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Tree Collateral Loan as a Sustainable Financing Instrument: Evidence from Smallholders' Livelihood Changes in Gunungkidul, Indonesia

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Abstract

Tree-collateral loans have been introduced in Indonesia to ease liquidity constraints faced by smallholder forest farmers, who often resort to premature harvesting. This study evaluates the impacts of the forestry microcredit called pinjaman tunda tebang (*PTT*) *scheme on household livelihood assets in Gunungkidul District, Yogyakarta. Data were collected from a survey of 180 households* (*90 borrowers and 90 non-borrowers*). *To reduce selection bias, propensity score matching was applied, yielding a balanced sample of 134 households* (*44 borrowers and 90 controls*). *The average treatment effect on the treated was then estimated across ten indicators representing financial, physical, human, social, and natural capitals. Results show that financial capital improved most, with borrowers more likely to diversify income, operate side businesses, and fall into higher monthly-income brackets. Natural and physical capitals showed modest differences, including larger forestland and higher-perceived infrastructure access, but these may reflect pre-existing assets rather than causal program impacts. By contrast, human and social capital were weaker, with borrowers participating less in training, reporting lower technical adequacy, and engaging less in farmer-group meetings. These findings highlight that while PTT is effective as a liquidity instrument, its transformative potential depends on integration with training and collective empowerment. For broader impact, rural microcredit must be coupled with extension services and group strengthening to align financial access with long-term rural livelihood resilience.*

Keywords: *forestry microcredit, smallholder forestry, sustainable livelihood capitals, propensity score matching, forest policy impacts*

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Introduction

Smallholder forests, locally known as *hutan rakyat*, are integral to rural livelihoods in Indonesia. These forests provide not only timber, a key source of household income, but also ecological services such as soil conservation, water regulation, and carbon storage (Resosudarmo et al., 2019). At the same time, many smallholders are compelled to practice *tebang butuh*, or premature tree harvesting, under urgent financial pressure. This behavior reduces the long-term economic value of timber, diminishes ecosystem benefits, and increases livelihood vulnerability (Nugroho et al., 2017).

One of the main drivers of premature harvesting is the lack of access to formal credit markets. Smallholder tree growers are often excluded from the formal credit markets because financial institutions do not accept standing trees as collateral (Oktoyoki et al., 2023). In response, the Indonesian government introduced the Tree-Collateral Loan, or *Pinjaman Tunda Tebang* (PTT), managed by the Indonesian Environment Fund (BPDLH). Through this mechanism, farmers can pledge their standing trees, subject to the condition that harvesting is postponed until maturity, providing liquidity without sacrificing future forest income. Similar innovations exist internationally. For example, Thailand's Tree Bank has integrated trees into the financial system by recognizing them as collateral for credit access (Starfinger, 2021). More recent reviews highlight that tree-based finance remains underexplored and should be examined not only from financial but also from social and ecological perspectives (Starfinger et al., 2023).

Although PTT has gained increasing policy relevance (Lusiya et al., 2020), most evaluations still focus on operational aspects, such as disbursement procedures, repayment rates, immediate income effects, and financial feasibility and outcome (Nugroho et al., 2017; Listiyawan et al., 2022; Oktoyoki et al., 2023). Evidence about the multidimensional impacts of PTT on household livelihoods remains scarce. Understanding this broader dimension is critical for assessing whether the scheme can contribute to long-term rural livelihood resilience rather than functioning merely as a short-term liquidity instrument.

The sustainable livelihood framework (SLF) offers an appropriate analytical lens. The framework conceptualizes

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household well-being as the combination of five interrelated capitals: natural, human, physical, financial, and social (Department for International Development, 1999; Scoones, 2009). Ellis (2000) emphasized how rural households strategically combine these assets to diversify livelihoods, while Scoones (1998) underlined their usefulness in understanding resilience under conditions of uncertainty. Recent studies have reaffirmed SLF's relevance in contemporary rural contexts in many countries (Carney, 1999; Natarajan et al., 2022). Research in China, for example, demonstrated that variations in livelihood capitals shaped household adaptability during poverty-alleviation resettlement programs (Ma et al., 2024). A study in Ethiopia revealed how dependence on forest goods influenced strategies of households living near protected areas (Hailemicheal et al., 2024). In Southeast Asia, access to credit enhanced financial capital; however, in the absence of supplementary training and institutional support, the effects on human and social capital were constrained (Tran et al., 2023). Indonesian evidence also shows that while rural households integrate industrial forest extraction and conservation with farming and livestock activities, the external interventions may increase livelihood capitals (Delvion et al., 2025) but do not automatically build local capacity (Nugroho et al., 2022) and have only a modest impact on rural livelihood outcomes (Greenhill et al., 2017).

Gunungkidul District in Yogyakarta is a relevant site for examining the policy impact of PTT dynamics on rural livelihoods. With more than 700 active PTT borrowers recorded in 2022 and a landscape strongly dominated by smallholder forests, the district has pioneered the implementation of tree-collateral finance in Indonesia (Pambudi, 2025). Its socio-ecological setting provides a natural laboratory to evaluate whether participation in PTT results in measurable improvements across livelihood capitals. This study, therefore, aims to assess the effects of the PTT program on household assets represented by five livelihood capitals and ten indicators of the SLF, and to apply a quasi-experimental approach—propensity score matching (PSM) combined with average treatment effect on the treated (ATT)—to estimate causal impacts. By doing so, the research contributes evidence on how innovative rural credit schemes can align financial access with sustainable livelihood enhancement and forest stewardship.

Methods

Study area The study was conducted in Gunungkidul District, Yogyakarta, Indonesia. The study site represents a relatively mature implementation setting for the PTT scheme, characterized by long-standing community forestry practices, active local farmer groups, and a comparatively high number of borrowers. This context provides a strong "best-case" environment to evaluate livelihood outcomes under stable institutional conditions. Smallholder forests, or community forests, in this district contribute significantly to household income and ecological services. Farmers rely on these forests for both timber and daily subsistence. At the same time, Gunungkidul has also become a key site for the Tree-Collateral Loan, called PTT. The district's long tradition of community forestry and its engagement with financing schemes under the BPDLH make it a relevant setting for examining how tree-collateral finance affects household livelihoods.

Sampling and data collection The study population consisted of 716 active PTT borrowers, members of 38 farmer groups, residing across 25 villages in 12 subdistricts of Gunungkidul. The population was divided into three subpopulations based on loan-size categories: stratum 1 (< IDR 50 million): 570 farmers, stratum 2 (IDR 50–100 million): 120 farmers, and stratum 3 (> IDR 100 million): 26 farmers. Sample size was determined using Yamane (1973)'s formula with a 10% margin of error, resulting in a minimum of 88 households; this was rounded to 90 borrowers and then proportionally distributed across the strata.

A comparison group of 90 non-borrowers was selected from the same villages through snowball sampling by asking the borrower to name another farmer with similar characteristics. This snowball sampling was chosen given the absence of a population list of non-participant debtors. This method was applied to identify households with similar demographic characteristics and forest conditions (Naderifar et al., 2017). In total, 180 households were surveyed (90 borrowers and 90 non-borrowers) between October 2024 and February 2025 using structured face-to-face interviews. The questionnaire was designed with the SLF as a guiding concept and included both closed- and semi-structured questions. A pilot test was conducted to ensure clarity and consistency before the primary survey.

Indicators Ten indicators were used to represent the five livelihood capitals in the SLF. These indicators capture multidimensional changes in household welfare and are directly aligned with the objectives of the PTT program (Table 1).

Table 1 Indicators representing the five livelihood capitals

Capital	Indicator	Measurement type
Natural	Forest land area	Hectares (continuous)
Human	Participation in forestry training	Binary (yes/no)
	Perceived benefit of training	Likert scale (1–5)
	Adequacy of forestry skills	Binary (adequate/inadequate)
Physical	Perceived access to forestry-related infrastructure	Likert scale (1–5)
Financial	Primary income source	Categorical (agriculture, trade, other)
	Side-business ownership/income	Ordinal scale
	Monthly household income	Ordinal brackets
Social	Frequency of farmer-group meetings	Likert scale (1–5)
	Perceived support from farmer groups	Likert scale (1–5)

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Data analysis This study applied propensity score matching (PSM) (Rosenbaum & Rubin, 1983) to address the potential selection bias of the farmers who joined the PPT scheme initially. To study the effect of PPT on livelihood changes, we compare them with the non-borrower farmers. The propensity score, defined as the probability of joining the PTT scheme, was estimated through a binary logistic regression with participation status as the dependent variable (borrower = 1, non-borrower = 0) (Stuart, 2010). Covariates included the sex of the household head, education level, and number of dependents. The matching process used the nearest-neighbor method with a caliper of 0.1 and without replacement. Balance between groups was evaluated using standardized mean differences (SMD), and after matching, all covariates fell below the 0.1 threshold (Austin, 2009). As a result, 134 households—comprising 44 borrowers and 90 non-borrowers—were retained for further analysis.

The next step involved estimating the ATT, which captures the causal impact of PTT on households that actually received the loan. The ATT framework is well established in observational program evaluations (Becker & Ichino, 2002) and is particularly suited for livelihood studies where random assignment is infeasible. Different regression models were applied according to the measurement scale of each indicator: ordinary least squares (OLS) regression for continuous outcomes, binary logistic regression for dichotomous variables, ordinal logistic regression for ordered categories, and multinomial logistic regression for nominal categories. These specifications follow best practices in applied econometrics (Angrist & Pischke, 2008). Recent methodological advances have strengthened the validity of this approach and shown that integrating weighting and matching improves treatment effect estimation, while Abadie and Cattaneo (2018) proposed refinements that reduce residual bias in non-experimental evaluations. Zhao and Li (2020) further enhanced the robustness of ATT through sensitivity analysis. Building on these developments, this study applies ATT to credibly assess the impact of PTT participation on household livelihood outcomes.

Results

Matching diagnostics Before program impacts could be estimated, the comparability of borrower and non-borrower groups was tested using PSM. Prior to matching, several covariates showed substantial imbalance, especially education level, with SMD reaching 0.57 for primary education and 0.68 for junior secondary education. These values suggest that program participation was not randomly distributed across households (Table 2).

As shown in Table 2 and Figure 1, the SMD for all covariates fell below 0.1 after matching, indicating that

Table 2 Standardized mean differences (SMD) before and after matching (n = 134)

Variable	SMD before	SMD after
Sex: Male	0.268	-0.036
Sex: Female	-0.268	0.036
Education: Primary	0.570	-0.023
Education: Junior secondary	0.680	0.045
Education: Senior secondary	-0.682	0.000
Diploma/Bachelor	-0.213	0.042
No schooling	-0.305	0.000
Household dependents	-0.131	-0.004

Note: SMD < 0.1 indicates satisfactory balance.

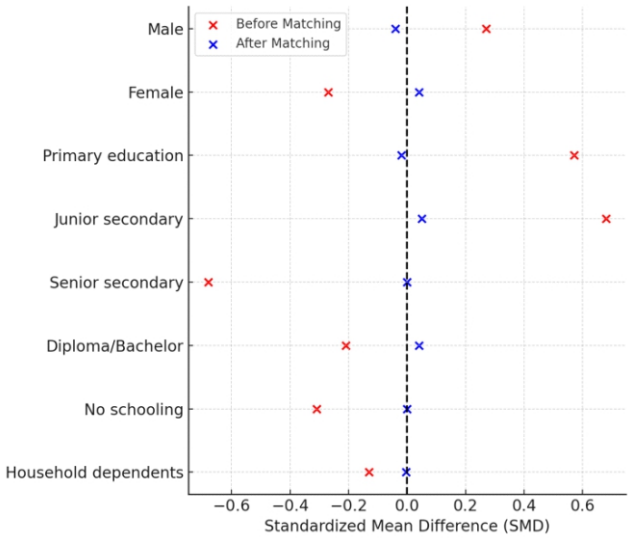

Figure 1 Standardized mean differences plot before and after matching (Red markers represent values before matching, while blue markers represent values after matching).

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balance between treatment and control groups was successfully achieved. Following trimming of observations with extreme propensity scores, the analytical sample consisted of 134 households (44 borrowers and 90 non-borrowers). With this balanced dataset, subsequent analyses of treatment effects can be interpreted more reliably, since differences in outcomes can be attributed to program participation rather than baseline disparities.

Livelihood outcomes The ATT was estimated for ten indicators representing the five livelihood capitals of the SLF. Table 3 compares borrowers and non-borrowers after matching and presents the estimated treatment effects. In general, the results indicate asymmetric outcomes: the financial capital exhibited the greatest and most consistent improvements, and the natural and physical capitals showed moderate but meaningful differences. In contrast, human and social capital revealed weaker or even negative effects of PTT. The detailed explanation of each indicator is provided in the following paragraphs.

The PTT program consistently improved financial capital. Borrowers were substantially more likely to rely on agriculture as their main income source (63% vs 44%), with a relative risk ratio of 3.83 (p-value = 0.005). At the same time, their reliance on trade was lower (11% vs 22%; RRR = 0.41, p-value = 0.033), while engagement in other sources such as wage labor or village-level positions increased (26% vs 34%; RRR = 2.14, p-value = 0.032). In addition, 73% of borrowers owned side businesses compared to 65% of non-borrowers, with an odds ratio of 2.45 (p-value = 0.024). Monthly income distributions also shifted upward: borrowers were 3.61 times more likely to fall into higher income brackets than non-borrowers (p-value = 0.001).

Indicators of human capital showed uneven results, and in some cases, unfavorable outcomes for borrowers. Training participation was markedly lower among borrowers, with only 43% attending, compared with 70% among non-borrowers. The estimated odds ratio was 0.43 (p-value = 0.029), indicating that borrowers had 57% lower odds of participating in training activities. Similarly, only 17% of borrowers reported adequate forestry skills, compared to 30% of non-borrowers, with an odds ratio of 0.02 (p-value < 0.001). Notably, borrowers who attended training reported significantly higher perceived benefits (0.61 vs 0.45 for non-borrowers; ATT = +0.31, p-value = 0.015).

Results for social capital were the weakest among the five capitals. Borrowers participated less frequently in farmer-group meetings, averaging 3.18 compared to 3.62 among non-borrowers (ATT = –0.44, p-value = 0.008). Perceived group support was slightly higher among borrowers (3.25 vs 3.06), but the difference was not statistically significant (ATT = +0.19, p-value = 0.157).

The estimated ATT for natural capital indicates that borrowers manage, on average, 3,850 m² more forest land

Table 3 Comparison of livelihood indicators between borrowers and non-borrowers after matching (n = 134)

Indicator	Borrowers (n = 44)	Nonborrowers (n = 90)	Effect (ATT/OR/RRR, 95% CI, Model)	*p-value*
Natural capital				
Forest land area (m²)	15,230 ± 6,812	11,380 ± 5,964	+3,850 (620–7,080), OLS	0.021**
Human capital				
Training participation (%)	43% (19/44)	70% (63/90)	OR = 0.43 (0.20–0.90), Logistic	0.029**
Perceived training benefit	0.61 ± 0.38	0.45 ± 0.41	+0.31 (0.06–0.56), OLS	0.015**
Adequate skills (%)	17% (7/44)	30% (27/90)	OR = 0.02 (0.00–0.10), Logistic	0.000***
Physical capital				
Infrastructure access	0.70 ± 0.33	0.45 ± 0.29	+0.32 (0.02–0.62), OLS	0.035**
Financial capital				
Main income: agriculture	63%	44%	RRR = 3.83 (1.50–9.80), Multinomial	0.005***
Main income: trade	11%	22%	RRR = 0.41 (0.18–0.93), Multinomial	0.033**
Main income: other	26%	34%	RRR = 2.14 (1.07–4.31), Multinomial	0.032**
Side business ownership (%)	73.2% (32/44)	64.9% (58/90)	OR = 2.45 (1.12–5.35), Ordinal Logit	0.024**
Monthly income (brackets)	Higher brackets	Lower brackets	OR = 3.61 (1.63–7.98), Ordinal Logit	0.001***
Social capital				
Group meetings (Likert 1–5)	3.18 ± 0.71	3.62 ± 0.68	-0.44 (-0.76 – -0.12), OLS	0.008***
Perceived group support (Likert 1–5)	3.25 ± 0.63	3.06 ± 0.59	+0.19 (-0.07–0.45), OLS	0.157

Note: * significance at α < 0.05; ** significance at α < 0.001; OR = odd ratio; RRR = relative risk ratio; CI = confident interval; OLS = ordinary least squares.

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than non-borrowers (15,230 m² compared to 11,380 m²). This implies that access to PTT was more feasible for households with stronger land endowments. Wider forest plots allow borrowers to manage tree harvest cycles better, diversify timber species, and secure ecological benefits, such as carbon storage.

Borrowers also exhibit a higher infrastructure access index than non-borrowers (0.70 vs. 0.45), corresponding to an ATT of approximately +0.32. This difference suggests that PTT households were more likely to be in areas with stronger connectivity, such as better road access or proximity to markets. The findings of natural and physical capitals between two groups may highlight an issue of inclusivity, in which natural and physical capitals were underrepresented among non-borrowers, even though they are often more vulnerable to income shocks.

Discussion

PTT as a liquidity-enhancing intervention: Insights from microcredit theory From the perspective of microcredit theory, the strongest and most consistent gains of PTT on financial capital are theoretically consistent with the role of credit in relaxing short-term liquidity constraints rather than inducing long-term structural change (Armendáriz & Morduch, 2010; Banerjee & Duflo, 2011). The observed increases in farming as a primary livelihood, side businesses, and higher income brackets suggest that PTT primarily functions as a consumption-smoothing and working capital instrument, enabling households to stabilize income flows and delay premature tree harvesting. Other studies (Listiyawan et al., 2022; Hailemicheal et al., 2024) observed similar results, where microcredit access supported income growth and improved financial resilience. However, microcredit theory also cautions that liquidity gains alone are insufficient to trigger durable income growth, especially when loans are not systematically invested in productive assets (Meager, 2019). Field observations indicate that not all borrowers invested loans in productive activities (Pambudi, 2025). A portion was used for immediate household consumption, such as education fees or ceremonies. While such expenditures provide short-term relief, they may limit long-term income improvements. Thailand's Tree Bank program demonstrates that when tree-based finance is embedded within community organizations, it can strengthen both financial and social capital simultaneously (Starfinger et al., 2023). For PTT, integrating loan access with farmer-group structures or cooperatives could help build stronger social cohesion and collective resilience.

Asymmetric capital effects under the SLF Within the SLF, livelihoods improve not through isolated gains in one capital, but through synergistic interactions across financial, human, social, physical, and natural capitals (Scoones, 1998; Ellis, 2000). The findings show clear asymmetry: financial capital improved substantially, while human and social capitals showed weaker or even negative effects. Borrowers were less likely to attend training, less confident in their technical skills, and less engaged in farmer-group meetings. At the same time, they reported greater benefits when they did attend training, suggesting that the relevance of training content was high, but access remained limited. The lower participation of the borrowers reflects limited access to training facilitation rather than low motivation. When training opportunities are available and attended, perceived benefits are high because the content is relevant and addresses practical needs related to forest management and household enterprises. This implies that, while participation rates were lower, borrowers recognized the training content's relevance and applicability more strongly.

These results highlight a structural weakness of credit-only interventions: while loans improve cash flow, they do not automatically build knowledge or strengthen collective action. Such asymmetry reflects the limitation of credit-only interventions: financial access does not automatically build human capital unless complemented by extension services. Evidence from Southeast Asia underscores that the combination of finance and extension is more effective in enhancing livelihood resilience and social network (van Toan et al., 2021). To enhance human capital, stronger linkages through forestry extension and skill development programs, such as Farmer Field School, are essential, although they may not consistently increase productivity or income.

Natural and physical capital: Selection effect and geographic bias The observed advantages of borrowers in terms of physical and natural capital require careful interpretation. Borrowers typically reported better access to infrastructure and owned larger forest plots than non-borrowers. Infrastructure plays a crucial role in lowering transaction costs, facilitating input supply, and improving access to credit institutions (Pouliquen, 1999). However, this advantage may also signal a geographic bias in program implementation. Farmers living in more remote or less accessible areas, who often face higher barriers to market integration, were less likely to participate. It may reflect program targeting and spatial selection processes, meaning that households located in areas with better connectivity and market access were more likely to be reached and included in the program. Also, the larger natural assets may allow them to derive greater ecological and market benefits; it may reflect pre-existing endowments rather than direct impacts of the loan. Such findings suggest that PTT, like other collateral-based credit schemes, is more accessible to wealthier households. Consequently, differences in physical and natural capital should be interpreted as pre-existing conditions shaping program entry, not as outcomes attributed to PTT participation.

Inclusivity and limits of tree collateral-based microcredit The findings highlight a broader structural concern, that is, PTT is more accessible to asset-rich smallholders, while smaller-scale farmers and more vulnerable households face significant barriers to participation and are less likely to benefit from the program. This is consistent with microcredit critiques emphasizing that collateralized schemes often reproduce existing inequalities by privileging households with larger landholdings and stronger institutional connections (Syamsu et al., 2019; Nugroho et al., 2022). From an SLF perspective, this pattern constrains livelihood transformation by reinforcing unequal access to financial capital and limiting opportunities for capital accumulation among poorer households. Smaller landholders—who are

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often more vulnerable to shocks—were less represented among borrowers. This pattern suggests that the program, although designed to ease liquidity constraints, tends to favor asset-rich farmers who can pledge larger areas of standing trees. This calls for adjustments in program design, such as introducing collective or group-based collateral systems, to ensure that smallholders also gain access to tree-collateral loans. Some studies suggest that group-based or collective collateral arrangements can mitigate such exclusion by pooling risk and lowering individual asset thresholds (Kugler & Opes, 2005).

PTT toward structural transformation Taken together, the results underscore that PTT operates primarily through a liquidity stabilization pathway, rather than a structural transformation pathway. PTT has been successful in delivering short-term liquidity relief and financial gains, but its developmental impact on other livelihood capital remains partial. Within SLF, structural transformation requires deliberate mechanisms that convert financial capital into human, social, and physical capital, supported by enabling institutions and collective action. Comparative evidence from other contexts reinforces this conclusion. Microfinance in Iran demonstrates stronger human and social capital outcomes where financial services are embedded in community organizations and accompanied by capacity-building initiatives (Tahmasebi & Askaribezayeh, 2021). In Vietnam, microfinance has improved collective knowledge, business experience, problem-solving skills, and members' willingness to support others (van Toan et al., 2021). International experiences, such as Thailand's Tree Bank, demonstrate that tree-collateral loans can simultaneously strengthen financial and social capital when embedded within collective institutions (Starfinger, 2021). These suggest that microfinance schemes without complementary support in training, extension, and group empowerment and improvements in human and social capital are unlikely to follow.

For Indonesia, the policy implication is clear: PTT should be conceptualized not as a stand-alone financial instrument, but as a component of a broader rural livelihood system. Linking loans with forestry extension, farmer group strengthening, and collective collateral mechanisms would enhance capital conversion and expand access for smaller landholders. Without such integration, PTT will remain effective in stabilizing livelihoods but limited in its capacity to drive long-term, inclusive, and sustainable transformation of smallholder forest-based livelihoods.

Conclusion

This study examined the livelihood impacts of the tree collateral loan (PTT) program on smallholder forest farmers in Gunungkidul, Yogyakarta, using propensity score matching and ATT estimation across five livelihood capitals. It concludes that, first, the findings confirm the role of PTT as an effective liquidity instrument that relaxes short-term credit constraints and reduces the need for premature tree harvesting, thereby aligning household financial stability with forest conservation objectives. Second, improved access to microfinance that enhances households' capacity to smooth consumption and invest in small-scale economic activities, does not automatically translate into broader improvements in human and social capital. The weak or negative outcomes observed for these capitals indicate that finance alone is insufficient to generate learning effects, skill accumulation, or collective action. Third, this finding contributes to the microfinance and sustainable livelihood literature by highlighting the limits of asset-based credit schemes in fostering multidimensional livelihood upgrading when they are implemented as stand-alone financial interventions. Fourth, the observed differences in natural and physical capital, specifically larger forest areas and better infrastructure access among borrowers, further emphasize the value of program design and targeting. These characteristics appear to reflect pre-existing endowments and eligibility conditions rather than program-induced change, suggesting that PTT currently favors farmers who are already relatively better positioned. Without deliberate corrective mechanisms, PTT risks reinforcing existing inequalities in access to microfinance and associated livelihood benefits.

Recommendation

In policy terms, these findings imply that PTT should be understood not as a comprehensive rural development instrument but as a foundational financial mechanism whose impacts depend critically on complementary interventions. To enhance its developmental and environmental effectiveness, PTT should be integrated with extension services, financial literacy programs, and initiatives to strengthen farmer groups. Embedding tree-collateral loans within collective platforms could help convert short-term liquidity gains into longer-term improvements in human and social capital while also lowering transaction costs and expanding access for smaller and more marginalized forest farmers. Finally, while Gunungkidul district provides a relatively mature and supportive institutional context for smallholder forestry in Indonesia, caution is required in generalizing the findings to regions with weaker governance structures or limited program outreach. Nevertheless, the positive financial capital outcomes observed in this study are consistent with evidence from microfinance programs elsewhere, suggesting that PTT's core liquidity function is likely transferable across contexts. Future research using longitudinal data would be particularly valuable in assesing whether sustained participation in PTT, when combined with complementary support, can generate dynamic changes in forest management practices and long-term livelihood resilience.

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Conflict of Interest

The authors declare that there is no conflict of interest related to the design, data collection, analysis, or publication of this article.

References

Abadie, A., & Cattaneo, M. D. (2018). Econometric methods for program evaluation. *Annual Review of Economics*, *10*(1), 465–503. https://doi.org/10.1146/annurev-economics-080217-053402

Angrist, J. D., & Pischke, J. -S. (2008). *Mostly harmless econometrics*. Princeton University Press. https://doi.org/10.2307/j.ctvcm4j72

Armendáriz, B., & Morduch, J. (2010). *The economics of microfinance*. MIT Press.

Austin, P. C. (2009). Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. *Statistics in Medicine*, *28*(25), 3083–3107. https://doi.org/10.1002/sim.3697

Austin, P. C., & Stuart, E. A. (2015). Moving towards best practice when using inverse probability of treatment weighting (IPTW) using the propensity score to estimate causal treatment effects in observational studies. *Statistics in Medicine*, *34*(28), 3661–3679. https://doi.org/10.1002/sim.6607

Banerjee, A. V., & Duflo, E. (2011). *Poor economics*: *A radical rethinking of the way to fight global poverty*. New York: Public Affairs.

Becker, S. O., & Ichino, A. (2002). Estimation of average treatment effects based on propensity scores. *The Stata Journal: Promoting Communications on Statistics and Stata*, *2*(4), 358–377. https://doi.org/10.1177/1536867X0200200403

Carney, D. (1999). *Livelihoods approaches compared: A brief comparison of the livelihoods approaches of the UK Department for International Development (DFID), CARE, Oxfam and the United Nations Development Programme (UNDP)*. London: Department for International Development.

Delvion, B. A., Permadi, D. B., & Marhaento, H. (2025). Fostering sustainable livelihood of the Saga indigenous community through conservation partnership in Kelimutu National Park, Nusa Tenggara Timur. *Jurnal Wasian*, *10*(02), 18–24. https://doi.org/10.62142/esswj444

Department for International Development. (1999). *Sustainable livelihoods guidance sheets*. Department for International Development.

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford University Press. https://doi.org/10.1093/oso/9780198296959.001.0001

Feder, G., Murgai, R., & Quizon, J. B. (2004). Sending Farmers Back to School: The Impact of Farmer Field Schools in Indonesia. *Review of Agricultural Economics*, *26*(1), 45–62. https://doi.org/10.1111/j.1467-9353.2003.00161.x

Greenhill, M., Walker, I., Mendham, D., & Permadi, D. (2017). West Kalimantan industrial plantation scheme: Twenty years on. *Forests, Trees and Livelihoods*, *26*(4), 215–228. https://doi.org/10.1080/14728028.2017.1320238

Hailemicheal, H. G., Senbeta, F., Tefera, T., & Seyoum, A. (2024). Rural household livelihood strategy, household reliance on forest goods, and its effect on protected area: Evidence from communities living adjacent to Kafta-Sheraro National Park, Tigray, Northern Ethiopia. *Journal of Agriculture and Food Research*, *17*, Article 101233. https://doi.org/10.1016/j.jafr.2024.101233

Kugler, M., & Oppes, R. (2005). Collateral and risk sharing in group lending: Evidence from an urban microcredit program.

Listiyawan, D., Syaukat, Y., & Falatehan, A. F. (2022). Pola pengelolaan hutan rakyat melalui program pinjaman tunda tebang di Kabupaten Wonogiri, Provinsi Jawa Tengah. *Forum Agribisnis*, *12*(1), 60–75. https://doi.org/10.29244/fagb.12.1.60-75

Lusiya, D. H., Darusman, D., & Nuryartono, N. (2020). Implementasi pinjaman tunda tebang hutan rakyat di Kabupaten Blora dan Kabupaten Wonosobo, Provinsi Jawa Tengah. *Jurnal Penelitian Sosial dan Ekonomi Kehutanan*, *17*(2), 117–135. https://doi.org/10.20886/jpsek.2020.17.2.117-135

Ma, L., Zhang, Y., Li, T., Zhao, S., & Yi, J. (2024). Livelihood capitals and livelihood resilience: Understanding the linkages in China's government-led poverty alleviation resettlement. *Habitat International*, *147*, Article 103057. https://doi.org/10.1016/j.habitatint.2024.103057

Meager, R. (2019). Understanding the average impact of microcredit expansions: A Bayesian hierarchical analysis of seven randomized experiments. *American Economic Journal*: *Applied Economics*, *11*(1), 5791.

Naderifar, M., Goli, H., & Ghaljaie, F. (2017). Snowball sampling: A purposeful method of sampling in qualitative research. *Strides in Development of Medical Education*, *14*(3), Article e67670. https://doi.org/10.5812/sdme.67670

Natarajan, N., Newsham, A., Rigg, J., & Suhardiman, D. (2022). A sustainable livelihoods framework for the 21st century. *World Development*, *155*, Article 105898. https://doi.org/10.1016/j.worlddev.2022.105898

Nugroho, B., Soedomo, S., & Dermawan, A. (2017). Policy effectiveness of loan for delaying timber harvesting for smallholder private forest in Indonesia. *Jurnal Manajemen Hutan Tropika*, *23*(2), 61–70. https://doi.org/10.7226/jtfm.23.2.61

Nugroho, E., Ihle, R., Heijman, W., & Oosting, S. J. (2022). The contribution of forest extraction to income diversification and poverty alleviation for Indonesian smallholder cattle breeders. *Small-Scale Forestry*, *21*(3), 417–435. https://doi.org/10.1007/s11842-022-09504-0

Oktoyoki, H., Windari, E. H., Pratama, B., & Ansiska, P. (2023). Post-permit social forestry: An analysis of the economic impact of the forestry revolving fund facility to the community of forest farmers. *E3S Web of Conferences*, *373*, Article 05007. https://doi.org/10.1051/e3sconf/202337305007

Pambudi, A.R. (2025). Kontribusi Pinjaman Tunda Tebang Terhadap Peningkatan Aset Penghidupan Petani dan Serapan Karbon Hutan Rakyat di Kabupaten Gunungkidul D. I. Yogyakarta. Tesis. Fakultas Kehutanan UGM.

Pouliquen, L. Y. (1999). *Rural infrastructure from a World Bank perspective: A knowledge management framework*. World Bank Publications. Retrieved from http://documents.worldbank.org/curated/en/160821468740106506

Resosudarmo, I. A. P., Tacconi, L., Sloan, S., Hamdani, F. A. U., Subarudi, Alviya, I., & Muttaqin, M. Z. (2019). Indonesia's land reform: Implications for local livelihoods and climate change. *Forest Policy and Economics*, *108*, Article 101903. https://doi.org/10.1016/j.forpol.2019.04.007

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41–55. https://doi.org/10.1093/biomet/70.1.41

Scoones, I. (1998). *Sustainable rural livelihoods: A framework for analysis*. IDS Working Paper, 72. Institute of Development Studies.

Scoones, I. (2009). The politics of global assessments: the case of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). *The Journal of Peasant Studies*, *36*(3), 547–571. https://doi.org/10.1080/03066150903155008

Starfinger, M. (2021). Financing smallholder tree planting: Tree collateral & Thai 'Tree Banks'–Collateral 2.0? *Land Use Policy*, *111*, Article 105765. https://doi.org/10.1016/j.landusepol.2021.105765

Starfinger, M., Tham, L. T., & Tegegne, Y. T. (2023). Tree collateral–A finance blind spot for small-scale forestry? A realist synthesis review. *Forest Policy and Economics*, *147*, Article 102886. https://doi.org/10.1016/j.forpol.2022.102886

Stuart, E. A. (2010). Matching methods for causal inference: A review and a look forward. *Statistical Science*, *25*(1), 1–21. https://doi.org/10.1214/09-STS313

Syamsu, I. F., Hardjanto, & Hero, Y. (2019). Delaying timber harvesting loan for smallholder private forest: Who accessing it? (Case study: Smallholder private forest in Bojonegoro). *Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan*, *9*(1), 114–127. https://doi.org/10.29244/jpsl.9.1.114-127

Tahmasebi, A., & Askaribezayeh, F. (2021). Microfinance and social capital formation- a social network analysis approach. *Socio-Economic Planning Sciences*, *76*, Article 100978. https://doi.org/10.1016/j.seps.2020.100978

Tran, D. B., Tran, H. T. M., Pham, T. D. N., & Nguyen, T. T. (2023). Education and agricultural household income: Comparative evidence from Vietnam and Thailand. *World Development Perspectives*, *29*, Article 100489. https://doi.org/10.1016/j.wdp.2023.100489

van Toan, D., Dinh Nghiep, N., & van Huan, N. (2021). The impacts of microfinance activities in developing human capital for sustainable livelihood in Duc Trong District, Lam Dong Province, Vietnam. *International Journal of Sustainable Development Research*, *7*(4), 76–84. https://doi.org/10.11648/j.ijsdr.20210704.12

Yamane, T. (1973). *Statistic: An introductory analysis*. Harper & Row.

Zhao, Y., & Li, M. (2020). Effect of water-saving society policy on water consumption in the cities of China: A propensity score matching analysis. *International Journal of Environmental Research and Public Health*, *17*(21), Article 8171. https://doi.org/10.3390/ijerph17218171