



Rice Postharvest Practices among Marginal-Land Farmers

Maftuh Kafiya^{1*}, Liana Fatma Leslie Pratiwi², Fadilla Ristya Aminda³, Ayu Kumala Sari⁴, Aisya Putri⁵, Alda Saskia Rahmawati⁶, Aulia Syaharani⁷, Fadhil Aysar Ramadhan⁸, Kharisa Jeniarti⁹, Zaki Ahmad Ghazali¹⁰

¹ Department of Agrotechnology, Universitas Pembangunan Nasional Veteran Yogyakarta, Indonesia

^{2,3,4,5,6,7,8,9,10} Department of Agribusiness, Universitas Pembangunan Nasional Veteran Yogyakarta, Indonesia

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Abstract

Gunungkidul Regency is the highest rice producer in the Special Region of Yogyakarta (DIY), despite being dominated by marginal lands consisting of karst hills and rain-fed drylands. This study aimed to (1) characterize rice postharvest practices among farmers in the three selected study locations (Ponjong, Rongkop, and Semin subdistrict), and (2) examine associations between study location and selected postharvest practices. A quantitative descriptive approach was employed, surveying 128 purposively selected rice farmers through structured interviews in May-June 2026. Frequencies and percentages were used to describe postharvest practices, while associations between subdistrict and selected single-response categorical variables were examined using Pearson's chi-square test of independence ($\alpha = 0.05$), with Cramér's V used to describe the strength of the association. Harvesting remained predominantly manual, whereas power threshers were used by more than 90% of respondents across the three locations. Drying duration, awareness of target grain moisture content, and storage duration were significantly associated with study location ($p < 0.001$), with Cramér's V values of 0.304, 0.417, and 0.281, respectively. Overall, 75.8% of respondents were unaware of the target grain moisture content. Harvest-timing indicators showed a borderline nominal association with study location ($p = 0.049$; Cramér's V = 0.222), which should be interpreted cautiously in the context of multiple statistical tests. These findings demonstrate heterogeneity in rice postharvest management among the selected study locations and support context-specific interventions, particularly for moisture-based drying management and storage.

Keywords: *Marginal land, Postharvest practices, Agricultural mechanization*

INTRODUCTION

Rice is a strategic food crop that not only determines household food availability but also influences farmers' incomes. Gunungkidul Regency is a key contributor to food security in the Special Region of Yogyakarta (DIY). Data from [Badan Pusat Statistik Kabupaten Gunungkidul \[BPS Gunungkidul\], 2025](#), confirm this, showing that Gunungkidul's rice production reached 115,738 tons—the highest in the province. This is particularly noteworthy given the regency's distinctive characteristics; despite consisting largely of marginal land, it manages to generate a grain surplus.

Marginal land is not synonymous with unproductive land; rather, it refers to land whose suitability and production potential are constrained by a combination of biophysical, geographical, and socio-economic factors. Marginality is also contextual and dynamic, as land can become more productive when supported by appropriate technology, infrastructure, institutional frameworks, and management practices ([Ahmadzai et al., 2021](#); [Csikós & Tóth, 2023](#)). Given this understanding, the management of marginal land should not focus solely on increasing on-farm production but must also encompass efforts to maintain the quantity and quality of the harvest during the

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Corresponding author's email: kafiyamaftuh@upnyk.ac.id

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postharvest stage.

This context is particularly relevant to Gunungkidul Regency, an area dominated by karst hill landscapes with varied topography and deep groundwater levels. Agriculture in the regency relies predominantly on rain-fed dryland farming, while irrigated paddy fields are relatively limited. Factors such as land conditions, dependence on rainfall, plot sizes, and road access to fields can contribute to crop losses. Consequently, postharvest losses in such marginal areas are strategically important, as they not only reduce income but also deplete food reserves.

Losses can be quantitative—such as scattered or shed grain—or qualitative, manifesting as increased moisture content, discoloration, microbial infestation, and a higher percentage of broken rice. SNI 9306:2024 identifies harvesting, threshing, transportation, drying, and milling as the key stages for measuring postharvest rice losses ([Balai Besar Perakitan dan Modernisasi Pascapanen Pertanian \[BRMP\], 2025](#)). Therefore, evaluating farmers' practices requires a sequential approach that follows the material flow, rather than assessing each activity in isolation.

Rice harvesting and postharvest technologies are available at varying levels of mechanization, and a growing body of Indonesian literature documents combine-harvester adoption and its determinants in lowland, irrigated production centers such as Aceh Besar, Sambas, and Bangkalan ([Athallah et al., 2023](#); [Asrita et al., 2025](#); [Baidok et al., 2026](#)). These studies, however, focus on relatively flat, irrigated rice areas with relatively good road access; comparatively little empirical evidence exists on how postharvest practices are carried out – and whether they differ – across contrasting marginal-land agroecosystems within a single regency, where topography, rainfall dependence, and market access can vary sharply over short distances. Regency-level statistics, such as those from [BPS Gunungkidul \(2025\)](#), report aggregate production figures but do not disaggregate postharvest handling by agroecosystem zone, so it remains unknown whether farmers in karst-dominated, rain-fed, and comparatively fertile zones of the same regency handle their harvest in comparable ways. This gap matters in practice because postharvest recommendations designed for one zone may not transfer well to another with different terrain, road access, or drying conditions. However, adoption among small-scale farmers is often hindered by equipment costs, business scale, land conditions, road access, the availability of machinery services, technical knowledge, and labor considerations. As a result, mechanization adoption tends to be uneven. This lack of continuity can diminish the technology's benefits, given that the quality of the material at any given stage is heavily influenced by handling during the preceding stage.

By purposively selecting one subdistrict from each of Gunungkidul's three contrasting agroecosystem settings – Ponjong (central zone, rain-fed dryland), Rongkop (southern zone, karst topography), and Semin (northern zone, comparatively fertile land) – this study compares postharvest practices across the selected locations. The agroecosystem classification provides contextual information for interpreting the observed differences rather than serving as an independently tested causal factor. This study therefore aims to (1) characterize rice postharvest practices among farmers in the three selected subdistricts (Ponjong, Rongkop, and Semin), and (2) examine associations between study location and selected postharvest practices.

LITERATURE REVIEW

Marginal land is often overlooked because it is deemed unproductive and difficult to manage due to limited nutrients and water availability, as well as unfavorable physical and chemical conditions for plant growth ([Waruwu & Waruwu, 2024](#)). Furthermore, marginal land has limiting factors that require additional effort to enhance its productivity ([Jayani & Juniarto, 2020](#)). Land may be classified as marginal for a specific commodity yet remain suitable for other commodities that are more tolerant of environmental stress. Marginal status can change through technological

improvements or the development of commodities adapted to local conditions. Consequently, marginality does not necessarily imply that the land cannot be utilized; rather, it indicates specific limitations that must be considered in its management (Csikos & Toth, 2023).

Gunungkidul Regency features a topography dominated by karst hills, characterized geologically by limestone formations with low water-retention capacity. Most agriculture in the region relies on rain-fed dryland farming, while irrigated paddy fields are relatively limited. These conditions render agricultural activities—particularly rice cultivation—highly dependent on the rainy season (BPS Gunungkidul, 2025; Widyastuti et al., 2012; Haryono & Day, 2004).

Improper harvest timing can reduce grain quantity while increasing the percentage of broken rice after milling: harvesting too early results in incomplete grain filling and a higher share of empty grains, while delayed harvesting increases the risk of grain loss through panicle shattering (Qu et al., 2021). Studies of combine-harvester adoption in other Indonesian lowland areas show that muddy conditions, narrow plots, and non-simultaneous harvesting patterns are real obstacles to mechanized harvesting (Yusun et al., 2024; Athaillah et al., 2023). Manual harvesting with sickles has been associated with harvest-and-transport losses of up to 10%, particularly when performed by unskilled labor (Irwanto, 2021). Elsewhere in Asia, a comparative study of paddy-harvesting systems in Sri Lanka similarly found that terrain and plot geometry, not only cost, shape which harvesting system is technically feasible (Kahandage et al., 2023). Recent work on mechanical harvesting in China links post-ripening delay and harvest-moisture content directly to measurable yield loss (Sun et al., 2025; Chandra et al., 2024).

Once harvested, paddy must be moved from the field to the threshing site before quality deteriorates further. The mode of transportation available is shaped by road infrastructure and plot accessibility, which in hilly or karst terrain can differ markedly from flat, irrigated areas (Yusun et al., 2024). Threshing has generally advanced further than harvesting: power threshers are now widely available even to small-scale farmers through rental/service arrangements, and studies on rice postharvest technology consistently identify threshing as the stage where mechanical loss reduction has been most successfully diffused, provided the equipment is operated correctly (Nath et al., 2024).

Drying aims to reduce grain moisture content to a level safe for storage and milling. Sun-drying remains the dominant method among smallholders because it requires no energy beyond sunlight, but it is highly weather-dependent and can produce inconsistent, hard-to-control drying times. Ideally, sun-drying should be conducted over three to four days on a tarpaulin base to reach a safe moisture content (Mita & Rahmatiyah, 2025). Because moisture content at the end of drying strongly determines both storability and milling recovery, awareness of and monitoring for a target moisture level – rather than reliance on visual estimation alone – are repeatedly identified in the literature as key determinants of drying-stage loss (Chandra et al., 2024; Kumar & Kalita, 2017).

During storage, grain stability is strongly influenced by moisture content, temperature, relative humidity, storage duration, sanitation, container characteristics, and exposure to insects and rodents. Conventional sack storage is accessible and inexpensive for smallholders but generally provides less isolation from environmental fluctuations and storage pests than sealed or hermetic systems. Consequently, appropriate grain moisture before storage and adequate storage management are essential to limit quality deterioration during prolonged storage (Kumar & Kalita, 2017; Nath et al., 2024).

Postharvest loss refers to the reduction in the quantity and quality of the produce occurring from the time of harvest until the grain is handled, processed, and stored (Food and Agriculture Organization [FAO], 2013). FAO (2013) further explains that quantitative loss relates to a reduction in the weight, volume, or count of the material, whereas qualitative loss relates to a decline in the product's physical, chemical, nutritional, and functional characteristics, as well as its safety.

Quantitative losses can manifest as grain shattering and remaining in the field, uncut plants, grain scattered during collection and transport, grain detaching from the panicles, and grain consumed by birds, rodents, or insects (Qu et al., 2021). Meanwhile, qualitative losses are evident in quality deterioration, such as increases in broken, yellow, damaged, chalky, and immature grains, as well as foreign matter, changes in aroma, mold contamination, and a reduction in nutritional value (Kumar and Kalita, 2017; Buggenhout et al., 2013).

The magnitude of rice postharvest loss varies widely across regions. These differences are influenced by factors such as variety, season, weather, harvest timing, equipment type, worker skills, operational scale, transport distance, drying technology, storage systems, and measurement methods (Qu et al., 2021; Nath et al., 2024). Previous studies also indicate that loss estimates based on farmers' perceptions may differ from those determined through direct measurement (FAO, 2013). Therefore, loss figures from other regions should not be applied directly to a specific location without conducting field measurements (FAO, 2013; BRMP, 2025).

Taken together, this body of work establishes what postharvest loss is, how it can occur at each stage, and how mechanization has diffused unevenly across regions – but it offers little direct, statistically comparable evidence on whether postharvest practices themselves differ across contrasting agroecosystem zones that share the same regency-level institutional and market context. This study addresses that gap using primary survey data from three subdistricts representing Gunungkidul's central, southern, and northern agroecosystem zones, combined with formal statistical testing rather than description alone.

RESEARCH METHOD

This study was conducted from May to June 2026 across three agroecosystem zones in Gunungkidul Regency. In this context, marginal land agroecosystems refer to rice production environments characterized by persistent constraints, including reliance on rainfall, limited water availability, soil and hydrological conditions typical of karst regions, uneven topography, and restricted land accessibility. This classification applies at the agroecosystem level rather than through plot-level land capability assessments. Research sites were selected using purposive sampling, identifying the sub-district with the highest rice production in the third quarter of 2025 within each agroecosystem zone. Semin Sub-district, known for its fertility, was selected for the Northern Zone (27,418 tons of irrigated paddy; 13,948.5 tons of dryland paddy); Ponjong Sub-district, a rain-fed area, was selected for the Central Zone (7,851 tons of irrigated paddy; 16,369 tons of dryland paddy); and Rongkop Sub-district, a karst area, was selected for the Southern Zone (10,215.7 tons of dryland paddy). Research subjects met the following criteria: (1) actively cultivating rice on marginal land within the study sub-districts, (2) having completed at least one full harvest and postharvest cycle during the current planting season, and (3) willing to participate in structured interviews. Sample size was determined using quota sampling, selecting 42–43 individuals from each sub-district, resulting in a total of 128 respondents. This sampling method was chosen due to constraints such as the difficulty of locating subjects who met the criteria and limitations regarding research resources (time and budget).

Data were collected through face-to-face structured interviews using questionnaires administered by trained enumerators. The research instrument was developed based on the postharvest stages defined in SNI 9306:2024 harvest timing determination, harvesting, transportation, threshing, drying, milling, and storage (BRMP, 2025) as well as the FAO (2013) framework for quantitative and qualitative losses. The questionnaire underwent a preliminary feasibility assessment via face validity, involving 2–3 peers and postharvest experts who reviewed the draft questions. Data were analyzed using descriptive and inferential statistics. Frequencies and percentages were used to summarize farmers' postharvest practices across the three subdistrict.

The relationship between the study location and selected single-response categorical postharvest variables (harvest timing indicators, harvesting tools, threshing methods, drying methods, drying duration, awareness of target grain moisture content, and storage duration) was tested using Pearson's chi-square test of independence at a significance level of $\alpha = 0.05$. Cramer's V was calculated as an effect size measure to describe the strength of the observed associations. Transportation moda and storage location were treated descriptively because these questionnaire items allowed multiple response; consequently, their response categories were not mutually exclusive and percentages could exceed 100%.

FINDINGS AND DISCUSSION

Overview of Rice Postharvest Practices

Postharvest rice practices in Gunungkidul Regency encompass a series of steps: determining harvest time, cutting panicles, gathering the harvest, transportation, threshing, drying, milling, and grain storage. Research findings indicate that most of these stages—particularly harvesting, gathering, drying, and storage—are still carried out using simple technology, whereas machinery is widely used during the threshing and milling stages. Postharvest losses, involving both quantitative and qualitative reductions, can occur simultaneously. The study focused on three subdistricts: Ponjong, Semin, and Rongkop. All three are characterized as marginal lands; in this context, [Nath et al. \(2024\)](#) state that postharvest technologies for marginal areas must be adapted to local physical conditions, production scale, economic capacity, seasonal factors, and the availability of support services.

Harvest Decision and Harvesting

The harvest timing indicator chart (Figure 1) shows that harvesting decisions are based on two factors: crop age and grain color. These indicators—crop age and grain color—should be used together to ensure a more accurate determination. Because the change in grain color from green to yellow does not always coincide with the optimum moisture content for harvest, reliance on this single visual cue should ideally be supplemented with a physiological-age or moisture-based check to minimize crop loss ([Qu et al., 2021](#)).

Farmers in the three subdistricts rely mainly on visual indicators – grain color and plant age – to determine harvest time, rather than on objective measurements such as grain moisture content. Harvest timing indicators showed a nominal association with study location ($p = 0.049$, Cramer's $V = 0.222$). However, because several separate chi-square tests were conducted without adjustment for multiple comparisons, this borderline result should be interpreted cautiously.

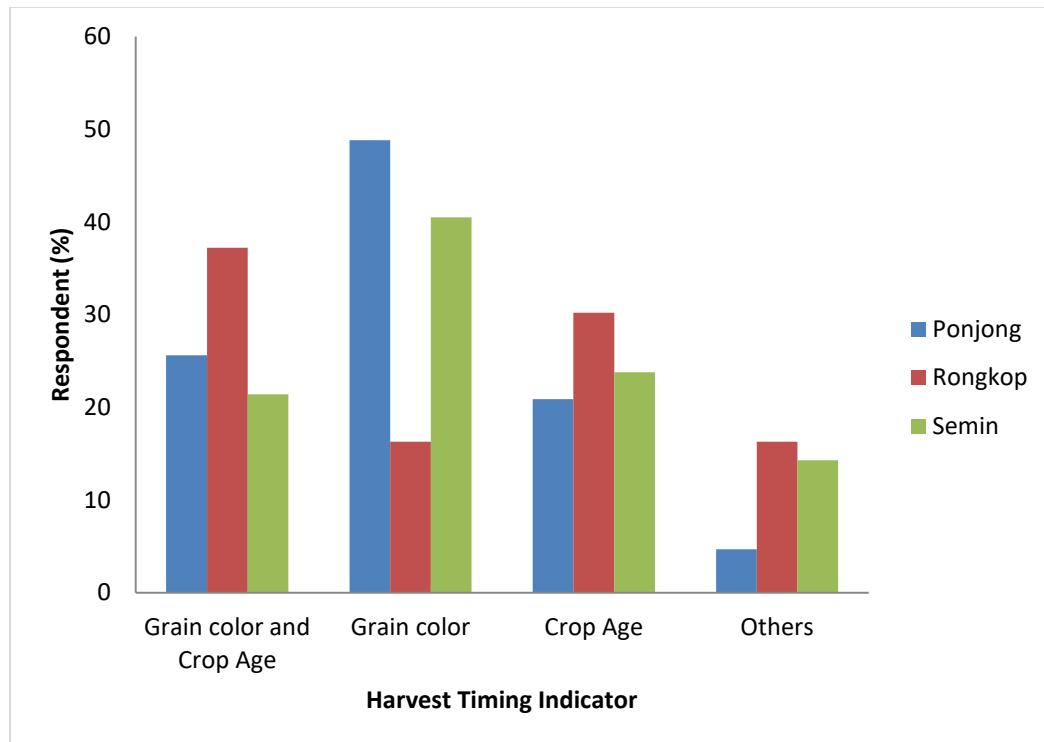


Figure 1. Graph of Harvest Timing Indicator

Harvesting is carried out almost exclusively with the regular sickle (95.3–100% of respondents across the three subdistricts); the serrated sickle appears only in Rongkop (2.3%), and the combine harvester only in Semin (4.8%). No statistically significant association was detected between study location and harvesting tool ($p = 0.413$, Cramer's $V = 0.125$). Nevertheless, harvesting was highly homogeneous across locations, with regular sickles overwhelmingly dominating observed practices. The near-total dominance of manual sickle harvesting across all three zones – regardless of whether the terrain is karst (Rongkop), rain-fed dryland (Ponjong), or comparatively fertile (Semin) – is consistent with adoption studies from other Indonesian lowland areas ([Athailah et al., 2023](#); [Yusun et al., 2024](#)), which attribute low combine-harvester uptake to small, irregular plots, uneven terrain, and limited machinery-service availability rather than terrain type alone.

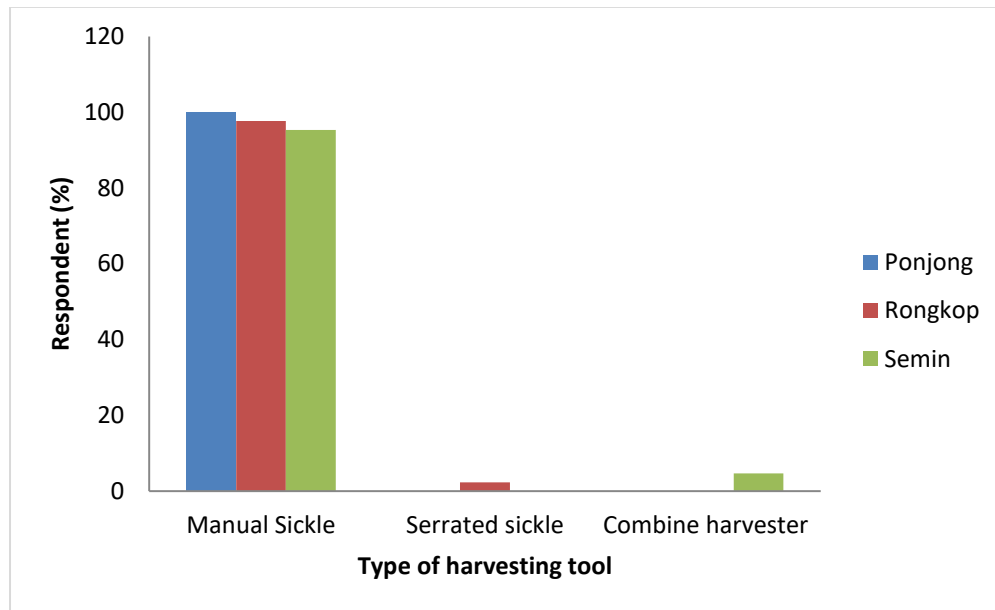


Figure 2. Type of harvesting tool

Collection and Transportation

After harvesting, paddy is typically collected in sacks and transported to the threshing site by motorcycle or pickup truck. Transportation modes varied across the three study locations because respondents could report more than one mode. Pickup trucks were most frequently reported in Ponjong (83.7%), whereas motorcycles were most frequently reported in Rongkop (74.4%) and Semin (57.1%). Previous studies have identified terrain, road infrastructure, and plot accessibility as factors that may influence transportation choice in rice-growing areas ([Kahandage et al., 2023](#); [Yusun et al., 2024](#)). However, these factors were not directly measured in the present study and therefore cannot be used to explain the observed differences among the study locations.

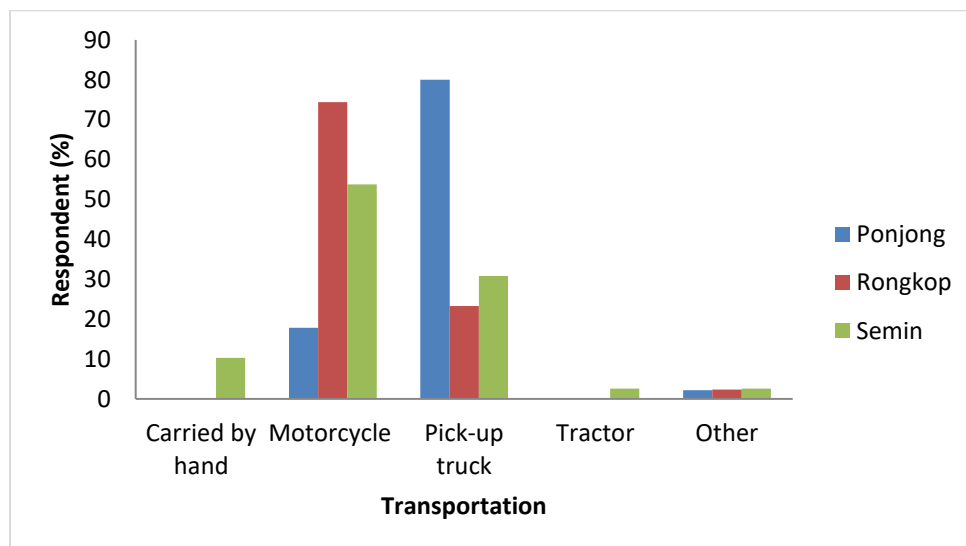


Figure 3. Mode of transportation for Harvested Paddy

Threshing

Threshing is dominated by power threshers in all three subdistricts (Ponjong 97.7%; Rongkop 90.7%; Semin 90.5%), with manual beating and pedal threshers together accounting for

less than 10% of cases. No statistically significant association was detected between study location and threshing method ($p = 0.674$, Cramer's $V = 0.096$). Power threshers predominated across all three locations. However, because the alternative threshing categories contained relatively few observations, the Pearson chi-square result should be interpreted cautiously.

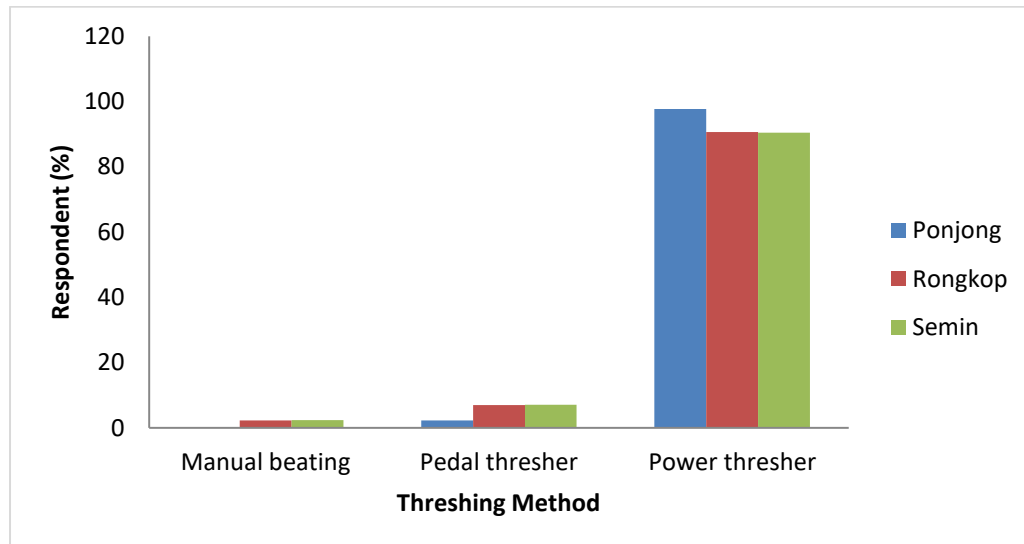


Figure 4. Threshing Method

Drying Practices

Table 1 shows that the vast majority of respondents (95.2–97.7%) dry paddy using natural sun-drying, with mechanical drying used by only 2.3–4.8%; this difference across subdistricts is not statistically significant ($p = 0.758$, Cramer's $V = 0.066$), confirming that sun-drying is the near-universal default regardless of agroecosystem zone. Drying duration, however, differs sharply and significantly by subdistrict ($p < 0.001$, Cramer's $V = 0.304$). The distribution of drying duration differs between Semin, where shorter drying durations are more common (76.2% finish within 1–2 days), and Rongkop, where longer drying durations predominate (67.4% dry for 3–4 days). Because sun-drying ideally requires three to four days on a tarpaulin base to reach a safe moisture content (Mita & Rahmatiyah, 2025), the shorter drying duration observed in Semin may warrant further investigation, as final grain moisture content was not directly measured in this study. Therefore, the adequacy of drying cannot be determined from drying duration alone.

Farmers' awareness of the target final moisture content was significantly associated with study location ($p < 0.001$, Cramer's $V = 0.417$). Among the variables examined, moisture target awareness had the largest Cramer's V (Table 3), indicating the strongest location-related association in the present dataset. Overall, 75.8% of respondents were unaware of the target grain moisture content, with the proportion varying considerably across the three locations.

Table 1. Characteristics of Drying

Variable	Category	Ponjong	Rongkop	Semin	Total
Paddy drying	Sun drying	42 (97.7%)	42 (97.7%)	40 (95.2%)	124 (96.9%)
	Mechanical	1 (2.3%)	1 (2.3%)	2 (4.8%)	4 (3.1%)
Drying duration	1–2 days	18 (41.9%)	11 (25.6%)	32 (76.2%)	61 (47.7%)
	3–4 days	21 (48.8%)	29 (67.4%)	8 (19.0%)	58 (45.3%)
	> 4 days	5 (11.6%)	3 (7.0%)	2 (4.8%)	10 (7.8%)
Knowledge of target moisture content	Aware (< 14%)	18 (41.9%)	12 (27.9%)	0 (0%)	30 (23.4%)

unaware	24 (55.8%)	31 (72.1%)	42 (100%)	97 (75.8%)
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Source: Primary Data Analysis (2026)

Storage Practices

Grain storage is dominated by two related practices: in-house storage (78.6–95.3%) and sack containers (85.7–100%). Sacks remain the dominant container type across all three subdistricts, so a formal statistical test could not be performed for this variable given its near absence of variation. In-house storage was the most frequently reported storage location across all three study areas. Because respondents could report more than one storage location, the distribution was interpreted descriptively rather than as mutually exclusive categories. Storage duration was also significantly associated with study location ($p < 0.001$, Cramer's $V = 0.281$), indicating differences in the distribution of storage periods among the selected locations. Rongkop shows by far the longest storage duration (81.4% storing for more than three months), followed by Semin (54.8%) and Ponjong (34.9%). Indoor storage is preferred because it facilitates easier monitoring at no additional cost, but the predominance of sacks limits protection against storage pests. [Kumar and Kalita \(2017\)](#) identify moisture content, temperature, humidity, sanitation, container, and duration as the key factors governing grain deterioration during storage – several of which (duration in particular) differ significantly across Gunungkidul's three zones.

Table 2. Characteristics of Storage

Variable	Category	Ponjong	Rongkop	Semin	Total
Paddy storage location	Warehouse	6 (14 %)	2 (4.7%)	9 (21.4%)	17 (13.3%)
	In-house	37 (86 %)	41 (95.3%)	33 (78.6%)	111 (86.7%)
	Other	0 (0 %)	0 (0 %)	6 (14.3%)	6 (4.7%)
Storage container	Sack	43 (100 %)	43 (100%)	36 (85.7%)	122 (95.3%)
	Other	0 (0 %)	0 (0%)	6 (14.3%)	6 (4.7%)
Storage duration	< 1 month	1 (2.3%)	0 (0%)	0 (0%)	1 (0.8%)
	1–3 months	27 (62.8%)	8 (18.6%)	19 (45.2%)	54 (42.2%)
	> 3 months	15 (34.9%)	35 (81.4%)	23 (54.8%)	73 (57%)

Source: Primary Data Analysis (2026)

This study has several limitations. First, purposive sampling limits the generalizability of the findings beyond the selected study locations. Second, the cross-sectional survey captured farmers' practices during a single farming season and may not represent seasonal or year-to-year variation. Third, most variables were based on self-reported postharvest practices and may therefore be subject to recall or reporting bias. Fourth, actual quantitative and qualitative postharvest losses, grain moisture content, pest infestation, and objective grain-quality indicators were not directly measured. Therefore, the results should be interpreted as evidence of variation in postharvest practices rather than as estimates of actual postharvest loss.

Table 3. Association between study location and selected rice postharvest practices

Variable	Pearson X^2	df	p-value	Cramers'V
Harvest timing indicator	12.63	6	0.049	0.222
Harvesting tool	3.95	4	0.413	0.125
Threshing method	2.34	4	0.674	0.096
Drying method	0.55	2	0.758	0.066
Drying duration	23.66	4	<0.001	0.304
Moisture-target awareness	22.04	2	<0.001	0.417
Storage duration	20.28	4	<0.001	0.281

Note: Statistical significance was determined at $\alpha = 0.05$

Cramer's V = effect size

Source: Primary Data Analysis (2026)

CONCLUSIONS & FURTHER RESEARCH

Rice postharvest management varied across the three selected study locations in Gunungkidul Regency and was characterized by uneven mechanization across stages. Threshing is highly mechanized, whereas harvesting remains predominantly manual. Sun drying was the dominant drying method across all locations. Among the practices examined, drying duration, awareness of target grain moisture content, and storage duration showed statistically significant associations with study location ($p < 0.001$), with Cramer's V values of 0.304, 0.417, and 0.281, respectively. Awareness of the moisture target showed the strongest association with study location among the variables examined. Harvest timing indicators showed a borderline nominal association with study location and should be interpreted cautiously. These findings indicate heterogeneity in postharvest management among selected locations rather than causal effects of agro-ecosystem conditions. Therefore, postharvest improvement strategies should consider location-specific practices, particularly moisture-based drying management and storage. Because actual quantitative and qualitative losses were not measured directly, the results should be interpreted as evidence of differences in postharvest practices and potential vulnerability rather than estimates of loss magnitude.

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