

The Role of Modern Harvesting Tools in Supporting Agricultural Modernization and National Food Security in Indonesia

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ABSTRACT

Modern harvesting tools have become essential in supporting agricultural modernization and strengthening food security in Indonesia. This study uses a qualitative approach, interviewing five farmers to explore their experiences with adopting and utilizing these tools. The findings reveal that modern harvesting tools significantly reduce labor requirements, save time, and improve crop quality, directly benefiting farmers' productivity. However, the adoption process is hindered by financial constraints, limited technical knowledge, and maintenance challenges. The study highlights the need for government support in providing subsidies, affordable credit, and local technical training to ensure the sustainable use of modern tools. These findings underscore the transformative potential of modern agricultural technologies in achieving national food security goals.

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1. INTRODUCTION

Agriculture has long been the backbone of Indonesia's economy, providing livelihoods for millions and serving as a critical contributor to national food security. However, the sector faces persistent challenges, including inefficiencies in production, post-harvest losses, and limited access to modern technology. As global populations rise and climate change continues to impact agricultural output, the need for modernization within Indonesia's agricultural sector has become increasingly urgent. Indonesia's agricultural sector is crucial for its economy and food security, yet

it faces significant challenges that necessitate modernization, such as unpredictable weather patterns, water scarcity, and increased frequency of floods and droughts, particularly affecting major regions like Java [1], [2]. Additionally, the conversion of agricultural land for infrastructure development reduces available farmland by 150,000 to 200,000 hectares annually, directly impacting food production [3]. Economically, the sector remains sluggish with only a 3.08% growth in 2019, while farmers continue to face low wages and limited land ownership, as reflected in the marginal growth of the Farmers Exchange Rate (NTP), indicating

poor economic returns (Setiartiti, 2021). Strengthening governance, such as restoring BULOG's role, could help stabilize food prices and incentivize production [3]. On the technological and policy fronts, adopting sustainable farming techniques and agroecology is seen as a way to mitigate environmental impacts and improve productivity [1]. Moreover, government policies like the National Medium Term Development Plan (RPJMN) aim to optimize agricultural output and achieve food sovereignty [2], while promoting high-value crops and improving infrastructure is essential for driving the sector toward modernization [4].

Modern harvesting tools represent a major advancement in agricultural technology, offering improved efficiency, reduced labor costs, enhanced crop quality, and minimized waste. Globally, the adoption of such machinery has been linked to increased productivity and better capacity to meet rising food demands; however, in Indonesia—particularly in rural areas—adoption remains uneven due to persistent reliance on traditional farming practices. While tools like combine harvesters can deliver substantial cost and time efficiencies, as evidenced by a study in Padang Siring Village, South Bengkulu, where harvesting costs were reduced from IDR 2,560,000 to IDR 1,865,000 per hectare and labor reduced to just one day per hectare [5], several barriers hinder widespread use. Advanced machines now incorporate technologies such as optoelectronic measuring devices, vibration meshes, soil filtering, and real-time optical sensors, which collectively improve crop handling and reduce waste [6], [7]. Nevertheless, rural adoption is constrained by unsuitable land conditions like narrow and muddy rice fields, inconsistent harvests, and the high costs of acquisition and maintenance, making these tools less accessible and affordable for small-scale farmers [5]. This highlights the need for more inclusive approaches that address both technological innovation and contextual realities in Indonesian agriculture.

This study focuses on the role of modern harvesting tools in supporting agricultural modernization and ensuring national food security in Indonesia. By examining the experiences and perspectives of five farmer informants from diverse agricultural backgrounds, this research seeks to uncover how these tools impact productivity, efficiency, and sustainability. Additionally, the study explores barriers to adoption, including economic constraints, knowledge gaps, and infrastructural limitations.

2. LITERATURE REVIEW

2.1 Agricultural Modernization and Food Security

Agricultural modernization in Indonesia is crucial for enhancing food security, especially given the country's large agricultural workforce and diverse farming systems. The transition from traditional to modern practices involves adopting advanced technologies and sustainable methods to increase productivity and minimize environmental impacts, thereby meeting the rising food demand driven by population growth. Technological innovations such as mechanization and automation play a pivotal role in improving productivity and reducing labor dependency and production time, which directly contributes to food security [8]. Precision farming, involving targeted input applications, further enhances farm efficiency and profitability [9]. Sustainable agricultural practices are equally vital, as they help conserve water and energy while improving farmers' livelihoods, ensuring long-term food security through a balance of productivity and environmental stewardship [10]. The transition is supported by farmer education and better access to financial resources [9]. However, Indonesia still faces challenges including knowledge gaps, financial constraints, and inadequate infrastructure. Addressing these through effective knowledge dissemination, tailored financing mechanisms, and supportive policies is essential [11]. Collaborative efforts among

farmers, policymakers, and researchers are key to overcoming these obstacles and realizing the full potential of agricultural modernization [11].

2.2 The Role of Modern Harvesting Tools in Agricultural Practices

Modern harvesting tools are pivotal in transforming agricultural practices by enhancing efficiency, reducing labor costs, and improving crop quality, particularly in Indonesia where the transition from traditional methods to mechanized farming is increasingly urgent due to rising food demands and labor shortages. The adoption of advanced machinery such as combine harvesters and crop-specific tools significantly boosts productivity and minimizes crop wastage, enabling timely harvesting and reducing grain damage, as demonstrated in rice farming where these tools decrease the incidence of broken grains and improve yield quality [7], [12]. Modern equipment like the agricultural efficient harvester integrates mechanisms such as rotating shafts and telescopic frames to streamline operations, thereby increasing harvesting efficiency [13], while optimal speeds and machine settings enhance threshing unit performance and reduce total losses [14]. Precision is further improved through the use of optical sensors that allow real-time monitoring to minimize grain damage and ensure higher quality yields [7]. Specialized rice harvesters effectively handle unique challenges such as stem straightening and cutting, which helps preserve grain integrity [15]. Moreover, the automation of harvesting processes reduces dependency on manual labor, lowering operational costs and intensity [16], and the incorporation of features like anti-locking assemblies and driving devices contributes to equipment durability and reduces long-term maintenance expenses [17].

3. METHODS

The study employs a qualitative research design to explore the perspectives and lived experiences of farmers in relation to the use of modern harvesting tools in

Indonesia. Qualitative methods are particularly well-suited for examining complex phenomena in real-world contexts and are ideal for capturing the depth of participants' attitudes, behaviors, and challenges [18]. This approach enables a nuanced understanding of how modern tools influence agricultural productivity and food security. The research was carried out in rural farming communities where agriculture is the main livelihood, using purposive sampling to select five farmers with varying agricultural backgrounds and familiarity with modern harvesting tools. The criteria for selection included at least five years of farming experience, prior use or knowledge of modern harvesting technologies such as mechanical harvesters, and geographic diversity to reflect different regional contexts [19]. While the sample size is small, it is adequate for qualitative research, allowing for rich, detailed interviews and the extraction of meaningful insights.

Semi-structured interviews were the primary data collection method, offering a balance of structure and flexibility. This allowed the researcher to explore core themes while encouraging participants to share their experiences in their own words. The interview guide included open-ended questions focused on four main areas: farmers' experiences with modern tools, challenges in adoption, impacts on productivity and food security, and perceptions of government policies and support. Interviews were conducted in Bahasa Indonesia to ensure comfort and clarity, lasting 45 to 60 minutes each, and were audio-recorded with participants' consent. Thematic analysis was employed to analyze the data, following Braun and Clarke's (2006) framework. The process involved familiarization with the transcripts, manual coding of key data points, grouping codes into broader themes, and refining and naming these themes to capture the essence of participants' responses. Final results were reported with supporting quotations to provide depth and authenticity to the findings. This method allowed for the

identification of key patterns and insights that reflect both the benefits and barriers to modern harvesting tool adoption in Indonesia.

4. RESULTS AND DISCUSSION

4.1 Adoption and Use of Modern Harvesting Tools

Farmers exhibited diverse levels of adoption of modern harvesting tools, with most respondents indicating the use of mechanical rice harvesters. However, the degree of usage varied depending on factors such as farm size, crop type, and financial capacity. Larger-scale farmers were more likely to integrate machinery into their operations due to better access to resources, while small-scale farmers often continued to rely on manual methods. The differences in adoption highlight how structural and economic conditions influence the ability of farmers to modernize their harvesting practices.

For instance, Farmer A noted, "With this rice harvester, the harvesting time has been significantly reduced. It used to take a week, but now it's just two days," underscoring the time-saving benefits of mechanization. Farmer B added, "These tools help us reduce the labor needed, especially during the busy harvest season. We can focus more on managing other parts of the farm," illustrating how efficiency gains allow for better resource allocation. In contrast, Farmer C remarked, "We use machines only for rice, but for vegetables, it's still manual because the tools are not suitable for small-scale farming like ours," pointing to the limitations of current technologies for diverse crop types and smaller plots. These insights collectively emphasize that while modern harvesting tools offer clear advantages, their benefits are not equally accessible to all farmers.

4.2 Benefits of Modern Harvesting Tools

The primary benefits of modern harvesting tools reported by farmers included improved labor efficiency, significant time savings, and reduced post-harvest losses. For example, Farmer D stated, "The time we save is very helpful. With these tools, we can

replant more quickly after harvesting," highlighting how mechanization accelerates the farming cycle. Similarly, Farmer E emphasized, "The tools also ensure a more consistent harvest, which sells for a better price," indicating that modern equipment contributes to better product quality and market value. Overall, agricultural modernization not only enhances productivity but also provides opportunities for farmers to optimize income through higher-quality yields and faster turnaround between planting cycles.

4.3 Challenges in Adopting Modern Harvesting Tools

Despite the clear benefits of modern harvesting tools, farmers identified several persistent challenges that hinder widespread adoption. High initial costs remain a major barrier, as many farmers lack the capital required to purchase such equipment upfront. As Farmer B explained, "The price is very high. Although the benefits are significant, we don't always have the initial capital to buy the tools," illustrating how financial limitations can prevent even willing adopters from accessing modern technologies. In addition to cost, limited technical skills among farmers further complicate the operation and upkeep of advanced machinery.

Maintenance issues also pose significant obstacles, particularly in rural areas where technical support is scarce. Farmer D shared, "If the tools break, we have to call a technician from another area because there's no one local who can repair them," pointing to the lack of local repair services and skilled technicians. These insights underline the urgent need for targeted support, such as affordable subsidies, accessible credit schemes, and local capacity building. Establishing community-based maintenance services and training programs could ensure the long-term sustainability and effectiveness of modern harvesting tools in enhancing agricultural productivity.

4.4 Impact on Agricultural Productivity and Food Security

The positive impact of modern harvesting tools on agricultural productivity

and food security was evident from the experiences shared by farmers. The use of such equipment enables more efficient and timely harvesting, which in turn allows for multiple planting and harvesting cycles within a year. As Farmer E noted, "With this equipment, we can harvest multiple crops a year, which wasn't possible with manual labor," emphasizing how mechanization enhances overall productivity and optimizes land use. This increased frequency of harvest contributes significantly to higher agricultural output and income potential.

In addition to boosting productivity, modern harvesting tools also support crop diversification, which is essential in building resilience against climate change and ensuring long-term food availability. Farmer C remarked, "The tools enable us to diversify our crops, which is crucial for ensuring food security in changing climates," highlighting the strategic role of technology in adapting to environmental challenges. These insights demonstrate that modern tools not only enhance efficiency but also empower farmers to respond proactively to food security concerns, thereby strengthening the stability of local food systems.

4.5 Discussion

The findings reveal that modern harvesting tools play a vital role in advancing agricultural modernization in Indonesia, offering clear benefits such as improved productivity, labor efficiency, and enhanced food security. However, the adoption of these technologies is not without challenges. Financial constraints and technical barriers remain significant obstacles, particularly for smallholder farmers. To address these issues, government intervention is essential through supportive policies that provide affordable financing options, such as subsidies or low-interest loans [20], and tailored financial mechanisms to increase access to machinery [11]. Equally important is the implementation of farmer training programs that build technical capacity and knowledge. Participatory methods like demonstrations and simulations have shown to be effective, as

evidenced by increased adoption of efficient tools such as sprayers [21].

Furthermore, ensuring the sustainability and functionality of modern tools requires the development of local repair services. The absence of nearby maintenance facilities often leads to extended downtime and increased operational costs. Establishing local repair and production centers not only ensures tool availability and functionality but also opens economic opportunities for Indonesia to become a producer and exporter of agricultural machinery [22]. These efforts must be supported by a holistic policy framework that encourages collaboration among farmers, government institutions, researchers, and industry stakeholders to create an enabling environment for effective agricultural mechanization [11], [20]. Such a comprehensive approach is crucial for making modern agricultural tools accessible, sustainable, and impactful in strengthening Indonesia's food security and rural livelihoods.

5. CONCLUSION

This study demonstrates that modern harvesting tools play a critical role in advancing agricultural modernization and enhancing food security in Indonesia. Farmers benefit significantly from these technologies through reduced labor demands, increased time efficiency, and improved crop quality, which together lead to higher productivity. Nevertheless, broader adoption is hindered by persistent challenges such as high initial investment costs, limited technical skills, and the lack of accessible maintenance services—issues that are particularly acute for small-scale farmers who have fewer resources and limited support.

To fully realize the potential of modern harvesting tools, it is essential for policymakers and stakeholders to implement targeted interventions that address these barriers. Financial support through subsidies and affordable credit schemes, comprehensive training programs to build technical expertise, and the establishment of local repair services are necessary to ensure

the sustainable use of these technologies. These measures will not only empower farmers but also strengthen the overall resilience of Indonesia's agricultural sector. The findings of this study highlight the transformative impact of modern agricultural innovations and underscore the importance of

embedding these tools into national agricultural development strategies. Continued government commitment and cross-sector collaboration will be key to fostering a productive and food-secure future for the country.

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