JPPIPA 11(5) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Increasing the Effective and Efficient Harvest of Rice (*Oryza sativa*. L) in Nabire Barat District

Simon Matakena[1*], Syusantie Sylfia Sairdama[1], Marloza Roy[1], Julianus Inggesi[1]

[1] Agribisnis, Faculty of Agriculture and Animal Husbandry, Universitas Satya Wiyata Mandala, Nabire, Indonesia.

Received: January 10, 2025
Revised: March 14, 2025
Accepted: May 25, 2025
Published: May 31, 2025

Corresponding Author:
Simon Matakena
monmatakena@gmmail.com

DOI: 10.29303/jppipa.v11i5.10888

Abstract: Increasing the effectiveness and efficiency of rice harvesting (*Oryza sativa.* l) in west nabire district, nabire regency, aims to determine the effectiveness and efficiency of the use of Combine Harvester in rice harvesting in West Nabire District, Nabire Regency. This study used a survey method with a sample of 26 respondents by simple random sampling, with an interview method using a previously prepared questionnaire. The results of the study showed that the use of the Combine harvester harvesting machine was more effective than the manual rice harvesting process with an effective value of 1.073, with a cost reduction of Rp 747.385.4 and a reduction in grain loss during harvest of 586.44 kg. The use of Combine harvester has a beneficial impact because it can reduce production by Rp 747.385.4 and reduce crop loss by 586.44 kg of grain.

Keywords: Combine harvester; Effectiveness; Harvest; Rice

Introduction

During the period of 2018, the performance of food commodities in general was quite encouraging. On a national scale, the production of rice field food commodities was 56.537.774 tons (dry grain) with a production of 32,419,910 tons of rice with a rice field area of 71.051.45 km2. For food crop production at the Papua Province level during the period of 2018 based on statistical data for rice crop production of 130,718 tons of dry grain with a production of 74,255 tons of rice with a harvest area of 31,133 ha. While for Nabire Regency, statistical data in the period of 2018 showed a rice harvest area of 2,909.10 ha with a production of 12,906.97 tons of dry grain where rice production was as large as. West Nabire District is one of the areas producing wet rice fields with a larger area than other areas such as Wanggar District and Makimi District. Based on data from the Central Statistics Agency of Nabire Regency, there are (Mulyani et al., 2022).

This increase in productivity can also occur if the harvest and post-harvest handling is correct and appropriate according to the age of the plant and a good harvesting process (Kailaku et al., 2023; Viršilė et al., 2024). In the process of harvesting rice using several methods, both conventional/traditional methods and several modern methods (Herdiansyah et al., 2023; Htwe et al., 2021; Lin & Fukushima, 2016). Traditional methods using a harvesting system based on culture by working together (contracting) using a sickle or sickle (Maeda et al., 2016; Murphy, 2017), then the harvest results through the process of releasing rice grains from the stems or straw using a thresher tool (Thresher) after that using a rice cleaning tool (Winnower) (Abdeen et al., 2021; Kaur et al., 2023), while the modern method used for handling the harvest and post-harvest is currently using agricultural tools and machines for rice production, namely the Combine Harvester harvest (Masruroh et al., 2025).

This harvesting machine has been used by farmers in Nabire Regency, especially in the West Nabire District, because by using the Combine Harvester harvesting machine, harvest handling can be carried out at once in a short time with little labor, the harvest results are in the form of clean wet rice and ready to be dried, so that the harvesting process can be carried out

How to Cite:
Matakena, S., Sairdama, S. S., Roy, M., & Inggesi, J. (2025). Increasing the Effective and Efficient Harvest of Rice (Oryza sativa. L) in Nabire Barat District. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 35–42. https://doi.org/10.29303/jppipa.v11i5.10888

effectively (Chojnacka et al., 2021; Yasin et al., 2020; Muchlisyiyah et al., 2023). The traditional method of harvesting rice fields can also cause a reduction in production due to high shrinkage (losses), both quantitatively and qualitatively. With the Combine Harvester rice field harvesting machine, there will be a reduction in shrinkage in rice field production so that productivity can increase and benefit farmers because the harvest and post-harvest handling are good and proper. The objectives of this study are: To determine the effectiveness of the use of Combine Harvester rice harvesting machines in West Nabire District, Nabire Regency; To determine the impact of the use of Combine Harvester rice harvesting machines on the use of rice harvesting machines in West Nabire District, Nabire Regency.

Research Usefulness: As a reference material for other researchers who are relevant to this study, for farmers to increase production and at the same time increase income through the use of Combine Harvester rice harvesting machines and for the government through related agencies in making policies for the interests of farmers in general. Based on the objectives of this study, the following hypotheses can be formulated: It is suspected that the use of Combine Harvester rice harvesting machines in West Nabire District, Nabire Regency is not yet effective; It is suspected that the impact of using Combine Harvester rice harvesting machines can increase income from rice farming in West Nabire District, Nabire Regency.

Method

Research Method

This research aims to determine the effectiveness of the use of Combine Harvester rice harvesting machines and the impact of the use of Combine Harvester rice harvesting machines on the amount of rice farming income in the West Nabire District, Nabire Regency with a descriptive analysis approach through research results and data analysis, both quantitatively and qualitatively. With this research design, the research method used is the descriptive method. The descriptive analysis approach is a method that aims to solve existing problems at the present time by collecting data, compiling data, managing, analyzing, describing and drawing conclusions.

Time and Place of Research

The time of this research took place for approximately 4 (four) months in the Odd Semester of the 2020/2021 Academic Year, and was located in the West Nabire District, Nabire Regency. The selection of this research location was deliberate (Purposive), because the West Nabire District has good and adequate technical irrigation that crosses 3 villages, namely; Bumi Raya Village (SP1), Kali Semen Village (SP2) and Wadio Village (SP3).

Types and Sources of Data

The types of data to be collected in this study include qualitative data, namely data obtained descriptively in the form of oral or written information and quantitative data, namely data obtained in the form of numbers from rice farmers and related agencies. The sources of data to be obtained are. Primary data, namely data that is ongoing obtained from rice farmers as research respondents and secondary data, namely supporting data obtained through documents or written reports and information from related agencies.

Population and Sample

Population is the entire object of research at the location where the research takes place. The population in this research plan is all rice farmers in the West Nabire District. The sample is a representative of the population taken by simple random sampling using the Slovin formula as follows:

$$n = N/(1+N.(e)2) \quad (1)$$

Where:
N: Sample size (number of samples)
n: Population size (number of populations)
e: Percentage of inaccuracy due to errors in sampling that can be tolerated, namely 15% For West Nabire District, there are approximately 350 farmers spread across existing farmer groups. with the number of the population of rice farmers, the number of samples used as respondents is 20 farmers obtained from:

n = 250 / (1 + 250. (20 / 100) 2)
n = 250 / [redacted] (1 + 250. (0.2 @) 2)
n = 250 / (1 + 250 (0.04))
n = 22.73

n (number of samples) = 23 farmers (this is the minimum number) based on the research results, the number of samples obtained was 26 rice farmer respondents, where 9 respondents used the Combine Harvester harvesting machine, and 17 respondents still harvested manually, so that the sample taken was more with a degree of freedom of 20%.

Data Collection Method

Data collection methods are divided into primary data and secondary data. Primary data collection is carried out through direct interviews with respondents through the instrument used, namely a list of questions (Questionnaire) that has been prepared before conducting the research. Secondary data is obtained from literature or from village, district or related agency statistics data. This secondary data includes the location of the village, geographical location, land ownership, population, village facilities and infrastructure and other data as supporting data in this study.

Analysis Method

The analysis method that will be used in this research plan is the quantitative and qualitative analysis method. The quantitative analysis method is used to determine the effectiveness of the use of the Combine Harvester rice harvesting machine by comparing the actual output with the target output (OA / OT) or it can also be used to compare the output of the rice harvest using the harvesting machine with conventional/ traditional harvesting, one of these two methods will be used based on the conditions that exist at the time of the study and will be calculated based on the productivity of the rice harvest (in hectares/ha). Meanwhile, to determine the impact of the use of the Combine Harvester rice harvesting machine, it can be seen from the comparison of conventional harvesting with harvesting using the Combine Harvester machine so that the proportion given by utilizing the harvesting machine is known. The qualitative analysis method is used through descriptions or describing the results of quantitative analysis according to the objectives to be achieved.

Result and Discussion

Several areas or regions producing lowland rice which can be seen in the following table 1. Based on the table 1, it can be said that Nabire Regency has a fairly large area of paddy fields with an area of 2,909.10 ha with a production of dry grain of 12,906.07 tons with an average dry grain productivity level of 3.6 tons/ha. This productivity value can be increased through the development of rice farming businesses both through intensification and extensification as well as rehabilitation of farming businesses. From the data in table 1 above, it can be seen that the highest level of rice productivity is in West Nabire District which reaches 4.80 tons/ha in the form of dry grain. This figure is not optimal because the type of seed used is the type of upland rice or inpari with a productivity capacity of up to 6 tons/ha based on rice production in other areas outside Nabire Regency.

Table 1. Land Area and Rice Production by Sub-district (District) in Nabire Regency, 2018

Subdistrict	Harvest Area (ha)	Production (ton)	Productivity (ton/ha)
Uwapa	388	1.629.60	4.20
Manou	-	-	-
Dipa	-	-	-
Yaur	64	217.60	3.40
Teluk Umar	5	11	2.20
Wanggar	357.50	1.501.50	4.20
Nabire Barat	1.105.00	5.304	4.80
Nabire	28	117.60	4.20
Teluk Kimi	58.25	238.83	4.10
Napan	-	-	-
Makimi	792.35	3.486.34	4.40
Wapoga	-	-	-
Moora	-	-	-
Siriwo	-	-	-
Yaro	11	399.60	3.60
Total Amount	2.909.10	12.906.07	35.10
Average	323.23	1.434.01	3.90

Effectiveness of Using Combine Harvester Machines

The effectiveness of using Combine Harvester machines by respondents of rice farmers in West Nabire District, Nabire Regency is seen based on the output of actual rice harvest results with the target harvest results expected by farmers by looking at the rice harvest results in the form of dry grain, the comparison of the output is also seen for farmers who harvest manually (Santoso et al., 2023; Shanmugam et al., 2025; Qu et al., 2021). Where it can be seen in the following table 2.

Based on the results of the analysis of the effectiveness of the use of the Combine Harvester harvesting machine, in table 2 above shows that using a harvesting machine is more effective than harvesting manually. Of the 9 (nine) respondents of rice farmers in West Nabire District who use the combine harvester harvesting machine from 26 farmer respondents in total, it was obtained that by comparing the actual output or production or reel in the field with the target output in the form of dry grain with a large effectiveness value of

1.073, this value actually shows that the actual output is more than the target output, where the actual output is 4,294.44 kg from 9 respondents with an average land area of 1.01 ha, while the target output is 4 tons or 4,000 kg. The effectiveness value shows more than one, so harvesting rice using the Combine Harvester harvesting machine is more effective than manual harvesting (Elsoragaby et al., 2019; Athaillah et al., 2023; Desrial et al., 2024).

Table 2. Average, Area of Production Land, Harvest Costs of Respondents of Rice Farmers in West Nabire District, Nabire Regency in 2020

Description	Manual Harvest	Combine Harvester Harvest
Land area	1 ha	1.01 ha
Rice Production krg		
-Current	3,708 kg	4.294
-target	4,000 kg (4 ton)	4,000 kg (4 ton)
Rice production	2,410 kg	2,683.33 kg
Selling Price of Rice	Rp 9,000	Rp 9,000
Acceptance	Rp 21,690,000	Rp 24,150,000
Total Cost of Harvesting	Rp 4,352,941	Rp 3,605,555.6
The difference in profit using a combine harvester machine	- Rp. 747,385.4	+ Rp. 747,385.4
Effectiveness of harvesting machines	0.927	1,073

Meanwhile, the manual harvest output shows a value of 0.927 from the comparison of the actual output of 3.708 kg with the target output of 4 tons (4,000 kg), from 17 respondents of rice farmers in the West Nabire District which is the research location with a total number of respondents of 26 farmer respondents. With the value of the results of the effectiveness analysis, it proves that manual harvesting is inefficient (Comparetti et al., 2022; Guevara et al., 2021). This can be seen from the average amount of production in the form of dry grain of 3,708 kg which is the actual manual harvest result, there is a difference with dry grain of 4,294.44 kg, the harvest result using the combine harvesting machine is 586.44 kg or a difference of 0.86%. This difference is referred to as harvest shrinkage due to manual harvesting so that farmers experience a loss of Rp 747,385.4 by carrying out the manual harvesting process (Qu et al., 2021; Darfour & Rosentrater, 2022). And if farmers carry out the harvesting process mechanically using a Combine Harvester harvesting machine, the depreciation value can be reduced and the harvesting cost expenditure can be reduced by IDR 747.385.4 (table 2).

This effectiveness value can also be seen from the comparison of the revenue value of farmers who harvest manually with the harvest receipts mechanically using a combine harvester in the form of rice harvest results (Belton et al., 2021), because the selling price applicable at the farmer level is the same, namely IDR 9,000/ kg for rice production in finished form or rice. The results of the analysis show that overall the respondents of rice farmers in the West Nabire District in Nabire Regency are profitable and feasible to cultivate (Purbiati et al., 2024; Kim et al., 2024), as can be seen in the following table 3.

Table 3. Average, Production Land Area, Harvest Costs of Rice Farmer Respondents in the West Nabire District, Nabire Regency in 2020

Description	Mark	Productivity
Land area	1,009 ha	1 ha
Dry grain production	3,910 kg	3,875.12 kg
Rice production	2,508 kg	2,485.63 kg
Selling Price of Rice	Rp 9,000	Rp 9.000
Acceptance	Rp 22,576,154	Rp. 22,370,664.02
Expenses		
- seed costs	Rp. 222,462	Rp. 220,477,70
- fertilizer costs	Rp. 1,941,731	Rp. 1,924,411,30
- pesticides	Rp. 1,092,115	Rp. 1,924,411,30
- workforce	Rp. 3,917,308	Rp. 3,882,366,70
- equipment rental	Rp. 4,435,768	Rp. 4,396,202,18
- tool depreciation	Rp. 163,155	Rp. 161,699,70
Total Cost of Expenditure	Rp. 11,772,540	Rp. 11,667,532,53
Income	Rp. 10,803,614	Rp. 10,703,131,81
RCR	1,92	1,92

Based on the calculation of cost and revenue analysis to obtain the income level, the average income of rice farmer respondents in Nabire District was IDR 10.803.614 with an average land area of 1.009 ha, which was obtained from the reduction of total income of IDR 22.576,154 minus the total costs incurred by farmers in one planting season or one rice farming production of IDR 11.772.540. In productivity or land area of 1 hectare, an income of IDR 10.703.131.81/ha was obtained with a large income of IDR 22.370.664.02/ha and a large cost of expenditure of IDR 11.667.532.53/ha. From the results of the feasibility analysis, a value of 1.92 was obtained. This means that rice farming in the research location, namely West Nabire District, Nabire Regency, is profitable and feasible to be pursued.

Impact of Using Combine Harvester

The use of Combine harvester can provide benefits or have negative and positive impact (Akter et al., 2024; Savickas et al., 2021; Siagian, 2019). The positive impact shows that by using Combine Harvester, farmers obtain more production because the reduction in harvest yields or lusse from the harvest process can be reduced, thus increasing the harvest yield. In addition, using a combine harvester can reduce labor, because it only requires 3 operators and 4-5 people to collect the harvest, while manual harvesting usually requires more than 20 people. Another advantage or positive impact is that the harvest process only takes a few hours, approximately 6-8 hours for 1 ha of land, while manual harvesting can be done for 2-3 days, so the use of a combine harvester is very efficient in utilizing the time needed in the harvesting process (Putri et al., 2020). In addition to the benefits felt as described above, there are also positive impacts or beneficial impacts, namely that it can reduce harvesting costs that are usually carried out by farmers using manual methods of approximately IDR 5.000.000, which can be reduced so that harvesting costs using a combine machine are approximately IDR 3.000.000 (Ekawati et al., 2021; Ani et al., 2018). The negative impact or weakness of using a combine harvester machine is that if there is limited fuel sold by the agent, farmers and machine operators must prepare fuel before the implementation or harvest process (Abiri et al., 2023; Ibitoye et al., 2023).

Furthermore, another weakness is that for agricultural land there are still remnants of large tree roots such as ironwood trees (Hairiah et al., 2020), the combine machine cannot carry out the harvesting process, also if the rice fields are flooded when harvested due to heavy rain so that the machine cannot operate in muddy rice fields. Another weakness is if the rice fields are on mountain slopes or the shape of the rice fields is terraced (Bwire et al., 2024; Iqbal et al., 2020; Islam et al., 2020; Xie et al., 2020), but for the research location in West Nabire District, the location of the rice fields is flat so that there are no rice fields that have a slope or slope. In addition, if there is damage to the machine in the harvesting process, the use of the machine is stopped because it takes time to repair and replace the machine parts, especially if the supply of spare parts for the combine harvester machine is not available to farmers or operators or agricultural services or even presspack shops. Other impacts can also be caused by the use of harvesting machines, namely air pollution. Such are the impacts of utilizing combine harvester machines. Which are positive and negative.

Conclusion

Based on the previous description of the research results with the title of the effectiveness of the use of combine harvester harvesting machines on rice harvesting in West Nabire District, Nabire Regency, it can be concluded as follows: The use of Combine harvester harvesting machines is more effective than the manual rice harvesting process with an effective value of 1,073, with a cost reduction of Rp 747.385.4 and a reduction in grain loss during harvest of 586.44 kg; The impact of using Combine harvester harvesting machines is positive and negative or beneficial and detrimental.

Acknowledgments

Thanks to all parties who have supported the implementation of this research. I hope this research can be useful.

Author Contributions

S. M., S. S. S., contributed to research, product development, data analysis, and article writing; M. R., J. I., as a supervisor in research activities until article writing.

Funding

This research is research funded by the researcher's own funds and does not receive funding from external parties.

Conflicts of Interest

The author declares that he has no conflict of interest.

References

Abdeen, M. A., Salem, A. E., & Zhang, G. (2021). Longitudinal Axial Flow Rice Thresher Performance Optimization Using the Taguchi Technique. *Agriculture*, *11*(2), 88. https://doi.org/10.3390/agriculture11020088

Abiri, R., Rizan, N., Balasundram, S. K., Shahbazi, A. B., & Abdul-Hamid, H. (2023). Application of digital technologies for ensuring agricultural productivity. *Heliyon*, *9*(12), e22601. https://doi.org/10.1016/j.heliyon.2023.e22601

Akter, H., Ali, Md. R., Alam, Md. S., Sarker, T. R., Ahamed, S., & Saha, C. K. (2024). Estimation of economic life and feasibility of combine harvesters in Bangladesh deploying a unique web-based app. *Smart Agricultural Technology*, *7*, 100378. https://doi.org/10.1016/j.atech.2023.100378

Ani, P., Eka, R. A., Yati, A., & Akira, I. (2018). Factors affecting paddy farmers perception of utilizing agricultural machines in Indonesia. *Journal of Agricultural Extension and Rural Development*, *10*(8), 150–157. https://doi.org/10.5897/JAERD2018.0963

Athaillah, T., Adib, & Shalwati. (2023). Analysis of farmers satisfaction with the use of combine harvester for rice harvesting in farming in Ujong Tanoh Village, Setia District, Aceh Barat Daya Regency. *IOP Conference Series: Earth and Environmental Science*, *1241*(1), 012045. https://doi.org/10.1088/1755-1315/1241/1/012045

Belton, B., Win, M. T., Zhang, X., & Filipski, M. (2021). The rapid rise of agricultural mechanization in Myanmar. *Food Policy*, *101*, 102095. https://doi.org/10.1016/j.foodpol.2021.102095

Bwire, D., Saito, H., Sidle, R. C., & Nishiwaki, J. (2024). Water Management and Hydrological Characteristics of Paddy-Rice Fields under Alternate Wetting and Drying Irrigation Practice as Climate Smart Practice: A Review. *Agronomy*, *14*(7), 1421. https://doi.org/10.3390/agronomy14071421

Chojnacka, K., Mikula, K., Izydorczyk, G., Skrzypczak, D., Witek-Krowiak, A., Moustakas, K., Ludwig, W., & Kułażyński, M. (2021). Improvements in drying technologies—Efficient solutions for cleaner production with higher energy efficiency and reduced emission. *Journal of Cleaner Production*, *320*, 128706. https://doi.org/10.1016/j.jclepro.2021.128706

Comparetti, A., Greco, C., Orlando, S., Ciulla, S., & Mammano, M. M. (2022). Comparison of Mechanical, Assisted and Manual Harvest of Origanum vulgare L. *Sustainability*, *14*(5), 2562. https://doi.org/10.3390/su14052562

Darfour, B., & Rosentrater, K. A. (2022). Pre-harvest and post-harvest farmer experiences and practices in five maize growing regions in Ghana. *Frontiers in Nutrition*, *9*, 725815. https://doi.org/10.3389/fnut.2022.725815

Desrial, Fauzan, I. D., & Wiyono, S. (2024). Performance and Economic Evaluation of Rice Combine Harvester in the Innovation Village of Subang, West Java, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *1386*(1), 012011. https://doi.org/10.1088/1755-1315/1386/1/012011

Ekawati, Ellyta, & Sugiardi, S. (2021). Economic feasibility analysis of service business of agricultural equipment and machinery in Kubu Raya Regency, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *637*(1), 012059. https://doi.org/10.1088/1755-1315/637/1/012059

Elsoragaby, S., Yahya, A., Mahadi, M. R., Nawi, N. M., & Mairghany, M. (2019). Comparative field performances between conventional combine and mid-size combine in wetland rice cultivation. *Heliyon*, *5*(4), e01427. https://doi.org/10.1016/j.heliyon.2019.e01427

Guevara, L., Rocha, R. P., & Cheein, F. A. (2021). Improving the manual harvesting operation efficiency by coordinating a fleet of N-trailer vehicles. *Computers and Electronics in Agriculture*, *185*, 106103. https://doi.org/10.1016/j.compag.2021.106103

Hairiah, K., Widianto, W., Suprayogo, D., & Van Noordwijk, M. (2020). Tree Roots Anchoring and Binding Soil: Reducing Landslide Risk in Indonesian Agroforestry. *Land*, *9*(8), 256. https://doi.org/10.3390/land9080256

Herdiansyah, H., Antriyandarti, E., Rosyada, A., Arista, N. I. D., Soesilo, T. E. B., & Ernawati, N. (2023). Evaluation of Conventional and Mechanization Methods towards Precision Agriculture in Indonesia. *Sustainability*, *15*(12), 9592. https://doi.org/10.3390/su15129592

Htwe, T., Sinutok, S., Chotikarn, P., Amin, N., Akhtaruzzaman, M., Techato, K., & Hossain, T. (2021). Energy use efficiency and cost-benefits analysis of rice cultivation: A study on conventional and alternative methods in Myanmar. *Energy*, *214*, 119104. https://doi.org/10.1016/j.energy.2020.119104

Ibitoye, S. E., Mahamood, R. M., Jen, T.-C., Loha, C., & Akinlabi, E. T. (2023). An overview of biomass solid fuels: Biomass sources, processing methods, and morphological and microstructural properties. *Journal of Bioresources and Bioproducts*, *8*(4), 333–360. https://doi.org/10.1016/j.jobab.2023.09.005

Iqbal, Supratomo, & Azis, A. (2020). Combine rice harvester performance test in Takalar Regency. *IOP Conference Series: Earth and Environmental Science*, *486*(1), 012063. https://doi.org/10.1088/1755-1315/486/1/012063

Islam, A. K. M. S., Alam, Md. A., Ashik-E-Rabbani, M., Bashir, Md. S., & Rahman, Md. M. (2020). Techno-Economic Feasibility of Zoomlion Combine Harvester in Haor Areas of Bangladesh.

Agricultural Sciences, *11*(12), 1170–1185. https://doi.org/10.4236/as.2020.1112077

Kailaku, S. I., Arkeman, Y., Purwanto, Y. A., & Udin, F. (2023). Appropriate harvest age of mango (Mangifera indica cv. Arumanis) for quality assurance in long distance transportation planning in Indonesia. *Journal of Agriculture and Food Research*, *14*, 100763. https://doi.org/10.1016/j.jafr.2023.100763

Kaur, B., Mansi, Dimri, S., Singh, J., Mishra, S., Chauhan, N., Kukreti, T., Sharma, B., Singh, S. P., Arora, S., Uniyal, D., Agrawal, Y., Akhtar, S., Rather, M. A., Naik, B., Kumar, V., Gupta, A. K., Rustagi, S., & Preet, M. S. (2023). Insights into the harvesting tools and equipment's for horticultural crops: From then to now. *Journal of Agriculture and Food Research*, *14*, 100814. https://doi.org/10.1016/j.jafr.2023.100814

Kim, W., Lee, M.-S., & Sung, J. (2024). Rice Production and Nitrogen Use Efficiency by Diverse Forms of Fertilization in Rice-Based Crop Rotation Systems. *Agronomy*, *14*(11), 2663. https://doi.org/10.3390/agronomy14112663

Lin, H.-C., & Fukushima, Y. (2016). Rice Cultivation Methods and Their Sustainability Aspects: Organic and Conventional Rice Production in Industrialized Tropical Monsoon Asia with a Dual Cropping System. *Sustainability*, *8*(6), 529. https://doi.org/10.3390/su8060529

Maeda, O., Lucas, L., Silva, F., Tanno, K.-I., & Fuller, D. Q. (2016). Narrowing the harvest: Increasing sickle investment and the rise of domesticated cereal agriculture in the Fertile Crescent. *Quaternary Science Reviews*, *145*, 226–237. https://doi.org/10.1016/j.quascirev.2016.05.032

Masruroh, E., Achmad, M., & Iqbal. (2025). Optimization of combine harvester in rice harvesting activities in Maros Regency. *IOP Conference Series: Earth and Environmental Science*, *1471*(1), 012001. https://doi.org/10.1088/1755-1315/1471/1/012001

Muchlisyiyah, J., Shamsudin, R., Kadir Basha, R., Shukri, R., How, S., Niranjan, K., & Onwude, D. (2023). Parboiled Rice Processing Method, Rice Quality, Health Benefits, Environment, and Future Perspectives: A Review. *Agriculture*, *13*(7), 1390. https://doi.org/10.3390/agriculture13071390

Mulyani, A., Mulyanto, B., Barus, B., Panuju, D. R., & Husnain. (2022). Geospatial Analysis of Abandoned Lands Based on Agroecosystems: The Distribution and Land Suitability for Agricultural Land Development in Indonesia. *Land*, *11*(11), 2071. https://doi.org/10.3390/land11112071

Murphy, K. M. (2017). A quiet harvest: Linkage between ritual, seed selection and the historical use of the finger-bladed knife as a traditional plant breeding tool in Ifugao, Philippines. *Journal of Ethnobiology and Ethnomedicine*, *13*(1), 3. https://doi.org/10.1186/s13002-016-0124-9

Purbiati, T., Anggraeni, L., Sugiono, S., Zubaidi, T., Purnama, S., Hermanto, C., Krismawati, A., Arifin, Z., Antarlina, S. S., Kilmanun, J. C., & Yustina, I. (2024). Performance and community acceptance of paddy management with balanced input cultivation technology in Kebonagung Village Madiun East Java Indonesia. *Heliyon*, *10*(9), e29834. https://doi.org/10.1016/j.heliyon.2024.e29834

Putri, R. E., Santosa, Cahyani, G. A., Fahmy, K., Arlius, F., & Hasan, A. (2020). Comparison of Performance and Total Energy Requirement for Several Harvesting Method of Indonesian Farmers. *IOP Conference Series: Earth and Environmental Science*, *515*(1), 012004. https://doi.org/10.1088/1755-1315/515/1/012004

Qu, X., Kojima, D., Wu, L., & Ando, M. (2021). The Losses in the Rice Harvest Process: A Review. *Sustainability*, *13*(17), 9627. https://doi.org/10.3390/su13179627

Santoso, A. B., Girsang, S. S., Raharjo, B., Pustika, A. B., Hutapea, Y., Kobarsih, M., Suprihatin, A., Manurung, E. D., Siagian, D. R., Hanapi, S., Purba, T., Parhusip, D., Budiarti, S. W., Wanita, Y. P., Hatmi, R. U., Girsang, M. A., Haloho, L., Waluyo, Suparwoto, & Sudarmaji. (2023). Assessing the Challenges and Opportunities of Agricultural Information Systems to Enhance Farmers' Capacity and Target Rice Production in Indonesia. *Sustainability*, *15*(2), 1114. https://doi.org/10.3390/su15021114

Savickas, D., Steponavičius, D., Špokas, L., Saldukaitė, L., & Semenišin, M. (2021). Impact of Combine Harvester Technological Operations on Global Warming Potential. *Applied Sciences*, *11*(18), 8662. https://doi.org/10.3390/app11188662

Shanmugam, V., Tyagi, V. C., Rajendran, G., Chimmili, S. R., Swarnaraj, A. K., Arulanandam, M., Kumar, V., Peramaiyan, P., Murugaiyan, V., & Sundaram, R. M. (2025). Perennial rice – An alternative to the 'one-sow, one-harvest' rice production: Benefits, challenges, and future prospects. *Farming System*, *3*(2), 100137. https://doi.org/10.1016/j.farsys.2025.100137

Siagian, V. (2019). Factor affected adoption of combine harvester in Banten province-Indonesia. *IOP Conference Series: Earth and Environmental Science*, *399*(1), 012050. https://doi.org/10.1088/1755-1315/399/1/012050

Viršilė, A., Gudžinskaitė, I., Laužikė, K., Kudirka, G., Pukalskas, A., & Samuolienė, G. (2024). Light Intensity Effects on Productivity and Post-Harvest

Quality in Perilla frutescens Cultivated in CEA. *Agriculture*, *14*(11), 2079. https://doi.org/10.3390/agriculture14112079

Xie, Y., Ferng, Y., Miao, J., Ren, J., & Zhang, X. (2020). Numerical and experimental study on optimization of paddy field blade used in initial mud-cutting process. *Computers and Electronics in Agriculture*, *170*, 105243. https://doi.org/10.1016/j.compag.2020.105243

Yasin, Darmal, R., & Nixiatenriawaru, A. (2020). Comparative of the application of combine harvester with the traditional harvest at Tanah Miring District, Merauke Regency. *IOP Conference Series: Earth and Environmental Science*, *473*(1), 012128. https://doi.org/10.1088/1755-1315/473/1/012128