

Technological and Digital Transformation for Sustainable Coffee Farming in Rural North Sumatra

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ABSTRACT

This Community Partnership Program (PKM) aims to enhance the productivity and self-reliance of coffee farmers through the implementation of appropriate technology and digital marketing innovation. The program was carried out with the Sadar Ingin Maju Farmers Group in Salak II Village, Salak District, Pakpak Bharat Regency. The activities focused on three main areas: applying a coffee bean hulling machine to improve post-harvest efficiency, utilizing coffee waste as organic fertilizer and livestock feed, and developing digital marketing strategies through online platforms. The results showed increased production efficiency, reduced organic waste, and expanded market reach. This program has proven effective in empowering farmers toward sustainable coffee agribusiness with higher added value.

INTRODUCTION

Indonesia is widely recognized as one of the world's leading coffee-producing countries, with a remarkable diversity of varieties and flavors influenced by its geographical and climatic conditions. Pakpak Bharat Regency, particularly Salak II Village, has significant potential for developing Arabica coffee due to its highland topography and favorable soil characteristics (Land et al., 2023). However, the productivity and economic value of coffee in this area remain relatively low. The main challenges faced by farmers include manual post-harvest processing, underutilized coffee waste management, and limited access to digital marketing channels (Tarigan, Budi, & Tarmadja, 2023).

Traditional methods of peeling coffee cherries result in low efficiency and inconsistent quality of the beans. Therefore, the implementation of coffee bean hulling machines serves as an essential innovation to improve production capacity and reduce processing time (Jufri, Sulfiana, Lamba, & Makassar, 2022). Meanwhile, the coffee husks generated during processing can be converted into organic fertilizer and animal feed through bioconversion, which has been proven to enhance Arabica seedling growth and reduce environmental pollution (Darliana, Wilujeng, & Wahyuni, 2025; Indonesia & Tahun, 2024).



Figure 1. The Head of the Community Service Team and the Head of the Farmer Group

Furthermore, coffee pulp and grounds can be utilized as alternative raw materials for fish feed due to their relatively high fiber and protein content (Articles et al., 2022; Juwita et al., 1995). This approach not only adds economic value for farmers but also supports the creation of a sustainable circular agricultural system.

Equally important is the enhancement of marketing strategies through digital technology. The implementation of social media marketing, online campaigns, and content-based promotion has been shown to effectively increase brand awareness and consumer interest in local coffee products (Anim & Putu, 2020; Soedarto, Nugroho, & Adriansyah, n.d.). By adopting digital marketing, coffee farmers are expected to expand their market reach and enhance the economic value of their products.

Through this Community Partnership Program (PKM), the service team aims to empower coffee farmers through three main initiatives: the implementation of coffee bean hulling machines for efficient post-harvest processing, the utilization of coffee waste into fertilizer and animal feed, and the digitalization of coffee marketing to improve product competitiveness. This program is expected not only to enhance the farmers' technical capacity but also to strengthen their economic independence and support sustainable agricultural development in Pakpak Bharat Regency (Harun, Hamni, & Ibrahim, 2021; Rahmat & Mirnawati, 2020).

IMPLEMENTATION AND METHODS

This Community Partnership Program (PKM) was implemented in the "Sadar Ingin Maju" Farmer Group, located in Salak II Village, Salak District, Pakpak Bharat Regency, North Sumatra Province. The implementation method adopted a participatory, educational, and applicative approach to ensure that farmers were actively involved in every stage of the activity.

Preparation Stage

A preliminary field survey was conducted to assess the farmers' needs and capacities. The service team coordinated with village officials and the farmer group to determine the activity schedule, location, and implementation scheme.

Table 1. Training, Technology Implementation, and Mentoring Activities

No	Activity
1	Training and mentoring partners in using the coffee bean peeler machine
2	Training and mentoring partners in processing coffee bean waste into fertilizer and animal feed
3	Training and mentoring partners in utilizing marketplaces and e-commerce platforms such as Shopee

Training and Technology Transfer

Farmers received training on the operation and maintenance of the coffee bean hulling machine designed by the team (Jufri et al., 2022). Additional training was provided on coffee waste utilization through bioconversion to produce organic compost and animal feed (Darliana et al., 2025; Indonesia & Tahun, 2024).

Field Implementation Stage

The hulling machine was operated directly by the farmers to process harvested coffee cherries. The resulting coffee husks were collected and processed into organic fertilizer and alternative fish feed (Articles et al., 2022; Juwita et al., 1995).



Figure 2. Coffee Bean Peeling Machine

Digital Marketing Stage

The team facilitated the creation of social media accounts and digital product catalogs, and trained the farmers in online promotion using content strategies and social media marketing campaigns to enhance brand awareness (Anim & Putu, 2020; Soedarto et al., n.d.).

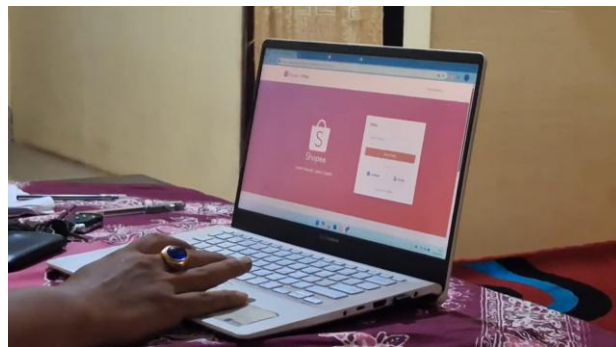


Figure 3. Marketplace Account Creation

Evaluation and Monitoring

Evaluation was carried out by comparing productivity levels before and after the program, as well as observing the level of technology adoption. Program success was measured through improvements in technical capability, post-harvest efficiency, and expansion of marketing networks.

This implementation method is expected to establish a sustainable empowerment model for coffee farmers, focusing not only on productivity improvement but also on value addition and local economic sustainability (Harun et al., 2021; Tarigan et al., 2023).

RESULTS AND DISCUSSION

The implementation of the Community Partnership Program (PKM) in Salak II Village, Salak District, Pakpak Bharat Regency, was successfully carried out with active participation from members of the Sadar Ingin Maju Farmer Group. The outcomes indicate significant improvements in three key areas: post-harvest efficiency, coffee waste utilization, and digital marketing capability.

Improvement in Post-Harvest Efficiency

Before the program, the coffee hulling process was done manually, taking about 6–8 hours to process 50 kg of coffee cherries. After introducing the 120 kg/hour coffee hulling machine, the processing time was reduced to just one hour for the same quantity (Jufri et al., 2022). This not only improved efficiency but also minimized bean damage during the hulling process.



Figure 4. Marketplace Account Creation

Such improvement directly increased farmers' productivity and income. As stated by Harun et al. (2021), the application of a clean and integrated production system in coffee processing can sustainably enhance competitiveness and product quality.

Utilization of Coffee Husk Waste

Coffee husks that were previously discarded are now converted into organic fertilizer and animal feed through a bioconversion process. According to Darliana et al. (2025), coffee husks contain nutrients that enhance soil fertility and promote the growth of coffee seedlings. Similarly, Articles et al. (2022) emphasized the potential of coffee husks and grounds as alternative feed ingredients due to their protein and fiber content.

With the provided training, farmers managed to produce around 30–40 kg of compost from every 100 kg of coffee husk waste, which was then reused in their coffee plantations. This practice not only reduced waste but also decreased dependency on chemical fertilizers.



Figure 5. Results of Coffee Peeling and Waste

Digitalization and Value Addition

In terms of marketing, farmers were trained to use social media and digital catalogs for product promotion. This activity followed strategies outlined by Anim and Putu (2020) and Soedarto et al. (n.d.), highlighting the importance of digital campaigns for building brand awareness and consumer loyalty. After the training, the farmer group successfully created business accounts on Instagram and Facebook to promote their roasted and ground coffee products. These efforts expanded their market reach beyond Pakpak Bharat.

Overall, the PKM program significantly enhanced the technical, managerial, and digital competencies of local coffee farmers. These outcomes are consistent with Tarigan et al. (2023), who found that coffee productivity in North Sumatra can be increased through the integration of technology, business management, and sustainable marketing strategies.



Figure 6. Group Photo of the Community Service Team and Partners

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Community Partnership Program (PKM) implemented in Salak II Village, Salak District, Pakpak Bharat Regency, has shown a significant positive impact on the empowerment and self-sufficiency of local coffee farmers. The introduction of a 120 kg/hour coffee hulling machine effectively improved post-harvest efficiency and productivity. Meanwhile, the conversion of coffee husks into fertilizer and livestock feed created additional economic value and supported the principle of sustainable agriculture.

Moreover, the digital marketing training encouraged farmers to utilize social media as a platform for product promotion and market expansion, enhancing the visibility and competitiveness of local coffee products from Pakpak Bharat. Overall, this PKM initiative demonstrates that technology-based empowerment and digital innovation can strengthen rural economies while promoting environmental sustainability through agricultural waste utilization.

Recommendations

- a. Further technical training is recommended to improve machine maintenance and develop derivative coffee products.
- b. Local governments and universities should continue mentoring and monitoring to ensure program sustainability.
- c. Farmer groups are encouraged to establish partnerships with coffee industry stakeholders and e-commerce platforms to broaden market reach.
- d. Future research should focus on optimizing the composition of animal feed and organic fertilizer derived from coffee waste to maximize their effectiveness and economic benefit.

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