

Women's role in supporting the sustainability of smallholder coffee plantations in North Sumatra, Indonesia

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ABSTRACT

This study examines the role of women in managing coffee plantations in traditional North Sumatra communities and its impact on household income, amidst restrictions imposed by the Dalihan Natolu system, a patrilineal tradition limiting their land rights and decision-making power. Using descriptive quantitative methods and Partial Least Squares Structural Equation Modeling (PLS-SEM), data were collected from six coffee-producing districts to analyze women's rights to land, crops, and income. The findings reveal that women's land tenure positively influences their rights to crops and income, emphasizing the need for secure land rights to enhance economic empowerment. Despite their significant contributions to coffee production, cultural norms marginalize women in land ownership, limiting their potential to improve household income. The study calls for institutional and policy reforms to address gender inequality, enhance women's access to land and decision-making authority, and promote sustainable agricultural practices in smallholder coffee plantations, ultimately contributing to economic development and gender equity.

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1. Introduction

The Dalihan Natolu custom, widely practiced in traditional communities in North Sumatra, serves as a framework that regulates social relationships, including property ownership within indigenous systems. In this customary system, men are recognized as the landowners and the heads of households who manage the family's interests, while women are viewed as part of the male-centric household structure. This positioning reflects the subordination of women within the system, even though they play significant roles in the daily management of natural resources, particularly in coffee plantation farming. Indigenous institutions involved in natural resource management, such as those managing coffee plantations, play a critical role

in regulating these resources (Chhetri and Ghimire, 2023; Pfammatter and Jongerden, 2023; Oloo et al., 2023; Abman and Carney, 2020; Martial et al., 2023a).

North Sumatra is home to extensive Arabica coffee farming, with men traditionally regarded as the plantation owners and women serving as internal workers, contributing to daily operations. Despite their labor, women in this customary system are often excluded from obtaining ownership or crop rights. The Dalihan Natolu custom intricately connects women to their roles as laborers in coffee plantations, yet they remain subordinate to men in both household and land management decisions. Women perform work on plantations according to men's decisions rather than their own preferences or what might be best for the family (Addinsall et al., 2023; Lestari and Suyanto, 2024; Norhadi et al., 2024; Honeybun-Arnolda et al., 2024).

Although women are often perceived as being responsible for household tasks, such as educating children, they paradoxically carry out demanding physical labor on plantations. Traditional communities see this work as an integral part of a woman's household duties rather than an act of

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discrimination. However, women's contributions to plantations are essential to maintaining these farms as a key livelihood source. Although women work alongside men, they are frequently not acknowledged for their role in the management of land, which remains controlled by men (Mokati et al., 2024; Addinsall et al., 2023; Huyer et al., 2021; Le et al., 2023; Ferritto, 2024).

Despite their extensive involvement, women in rural communities are expected to follow the men's lead when it comes to managing coffee plantations. Men, as household heads, typically make all significant decisions related to coffee plantation management, from the initial planning stages to the execution of daily tasks. The land for coffee plantations is often inherited and controlled by men, and women are only involved in plantation work because it is seen as part of the household's income-generating activities.

Households typically rely on coffee plantation products to meet their economic needs, but other crops are often grown to supplement income. When coffee crops do not meet family needs, men often decide to replace coffee with other crops. These decisions are economically driven and are typically made by men without consulting women, who contribute significantly to maintaining the plantations. Women's role in these decisions is often disregarded, reflecting their lack of ownership or control over the land they work.

Ironically, although women play a critical role in the physical management of coffee plantations, they lack the freedom to make decisions about their labor. Local customs perpetuate this disparity, as they formalize rules that institutionalize the subordination of women under the Dalihan Natolu system. Consequently, women's significant contributions to coffee plantation management are often overlooked, despite their critical role in sustaining this agricultural system. Considering this, recognizing women's contributions is crucial to ensuring the sustainability of the coffee plantation system in North Sumatra.

The role of local policies and institutions in reinforcing men's ownership rights further exacerbates the exclusion of women. Policies in North Sumatra frequently neglect to consider gender equality, leaving women marginalized in both property rights and decision-making. Indigenous communities often accept this institutionalized discrimination as part of life, making it difficult for women to secure their rights (Silander et al., 2024). Women's labor is often seen as part of their inherent responsibilities within the household, even when it involves tasks typically reserved for men, such as managing plantation land. As Mokati et al. (2024) observed, institutionalized discrimination in such systems is normalized, and seen as an unalterable component of indigenous social structures. To challenge and reform these entrenched customs, a comprehensive review of the existing rule systems is necessary, particularly those that perpetuate gender discrimination.

To recognize and empower women in coffee plantation management, their rights to land and crops must be strengthened. Securing these rights would not only empower women but also promote gender equality and enhance the sustainability of coffee plantations (Bjegovic-Mikanovic et al., 2024; Rettig and Hijmans, 2022; Akpa et al., 2024). Reforming the traditional institutions that govern land ownership and labor roles is essential for achieving equality. When women have more control over land and farming decisions, they can contribute more effectively to household income, which in turn benefits the broader community.

In conclusion, ensuring women's rights in coffee plantation management is vital for sustainable agricultural practices. Addressing the inherent inequalities in the traditional Dalihan Natolu system would allow for more inclusive and equitable resource management, ultimately supporting long-term agricultural sustainability and community development (Sharif et al., 2024; Yavorska et al., 2024; Dharamshi et al., 2023). Inequalities in these areas, by contrast, exacerbate the unsustainable exploitation of natural resources. Addressing these disparities is crucial for promoting both gender equality and sustainable agricultural practices in indigenous communities. By strengthening women's rights and reforming traditional customs, communities in North Sumatra can ensure that coffee plantations are managed in a more sustainable and gender-inclusive manner.

2. Research methodology

We employed quantitative descriptive methods to examine the contributions of women in managing coffee plantations owned by the Var Arabica community in North Sumatra. The study was conducted in six districts recognized as central hubs for Var Arabica coffee plantations, where the traditional Dalihan Natolu system significantly influences daily life. Our research focused on understanding women's roles in plantation management, their rights to land and crops, and their impact on household incomes. Women's rights include ownership of land, coffee trees, and the products derived from them. An empirical analysis was conducted using Structural Equation Modeling (SEM) with Partial Least Squares (PLS), utilizing SmartPLS software version 3.0.

2.1. Field research design

This study was conducted from April 2023 to April 2024, with field research being an integral part of the data collection process. The sampling method employed was non-probability sampling due to the unquantifiable nature of the population. More specifically, purposive sampling was utilized, whereby participants were selected based on predefined criteria established by the researchers (Sibona et al., 2020; Andrade, 2021). In alignment with the study's objectives, the selected participants

were female coffee farmers who actively work on and own coffee plantations. These women were identified as key respondents given their direct involvement in the coffee production system in North Sumatra.

The research focused on women farmers from six districts in North Sumatra: Dairi, Karo, Simalungun, Humbang Hasundutan, North Tapanuli, and Mandailing Natal. A total of 112 respondents were selected as the sample for this study, all of whom met the specified criteria. The selection process was particularly focused on women engaged in the coffee production system, emphasizing their role within the broader agricultural framework of the region.

The research was set in the context of a traditional socio-cultural system known as Dalihan Natolu, a key aspect of Batak society. This customary system operates under a patrilineal structure where men traditionally hold positions of authority within the household and community, particularly in matters of land and property ownership. The Dalihan Natolu system typically assigns different roles to men and women, with men commonly owning property and women often regarded as subordinate in household and agricultural decision-making. This system of differentiation is particularly evident in land tenure and resource management practices, where men are seen as the primary landholders.

Understanding the gendered dynamics within this system is crucial for recognizing the role of women in plantation land management. This focus aligns with global efforts to promote sustainable development in agriculture, where gender equity in resource management is increasingly recognized as a key factor (Efendi et al., 2023). In this context, the role of women in land and resource management can offer valuable insights into achieving sustainability goals in the agricultural sector.

The data collection methods used in this study were comprehensive, involving multiple techniques

to ensure the richness and depth of the data gathered. These methods included direct observation, structured questionnaires, semi-structured interviews, and document analysis. The use of triangulation through these diverse methods helped to enhance the reliability and validity of the research findings. This approach ensures that the study reflects the specific gendered roles in agricultural production and land management, contributing to a deeper understanding of the socio-economic challenges and opportunities faced by women in these communities. The questionnaires were meticulously validated through pilot testing on a small group of respondents to refine and adjust the instrument as needed before full-scale deployment.

2.2. Procedures

Women's contributions to land preparation, crop cultivation, and plantation maintenance highlight their important role in society. Their involvement includes tasks such as garden management, decision-making, skill application, knowledge sharing, and managerial responsibilities. These activities span various stages: land preparation involves clearing and tilling; crop cultivation includes planting coffee and shade trees, as well as harvesting; and maintenance covers fertilization, lawn care, watering, pruning, and pest and disease control. Women's rights are influenced by several factors, including their ownership and access to land, coffee plants, and the resulting products. The FAO's developed approach bases these rights on the rights of women involved in coffee farming (Mottet et al., 2020; Reyes et al., 2020; Tapsoba et al., 2023). Furthermore, Arabica coffee farming generates income that women contribute to and control in farmer households. Table 1 shows the observed research variables, while Fig. 1 shows the overview of the basic model approach we propose.

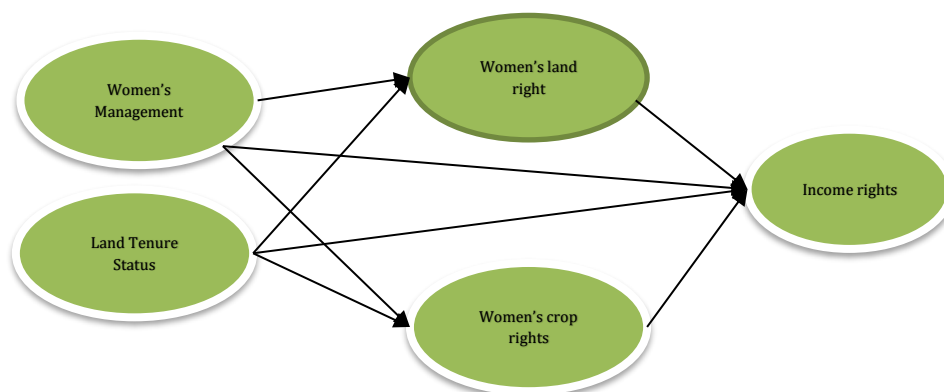


Fig. 1: A basic model of women's rights in smallholder coffee plantations

2.3. Multivariate analysis

We used multivariate analysis with SEM-PLS to determine the relationship between the variables developed in relation to the role of women in coffee plantation management in North Sumatra. The

developed approach encompasses the following variables: 1) coffee plantation management variables (M), which measure the involvement of women in work and decision-making within coffee plantation management; 2) land tenure status variable (L), encompassing the legality and certainty of women's

land access (Abman and Carney, 2020; Martial et al., 2023b) 3) Variables of women's land rights (W); 4) Variables of women's crop rights (R); and 5) As well as the dependent variable, namely women's rights in coffee harvest (Income rights) (I) (Phuong, 2023; Chigbu, 2019; Akpa et al., 2024; Rugadya, 2020), This is how women can determine their control over the income they generate from coffee products. We are using this approach to explore the following hypotheses:

1. Women's land tenure status positively enhances their rights to coffee plants, which in turn leads to an increase in income rights.
2. Women's management has a positive effect on improving women's rights in plants and ultimately contributes positively to income rights.

Table 1: Variables observed in the study

Variable	Code	Description
Women's management	M1	Role in garden management
	M2	Decision-making in the garden
	M3	Skills and knowledge
	M4	Managerial abilities
Land tenure status	L1	Legal documents
	L2	Freedom of tenure
	L3	Security of land rights
	L4	Access to land
	L5	Support of local communities
Women's land right	W1	Land use rights
	W2	Right to regulate land use
	W3	Right to increase land productivity
	W4	Recognition of land rights
	W5	Equality of access rights
	W6	Freedom of discrimination on land rights
Women's crop rights	R1	Full right to harvest
	R2	Right to choose plant type
	R3	Right to sell crop
	R4	Right to control crop
Income rights	I1	Control of income
	I2	Contribution to households
	I3	Right to use crop products
	I4	Comparison of utilization with contribution

3. Result

3.1. Sample background analysis

The study area in North Sumatra is renowned as a key center for arabica coffee cultivation, encompassing six districts. This research was conducted in a purposefully selected region known for its distinctive Dalihan Natolu customary system, a traditional practice followed by the Batak people.

The primary goal of the study is to examine the role and rights of women in the management of coffee plantations in this region. The research specifically focuses on six districts: Dairi, Karo, Simalungun, Humbang Hasundutan, North Tapanuli, and Mandailing Natal, all of which are recognized as significant hubs for arabica coffee farming.

Coffee farmers in these regions largely adhere to traditional practices, having cultivated coffee for generations. This research investigates the participation of women in coffee plantation management, an aspect deeply influenced by the Dalihan Natolu system. This customary system, grounded in a strong patrilineal structure, designates men as heads of households, controlling property ownership. Women, in contrast, are often relegated to subordinate roles, particularly in the control and ownership of land and other resources. This differentiation highlights a crucial distinction in the roles assigned to men and women, particularly in land tenure. Exploring women's roles in land management is therefore key to fostering sustainable development, particularly in the agricultural sector.

The research surveyed 112 female coffee farmers who met the study criteria, specifically women involved in the coffee production system in North Sumatra. The descriptive analysis (Table 2) shows the average age of the female farmers is 46 years, ranging from 23 to 79 years. Despite their advanced age, many women continue to work productively on their coffee plantations. Most female farmers belong to large families, with an average of nearly three dependents and up to eight in some cases, which underscores the significant economic burden these women carry.

These women have long-standing ties to the land, with an average residency of over 22 years, indicating a high level of experience in managing agricultural land. On average, they have been managing coffee plantations for about 17 years, indicating a deep-rooted tradition of coffee cultivation passed down through generations. Interestingly, the average educational level of the women surveyed is high school, which suggests they possess adequate understanding and knowledge of cultivation techniques, particularly in coffee production.

Table 2: Background and activities of sample farmers

	Mean	Mode	Minimum	Maximum
Age	46.26	45	23	79
Number of dependant	2.87	2	0	8
Length of stay	22.67	15	3	62
Education	2.56	3	1	4
Land area	1.060	0.5	0.1	6.0
Land status	1.20	1	1	3
Number of women's work	7.87	8	5	10
Length of plantation	17.12	8	4	80
Number of land right	1.84	2	1	3
Number of coffees right	3.17	3	2	6
Yields	15472589.29	7000000	380000	89200000

While the average land area per farmer is 1 hectare, some farmers manage as little as 0.1 hectares, with the largest holding reaching 6 hectares. Most farmers either own or share ownership of the land they cultivate, though a small number lease their plots. Coffee plantations in North Sumatra are typically composed of small, inherited plots of land passed from parents to sons, as per the Dalihan Natolu system. The annual income generated from these plantations averages 15 million rupiah, with a wide variation from 380,000 rupiah to over 89 million rupiah.

The Dalihan Natolu system underscores the gender-based disparity in property ownership, with men generally holding ownership rights. This patriarchal system limits women's access to landownership and reinforces gender inequality, despite women's significant role in agricultural production. Understanding the role of women in this context is essential to addressing issues related to gender inequality and economic empowerment in agricultural communities.

3.2. Evaluation of measurement instruments (outer model)

The construct a robust model, we first conducted an analysis of various multidimensional variables related to the role of women in managing smallholder coffee plantations. Specifically, the variables were related to women's rights over land and coffee crops, as well as their income from farming, to better understand their overall contribution to plantation management. The analysis follows the Structural Equation Modeling (SEM) approach, using outer loading factors to develop the construction model based on exogenous factors (Miller et al., 2020; Edeh et al., 2022).

To assess the reliability and validity of the instrument, we applied two key measures: Cronbach's alpha and composite reliability (CR). Cronbach's alpha values above 0.7 indicate good reliability for the constructs, while CR provides a more conservative estimate. The convergence validity was evaluated using the average variance extracted (AVE), with a threshold of 0.5 as the indicator of good convergence. We also used the

Fornell-Larcker Criterion and Cross Loading to validate discriminant validity, ensuring that the constructions measured were more strongly correlated with their own indicators than with others.

In addition, we assessed the structural model by measuring path coefficients to support the research hypothesis, using bootstrapping to test the significance of these paths. The R-squared (R^2) values indicate the model's ability to explain variance in endogenous constructs, with higher values reflecting stronger predictive power (Rehman et al., 2023; Edeh et al., 2022).

3.3. Structural model analysis

The validity and reliability values confirm the suitability of the construct variables in forming the model. Cronbach's alpha values exceeded 0.7, indicating reliable internal consistency for all five endogenous variables, income rights, land tenure status, women's management, and women's crop and land rights. Furthermore, the AVE values were all above 0.5, confirming the convergent validity of the constructs (Table 3 and Table 4). This strong reliability and validity indicate that the indicators used are appropriate for constructing the model. Furthermore, the path coefficients suggest significant relationships between land tenure status and women's crop rights, as well as between women's crop rights and income rights (Table 5).

3.4. Relationship between variables based on path coefficient

The path coefficient analysis (Fig. 2 and Table 5) reveals that land tenure status significantly affects women's crop rights, with a coefficient of 0.851. This indicates that stronger land tenure status leads to enhanced rights to crops for women. Similarly, a strong land tenure status positively influences women's land rights, with a coefficient of 1.093. However, women's management negatively impacts their land rights, suggesting institutional and cultural barriers limiting women's access to land despite their active role in plantation management.

Table 3: Construct reliability and validity

	Cronbach's alpha	Rho_A	CR	AVE
Income rights	0.858	0.914	0.907	0.717
Land tenure status	0.945	0.948	0.958	0.822
Woman's management	0.929	0.932	0.950	0.827
Women's crop rights	0.930	0.935	0.950	0.828
Women's land rights	0.957	0.959	0.966	0.825

Table 4: Discriminant validity based on the Fornell-Larcker criterion

	Income rights	Land tenure status	Woman's management	Women's crop rights	Women's land rights
Income rights	0.847				
Land tenure status	0.975	0.907			
Woman's management	0.942	0.934	0.909		
Women's crop rights	0.989	0.989	0.942	0.910	
Women's land rights	0.970	0.995	0.916	0.987	0.908

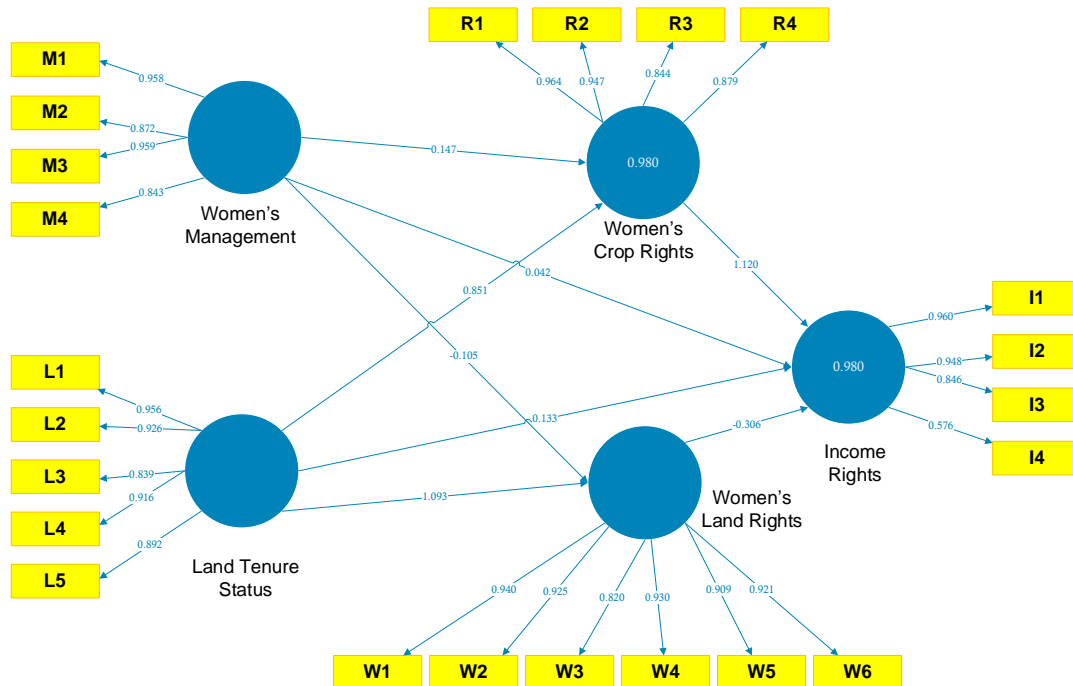


Fig. 2: Load factors, path coefficients, and R-squared values of constructs

Table 5: Path coefficient relationships between endogenous variables

Path	O	M	SD	T-statistics (O/SD)	P-values
Land tenure status -> income rights	0.133	0.143	0.220	0.605	0.545
Land tenure status -> women's crop rights	0.851	0.852	0.024	35.017	0.000
Land Tenure Status -> women's land rights	1.093	1.094	0.022	49.859	0.000
Woman's management -> income rights	0.042	0.044	0.052	0.819	0.413
Woman's management -> women's crop rights	0.147	0.146	0.026	5.758	0.000
Woman's Management -> women's land rights	-0.105	-0.106	0.024	4.435	0.000
Women's crop rights -> income rights	1.120	1.120	0.140	8.002	0.000
Women's land rights -> Income rights	-0.306	-0.318	0.231	1.326	0.185

O: Original sample; M: Sample mean; SD: Standard deviation

Women's crop rights significantly and positively influence their income rights, with a coefficient of 1.120 at a 5% significance level. This strong positive relationship indicates that when women gain greater control over crops—such as deciding which crops to grow, their uses, and the sale of produce—their income increases directly. These findings suggest that empowering women with greater control over agricultural resources can significantly improve their economic status and financial independence.

Additionally, women's management activities on plantations positively affect their crop rights. A coefficient of 0.147 shows that as women take on more agricultural management roles, particularly on coffee plantations, their control over crop rights increases. This suggests that involving women in decision-making related to agricultural practices strengthens their crop rights. However, women's management roles have a negative impact on their land rights, with a coefficient of -0.105. This indicates that even as women take on more responsibilities in plantation management, it does not lead to greater land ownership. Instead, cultural and social barriers restrict their access to land rights.

These cultural barriers are rooted in the local customary system, Dalihan Natolu, which traditionally reserves land rights for men. Despite women's significant contributions to plantation labor and management, these roles do not translate

into land ownership. Traditional practices and institutional laws continue to limit women's ability to own land, reflecting persistent gender discrimination in the legal and cultural frameworks governing land ownership.

The analysis also shows that land tenure status has no significant effect on women's income rights, with a non-significant coefficient of 0.133. This weak relationship suggests that land tenure status is not a key determinant of women's income rights, and other factors may play a larger role in shaping their financial outcomes. Similarly, women's management activities have no significant impact on their income rights, as indicated by the small coefficient of 0.042. This highlights a missed opportunity to leverage women's management roles for improving their economic welfare, pointing to a need for more focused efforts in this area.

Furthermore, women's land rights negatively affect their income rights, with a coefficient of -0.306. This finding reveals a complex dynamic: while women's crop rights enhance their income, their land rights remain restricted. These restrictions are driven by local regulatory systems that severely limit women's land ownership, even as they gain more control over agricultural production and income.

In summary, while women's crop rights play a critical role in improving their income, the study highlights significant institutional and cultural

barriers, particularly regarding land ownership, that hinder women's overall economic empowerment. To effectively enhance women's income and land rights, interventions must address these broader systemic challenges and focus on reducing gender discrimination in agricultural and land governance.

3.5. Specific Indirect Effects

The path coefficient and its impact on the structural model reveal specific indirect effects (Table 6). The land tenure status construct has a positive effect on income rights through women's crop rights (0.953). The specific indirect effect value of 0.953 shows that land tenure status has a substantial indirect effect on income rights through women's crop rights at the level of 5 percent (Table

7). This means that when land tenure status is strengthened, it will significantly increase women's rights to crops, which in turn substantially increases their income rights. This high value shows that women's rights to plants are an important pathway that links land tenure status with income rights.

Meanwhile, the Woman's Management construct shows a positive indirect influence on income rights through women's crop rights (0.165). The coefficient of 0.165 shows the positive indirect effect of management by women on income rights through women's rights to crops and is significant at the level of 5 percent. This means that although women's management has a positive effect on income rights, it has a smaller effect compared to land tenure status.

Table 6: Specific indirect effects

Path	O	M	SD	T-statistics (O/SD)	P-values
Land tenure status -> women's crop rights -> income rights	0.953	0.955	0.127	7.509	0.000
Women's management -> women's crop rights -> income rights	0.165	0.163	0.032	5.138	0.000
Land tenure status -> women's land rights -> income rights	-0.335	-0.348	0.253	1.321	0.187
Women's management -> women's land rights -> income rights	0.032	0.034	0.027	1.210	0.227

Table 7: Results of hypotheses proposed in the model

Hypothesis	Evaluation of the hypothesis	Confidence levels	T-statistic	Path coefficient
Hypothesis 1	Accepted	YES	p<0.01	Yes
Hypothesis 2	Accepted	YES	p<0.01	Yes

The land tenure status construct has a negative indirect effect on income rights through women's land rights, with a coefficient of -0.335. This suggests that an increase in land tenure status may reduce income rights through women's land rights; however, this effect is not statistically significant at the 5% level. This negative impact reflects strict local regulations that restrict women's land tenure rights, even though such regulations may encourage women to increase their incomes. Similarly, the indirect effect of women's management on income rights through women's land rights is negligible. The coefficient of 0.032 indicates a minimal indirect effect, demonstrating that women's management does not significantly influence income rights through their land rights.

A model that includes independent variables such as land tenure status, women's management, women's crop rights, and women's land rights can explain 98% of the variability in income rights, as indicated by R-squared Income Rights = 0.980 (Fig. 2 and Table 8). The high R-squared values demonstrate the model's robustness and its ability to predict income rights, women's crop rights, and land rights with great accuracy (Table 8). This study provides a valuable framework for understanding gender dynamics in agricultural land management, offering important insights for policymaking to promote gender equality and economic empowerment.

4. Discussion

These findings highlight several key insights into the role of women in the management of smallholder

coffee plantations in North Sumatra. The results underscore both the positive impacts of women's management and rights on income generation and the ongoing challenges related to gender inequality, especially concerning land tenure. In the following discussion, we will explore the broader implications of these findings, particularly in the context of sustainable agriculture, and propose actionable strategies to enhance women's empowerment in this sector.

Table 8: R-squared and adjusted R-squared values for key constructs

	R-squared	R-squared adjusted
Income rights	0.980	0.980
Women's crop rights	0.980	0.980
Women's land rights	0.991	0.991

4.1. Land tenure status effect

Based on the path coefficient of the land tenure construct, land tenure status had a positive effect on women's crop rights (Table 5). A positive effect indicates that the land tenure status aligns with the women's crop rights. The fact was that women in the Dalihan Natolu indigenous community had limited land ownership rights. Consequently, their rights to the products of the land were also limited. Women's restricted access to land correlates directly with their limited decision-making power over crop production and its benefits. The Dalihan Natolu customary system in North Sumatra plays a crucial role in determining land tenure, where men hold dominant control over land ownership, further restricting women's rights. Low levels of women's land rights have an impact on their crop rights, and

vice versa. This is in line with [Yang et al. \(2020\)](#) which explains that a clear understanding of the land status enhances the effectiveness of land management. [Nchanji et al. \(2023\)](#) further emphasized that weak land tenure is primarily caused by limited land ownership. However, in North Sumatra, women's land rights are weakened due to local regulations that place land ownership under the control of men. Even though local regulations in North Sumatra dictate the land tenure system, there are potential changes that could impact women's agricultural rights. Certainty of land tenure regulations can also empower women, including increasing land productivity ([Bizoza and Opio-Omoding, 2021](#)).

Local regulations play a significant role in determining land tenure status, especially where men dominate decision-making over women. This dominance explains why women have limited access to land rights, particularly for agricultural purposes. The prevailing local customs restrict women's access to resources, which in turn affects their ability to manage and utilize land effectively. As highlighted by [Camara et al. \(2023\)](#), these local systems of land tenure regulation can become a barrier to resource management. This form of gender-based discrimination limits women's autonomy in making decisions related to agricultural practices, including the use of plant products.

To counter this inequality, it is crucial to enhance the decision-making capacity of women. [Le et al. \(2022\)](#) stressed the importance of increasing the proportion of women involved in strategic agricultural decisions. Women require social incentives to develop their skills and capabilities, as supported by [Naser and Al-Tit \(2023\)](#) and [Bakoben \(2024\)](#). The lack of local institutional support and ineffective social systems have left women farmers disempowered and without the necessary access to resources ([Lountain et al., 2024](#)). Therefore, to achieve equality in resource access, empowerment programs must be backed by comprehensive development initiatives ([Ferritto, 2024; Kelley et al., 2024](#)). Furthermore, the positive relationship between land tenure status and women's rights over land shows that improving tenure can strengthen women's land rights. Women view this enhancement to secure their land rights, although local customary regulations such as the Dalihan Natolu system continue to dominate. Formal land tenure rules often fail to adequately address lands inherited through customary means ([Ibrahim et al., 2023](#)). While some reforms to the land tenure system have increased women's rights, these improvements are still limited in scope.

[Ajefu and Abiona \(2020\)](#) argued that strengthening land tenure status correlates with increased agricultural productivity. Although legal frameworks do not always provide women with full land ownership, they can reinforce their land rights by improving productivity on their farms. Many rural farmers distrust the security of formal legal land possession ([Rao et al., 2020](#)). In practice, women

gain recognition of their land rights primarily through their ability to productively manage farmland. Securing land tenure, as [Olagunju et al. \(2023\)](#) noted, reduces the risks of system failure and crop losses. However, despite the recognition of their land rights, women often face restrictions on transferring land rights due to customary rules like those of Dalihan Natolu. Social systems continue to create unequal claims to natural resources for women ([Selvadurai et al., 2020](#)).

4.2. The effect of women's management

The construction of women's management has a positive effect on women's crop rights, with a coefficient of 0.147, showing a significant influence at the 5 percent level ([Table 5](#)). This suggests that women's participation in coffee plantation activities can enhance their rights to crop yields. However, women's management also has a significant negative impact on their land rights, accounting for 5 percent of the total. The existence of these divergent effects—positive on crop rights and negative on land rights—suggests that while women may expect greater control over crop products, their land rights remain restricted. This indicates that increasing women's involvement in plantation management allows them to exercise greater control over the use of crop products, but not over the land itself. Women play a key role in farming to achieve financial stability, but this role does not extend to accessing land finance directly ([Ozili, 2024](#)).

According to [Pandey \(2024\)](#), women face the struggle for equal rights across gender, religion, and societal differences. Local communities shape gender constructs based on perception rather than capability ([Spence et al., 2023; Karananeethi et al., 2024; Tourtelier et al., 2023](#)). In terms of income, women can contribute more significantly to household income when their rights to crops are enhanced. This situation aligns with the traditional values of the Dalihan Natolu indigenous community, where women are often regarded as laborers who must adhere to the will of men, who are considered the heads of households. Although women perform most of the tasks in coffee plantations, the ownership of the land typically belongs to men. Consequently, men hold greater authority in making decisions related to the management of coffee plantations compared to women.

On the other hand, the management of plantations by women has a marked negative effect on their land rights. This highlights the duality of plantation management in the region. As [Santpoort et al. \(2021\)](#) noted, in terms of access to and control over land and other natural resources, women do not receive equal treatment compared to men. In North Sumatra, despite increased female labor participation, women's land rights have diminished due to local customary laws that restrict women's land ownership. These findings demonstrate that as women's management activities in agriculture increase, indigenous local rules within North

Sumatra communities tend to further restrict women's land rights. Women can manage plantations and gain rights over crops, but their land rights—such as the ability to transfer or change the status of land tenure—remain tightly constrained.

This gender inequality in land rights stems from broader societal systems of discrimination, which operate at both local and global levels (Yavorska et al., 2024). The Indigenous Dalihan Natolu communities of North Sumatra exemplify this pattern in their coffee plantation management. Women are encouraged to contribute to the household economy by promoting their rights over crop products, but their land rights remain limited. This systematic discrimination supports women's productivity to enhance household income but confines them within a family production system where they serve as laborers without full land ownership. The Dalihan Natolu communities advocate for women's active use of crop products but maintain the men's dominance over land ownership.

When women participate actively in plantation management, they gain control over crop products, allowing them to make more informed decisions about agricultural practices and crop management. This contribution positively affects household income. However, the simultaneous limitation of their land rights points to a double standard by local institutions, which encourages women's roles in natural resource management while restricting their access to land ownership (Kelley et al., 2024).

4.3. The effect of women's crop rights

The study finds that women's crop rights significantly impact their income rights, indicating that as women's control over crops (yields) increases, so does their ability to claim and manage income derived from these resources (Table 5). When women gain rights to their crops, they can exert more control over how farm produce is utilized. Typically, these crop rights are strengthened when women's land tenure status is clarified. The coefficient reveals a robust relationship between women's crop rights and their income rights, suggesting that women attain stronger income control when they hold rights over crops and their products. This reflects an ongoing effort by women to secure equal control over resources (Ghanea, 2022).

This finding indicates that women are encouraged to be more productive in coffee plantation activities. It provides evidence of a dualism in women's rights in managing coffee plantations. The support they receive is primarily aimed at increasing their productivity rather than strengthening their rights over land ownership. Women's rights over land do not improve despite their increased labor input. There remains a disparity in land ownership rights between men and women. This is consistent with the findings of Njogu et al. (2024), who highlighted the weakened position

of women's rights due to unequal decision-making power within households, which are often dominated by their husbands. As a result, women have limited access to financial resources and other assets.

In another study, Shamsuddoha et al. (2024) demonstrated that the low level of women's rights is linked to limited economic opportunities, often stemming from poor education and health. This situation slightly differs in the Dalihan Natolu indigenous community, although it still reflects restrictions on women's rights. The limitation on women's rights in these communities is mainly a result of the disproportionate division of labor between men and women, rooted in customary practices. Mubangizi and Tlale (2023) further argued that the low level of women's rights is due to fundamental discrimination, which contradicts basic human rights principles.

However, in many traditional settings, women face challenges in securing full land ownership due to customary laws that favor men as primary landholders. Nevertheless, the evidence shows that when women can control their crops and products, they also gain greater rights over the income they generate.

Therefore, women play a crucial role in their communities, particularly through their contributions to households (Lajci et al., 2024). By exercising control over their crops, women can make more informed decisions regarding their utilization. This approach serves as a strategy to empower women, granting them the autonomy to manage crop-related decisions and strengthening their rights over agricultural yields and products.

These findings highlight the complexity of gender dynamics in rural agricultural settings, where women's contributions to the workforce are not adequately recognized through the provision of equal land ownership rights. While efforts to increase productivity are important, they should be complemented by measures that ensure equitable access to land and resources for women. Without such changes, gender inequality in agricultural communities will persist, limiting women's potential to contribute fully to economic development and social progress.

4.4. Result of hypotheses

The construction of Land Tenure Status demonstrated a specific indirect effect on income rights through women's crop rights, with a value of 0.953. This substantial indirect effect indicates that improving women's land tenure status significantly influences their income rights via the strengthening of crop rights (Table 6). As land tenure becomes more secure, women gain greater control over crops, which, in turn, leads to a marked increase in their income, supporting Hypothesis 1. These findings highlight women's efforts to contribute to household income by enhancing their rights over agricultural yields.

Meanwhile, the construction of Women's Management also showed a positive indirect effect on income rights through crop rights, with a coefficient of 0.165. This indirect effect, significant at the 5 percent level, suggests that the management activities women engage in have a notable impact on their income rights by strengthening their control over crop yields (Hypothesis 2). These results demonstrate that, despite limitations imposed by local customary laws and institutions, women strive to assert and strengthen their rights.

As noted by Santpoort et al. (2021), rural women often endeavor to reinforce their rights depending on the specific challenges they encounter. In the context of North Sumatra, rural women are working to overcome marginalization within a system that restricts their land tenure rights. Women are taking the initiative to achieve gender equality by strengthening their rights to crops and contributing to household income through plantation management, as observed in the case of coffee plantations (Yavorska et al., 2024). This highlights the ability of women to adapt and modify their roles according to the circumstances they face, making significant efforts to secure their rights.

However, these efforts also reveal the constraints women face in plantation work. Local customs encourage women to take active roles in managing plantations to support household income, yet their control over crops and decision-making remains limited, and their roles within families are often subordinate to men. Although women are key contributors to plantation labor and significantly impact household income, their rights are severely restricted due to the influence of customary practices. In North Sumatra, the cultural norm known as Dalihan Natolu reflects these restrictions, limiting women's rights and authority.

Despite these challenges, local customs in North Sumatra do encourage women's participation in plantation management by granting them rights over crops and produce, yet these rights are constrained by limited decision-making power. Women, particularly those who own smallholder coffee plantations, face significant discrimination, despite managing most of the plantation work and contributing substantially to household income. This gender inequality, rooted in local customs and community rules, prevents women from assuming more prominent decision-making roles. Additionally, as Silander et al. (2024) noted, current policy instruments fail to fully incorporate gender equality, further inhibiting women's ability to expand their roles. Therefore, there is a clear need for local institutions to develop policies that promote and protect women's rights in managing smallholder coffee plantations.

5. Conclusion

This study highlights the crucial role of women in the management of smallholder coffee plantations in North Sumatra, particularly in the context of the

Dalihan Natolu system, which limits women's land rights and decision-making power. The findings underscore that while women are actively involved in agricultural management, their land tenure status and rights to crops remain constrained by traditional cultural norms. However, the study demonstrates that women's land tenure status significantly influences their rights to crops, and in turn, these crop rights positively impact household income. This indicates that securing women's land rights is essential for improving their economic empowerment.

The research contributes to the broader body of knowledge on gender inequality in agricultural management by providing empirical evidence from North Sumatra, where traditional customs continue to dictate women's roles in land ownership. The study emphasizes the need for institutional and policy reforms to dismantle gender-based barriers and promote equal access to land and agricultural resources for women. Such reforms would not only improve household income but also contribute to the long-term sustainability of smallholder coffee plantations.

The key implication of this study is that empowering women through land and crop rights can lead to more equitable and sustainable agricultural practices. The study suggests that future research should focus on exploring the effectiveness of policy interventions aimed at enhancing women's land rights in other regions or agricultural sectors. Additionally, examining the long-term impacts of gender equality in agricultural management on community development could offer further insights into sustainable economic growth in rural areas. This research sets the stage for further investigations into the intersection of gender, land rights, and sustainable agriculture.

Compliance with ethical standards

Ethical considerations

Informed consent was obtained from all participants, and confidentiality was maintained throughout the study. The research adhered to ethical guidelines and respected local cultural norms, ensuring no harm to participants or disruption to the community.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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