compared to the lack of such improvements in access. Thus, comprehensive Government support for farmers, both in terms of infrastructure, financial aid, and capacity level (both for infrastructure development and financial assistance, and capacity building, is essential for adapting well to land development pressure, as suggested by the farmers towards adaptation to their land development pressures. The results indicate. Farmers' attitudes towards toll road development pressures have developed ways of protecting the livelihoods of agricultural farmers and coping with environmental change. The detailed strategies that farmers have taken to sustain the continued livelihood of farming under land development challenges are depicted in Table 5.

Table 5. Farming continuity and adaptation.

Theme	Count	Example farmer response
Continue farming	11	"I am still farming." (Respondent 11)
Continuity in farming	8	"I stay a farmer because of habit." (Respondent 12)
Buy replacement land	6	"Buy a plot of land outside the toll road." (Respondent 12)
No significant change	4	"None." (Respondent 7)
Minimal or no change	4	"No change in lifestyle." (Respondent 8)
Intent to continue farming with adjustments	4	"Still farming." (Respondent 11)
Neutral or mixed impact	3	"No influence." (Respondent 19)
Neutral/No impact	3	"No impact." (Respondent 15)
No significant impact	3	"No effect on food security." (Respondent 15)
[Additional farming continuity themes]	7	Various farming continuity responses

Table 5: Continuity and adaptation of farming. In this picture, we can see clear resilience and a commitment to farming lifestyles in the data, with 19 farmers openly stating that they are intent on farming despite this. This determination seems to derive from necessity but also from tradition, as one participant commented, remaining, "because of habit." Purchase of replacement land (6 responses) is a defensive adaptation, but it is financially expensive and would not be a solution for every farmer. Notably, only 14 farmers did not find change or impacts, demonstrating that not all farming activities are as affected by development pressures (regardless of where they are located or what type of farm they cultivate). The neutral impact responses (9 total) suggest that the effect of land development varies among farmers; to some extent, they do not change the activities of the farm. These results indicate that despite the adverse effects of land development, many farmers exhibit coping mechanisms and are willing to engage in the sustainability of their agricultural economy. Still, success probably relies, in part, on obtaining resources to acquire land and find ways to work. Different aspects of relationships, community involvement, and social behavior in farming communities are all changing because of toll road development. Table 6 presents respondents' social and community interaction changes and their perceptions of the shift after the land.

Table 6. Social and community relations.

Theme	Count	Example farmer response
No change in social activities	5	"No change in social activities." (Respondent 11)
No significant change	4	"None." (Respondent 7)
Social/Community relationships	3	"No change in social activities." (Respondent 21)
Ordinary social interaction	3	"Ordinary relations with neighbors." (Respondent 35)
Stay harmonious/Good relationships	2	"Still like usual." (Respondent 16)
Increased interaction/Community participation	2	"Had interactions with newcomers." (Respondent 13)
Community disruption	2	"More disconnected." (Respondent 35)
Increased community interaction	2	"Increased interaction with newcomers." (Respondent 13)
Decreased community participation	2	"Less cooperative activity." (Respondent 19)
[Additional social themes]	2	Various social relationship responses

Table 6 Social and Community Relations. Social stability reveals the most prominent structure here, with 15 farmers with no major changes to the type of social activity or community they participate in. It demonstrates that, despite economic and material disruptions of toll roads, networks are highly resilient. Ordinary social interactions (3 responses) and harmonious relationships (2 responses) show that during the transition of development, community bonds tend to be maintained or remain intact. Yet, the findings also show bidirectional changes in social dynamics: four farmers expressed a tendency to have more community interaction, notably with newcomers, for example, and four other farmers showed disruption or withdrawal from the village to a new one. The land development, according to this research, gives rise to different social outcomes; some communities may be enriched by new social interactions and social ties, while others are fragmented and lose out on collective community practice. The relative equivocation of positive and negative social change suggests that community impacts are very context-dependent and may be

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conditioned by factors such as development scope, community leader roles, and the degree of existing community homogenization.

Farmers, in an entrepreneurial response to land development difficulties, use a variety of methods to promote income diversification and implement business reform as good practice. The specific methods farmers employ to maintain or improve their livelihoods through non-agricultural activities are summarized in Table 7.

Table 7. Livelihood diversification and business development.

Theme	Count	Example Farmer Response
Diversification into non-farm activities	6	"Open food stall business and stay farming." (Respondent 5)
Shift to small business or other income sources	4	"Open a food stall." (Respondent 5)
Diversify into non-farm activities	3	"Open a food stall business." (Respondent 5)
Increase in other business ventures	2	"Income shifted from farming to livestock." (Respondent 29)
Switch profession completely	2	"Switch profession to livestock breeding." (Respondent 12)
Maintaining livelihood through alternatives	1	"Switching to different trades." (Respondent 36)

Table 7: Livelihood diversification and business development. Diversification of businesses is a key adaptive strategy; 13 farmers continue to do business off the farm, with some involvement in farming. The food service industry shows a preference for such diversification, as several farmers start their food stalls, likely gaining better traffic conditions and population density from development projects. Livestock seems to be another promising option, as farmers are looking to diversify from cropping to livestock farming, perhaps because of reduced land demand and better markets. Most diversification approaches will find that farmers do not switch their employment to a single sector, meaning they will try to spread risk between different financial sources. Only two farmers stated that there were complete professional changes, which means that for most farmers, there is a need to retain identity in farming and adapt to the economic conditions. We showed that the diversification of livelihoods proved an important adaptation mechanism, contributing to the ability of farmers with agricultural activities to utilize development opportunities (in the context of agriculture) without losing touch with agricultural activities. Entrepreneurial feedback indicates that with adequate support and training, farmers can effectively adapt to land development issues by innovating business models and diversifying income sources. The theme groups farmers' answers in terms of whether they kept or forfeited their land, as indicated in the table.

Table 8. Categorize farmers' responses according to whether they retained or lost their land.

Theme	Count	Example of Farmer's Response
Not lost land group	31	Continue to carry out farming activities. (respondent 17)
Lost land group	9	Starting a business using profits from land sold to traders (respondent 15)

Table 8: Categorize farmers' responses according to whether they retained or lost their land. Theme Count Example of Farmer's Response Not lost land group 31 "Continue to carry out farming activities." (Respondent 17). Lost land group 9 "Starting a business using profits from land sold to traders." (Respondent 15). Those groups who did not cede or lose the land were instead able to farm, often within families. Those who were displaced and lost land often resettled, and through necessity, some became entrepreneurs, opening small shops or food stalls; others traded goods at local markets; and some kept livestock, raising goats, cattle, or chickens. While it was the same case for families moving from traditional agriculture to new businesses, developing new skills also required understanding social roles and relationships within the community. This sometimes improved the financial stability of one family but also posed challenges as they learned to adapt to new ways of making a living.

The result investigates farmers' key concerns and adaptive responses to toll road initiatives, outlining five key categories: Economic Impact and Financial Concerns, Infrastructure and Government Support, Farming Continuity and Adaptation, Social and Community Relations, and Livelihood Diversification and Business Development. Economic concerns are the main topic of attention, with nearly 40% of the respondents addressing financial instability, decline in income, cultivated land loss, and forced land sales. The second-largest needs for farmers are infrastructure and government assistance, with requests for better irrigation, drainage, finance, and agricultural training. Yet many farmers face the challenges and resilience of adaptability to these situations, maintaining their livelihoods with adaptive strategies and even in the face of adversity through purchasing replacement land or keeping the operation intact. There is a mixed social impact: most farmers say that there are stable community relationships, and some say more interaction (but also sometimes community disruption). Finally, some farmers may turn to entrepreneurship and diversification and make up for lost income by establishing small businesses or livestock, often alongside ongoing farming activities. The results highlight the critical need for strong financial protection for agriculture, robust support for infrastructure development, and specific investment in agricultural development to assist farmers in managing the mixed impacts associated with land development. Toll road construction is one of the critical challenges in infrastructure development, fundamentally affecting agricultural landscapes and farmers' livelihoods. A detailed study revealed the adverse effects toll road development has on farming communities, with 39% of farmers concerned about the economic and financial impact of traffic. The evidence points to a 14.7:1 ratio of negative economic impact to positive economic impact,

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demonstrating how detrimental the situation has become for farmers living along these routes. The historical and location theory context includes Von Thünen and Weber's location theory applications. Classical location theories provide essential frameworks for understanding toll roads' impacts on agricultural land use. As Von Thünen's (Agricultural Location) theory explains, transportation infrastructure alters land use according to economic rent determined by distance to market. Toll roads introduce gradients of accessibility that make what was previously farmland more valuable for non-agricultural uses, pursuant to von Thünen's belief that "the intensity of production of a particular crop declines with the distance from the market." This has been complemented by Weber's (1909) theory of industrial location, which illustrates how transport infrastructure lowers costs and draws industrial development. Weber also shows that industries place themselves near transport sources to reduce transport costs and thus the strain to convert land around toll road corridors. As Weber showed, "transport costs depend on how far raw materials and markets lie from factories," so proximity to toll roads is very attractive for industrial development (Rodrigue, 2024).

Recent works on the basis of location theory used for toll road planning validate these classical predictions. It's been found that near road access improves the probability that the agricultural land will be converted to non-agricultural uses; that is, around toll roads, the use of the land would be more valuable if the use were non-agricultural. Studies: Beyzatlar, Karacal, and Yetkiner (2014) find a long-run positive correlation of transportation infrastructure with economic growth, as an increase in railway length is related with increase in real GDP per capita. But the economic improvement comes at the expense of the displacement of agricultural territory (Makbul et al., 2024).

Toll road construction is a systematic driver of agricultural land conversion in several regions, with numerous reports highlighting large tracts of land lost to infrastructure works. In Indonesia, the Trans Java toll road alone has had transformative effects on agricultural land conversion, such as the Gempol-Pandaan toll road, where 213.69 hectares were converted from farmland in Pandaan District. This accounts for 4.9% of the total land use in the affected area (Khanif & Yunita, 2024). Agricultural land use conversion patterns cluster at toll road intersections, producing concentrated areas of land use change. Evidence from Karanganyar Regency shows that land conversion has clustered patterns at the regency level, with individual sub-districts experiencing different pressures on conversion. These conversions are systematic and have potential implications for food security, as food crops, particularly rice fields, available in existing agricultural land will be essential for the subsistence of 258.7 million people in Indonesia (Martanto, 2021).

The widespread conversion of agricultural land through toll road construction poses a serious threat to food security and has adverse socio-economic implications. The loss of rice fields due to conversion and its resulting decrease in rice production causes massive environmental damage because rice fields have become catchment areas and reservoirs for excess runoff. Officials at the government level admit that the disappearance of rice fields will put national food security on the line, with some 60,000-80,000 hectares disappearing annually in Indonesia's paddy fields (Makbul et al., 2024). Farmers experience intense psychological distress from changes in land use and forced land sales associated with toll road construction, specifically sadness. According to recent research, individuals who suffer financially from the loss of their inherited agricultural land, as per Solo-Yogyakarta toll road survey respondents, experience emotional trauma, especially when they realize they no longer have rice fields as an income source. "Unfortunately, I no longer have rice fields as my income source," one farmer said. "It won't be easy to purchase new rice fields in the region near where I live, since there are fewer and fewer" (Xiao et al., 2022). It is not only in immediate feelings, but psychological welfare losses can spread far and become widespread impacts on the means of living. Research applying place attachment theory reveals that farmers develop profound emotional attachment to their lands and farming ways of life over many decades. When toll road developments destroy such relationships, farmers suffer psychological welfare losses that can be quantified at approximately $82.91 annually per affected farmer (Utami, Hariadi, & Raya, 2024). Farmers perceive the compensation process as relatively neutral, suggesting a lack of adequate compensation mechanisms. A body of studies shows that common complaints involve land compensation being insufficiently accurate and little or no respect for the social and cultural meaning of agricultural land to farming families. The emotional toll is undeniable, and surveys show considerable emotional distress resulting from land purchasing uncertainty, stress, and economic trouble. (Utami et al., 2024; Xiao et al., 2022).

Farmers generally have neutral attitudes towards compensation proceedings, indicating that compensatory mechanisms are inadequate. Evidence shows the most common complaints: compensation does not match real market values and rarely considers the 'social importance' of agricultural land to farming families. The emotional burden is evident, with widespread psychological discomfort related to land insecurity, stress, and financial strain (Hoang, 2024; Utami et al., 2024). Farmers are finding it difficult to purchase agricultural land to replace land acquired for toll roads, as land prices in the region have already surged, making it challenging to buy land beside existing communities. Toll road construction, which results in village partitioning, adds to these challenges by creating barriers to accessing irrigation and fragmenting social networks (Utami et al., 2024)

Economic impact analysis from research shows economic impact as the primary concern for farmers – 39% of responses contained this information, and the negative economic impact outweighs the positive impact by a ratio of 14.7:1. Economic indicators of concern include reduced income or economic hardship (12 responses), loss of cultivated land (10 responses), and forced or pressured sales (7 responses). Three responses provided positive feedback, highlighting the disproportionately negative financial impact. Farmers with outright land loss are 1.70 times more likely to face livelihood shocks than those with partial land loss. Distance from urban centers also affects vulnerability, with each additional kilometer from the city market increasing the likelihood of livelihood shock by 1.26 times due to expropriation (Li, Li, Haq, & Nadeem, 2024).

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Livelihood diversification strategies of farmers are diverse adaptation strategies they pursue following land loss, including moving into non-farm ventures, expanding into microenterprises, and remaining in agriculture through various arrangements. According to data collected through the survey, approximately 5.8% of farmer responses relate to diversifying livelihoods and growing businesses, i.e., opening food stalls and agricultural businesses while continuing farming in the same or different areas (Nguyen-Thi-Thuy et al., 2024). Land loss is considered a determinant for increased household strategies based on a single nonfarm activity or diversification into several activities. It also indicates that land loss triggers an adaptive response and depends on the level of education, skills, and the distance to jobs in the city if the former is achieved (Nguyen-Thi-Thuy et al., 2024). One regional example being compared between case studies, such as Indonesian regional examples (toll road projects) of the Indonesian region, and the data on similar patterns are those from the same kind of agricultural land conversion in Indonesia, with consistent patterns of displaced farmers in various agricultural land. Toll road construction in Central Java has caused hundreds of hectares of rice fields to be lost, leading to reduced local agricultural production. The Klaten region provides an example for this, as even compensation mechanisms, while generally accepted, rarely alleviate long-term economic vulnerability (Khanif & Yunita, 2024; Makbul et al., 2024). The distribution of agricultural land conversion in West Java Province is clustered, with major cities showing conversion rates around 80%, and high concentration levels at urban centers. Spatial distribution analysis indicates that agrarian land percentages remain high in some regions, but conversion rates vary significantly from sub-district to sub-district (Maryati, Humaira, & Pratiwi, 2018).

International comparative evidence about infrastructure development and converted agricultural land is a worldwide topic with documented socio-economic impacts. Over the past 50 years, developing countries have conducted meta-analysis studies showing widespread agricultural land conversion and its main socio-economic effects. The trend of infrastructure-based conversion seems to mirror across national contexts for each country, indicating that the pressures on agricultural systems are uniform (Huang et al., 2023; Zhang et al., 2023). An initial analysis of policy needs highlights the importance of a systematic need for evidence-based policy recommendations to address farmland conversion results, support farmers, and prevent negative impacts on rural communities. Key recommendations include.

1. Stronger compensation systems that reflect, as much as possible, the fair market value and cultural significance of agricultural land.
2. A participatory community planning to enhance both the material and psychological well-being of displaced farmers.
3. Improved monitoring and law-enforcement of sustainable food agricultural land (LP2B) protections.

A sustainable development strategy would necessitate the government planning how land conversion corresponds with the needs and objectives of farmers and rural communities, which can create continuous agricultural sector development in the long term. This implies that development goals should be tempered by the protection of land necessary for the livelihood of displaced farmers through thoughtful planning of compensation programs and instruction in reinvestment. The development of policies should lay the groundwork for support programs that guarantee compensation funds effectively create sources of new income for affected farmers. Such programs involve vocational training initiatives, microfinance access, and business financing to ensure successful transitions to sustainable livelihoods.

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