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Extension Program Design for Processing Coffee Leaves into Coffee Leaf Tea in Sampean Village, Sipirok District, South Tapanuli Regency

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Abstract

Coffee leaves obtained through selective picking before coffee plant pruning in Sampean Village, Sipirok District, South Tapanuli Regency, remain underutilized despite their potential to be processed into coffee leaf tea with added economic value. This study aimed to evaluate the suitability of an agricultural extension program design, assess coffee growers' acceptance of the program, and determine changes in their knowledge and attitudes toward coffee leaf utilization. An evaluative research design with a quantitative descriptive approach was employed from April to May 2026. The study involved 66 coffee growers from seven farmer groups, with the sample size determined using the Slovin formula and participants selected through proportional stratified random sampling. Data were collected through observation, interviews, questionnaires, and documentation and analyzed using Likert scales, continuum analysis, and the normalized gain (N-Gain) test. The extension program comprised instructional materials on coffee leaf tea processing, lectures, practical demonstrations, discussions, printed folders, authentic tools and materials, and tutorial videos. The findings show that growers' acceptance of the extension

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design reached 85.65%, indicating a very high level of acceptance. Their knowledge increased from 63.4% on the pre-test to 91.4% on the post-test, with an N-Gain score of 76.7%, categorized as high. Growers' attitudes toward the innovation reached 88.45%, reflecting a very positive response. The study concludes that the extension program design was highly accepted and effective in improving growers' knowledge and attitudes toward processing coffee leaves into coffee leaf tea. These findings provide practical implications for agricultural extension agencies and farmer groups seeking to promote the productive use of coffee by-products, strengthen innovation adoption, and create additional economic opportunities for coffee-growing communities.

Keywords: Agricultural Extension; Coffee By-Products; Coffee Growers; Coffee Leaf Tea; Innovation Adoption

INTRODUCTION

Coffee (*Coffea* sp.) is one of the most important plantation commodities cultivated extensively in tropical regions worldwide, including Indonesia. The commodity plays a strategic role in the agricultural sector due to its broad cultivation area, economic contribution, and significant involvement in supporting rural livelihoods. Indonesia is recognized as one of the largest coffee-producing countries globally, ranking fourth after Brazil, Vietnam, and Colombia. This position indicates that coffee has substantial potential for further development, not only through increasing production capacity but also through optimizing the utilization of various parts of the coffee plant that remain underutilized (Amanda & Rosiana, 2023). The increasing demand for coffee products in both domestic and international markets has encouraged efforts to strengthen coffee development from upstream production activities to downstream processing innovations.

According to the Indonesian Central Bureau of Statistics, the national coffee plantation area in 2025 reached approximately 1,275,900 hectares with total production of 832,700 tons. Coffee production is predominantly concentrated in Sumatra, particularly in South Sumatra, Lampung, Aceh, and North Sumatra, which contribute significantly to national coffee production. These conditions demonstrate that Indonesia possesses considerable potential as a coffee-producing country, supported by extensive plantation areas and suitable agroecological conditions. Among coffee-producing provinces, North Sumatra

represents one of the important production centers with considerable opportunities for improving coffee productivity and developing derivative products from coffee plants.

The development potential of coffee cultivation in North Sumatra is distributed across several regencies, including Dairi, North Tapanuli, Humbang Hasundutan, Simalungun, Karo, and South Tapanuli. These areas collectively contribute to coffee production with diverse geographical characteristics and cultivation systems (Badan Pusat Statistik Sumatera Utara, 2025). South Tapanuli Regency has favorable conditions for coffee cultivation due to its varied altitude and climatic suitability, with elevations ranging from 0 to 1,985 meters above sea level. Among the coffee-producing areas in this regency, Sipirok District represents one of the major production centers, with a coffee plantation area of 2,283 hectares and production reaching 2,343.21 tons (Badan Pusat Statistik Tapanuli Selatan, 2025). The high production potential in this area indicates the availability of abundant coffee biomass resources, including agricultural residues generated from cultivation activities.

Coffee cultivation activities involve various maintenance practices, including pruning and plant rejuvenation, which generate substantial amounts of organic residues, particularly coffee leaves. These residues are commonly considered waste materials and are frequently left unmanaged in plantation areas. Although coffee leaf waste has potential as a source of organic material, improper management may create environmental and plant health problems. Accumulated wet and humid coffee leaves can provide favorable conditions for the development of pathogenic fungi associated with coffee diseases, including *Cercospora coffeicola*, *Hemileia vastatrix*, *Capnodium coffeicola*, and *Fusarium* sp. (Nadila et al., 2025). Therefore, ineffective management of coffee leaf waste not only reduces the potential economic value of agricultural residues but may also negatively influence plantation sustainability.

The accumulation of agricultural waste reflects the need for alternative utilization strategies that transform waste materials into valuable products. Agricultural waste management through value-added processing has become an important approach to supporting environmental sustainability while improving economic benefits for farming communities. The utilization of coffee leaf waste provides an opportunity to develop innovative products because coffee leaves contain bioactive compounds with potential health benefits. Maghfuri (2023) explains that agricultural waste can be transformed into useful products that contribute to economic improvement and environmental management.

Therefore, coffee leaf waste should no longer be viewed merely as an unwanted residue but as a potential agricultural resource that can be developed through appropriate processing technologies.

One potential innovation in utilizing coffee leaf waste is processing fresh coffee leaves into herbal beverages, particularly coffee leaf tea. Coffee leaves contain several bioactive compounds, including flavonoids, phenolic compounds, tannins, steroids, saponins, and alkaloids, which are associated with antioxidant, antimicrobial, and health-supporting activities. These compounds indicate that coffee leaves have functional potential beyond their conventional role as plantation residues. Furthermore, coffee leaf tea has received increasing attention as an alternative natural beverage because it provides a different utilization pathway for coffee plants while supporting the diversification of agricultural products.

Previous studies have demonstrated the feasibility of processing coffee leaves into tea products. Lazuardina et al. (2022) reported that community-based processing of coffee leaf waste into health beverages could improve public awareness regarding the economic value of coffee leaf residues. Similar findings were reported by Masyadi et al. (2024), who showed that training activities on producing coffee leaf tea bags improved participants' ability to produce marketable products. Santoso et al. (2025) also found that innovation-based training on herbal coffee leaf tea increased community understanding and practical skills in processing coffee leaves. These studies indicate that coffee leaf utilization has considerable potential to be developed through agricultural extension activities.

However, despite the availability of coffee leaf resources and evidence regarding its processing potential, the utilization of coffee leaf waste among coffee farmers in Sipirok District remains limited. Based on preliminary identification of regional potential conducted with agricultural extension officers, coffee farmers in Sampean Village, Sipirok District, still demonstrate relatively low knowledge and attitudes regarding coffee leaf waste utilization. Most farmers continue to perceive coffee leaves as agricultural residues rather than potential raw materials for value-added products. This condition indicates that the main challenge is not the availability of raw materials but the limited understanding, acceptance, and readiness of farmers to adopt coffee leaf processing innovations.

Agricultural extension has an important role in addressing this problem because it functions as an educational process that facilitates behavioral change among farmers.

According to the Ministry of Agriculture Regulation No. 27 of 2023, agricultural extension is a learning process designed to enable farmers and agricultural actors to access information, technology, resources, and market opportunities to improve productivity, efficiency, income, and environmental awareness. Therefore, extension activities related to coffee leaf utilization need to be designed systematically by considering farmers' characteristics, local conditions, and learning requirements.

The effectiveness of agricultural extension depends not only on the delivery of information but also on the suitability of extension components, including materials, methods, media, volume, location, timing, and cost. Identification of regional potential becomes an essential foundation in designing extension programs because each agricultural area has different characteristics and development opportunities. Suryono et al. (2022) emphasized that participatory approaches such as Rapid Rural Appraisal (RRA) are useful for identifying local potential and agricultural problems as the basis for developing appropriate extension strategies. Through this approach, extension programs can be designed according to actual conditions and farmers' needs.

Based on these conditions, researchers argue that the development of an extension design for coffee leaf waste utilization is necessary to encourage farmers in Sampean Village to recognize the economic and environmental potential of coffee leaves. The extension program is expected not only to increase farmers' knowledge but also to improve their attitudes toward adopting coffee leaf processing innovations. A well-designed extension approach can serve as a bridge between agricultural resources available in the field and the ability of farmers to transform these resources into economically valuable products.

Previous studies related to coffee leaf waste utilization have generally focused on product development, community training, and improvement of practical skills. Research conducted by Masyadi et al. (2024) demonstrated that training activities on transforming coffee leaf waste into tea products could improve participants' ability to produce tea bags with commercial potential. The study emphasized the importance of practical assistance in developing community skills, particularly in processing agricultural waste into value-added products. However, the study primarily focused on the implementation of training activities and product outcomes, while the systematic design of agricultural extension components was not discussed comprehensively.

Furthermore, Santoso et al. (2025) investigated the innovation of herbal tea production from coffee leaf waste through educational activities, practical training, and post-activity evaluation. The findings indicated that participants gained better understanding regarding the benefits of herbal coffee leaf tea and improved their ability to process coffee leaves into functional beverages. Although this research provided evidence regarding the potential of coffee leaf utilization, it did not specifically analyze the planning aspects of extension programs, such as determining appropriate materials, methods, media, location, time, and cost based on farmer characteristics.

Another study conducted by Lestari et al. (2025) examined the improvement of farmer motivation through participatory extension activities for coffee leaf waste utilization. The study found that demonstrations, direct practices, and supporting learning media such as presentations and leaflets could increase farmers' motivation and understanding. However, the research mainly emphasized changes in motivation and knowledge after extension activities without developing a comprehensive extension design that could be adopted as a structured guideline for future implementation.

Research by Lazuardina et al. (2022) also showed that direct demonstrations of coffee leaf processing could increase community knowledge and awareness regarding the economic potential of coffee leaf waste. The study confirmed that coffee leaf waste could be processed into health beverages with economic value. Nevertheless, the research was conducted within a community empowerment framework and did not specifically examine the relationship between extension planning components and farmers' acceptance toward the proposed extension design.

Similarly, Prabowo and Hadi (2025) reported that empowerment-based extension activities could encourage communities to process coffee leaves into herbal tea products with economic value. The research highlighted the importance of community participation in developing local economic activities. However, there remains limited discussion regarding how extension programs should be designed systematically by considering farmers' needs, local conditions, and behavioral aspects before implementation.

Based on previous studies, it can be identified that research regarding coffee leaf waste utilization has mostly focused on processing techniques, training effectiveness, and community empowerment outcomes. These studies provide valuable evidence regarding the feasibility of coffee leaf tea development; however, they have not extensively examined the

planning stage of agricultural extension as an essential factor in ensuring successful innovation adoption. This condition represents a research gap, as the availability of processing technology alone does not guarantee that farmers will adopt and continue implementing the innovation. Farmer acceptance, understanding, and attitudes toward innovation must also be considered through an appropriate extension planning approach.

The research gap addressed in this study lies in the limited availability of studies that develop a comprehensive agricultural extension design specifically for utilizing coffee leaf waste into coffee leaf tea based on local conditions in coffee-producing areas. Previous research has demonstrated the potential of coffee leaf processing, but fewer studies have examined how extension components should be arranged systematically to meet farmer characteristics and regional conditions. Therefore, this study attempts to fill this gap by developing an extension design that integrates technical information on coffee leaf tea processing with appropriate extension strategies.

The novelty of this research is reflected in the development of a contextual agricultural extension design for coffee leaf waste utilization in Sampean Village, Sipirok District, South Tapanuli Regency. Unlike previous studies that mainly evaluated training outcomes after implementation, this research emphasizes the formulation and evaluation of an extension design consisting of materials, methods, media, volume, location, timing, and cost. The proposed design is developed based on regional potential identification and farmer conditions, allowing the extension program to be more relevant, applicable, and responsive to local agricultural characteristics.

The development of this extension design is supported by the concept that agricultural extension functions as a process of behavioral change through education, communication, and empowerment. Farmers' knowledge and attitudes are important indicators in measuring the effectiveness of extension activities because knowledge influences farmers' understanding of innovation, while attitudes determine their willingness to accept and implement new practices. Nurdayati et al. (2021) stated that knowledge improvement represents an important stage in behavioral change because it provides the cognitive foundation required for decision-making among farmers.

In addition to knowledge, farmer attitudes play a significant role in innovation adoption. Positive attitudes toward agricultural innovation encourage farmers to recognize benefits, develop confidence, and consider implementation in their farming activities. Irdiana

et al. (2023) explained that changes in farmer attitudes are important indicators of successful extension because attitudes reflect the level of acceptance toward introduced innovations. Therefore, the extension design in this study does not merely focus on knowledge transfer but also considers efforts to develop positive farmer perceptions toward coffee leaf waste utilization.

The selection of appropriate extension methods and media is another important aspect in supporting farmer understanding and acceptance. Extension methods such as lectures, discussions, and demonstrations provide different learning experiences that influence how farmers receive information. Demonstration methods are particularly relevant for introducing coffee leaf tea processing because farmers can directly observe and practice each stage of production. Pulungan & Lestari (2025) explained that demonstration methods are effective in improving farmers' skills because participants are involved in direct observation and practical learning processes.

Extension media also contribute to improving communication effectiveness between extension agents and farmers. The use of printed materials, audiovisual media, and actual objects can support farmers in understanding both conceptual and technical aspects of innovation. Azuz et al. (2024) stated that appropriate extension media assist the delivery of information by stimulating farmers' senses and improving message retention. Therefore, the extension design developed in this research combines printed media, audiovisual materials, and real objects to provide a more comprehensive learning experience.

The implementation of agricultural extension also requires consideration of operational factors, including extension volume, location, time, and cost. These components determine whether the planned activity can be implemented effectively according to farmers' conditions. The selection of appropriate locations and schedules is particularly important because farmers' participation is influenced by accessibility and compatibility with their agricultural activities. Febrian et al. (2025) emphasized that farmer participation is a crucial factor in extension success, making location selection an important consideration in extension planning.

The evaluation of extension design is also necessary to determine whether the planned program meets farmers' expectations and conditions. Evaluation provides information regarding the suitability of extension components and becomes a basis for improving future activities. According to the Ministry of Agriculture Regulation No. 03 of

2018, extension evaluation is conducted systematically to assess the effectiveness of materials, methods, and media while supporting continuous improvement in agricultural extension implementation.

Based on the identified problems, research gaps, and theoretical considerations, this study focuses on designing an agricultural extension program for utilizing coffee leaf waste into coffee leaf tea in Sampean Village, Sipirok District, South Tapanuli Regency. The objectives of this research are to analyze the appropriate extension design components, evaluate farmer acceptance toward the proposed extension design, and analyze farmers' knowledge and attitudes regarding the utilization of coffee leaf waste as coffee leaf tea. Through this approach, the research is expected to contribute to the development of sustainable agricultural waste management strategies and provide a practical reference for agricultural extension officers in promoting value-added utilization of coffee plantation residues.

METHODS

This research was conducted from April to May 2026 in Sampean Village, Sipirok District, South Tapanuli Regency, North Sumatra Province, Indonesia. The research location was selected purposively based on objective and subjective considerations. From an objective perspective, Sampean Village was selected because it represents one of the largest coffee plantation areas and coffee-producing regions in Sipirok District, resulting in abundant coffee leaf resources that have the potential to be further utilized. From a subjective perspective, the selection of the research site was based on the suitability between the characteristics of the area and the research objectives, as well as the accessibility of obtaining relevant information from respondents regarding the utilization of coffee leaf waste into coffee leaf tea.

This study employed an evaluative research design with a descriptive quantitative approach. Evaluative research is a form of applied research aimed at assessing the effectiveness, benefits, usefulness, and feasibility of a particular program or activity (Yuniarti et al., 2021). In this study, the evaluative approach was applied to assess farmers' acceptance level toward the extension program design for utilizing coffee leaf waste as coffee leaf tea. The descriptive quantitative approach was selected because the research focused on describing existing conditions and measuring phenomena based on numerical data analyzed

systematically through statistical techniques to obtain objective findings (Agustina et al., 2024). Through this approach, the study not only described farmers' acceptance of the extension design but also measured behavioral changes among farmers, including changes in knowledge and attitudes after the extension activity.

The research design consisted of several stages, namely regional potential identification, extension program design development, implementation of extension activities, and evaluation of farmers' acceptance and behavioral changes. Regional potential identification was conducted to obtain an overview of the natural resources and human resources conditions in the research area as the basis for developing the extension program design. The extension program design was developed based on agricultural extension components consisting of extension materials, methods, media, volume, location, time, and cost. These research indicators were used to measure farmers' acceptance of the extension program design for utilizing coffee leaf waste into coffee leaf tea. The measurement of extension design indicators was based on the concept of agricultural extension evaluation, which assesses the suitability of extension components with the needs and characteristics of the target participants.

In addition to evaluating the extension program design, this study also measured farmers' behavioral changes through knowledge and attitude indicators. The knowledge indicator was used to determine farmers' understanding of utilizing coffee leaf waste as raw material for coffee leaf tea, while the attitude indicator was used to identify farmers' willingness to accept and implement the innovation. Attitude measurement was conducted using a Likert scale, which is commonly applied to measure individuals' or groups' attitudes, opinions, and perceptions toward a particular social phenomenon (Sugiyono, 2019). The use of these indicators aimed to determine the extent to which extension activities contributed to changes in farmers' cognitive and affective aspects as innovation recipients.

The participants in this study were coffee farmers who were members of farmer groups in Sampean Village, Sipirok District, South Tapanuli Regency. The research population was determined purposively with several criteria, including coffee farmers located in Sampean Village as the center of coffee production in Sipirok District, members of farmer groups whose main commodity is coffee, farmers who had not utilized coffee leaf waste into tea products, and farmers owning more than one hectare of coffee plantation area. Based on data from Simluhtan Sipirok District in 2026, the research population consisted of 193

farmers from seven farmer groups, namely Mekar Sari, Mekar Sari Perkebunan, Aek Sagala, Aek Sagala Perkebunan, Satahi, Satahi I, and Satahi II.

The sample size was determined using the Slovin formula with a margin of error of 10%. Based on the calculation results, a total of 66 respondents were selected as research samples. The sampling technique applied was proportional stratified random sampling by considering the number of members in each farmer group. This technique was used to ensure that all farmer groups were proportionally represented according to their population size (Minarni et al., 2021). The selection of respondents was carried out by calculating the proportion of each farmer group's population compared with the total population, which was then multiplied by the predetermined sample size.

The research instruments consisted of questionnaires, interview guidelines, observation sheets, and documentation records. Data collection was conducted using both primary and secondary data sources. Primary data were obtained directly from respondents through interviews and questionnaire distribution to coffee farmers regarding their acceptance of the extension program design and behavioral changes after participating in the extension activities. Meanwhile, secondary data were collected from supporting documents, including Agricultural Extension Center (BPP) programs, Central Statistics Agency (BPS) reports, books, scientific journals, e-books, and other relevant documents related to the research topic. According to Sugiyono (2022), primary data refer to data obtained directly from the first source through observation, interviews, or questionnaires, while secondary data are obtained from previously available documents or sources.

Data collection techniques included interviews, questionnaires, observation, and documentation. Interviews were conducted with coffee farmers and agricultural extension officers to obtain information regarding regional conditions, problems related to coffee leaf waste utilization, and extension needs. Questionnaires were used to measure farmers' acceptance of the extension program design and behavioral changes. Observation was conducted through direct field observation to identify existing problems related to the underutilization of coffee leaf waste. Documentation was used as supporting data obtained from archives, reports, and official documents related to the research (Khaddafi et al., 2025). The application of appropriate data collection techniques is essential to ensure that the obtained data align with research objectives and produce relevant conclusions (Sahir, 2022).

Before being applied in the main data collection process, the research instruments were tested through validity and reliability assessments. The validity test was conducted to determine the extent to which the instruments accurately measured the intended research variables (Sugiyono, 2021). The validity assessment used the Pearson Product Moment correlation technique by comparing the calculated r-value with the r-table value at a 5% significance level. An instrument item was considered valid when the calculated r-value was higher than the r-table value. Furthermore, reliability testing was conducted using Cronbach's Alpha analysis to determine the internal consistency of the instruments. An instrument was considered reliable when the Cronbach's Alpha value exceeded the reliability threshold of 0.600. The test results indicated that both the extension design instrument and behavioral evaluation instrument met the reliability criteria and were suitable for use in the research.

The collected data were analyzed using descriptive quantitative analysis. Data obtained from questionnaires regarding farmers' acceptance of the extension program design were analyzed using a Likert scale by calculating the percentage of obtained scores compared with the maximum possible score. The results were then interpreted using a continuum line with categories ranging from strongly unacceptable, unacceptable, moderately acceptable, acceptable, to strongly acceptable. Meanwhile, changes in farmers' knowledge were analyzed by calculating the increase between pre-test and post-test scores using the N-Gain approach to determine the effectiveness level of knowledge improvement (Hake & Reece, 1999). Changes in attitudes were analyzed based on the percentage scores obtained from the Likert scale and categorized using the continuum line ranging from strongly unwilling to strongly willing. Through these analytical procedures, the study was able to describe the effectiveness of the extension program design and the behavioral changes of farmers regarding the utilization of coffee leaf waste into coffee leaf tea.

RESULTS

The results of the Regional Potential Identification (RPI) showed that Sampean Village, Sipirok District, possesses natural and human resources that support the development of an innovation utilizing coffee leaf waste into coffee leaf tea. The identification of regional potential was conducted using the Rapid Rural Appraisal (RRA) method through field observations, semi-structured interviews, group discussions, and secondary data collection. The assessment results indicated that coffee farming is one of the

main sectors supporting the economic activities of the community in Sampean Village. The geographical condition of the area, which is located in a highland region with environmental characteristics suitable for coffee cultivation, makes coffee one of the leading agricultural commodities developed by the local community.

Field observations revealed that coffee cultivation activities not only produce coffee beans as the main product but also generate agricultural waste in the form of coffee leaves resulting from pruning and plant maintenance activities. Currently, these coffee leaves have not been utilized optimally by the community and are still considered plantation waste. Based on these conditions, the utilization of coffee leaf waste into coffee leaf tea was selected as an appropriate innovation because it utilizes locally available resources and has the potential to produce value-added agricultural products.



Figure 1. Identification of Regional Potential Activities

Figure 1. Identification of Regional Potential Activities shows that the identification of regional potential was conducted directly in coffee plantation areas to observe local resources, farming conditions, and the availability of coffee leaves as potential raw materials for developing coffee leaf tea products.

Based on the results of regional potential identification, the extension program design was developed by considering local resources, target characteristics, and farmers' needs. The research involved 66 respondents from seven farmer groups in Sampean Village. The respondents were predominantly coffee farmers of productive age with experience in coffee farming activities and direct involvement in coffee plant management. These conditions became the basis for determining an appropriate extension approach, particularly in selecting the extension materials, methods, and supporting media.

The extension program design consisted of several main components, including extension materials, methods, media, implementation volume, location, schedule, and costs. The extension materials focused on the utilization of coffee leaf waste into coffee leaf tea, including the potential benefits of coffee leaves, product advantages, and processing stages starting from raw material selection, washing, drying, processing, and packaging. The extension methods applied included lectures, demonstration practices, and discussions, while the supporting media consisted of folders, actual tools and materials, and video tutorials.

The analysis of farmers' acceptance toward the extension program design showed positive responses toward all components. The average acceptance level reached 85.65%, which was categorized as highly accepted. The findings indicate that the extension design was considered appropriate and relevant to support the implementation of coffee leaf waste utilization innovation. The high acceptance level reflects farmers' readiness to receive information and adopt new knowledge related to the processing of coffee leaf waste into value-added products.

The evaluation of the extension activity was conducted to determine its effectiveness in improving farmers' understanding and acceptance of coffee leaf tea innovation. Knowledge improvement was measured using pre-test and post-test instruments involving 66 respondents. The results demonstrated a substantial increase in farmers' knowledge after participating in the extension program. Before the extension activity, the average knowledge score was 5.07 out of a maximum score of 8.00, equivalent to 63.40%. Following the extension, the average score increased to 7.32, representing 91.43% of the maximum score. This indicates an improvement of 2.24 points, or 28.03 percentage points, compared with the pre-test results. Furthermore, the calculated N-Gain value was 0.767 (76.70%), which falls within the high category, indicating that the extension program was highly effective in improving farmers' knowledge regarding coffee leaf tea processing. The increase in knowledge suggests that the combination of lectures, practical demonstrations, and interactive discussions successfully enhanced farmers' understanding of the innovation and its potential benefits.

In addition to knowledge improvement, the study also evaluated changes in farmers' attitudes after participating in the extension activity. Attitudes were assessed using three dimensions: cognitive, affective, and conative. The cognitive dimension measured farmers' understanding and acceptance of the benefits of utilizing coffee leaves as a value-added

product. The affective dimension evaluated farmers' interest, enthusiasm, and positive perceptions toward the introduced innovation. Meanwhile, the conative dimension assessed farmers' willingness, intention, and readiness to adopt and implement coffee leaf tea processing in their farming activities. The evaluation of these three dimensions provided a comprehensive understanding of farmers' behavioral responses toward the extension program and the introduced innovation.

Table 1. Results of Farmers' Attitude Evaluation toward Coffee Leaf Waste Utilization into Coffee Leaf Tea

Attitude Aspect	Obtained Score	Maximum Score	Percentage (%)	Category
Cognitive	885	990	89.39	Very Good
Affective	873	990	88.18	Very Good
Conative	869	990	87.78	Very Good
Total	2.267	2.970	88.45	Very Good

Source: Compiled by the researcher (2026)

Table 1. Results of Farmers' Attitude Evaluation toward Coffee Leaf Waste Utilization into Coffee Leaf Tea shows that farmers demonstrated positive attitudes toward coffee leaf tea innovation. The cognitive, affective, and conative aspects obtained high scores, indicating that farmers had good understanding, strong interest, and willingness to implement the introduced innovation. These results indicate that the extension activity was not only successful in increasing farmers' knowledge but also contributed to building positive perceptions and encouraging behavioral readiness toward the utilization of coffee leaf waste.

Overall, the findings demonstrate that the extension program design for utilizing coffee leaf waste into coffee leaf tea was well accepted by farmers in Sampean Village. The high level of acceptance, combined with improvements in knowledge and positive changes in attitudes after the extension activity, indicates that an extension approach developed based on regional potential and farmers' needs can effectively support the introduction of agricultural waste processing innovations into value-added products.

DISCUSSION

The findings of this study indicate that the extension program design for utilizing coffee leaf waste into coffee leaf tea in Sampean Village, Sipirok District, was developed based on local potential, farmer characteristics, and community needs. The Regional Potential Identification (RPI) conducted through the Rapid Rural Appraisal (RRA) approach

revealed that Sampean Village has adequate natural and human resources to support the development of coffee-based product innovations. Coffee cultivation represents the main agricultural activity of the community, while coffee leaves produced from pruning and maintenance activities remain underutilized. Therefore, transforming coffee leaves into tea products provides an alternative strategy to reduce agricultural waste while increasing the added value of coffee commodities.

The availability of coffee leaves as raw materials indicates that local resources can become a foundation for developing sustainable agricultural innovations. Previously, coffee leaves were generally considered agricultural waste because their economic potential had not been widely recognized by farmers. However, coffee leaves contain bioactive compounds, including flavonoids and phenolic compounds, which have antioxidant properties and potential health benefits (Yesika et al., 2026). This condition strengthens the importance of extension activities in changing farmers' perceptions regarding agricultural waste from unused residues into valuable resources. The development of coffee leaf tea also supports the concept of agricultural diversification by creating additional products derived from existing agricultural resources.

The characteristics of farmers involved in this study also contributed to the success of the extension program. Most respondents were categorized as productive-age farmers with sufficient farming experience and ownership of cultivated land. These characteristics indicate that farmers already possess practical knowledge related to coffee cultivation, which can support the process of adopting new innovations. Farming experience allows farmers to evaluate the suitability of introduced technologies based on their previous agricultural practices and knowledge (Hamyana et al., 2020). Although the formal education level of some farmers was relatively moderate, this condition did not become a major obstacle because the extension approach emphasized practical learning through demonstrations and direct involvement.

The formulation of extension objectives using the SMART and ABCD principles contributed to the systematic implementation of the program. The results showed that the targeted acceptance level of more than 52% was successfully exceeded, with an actual acceptance score of 85.65%, categorized as highly accepted. This finding indicates that the objectives, materials, and methods applied were appropriate to farmers' needs and local conditions. The high acceptance level also demonstrates that coffee leaf tea innovation has

good compatibility with rural communities because the raw materials are easily obtained and the processing techniques are relatively simple to apply.

The success of the extension design was also influenced by the suitability of extension components, including materials, methods, media, volume, location, timing, and financial arrangements. Extension materials obtained the highest acceptance score of 87.98%, indicating that farmers considered the information provided relevant and applicable to their agricultural conditions. The materials introduced information regarding the benefits of coffee leaves, processing techniques, and opportunities for developing value-added products. Research by Nasution & Br Manullang (2020) confirmed that coffee leaf tea has antioxidant activity, supporting its potential as a functional beverage product.

The combination of extension methods consisting of lectures, demonstrations, and discussions received a high acceptance score of 85.62%. This result shows that the integration of various learning methods was effective in improving farmers' understanding because participants received both theoretical explanations and direct practical experiences. Demonstration methods are particularly important in agricultural extension because farmers can directly observe and practice the innovation process rather than only receiving verbal information. Pulungan & Lestari (2025) explained that demonstration methods can improve farmers' knowledge and skills through direct learning experiences. Furthermore, discussion activities provided opportunities for farmers to exchange experiences and communicate difficulties related to the implementation of coffee leaf tea processing.

The use of extension media, such as folders, processing tools, raw materials, and tutorial videos, achieved an acceptance score of 86.21%. This finding indicates that appropriate media selection supported the effectiveness of information delivery because farmers were able to understand the processing stages more clearly. Audiovisual media also helped participants recall the procedures after the extension activity was completed. Faisal & Arifin (2022) stated that suitable extension materials and media influence farmers' acceptance of agricultural innovations.

The evaluation results demonstrated that the extension activity successfully improved farmers' knowledge and attitudes toward coffee leaf tea innovation. The average knowledge score increased from 63.4% in the pre-test to 91.43% in the post-test, with an N-Gain value of 76.7%, indicating a high level of learning effectiveness. This improvement confirms that the extension program functioned not only as a means of transferring information but also

as a learning process that encouraged farmers to understand the economic potential of coffee leaf utilization. According to Hake & Reece (1999), an N-Gain value above 70% indicates a high category of learning improvement.

The increase in knowledge was followed by positive changes in farmers' attitudes, reflected by the attitude score of 88.45%. This result shows that farmers developed positive perceptions, interest, and readiness to implement coffee leaf tea processing. The cognitive aspect was reflected through farmers' understanding of the benefits and economic value of coffee leaves, while the affective and conative aspects indicated willingness to try and apply the innovation. Pello & Djunina (2024) emphasized that appropriate extension methods and media can increase farmers' acceptance of agricultural innovations.

The findings also demonstrate that a local resource-based approach plays an important role in supporting innovation sustainability. Coffee leaf tea production utilizes materials that are already available within the village, reducing dependence on external resources and increasing the possibility of continuous implementation. This approach aligns with sustainable agricultural development, which emphasizes the optimization of local resources to improve community welfare (Yulistiani et al., 2022). The involvement of seven farmer groups in supporting locations, materials, and facilities further indicates that community participation contributed to the success of the program.

Farmer group involvement is also essential for maintaining innovation sustainability after the completion of extension activities. Farmer groups function as platforms for knowledge exchange, cooperation, and strengthening community capacity. Through these groups, farmers can continue discussing product development and improving production skills. Aldayani et al. (2023) stated that farmer participation in extension activities contributes to strengthening group capacity and supporting community empowerment programs.

Compared with previous studies, this research provides a broader contribution because it does not only examine knowledge improvement but also develops a comprehensive extension design consisting of regional identification, objective formulation, extension component determination, and evaluation of acceptance and behavioral changes. The findings reinforce that agricultural innovation success depends not only on technological aspects but also on the suitability of the extension process with social and economic conditions of the target community. Irdiana et al. (2024) explained that extension programs designed according to local conditions and farmer needs tend to achieve higher effectiveness.

Nevertheless, this study has several limitations. The research was conducted in only one village, meaning that the findings cannot be fully generalized to all coffee-producing areas with different characteristics. The number of respondents was also limited to 66 farmers, requiring further research with broader coverage. In addition, this study focused mainly on acceptance, knowledge improvement, and attitudes, while long-term aspects such as adoption sustainability, production capacity, marketing strategies, and economic feasibility require further investigation.

Future studies should examine the continuation of coffee leaf tea innovation implementation, including production cost analysis, consumer acceptance, market development, and its potential as a village-based agroindustry product. Despite these limitations, this study demonstrates that a participatory extension approach based on local potential can effectively improve farmers' acceptance, knowledge, and attitudes toward utilizing coffee leaf waste into value-added products. The findings highlight the importance of integrating local resources, farmer participation, and appropriate extension strategies in supporting sustainable agricultural innovation.

CONCLUSION

Based on the research findings regarding the extension program design for utilizing coffee leaf waste as coffee leaf tea in Sampean Village, Sipirok District, South Tapanuli Regency, it can be concluded that the developed extension program was appropriate with the needs, local conditions, and characteristics of coffee growers as the target participants. This study successfully addressed its objectives by evaluating the suitability of the extension program design, measuring growers' acceptance of the program, and assessing changes in growers' knowledge and attitudes after participating in the extension activities. The designed extension program consisted of coffee leaf tea processing materials, lecture methods, practical demonstrations, and discussions, supported by extension media including folders, actual tools and materials, and tutorial videos. These components were considered effective in facilitating innovation transfer because they were adapted to the local context and the characteristics of the target community.

The results demonstrated that growers' acceptance of the extension program reached 85.65%, categorized as highly accepted. This finding indicates that the developed extension design had a high level of suitability and was well received by the target participants.

Furthermore, the extension activities positively influenced growers' behavioral changes, particularly in terms of knowledge and attitudes. The improvement in knowledge reflects the effectiveness of the extension activities in increasing growers' understanding of coffee leaf utilization as an alternative raw material for tea production. Meanwhile, the positive attitude changes indicate growers' willingness and readiness to adopt the introduced innovation as a strategy for optimizing local agricultural resources.

This study contributes practically to the field of agricultural extension by providing an extension program model based on local potential that can serve as a reference for developing agricultural product innovations. The findings also emphasize the importance of designing extension activities by considering various components, including materials, methods, media, implementation time, location, and cost, to improve innovation acceptance among rural communities. From a practical perspective, the results provide valuable input for agricultural extension workers, farmer groups, and relevant stakeholders in promoting the utilization of agricultural waste into economically valuable products.

The implementation of this research is expected to encourage coffee growers to expand their focus beyond coffee bean production by developing derivative products from available local resources. Coffee leaf tea has potential as an alternative diversification product that can increase the added value of coffee commodities. Future research is recommended to further investigate product quality, nutritional characteristics, economic feasibility, marketing strategies, and business development opportunities for coffee leaf tea production on a broader scale. Such studies are expected to support the sustainable development of coffee leaf utilization and enhance its economic benefits for local communities.

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