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Sustainable Soybean Cultivation and Digital Marketing for Food Diversification in Sandy Soils

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Abstract

Sandy soil, low productivity, poor crop management, and limited marketing opportunities are the main challenges faced by soybean farmers in Jenetaesa Village, Maros Regency. The Langkasa and Langkasa Baru farmer groups collaborated with the team from Paulus Christian University of Indonesia to address these issues through a community service program. The program aimed to empower farmers by introducing sustainable soybean cultivation practices and innovations to support food diversification and better use of rainfed land during the dry season. The methods included socialization, practical training, field demonstrations, and ongoing mentoring. Farmers learned composting techniques using soybean waste, operating compost shredders and soybean threshers, the benefits of superior seeds, proper planting timing, and basic digital marketing to reach wider markets. The results showed increased farmer knowledge and skills in managing sandy soil, reducing post-harvest losses, and applying sustainable practices. Farmers began using compost to improve soil fertility, adopted mechanical threshers to minimize seed waste, planted superior varieties, and started exploring online marketplaces. The introduction of appropriate low-cost technologies proved effective in more productively utilizing sandy rainfed fields. The program not only enhanced soybean production and marketing but also contributed to household food security and economic improvement for the farming community.

Keywords

Soybean Cultivation, Production Management, Food Diversification, Digital Marketing

1. Introduction

Maros Regency, located at an altitude of 5 m above sea level with a geographical position of 119°30' East Longitude and 5°00' South Latitude, and alluvial soil type, is one of the soybean-producing areas in South Sulawesi (Badan Pusat Statistik Sulawesi Selatan, 2025). However, overall soybean production in Indonesia remains low relative to demand, with domestic output meeting only about 20-30% of demand, leading to a heavy reliance on imports (Malik & Nainggolan, 2020; Sibuea et al., 2024). Jenetaesa Village, located in Simbang District, has an area of 10.08 km², is 13 km from the capital of Maros Regency, is at an altitude of 38 m above sea level, has a population of 4,820 people with a density of 832 people per km² (Badan Pusat Statistik Kabupaten Maros, 2025a). Based on data on the area of non-technical irrigated rice fields of 84 Ha and rain-fed rice fields of 199 Ha, there are 283 Ha that can be planted with soybeans during the dry season (Badan Pusat Statistik Kabupaten Maros, 2025b). This significant rainfed lowland area offers great potential for soybean expansion, as similar suboptimal lands across Indonesia have been successfully used for legume cultivation with proper management (So & Ringrose-Voase, 2000; Harsono et al., 2022). Based on the above area, the potential land area for soybean cultivation remains sufficient to improve the economy of the residents of Jenetaesa Village.

Government Regulation Number 17 of 2015 concerning Food Security and Nutrition, Article 25, states that food diversification is an effort to increase the availability of diverse foods based on the potential of local resources to: (1) meet diverse, nutritionally balanced, and safe food consumption patterns; (2) develop food businesses; and/or (3) improve community welfare (Republic of Indonesia, 2015). Soybean plays a key role in this diversification, providing affordable protein sources like tofu and tempeh that are staples in Indonesian diets (Arwanto et al., 2022; Purwandari et al., 2025). Furthermore, Article 26 (letter g) states that food diversification, as referred to in Article 25, is achieved, among other things, through optimizing land use.

The rice fields in Jenetaesa Village are generally sandy. Sandy soils pose clear challenges for farmers, including low water and nutrient retention, high porosity leading to rapid drainage, and reduced organic matter, which limit crop growth during dry periods (Agegnehu et al., 2011; Osman, 2018). Therefore, during the dry season, when water sources are limited, many rain-fed rice fields are difficult to cultivate due to high soil porosity, which causes rapid water loss into the soil. The Langkasa and Langkasa Baru Farmers Groups, active in various government initiatives such as environmental health, nutrition improvement, and other activities, are eager to utilize their rain-fed rice fields during the dry season. They frequently discuss potential uses for the land but limited scientific and technological knowledge and skills hinder their efforts to use the land productively.

Another challenge with utilizing this sandy soil is seed availability. Generally, the seeds available in the field are those that have been planted repeatedly and are often of unknown varieties, resulting in very low yields, ranging from only 1.0 to 1.1 tons per hectare. Using superior varieties can address this, as they are bred for better adaptation to local conditions, higher yields, and resistance to stresses such as drought and pests (Begna, 2020; Harsono et al., 2021). Harvesting methods are also a production challenge, with yield losses from conventional harvesting methods, which involve threshing soybean stalks, which can result in significant losses of up to 20% (Cahyaningrum & Irawati, 2022). Post-harvest losses remain a major issue nationwide, reducing overall output and farmer income (Olakiumide, 2021). Limited market access further compounds these problems, as traditional chains keep prices low for farmers while consumers pay more (Juswadi et al., 2020).

The main problems faced by soybean farmers in Jenetaesa Village are thus: (1) sandy soil with poor moisture and nutrient holding; (2) use of low-quality, recycled seeds leading to low productivity; (3) high post-harvest losses from manual methods; and (4) restricted marketing opportunities limiting income. The program, dedicated to optimizing land use during the dry season in Jenetaesa Village, aims to improve farmers' knowledge on optimally utilizing sandy land for productivity, proper crop management for maximum production, and optimally expanding market share to meet farmers' protein and mineral needs, while increasing household income.

2. Literature Review

2.1. Improving Sandy Land

One solution for improving sandy soil is the application of compost. Saptiningsih et al. (2024) found that adding compost along with humic acid greatly improves soil productivity and supports better growth of mustard greens on sandy land. Compost increases soil porosity, adds organic matter, and improves both absorption and drainage. It also helps maintain soil moisture longer and brings the pH closer to neutral. Kristanti et al. (2025) showed that organic amendments have strong potential to raise cation exchange capacity and water-holding ability in sandy soils. These changes make the soil looser, more fertile, and healthier overall for plants.

Sandy soils in rainfed areas often lose water quickly and lack nutrients, which limits crop choices during dry seasons. Farmers in many parts of Indonesia face the same problem, where high porosity causes rapid drainage and poor plant establishment. Adding organic material becomes a low-cost way to address these issues without relying heavily on chemical inputs. Studies confirm that regular compost use improves soil structure over time, yielding sustained benefits. Suzuki et al. (2007) explained how organic matter reduces the dominance of sand particles and promotes better aggregation. Agegnehu et al. (2016) further supported this through a meta-analysis, showing that compost applications consistently improve soil quality and crop yields in tropical regions. In Indonesian contexts, similar approaches have turned marginal lands into productive fields for legumes and vegetables. Local farmers can easily make compost from readily available materials such as crop residues, manure, and kitchen waste. This practice not only solves soil problems but also reduces waste and fertilizer costs. When combined with good management, compost helps farmers achieve stable production even in challenging environments. The evidence clearly points to compost as a practical and effective tool for improving sandy land.

2.2. Improving Seed Quality

To improve seed quality, superior seeds adapted to the climate and soil conditions must be planted, starting with the foundation seed, so that they can be passed down through the various levels. Madani et al. (2023) tested several soybean varieties in rainfed rice fields and found that high-yielding types performed well when supported by proper timing and care. The use of superior seeds, if not supported by proper crop management, will result in decreased yields at harvest and even possible crop failure. Soybean plants are highly sensitive to water during critical stages, especially near harvest. An inappropriate planting schedule can push harvesting into the rainy season, causing poor pod filling or rot.

Ruminta et al. (2020) analyzed the impacts of climate on soybeans in Garut and stressed the need for strategic planting dates to avoid heavy rains at maturity. Farmers who plant too late often harvest early to escape waterlogging, resulting in immature beans and lower quality. Choosing varieties with drought or short-duration tolerance helps reduce these risks. Hapsari et al. (2025) highlighted genotypes that resist pod shattering and maintain yield stability under variable conditions. Harsono et al. (2021) reviewed national efforts and noted that certified

superior seeds can significantly increase average yields when farmers follow recommended practices.

Recycled seeds from previous harvests often lose vigor and uniformity over generations. Unknown varieties common in villages usually give low outputs because they lack breeding for modern stresses. Switching to certified seeds brings genetic advantages such as better disease resistance and greater potential. When combined with adjusted calendars based on local weather patterns, this approach offers a reliable path to improved production in rainfed systems.

2.3. Use of Agricultural Tools and Machinery

Harvesting methods using agricultural tools and machinery are highly recommended to minimize yield losses. Cahyaningrum and Irawati (2022) demonstrated that proper post-harvest handling in Bantul reduced both quantity and quality losses for soybean farmers. The application of post-harvest soybean handling technology is one way to increase the quantity and quality of soybean production. Yield losses always occur during every post-harvest handling activity. These losses can be quantitative, in terms of weight reduction, or qualitative, in terms of damaged seeds that fetch lower prices.

Takdir et al. (2025) assisted farmer groups with improved harvest and post-harvest practices, showing clear gains from the use of mechanical threshers. Traditional threshing by beating stalks on the ground scatters seeds and causes breakage, sometimes wasting up to 20 percent of the crop. As shown in Figure 1, sandy rainfed rice fields in the dry season remain idle without intervention, highlighting the need for efficient tools to make soybean cultivation worthwhile. Simple machines like pedal or motor threshers separate grains cleanly and quickly, saving time and labor. Li et al. (2023) reported similar benefits in edamame processing, where mechanization preserved quality and added value.

Small-scale machinery fits the needs of village farmer groups who cannot afford large equipment. Introducing shredders for compost preparation and threshers for seed cleaning addresses two major bottlenecks at once. Farmers gain not only higher recoverable yields but also better seed quality for next planting or sale. These tools encourage wider adoption of soybean on marginal lands by making the work less risky and more profitable.

3. Methods

The method applied to empower the soybean center's fostered villages is the adoption of innovations and sustainable soybean cultivation methods to promote food diversification. The innovations implemented include the use of high-yielding seeds and agricultural machinery (compost shredders and soybean threshers), as well as a sustainable cultivation system that employs sandy land management and appropriate planting timing to respond to climate change in Jenetaesa Village. This program began with careful planning, involving discussions with the Langkasa and Langkasa Baru farmer groups to identify their needs and ensure full participation.

Socialization formed the first key step, focusing on how to utilize sandy land during the dry season through composting, sustainable cultivation, the use of agricultural machinery, and post-harvest marketing along with digital marketing. This socialization method used visualizations of land use and post-harvest management, presented via slides on an LCD projector, along with demonstrations of the machines and materials used. This socialization method was expected to provide farmer groups with an understanding of the Appropriate Technology that would be implemented.

Training on compost production and the use of agricultural machinery was conducted at the village hall so that farmer groups could observe it directly. The training covered how to make compost using soybean waste that has been threshed,

added with bran, cow manure, molasses, and EM4 with a ratio of soybean waste to bran and cow manure of 5:1:1, then given molasses and EM4. Training was also conducted on how to use a compost shredder to produce compost materials and a soybean threshing machine to overcome post-harvest soybean seed losses.

The application of science and technology to compost shredders and soybean threshers was conducted in the field, with an illustration showing how to use these machines. The compost shredder was used, and the resulting compost was visualized. Similarly, the use of the soybean thresher was demonstrated, showing that it could minimize soybean yield losses compared to conventional methods of threshing soybean stalks. Mentoring was provided during outreach on sustainable soybean cultivation, crop management, marketing, and the use of science and technology, as well as during training on the compost shredder and soybean thresher, and on proper compost preparation and storage.

This was intended to minimize or eliminate failure rates in the cultivation and use of these agricultural machines, thereby maximizing production. The team always monitored the program's sustainability by providing the latest information to farmers regarding the technology that had been implemented or by introducing new technologies that had similarities or other modifications that could be applied so that farmers could utilize their land productively and handle post-harvest production properly and appropriately, especially those located in partner villages in Jenetaesa Village. Program evaluation used indicators such as increased farmer knowledge, active participation in training, adoption of composting and machinery, initial digital marketing steps, and ongoing monitoring to assess long-term productivity and income gains.

4. Results

The community service program in Jenetaesa Village brought clear benefits to the Langkasa and Langkasa Baru farmer groups. These groups belong to the Sipakatau Farmers Group Association. Farmers gained more knowledge and skills in sustainable soybean farming on sandy land. They also learned better ways to handle crops after harvest and reach new markets. The socialization activities played a big role in building farmer knowledge. Farmers learned how to manage sandy soil better through composting, the importance of planting at the right time, and using superior seeds that fit climate changes. Many farmers said they now feel more confident about these practices. The sessions used slides and live examples, which helped everyone follow along easily. Participants were actively involved during the socialization of sustainable soybean cultivation, crop management, and digital marketing. As a result, farmers started to see sandy land as a real opportunity during the dry season instead of leaving it unused.

Training sessions gave farmers hands-on experience that changed how they work. They learned to make compost from soybean stalks that usually go to waste, using a simple ratio of soybean waste, bran, cow manure, molasses, and EM4. Farmers practiced cutting materials with the compost shredder and separating seeds with the soybean thresher. These machines made the work faster and cleaner than old methods. As shown in Figure 3, farmers were enthusiastic while training on using soybean threshers and compost shredders. Hands-on practice allowed them to try the machines themselves, reinforcing the lessons.

After the training, farmers quickly applied what they learned in their fields. They spread compost on sandy soil to hold water and nutrients better. This matches findings from other studies in Indonesia, where compost helps sandy soil retain moisture and supports healthier plants. Farmers reported that their soil felt looser and plants looked stronger early on. The training on compost making and using soybean planting tools helped farmers understand each step clearly. Using superior seeds also helped, as these varieties handle dry conditions better and have higher

yield potential. In similar rainfed areas, superior seeds often raise productivity from around 1.0-1.1 tons per hectare to 1.5-1.6 tons or more with good management.

The soybean thresher proved very useful in reducing post-harvest losses. Traditional ways of beating stalks can waste up to 20% of the seeds. With the machine, losses dropped significantly, similar to reports from other parts of Indonesia where threshers cut waste substantially and keep seeds in better condition. Farmers said the thresher saved time and gave cleaner results, which means more seeds to sell or plant next season. This small change can add real value to their income over time. Digital marketing training opened new doors for the farmers. They learned basic ways to use online marketplaces and social media to sell directly to buyers outside the village. Before, they relied only on local middlemen who offered low prices. Now, some farmers have started listing their products online and reaching customers across South Sulawesi. This broader market helps them secure better prices, especially for high-quality seeds. Combined with higher yields from better practices, farmers expect their household income to rise during harvest seasons.

The program led to clear improvements in farming practices. Farmers now apply compost regularly, use machines to save seeds, choose better varieties, and try digital sales. In demonstration plots, early signs showed productivity moving toward 1.6 tons per hectare, compared to the usual 1.0-1.1 tons before. This aligns with national trends, where integrated approaches such as composting and high-yielding seeds boost yields by 30-50% in rainfed areas. Farmers also feel more secure about meeting their family's protein needs from home-grown soybeans while selling the rest at fair prices.

The activities built stronger community ties too. Farmer groups worked together more during sessions and field practice. They shared ideas and helped each other with the new tools. Ongoing mentoring from the team keeps the momentum going, with farmers asking for updates on new techniques. This support helps ensure the changes last beyond the program period. In the end, the results show that simple, low-cost innovations can make a big difference for smallholder farmers on sandy land. The combination of better soil care, quality seeds, efficient machines, and modern marketing addresses the main challenges in Jenetaesa Village. Farmers are now better equipped to grow more soybeans sustainably, improve their food security, and increase their families' incomes.

5. Discussion

The socialization of sustainable soybean cultivation, crop management, and marketing has an impact on increasing the income of farming households during the soybean harvest by improving seed quality so that it can be marketed at a more reasonable price, and also increasing productivity from the usual 1.1 tons/Ha to 1.6 tons/Ha, as well as wider marketing opportunities by entering the digital market so that it can be marketed between regions in the province of South Sulawesi. This assisted village empowerment program will provide quality protein and minerals for Langkasa and Langkasa Baru farmer groups, while enabling them to market at a reasonable price at the breeding-seed and consumption-seed levels through a wider digital market reach. These improvements come from practical steps like using compost to improve sandy soil and using machines to reduce harvest losses, which farmers started applying right after training. However, it's worth noting that the productivity jump to 1.6 tons/Ha was seen in small demonstration plots and scaling it up to all 283 Ha of potential land might face hurdles like varying soil conditions or weather changes.

The social impacts for partners include increased product quality and diversification, as well as productivity; for farming households, there is an increase in household income at harvest time, as well as improved access to protein and

minerals, and greater food security and resilience. Farmers now have more options, such as turning soybean waste into compost, which not only boosts soil health but also reduces the need for chemical fertilizers. This kind of recycling fits well with sustainable practices seen in other areas. For example, as found by Saptiningsih et al. (2024), adding compost to sandy soil significantly improves water retention and plant growth, which aligns with what our farmers reported after trying it. But critically, while our program showed quick knowledge gains through questionnaires, long-term adoption could slip if there's no ongoing support, like in some cases where new tech gets abandoned after the team leaves.

When compared with similar community service initiatives in Indonesia, this program demonstrates alignment with the PPDM scheme implemented in Raanan Baru Village, where farmer empowerment in non-rice commodities contributed to improved food self-sufficiency over a three-year period. That program emphasized training and mentoring to promote sustainable farming practices and reported sustained improvements in household income, which is consistent with the initial indications of increased yields and expanded digital marketing observed in the present intervention.

Nevertheless, the emphasis on soybean cultivation in sandy rainfed land introduces a distinctive contribution, particularly in South Sulawesi, where soybean production remains limited at approximately 6.4% of the province's total agricultural output. In contrast to the PISAgro partnership, which integrates government and private sector actors to enhance national agricultural productivity, the initiative illustrates that small-scale, locally tailored innovations can effectively address specific challenges, such as post-harvest losses. Previous research by Cahyaningrum and Irawati (2022) demonstrated that the application of appropriate post-harvest technology significantly reduced soybean losses in Bantul. Similar outcomes were observed in this program, where thresher operation training substantially lowered post-harvest losses from approximately 20% during demonstration activities. However, a key limitation remains the absence of longitudinal measurement of farmers' income across multiple planting seasons. Consequently, unlike large-scale programs that systematically monitor economic indicators over time, the overall economic impact of this intervention cannot yet be determined with certainty.

Madani et al. (2023) tested superior soybean seeds in rainfed fields in Central Java and found yields up to 1.5–2.0 tons/Ha with proper management, which supports our choice of seeds adapted to dry conditions. This comparison shows our results are realistic but depend on consistent use. In Sulawesi, programs such as the Mondau farming system among the Tolaki community emphasize storing crops for food security, a practice we encouraged through improved production (Sabara, 2022; Fadeeva & Van Berkel, 2023). Critically, though, climate change could affect planting timing, as Ruminta et al. (2020) warned of the risks of the rainy season leading to pod rot in Garut. Our use of Cropsyst for scheduling helps mitigate that, but future evaluations need to check if farmers keep using it without team help.

These results suggest that combining technologies such as shredders and digital marketing with farmer training can transform underused land into productive assets. But a fair critique is that our program, like many PKMs, relies on short-term grants, so sustainability hinges on community ownership. Compared to the SFITAL project, which links small farmers to global chains in Asia, our local focus builds grassroots resilience but might require partnerships for broader market access (Prain et al., 2020). The implications of this program go beyond Jenetaesa Village. On an economic level, higher yields and better prices could lift household incomes, helping to reduce poverty in rural Maros, in line with national goals set out in Government Regulation No. 17/2015 (Republic of Indonesia, 2015). Socially, it promotes food

diversification, ensuring families get balanced nutrition from local soybeans instead of imports. 6. Conclusion

Based on the results obtained during the community service activities with the Langkasa and Langkasa Baru farmer groups under the Sipakatau Farmers Group Association, the program successfully introduced appropriate technologies that fit the needs of soybean farmers in Jenetaesa Village. The use of compost shredders, soybean threshers, superior seeds, and basic digital marketing tools proved effective in addressing sandy soil problems, low productivity, high post-harvest losses, and limited market access. Farmers showed clear gains in knowledge and skills through active participation in socialization, training, and field demonstrations. These changes led to better land use during the dry season, higher expected yields, reduced waste, and new ways to sell products at better prices. Overall, the combination of sustainable cultivation practices and simple machinery helped turn underused rainfed fields into more productive assets while supporting household food needs.

This program has important implications for rural development, as it shows that low-cost innovations can improve food diversification and household income for smallholder farmers. However, the results are still based on short-term activities and early adoption, so full impacts on productivity and income may take several planting seasons to become clear. Limitations include the small scale of demonstration plots and reliance on external team support for initial implementation. For future studies, it is suggested to continue long-term monitoring of the same farmer groups, measure actual yields and income over multiple seasons, expand the program to more villages in Maros Regency, and explore additional support like seed subsidies or stronger links to larger markets to ensure lasting benefits.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest.

Ethical Approval and Originality Statement

Ethical approval was obtained for this study. The manuscript represents original work and has not been previously published, nor is it under consideration by another journal.

Data Disclosure Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.



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