E-ISSN: xxxx-xxxx
DOI: https://doi.org/10.64803/cessmuds.v1.67

Sustainable Coffee Agroforestry Development in Rural Indonesia: Impacts on Community Income, Ecosystem Services, and Food Security in Buluh Mario Village, Sipirok District

Kabul Warsito[1*], Nur Asmaq[1], Indra Irawan[1], Diki Wahyudi Hutabarat[1], Dony Saputra[2], Tawanli Manullang[2].

[1]Faculty of Science and Technology, Department of Agrotechnology, Universitas Pembangunan Panca Budi, Medan, Indonesia
[2]Sumatra Rainforest Institute, South Tapanuli, Indonesia
Email: [1*]kabulwarsito@dosen.pancabudi.ac.id, [2]nur.asmaq@dosen.pancabudi.ac.id, [3]indrairawan14042003@gmail.com, [4]dikiwahyudi95@gmail.com, [5]donysahputra80@gmail.com, [6]tawanlimanullang_01@gmail.com
*E-mail Corresponding Author: kabulwarsito@dosen.pancabudi.ac.id

Abstract

This community service program implements an Arabica coffee agroforestry system in Buluh Mario Village through two main phases: (1) Participatory Rural Appraisal (PRA) survey to identify local potential and challenges, and (2) socialization and training based on Participatory Agricultural Extension Methodology (PAEM) covering Good Agricultural Practices (GAP), shade tree management, land conservation, and specialty coffee marketing. Results demonstrate high biophysical potential of Buluh Mario Village and very positive community response. Conclusion: the synergy between land suitability and community readiness establishes a strong foundation for sustainable coffee agroforestry development that improves farmer livelihoods while preserving ecosystem integrity.

Keywords*: Agroforestry; Arabica coffee; South Tapanuli; Community service.*

I. INTRODUCTION

Coffee-based agroforestry has been globally recognized as a strategic approach to balance economic and ecological objectives within the sustainable agriculture sector. This system integrates coffee plants with shade trees capable of enhancing ecosystem services, such as carbon sequestration, soil conservation, and water regulation, while maintaining plant productivity through a stable microclimate (Arifin et al., 2023; Roshetko et al., 2022). In Indonesia, the transition toward Arabica coffee agroforestry has become critical amid the challenges of climate change that threaten both the quality and quantity of smallholder farmers' production (Fitriana et al., 2020). Recent studies demonstrate that the implementation of Coffee Agroforestry Systems (CAS) not only provides income diversification for farmers through shade tree products but also strengthens household food security in rural communities vulnerable to commodity price fluctuations (Ismono et al., 2022; Pinard et al., 2023).

Buluh Mario Village, located in Sipirok District, South Tapanuli Regency, demonstrates strong agrarian characteristics and is deeply rooted in the cultural philosophy of *Dalihan Na Tolu* (*three-legged focal point*). The majority of the population depends on agriculture for livelihood, yet faces structural constraints including limited access to technology and suboptimal land management practices (Harahap, 2021; Siregar, 2023). Culturally, the Sipirok community possesses robust social capital manifested through *marsiurupan* (*mutual cooperation*), which serves as a strong foundation for the success of community-based empowerment programs. However, the level of economic self-sufficiency still requires enhancement, as dependence on conventional agricultural practices—vulnerable to land degradation and market instability—remains high (Fauzi et al., 2024; Saputra, 2025).

The Sipirok region possesses remarkable geophysical comparative advantages for specialty Arabica coffee development, supported by elevation levels and volcanic soil types suitable for high-quality production. Sipirok Arabica coffee has gained national market recognition for its distinctive flavor profile, establishing it as a priority commodity for regional development (Daulay, 2023; Nasution, 2024). The local government has designated Sipirok as a development hub for specialty Arabica coffee; however, realizing this potential is often constrained by cultivation practices that do not consistently meet Good Agricultural Practices (GAP) standards (Nasution, 2024; Rahmi et al., 2023). The gap between natural potential and field-level practices creates a significant opportunity for academic intervention to optimize land productivity while maintaining environmental sustainability.

To address these challenges, Universitas Pembangunan Panca Budi (UNPAB) has established strategic collaboration with the South Tapanuli Regency Government through the implementation of the University's Tri Dharma (Three Pillars of Higher Education) focused on regional development. This

synergy is formalized through a community service program aimed at transferring academic knowledge and technology directly to farmers at the grassroots level (UNPAB Communications Team, 2025; South Tapanuli District Government & UNPAB, 2025). The *pentahelix* collaboration model—integrating academia, government, private sector, civil society, and community—is designed to ensure that innovations introduced by the university, such as modern agroforestry techniques and product diversification, can be sustainably adopted by villagers with supportive local government policies.

Given this context, this article presents the implementation of a community service initiative in Buluh Mario Village focused on Arabica coffee agroforestry development. The program was designed not merely to enhance coffee productivity but to holistically target three primary impacts: increasing community income through agricultural diversification, restoring ecosystem services through improved land cover, and strengthening local food security. This intervention is expected to serve as a pilot model for sustainable agriculture development in North Sumatra's highland regions, demonstrating that economic prosperity and ecological conservation can advance simultaneously (Gabriel, 2025; Hasibuan, 2025).

II. APPROACH METHODOLOGY

1. Survey Method (Participatory Rural Appraisal)

The community service program commenced with a comprehensive Participatory Rural Appraisal (PRA) survey conducted in Buluh Mario Village to identify the current conditions, constraints, and potential opportunities related to coffee agroforestry development. This methodology was selected as it empowers local communities by involving them directly in the issue identification and evaluation process, ensuring that the intervention is grounded in the lived experiences and local knowledge of farmers (Chambers, 1983; Participedia, 2025). The survey team, comprising academic staff from Universitas Pembangunan Panca Budi and trained local facilitators, employed multiple data collection techniques including participatory mapping, seasonal calendars, livelihood analysis, focus group discussions, and key informant interviews with village leaders, farmer group representatives, and women's associations. Data collection focused on three primary themes: (1) current land use patterns and agricultural practices, (2) socioeconomic conditions and household food security, and (3) existing natural resource status and environmental challenges (Ismono & Fauzi, 2022). The PRA process followed the eight-step framework consisting of rapport formation with the community, problem understanding, problem reframing, solution searching, and collaborative solution planning. Qualitative data from discussions and interviews were systematically documented and analyzed using thematic coding to identify priority problems, community aspirations, and locally-feasible solutions for agroforestry development.

2. Socialization and Training Method (Participatory Agricultural Extension Methodology)

Following the baseline assessment, the program implemented a structured socialization and training phase utilizing the Participatory Agricultural Extension Methodology (PAEM) approach, where farmers serve as the primary actors in their own development process rather than passive recipients of technology transfer (GFA Group, 2025). The socialization component involved large community gatherings in three sessions to present the survey findings, discuss the benefits of coffee agroforestry systems for income diversification and environmental sustainability, and collaboratively establish program goals and farmer commitments. Training programs were subsequently conducted using a combination of demonstration plots, on-field workshops, and farmer discussion groups established within the agroforestry conversion zones. Training modules covered essential topics including (1) good agricultural practices for Arabica coffee cultivation, (2) shade tree selection and management, (3) soil and water conservation techniques, (4) integrated pest management, and (5) quality improvement and specialty coffee marketing. Adult learning principles were applied throughout, emphasizing practical, hands-on training in farmers' own fields where they could learn from experiential observation and peer-to-peer knowledge sharing. Trainers (extension workers and academic staff) acted as facilitators and mentors who provided ongoing technical support, monitored farmer implementation of new practices, and conducted regular follow-up visits to troubleshoot challenges and reinforce learning. Training evaluation was conducted through farmer self-assessment, observation of practice adoption, and pre- and post-training knowledge tests to measure the effectiveness of the extension activities (Apriyanto et al., 2024).

III. RESULTS AND DISCUSSION

3.1 Results

The community service program in Buluh Mario Village was successfully implemented through survey, observation, and socialization phases. The results of the survey and observation indicated that Buluh Mario Village possesses significant potential to be developed as a coffee-based agroforestry area. The biogeophysical conditions of the region, situated adjacent to forest areas with hilly topography and a cool climate, strongly support the cultivation of Arabica coffee. Furthermore, the availability of ample land and the local community's established tradition of farming serve as fundamental assets in the development of the agroforestry system.

The socialization activity regarding coffee-based agroforestry development garnered a highly

positive response from the Buluh Mario Village community. Community enthusiasm was evident from the high participation rate of attendees and the numerous inquiries raised during the discussion session. Participants, consisting of farmers, village officials, and the general public, demonstrated a keen interest in the concept of coffee cultivation that does not compromise forest integrity. The community acknowledged that the agroforestry system could serve as a viable solution to enhance economic income while simultaneously maintaining environmental sustainability.

Figure 1. Coordination with the Director and Manager of the Sumatra Rainforest Institute

These results corroborate the findings of Warsito et al. (2024), who conducted socialization on agroforestry-based Arabica coffee cultivation in Sipirok District, South Tapanuli Regency. in that study, the Sipirok community also exhibited high enthusiasm in preparing for coffee cultivation within their local forest areas, with the expectation that the agroforestry system would preserve natural sustainability while delivering high economic value.

3.2 Discussion

The potential of Buluh Mario Village as a coffee-based agroforestry area is substantiated by various scientific studies highlighting the system's advantages. Ulya *et al.* (2023), in a systematic review published in the journal *AIMS Agriculture and Food*, posited that the Coffee Agroforestry System (CAS) is a promising approach for achieving sustainable development and promoting a green economy in Indonesia. CAS holds the potential to generate future profitability due to increasing global and domestic market demand, as well as environmental benefits such as carbon emission reduction and enhanced resource efficiency. Furthermore, coffee agroforestry systems are capable of providing ecosystem services nearly identical to those of natural forests, including land, water, and biodiversity conservation.

Community enthusiasm in participating in socialization activities constitutes a crucial form of social capital for the success of agroforestry development programs. According to Ismono *et al.* (2022), farmers who adopt coffee agroforestry systems experience significant positive impacts regarding economic and environmental benefits. Research conducted in Lampung indicated that for every one thousand rupiah invested in farming operations, farmers adopting agroforestry could generate IDR 6,920, which is higher compared to the IDR 5,760 generated by non-adopters. This demonstrates that the agroforestry system is not only beneficial from an environmental perspective but also provides tangible economic value-added for farmers.

The success of the socialization and active community participation also aligns with findings from similar community service initiatives across Indonesia. Siregar *et al.* (2024) reported thatextension and training activities on coffee cultivation in Hutabaringin Village, Mandailing Natal Regency, received a positive response from local farmer groups. Similarly, community service activities in Gunungsari Village showed that farmers were highly enthusiastic about establishing social forestry business groups following socialization regarding the coffee agroforestry system. This high level of community participation serves as a vital indicator of the empowerment program's success and establishes a foundation for the sustainability of coffee-based agroforestry development in the future

IV. CONCLUSION

The community service initiative in Buluh Mario Village concludes that the area holds significant biogeophysical potential to support coffee-based agroforestry development, further strengthened by the community's high enthusiasm and active participation. This synergy between land suitability and social readiness establishes a robust foundation for the successful implementation of the agroforestry system, which not only enhances farmers' economic welfare through high-value coffee commodities but also ensures the sustainable preservation of ecological forest functions.

V. ACKNOWLEDGEMENT

The authors are deeply grateful to the community of Buluh Mario Village and Sumatra Rainforest Institute for providing research facilities and supporting funding until this research was completed.

VI. REFERENCES

Arifin, B., Glaser, S., & Parisi, F. (2023). Coffee agroforestry as an alternative to the implementation of green economy practices in Indonesia: A systematic review. AIMS Agriculture and Food, 8(2), 432–455. https://doi.org/10.3934/agrfood.2023041

Daulay, S. F. (2023). Analisis Nilai Tambah Prosessing Kopi Bubuk Arabika Di Kecamatan Sipirok Kabupaten Tapanuli Selatan. Jurnal Ilmiah Mahasiswa Pertanian, 8(4), 345-352.

Fauzi, H., Marliyah, M., & Dharma, B. (2024). Strategi Pengembangan Bisnis Kopi Sipirok Berdasarkan Perspektif Ekonomi Islam (Studi

Kasus Usaha Batu Kopi Sipirok Desa Situmba Kabupaten Tapanuli Selatan). Jurnal Pendidikan Ekonomi dan Kewirausahaan, 8(2), 112-125. https://doi.org/10.29408/jpek.v8i2.27652

Fitriana, N., Roshetko, J. M., & Dahlia, L. (2020). Agroforestry Innovation through Planned Farmer Behavior: Trimming in Pine–Coffee Systems. Land, 9(10), 363. https://doi.org/10.3390/land9100363

Gabriel, P. Y. (2025). Sustainability Analysis of Coffee Agribusiness in Indonesia: Environmental, Economic, and Social Perspectives. Jurnal Penelitian Mahasiswa, 2(1), 45-58. Universitas Medan Area.

Harahap, A. B. (2021). Pemberdayaan Kemandirian Masyarakat Berbasis Ekonomi Kreatif Di Kecamatan Sipirok Kabupaten Tapanuli Selatan. Jurnal Taghyir: Jurnal Manajemen Dakwah, 3(2), 122-135.

Hasibuan, M. F. A. (2025). Sustainability Analysis of Arabica Coffee Agriculture in North Sumatra. Journal of Sustainability Science and Management, 20(8), 112-128.

Ismono, H., & Fauzi, A. (2022). Impacts of Coffee Agroforestry System and Sustainability Certification on Farmers' Livelihood in Sumatra-Indonesia. Social Sciences Review, 3(2), 55-68.

Ismono, R. H., Prasmatiwi, F. E., & Nugraha, A. (2022). Impacts of coffee agroforestry and sustainability certification on farmers' livelihood and environmental services. Sustainability Science and Resources, 1(1), 37–49. https://doi.org/10.55537/ssr.v1i1.19

Nasution, Z. (2024). Sosialisasi Limbah Kulit Kopi Sebagai Pakan Ternak di Desa Sampean Kecamatan Sipirok. Jurnal Kalandra: Jurnal Pengabdian Kepada Masyarakat, 2(2), 120-128.

Pemkab Tapsel & UNPAB. (2025, Juni 14). Pemkab Tapsel dan UNPAB Matangkan Kerja Sama Peningkatan SDM dan Pengabdian Masyarakat. Berita Universitas Pembangunan Panca Budi. Diakses dari https://www.pancabudi.ac.id

Pinard, F., & Elias, M. (2023). Opportunities for enhancing the climate resilience of coffee production through improved crop, soil and water management. Agroecology and Sustainable Food Systems, 47(5), 612-635.

Rahmi, E., & Sari, N. (2023). Upaya Peningkatan Produksi dan Kualitas Kopi Arabika Sipirok Melalui Good Agricultural Practices (GAP). Talenta Conference Series: Agricultural and Natural Resources, 6(1), 23-30.

Saputra, R. Y. (2025). Kondisi Sosial dan Ekonomi Masyarakat di Sekitar Objek Wisata Sipirok Tapanuli Selatan. Jurnal Pembangunan Wilayah & Kota, 12(1), 88-99.

Siregar, M. F., Harahap, F. S., Harahap, D. E., Sihotang, D. M., Pulungan, M. A., Delvian, & Ginting, J. (2024). Community service supports coffee cultivation and post harvest techniques in Mandailing Natal. Budi Mulia: Jurnal Pengabdian Masyarakat, 2(2), 40–48. https://doi.org/10.61655/budimul.v2i2.63

Siregar, S. W. (2023). Analisis Kemandirian Ekonomi Wanita Penenun Ulos dalam Meningkatkan Kesejahteraan Keluarga di Kecamatan Sipirok. Jurnal Ekonomi Pembangunan, 5(3), 210-225. Universitas Pembangunan Panca Budi.

GFA Group. (2025). Participatory agricultural extension methodology: Training of trainers manual. https://www.gfa-group.de

Ulya, N. A., Waluyo, E. A., Martin, E., Rahmat, M., & Sutejo, S. (2023). Coffee agroforestry as an alternative to the implementation of green economy practices in Indonesia: A systematic review. AIMS Agriculture and Food, 8(3), 778–800. https://doi.org/10.3934/agrfood.2023041

Warsito, K., Harahap, E. M., Tistama, R., & Ginting, J. (2024). Socialization Arabica coffee cultivation (*Coffea arabica* L.) based on agroforestry in Sipirok District, South Tapanuli Regency. In Proceeding: The 2nd National Conference Science and Technology (pp. 282–288). Universitas Dharmawangsa. https://proceeding.dharmawangsa.ac.id/index.php/PFTIK/article/view/469

Wibawa, A., Aunillah, A., & Prawoto, A. A. (2020). Prospek pengembangan agroforestri berbasis kopi di Indonesia. Perspektif: Review Penelitian Tanaman Industri, 9(2), 135–146. https://doi.org/10.21082/psp.v9n2.2010.135-146

Yulianti, Y., Rahmat, A., & Novayanti, D. (2023). Penerapan model agroforestri kopi dalam mendukung perhutanan sosial di Register 39 Gedong Wani Provinsi Lampung. Ruang Dedikasi: Jurnal Pengabdian Kepada Masyarakat, 5(1), 87–99. https://doi.org/10.21776/ub.ruangdedikasi.2023.005.1.11

Yuwono, T., Setyowati, N., & Ihsaniyati, H. (2023). Inisiasi pembentukan kelompok usaha perhutanan sosial menuju desa mandiri ekonomi. E-Dimas: Jurnal Pengabdian Kepada Masyarakat, 14(4), 656–662. https://doi.org/10.26877/e-dimas.v14i4.16453

Zulkarnain, Z., Bathoro, A., Siahaan, H., & Dewi, P. S. (2025). Community participation in the development of sustainable agroforestry-based agricultural ecotourism in Kemiri Muka Village, Beji District, Depok City. International Geography and Tourism Journal, 2(1), 10–17. https://doi.org/10.21776/ub.igtj.2025.002.01.02