# Operational Assessment of Sustainable Land Management Practices for Inpari 32 Rice Cultivation at Mojosari Experimental Farm

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**Abstract**

Sustainable rice production depends on coordinated field operations, yet operational records are rarely evaluated as reproducible agronomic evidence. This study examined Inpari 32 rice cultivation at Mojosari Experimental Farm, East Java, from June to August 2025 as an observational, non-replicated case study reconstructed from field records, direct participation, structured observation, interviews, and literature benchmarking. Ten prespecified stages, from land preparation to postharvest drying, were documented (10/10; 100% operational completeness). Recorded indicators included 40 kg seed ha-1, 18-day-old seedlings, jajar legowo 2:1 spacing (40-cm alley, 20-cm paired-row spacing, and 10-cm within-row spacing), an estimated 333,333 hills ha-1, and three split applications supplying 183 kg N, 45 kg P2O5, and 45 kg K2O ha-1. A literature-referenced qualitative matrix yielded 76 of 144 possible points (52.8%; mean 1.58/3), indicating moderate cross-functional alignment rather than validated sustainability performance. The package was operationally complete, but grain yield, yield components, water input, pest density, and soil-test-based nutrient balance were not measured. Accordingly, the observed practices may align with food-security, water-efficiency, responsible-input-use, and climate-action objectives, but environmental or productivity impacts cannot be claimed without replicated field measurements.

***Keywords:*** Inpari 32, integrated crop management, paddy field, nutrient-use efficiency, sustainable rice production

## Introduction

Rice remains a strategic crop for food security because it supplies a major share of dietary energy in Asia and sustains rural livelihoods across irrigated and rainfed landscapes (Fukagawa & Ziska, 2019). In Indonesia, stable rice supply depends on the interaction of land availability, climate variability, input prices, and field-level management. The local production context is particularly relevant for an assessment conducted in Mojokerto Regency. In 2024, the regency recorded 47.29 thousand ha of harvested paddy area and 285.71 thousand t of dry unhusked paddy (Badan Pusat Statistik Kabupaten Mojokerto, 2025). These local data show why geographically grounded management evidence matters. Sustained production cannot rely only on area expansion; it also requires variety-specific crop establishment, balanced nutrient supply, timely pest and weed control, and accountable water management.

The adoption of improved varieties is one route for increasing rice production under land scarcity. Multi-environment testing in Indonesian tropical lowlands reported that Inpari 32 combined competitive yield with stable agronomic and grain-quality performance; its mean yield across the reported environments was 7.27 t ha-1, with an average plant height of 100 cm and 17 tillers plant-1 (Aswidinnoor et al., 2023). An adoption study in Indramayu also reported farmer-level productivity of approximately 7.2 t ha-1 for Inpari 32 (Agustian et al., 2022). These values provide comparison points, not an expected outcome for Mojosari, because yield depends on site, season, crop establishment, and input management. Genetic potential cannot compensate for uneven puddling, poor water control, unbalanced nutrition, weed competition, or delayed pest monitoring; consequently, varietal performance must be interpreted together with the complete management package.

Lowland rice management differs from upland management because water, tillage, redox conditions, and nutrient transformations interact in the puddled layer. Primary tillage and puddling can suppress weeds, reduce percolation, and create a soft rooting environment, but excessive or poorly timed operations may damage soil structure and increase energy use. Irrigation must likewise maintain crop water supply while limiting unproductive losses. Alternate wetting and drying can reduce water input, but its performance depends on soil, groundwater, rainfall, crop stage, and the re-irrigation threshold (Carrijo et al., 2017; Chen et al., 2024; Yao et al., 2024). Canopy humidity and grain filling may also respond to irrigation regime, reinforcing the need to relate operational water decisions to crop physiology (Chen et al., 2025). At an experimental farm, controlled irrigation should therefore be documented with water depth, timing, rainfall, and applied volume rather than described only as a calendar operation.

Nutrient management is another critical element of sustainable rice production. Nitrogen supports canopy formation, tillering, photosynthesis, and grain filling, but recovery efficiency declines when fertilizer exceeds crop demand or is poorly synchronized with water conditions. A synthesis of 2,293 rice observations identified N application rate as the strongest inhibitor of agronomic N-use efficiency at the global scale (Chen et al., 2023). Recent field studies further show that integrated nutrient management, deep placement, organic amendments, and site-specific scheduling can increase yield or N-use efficiency while reducing avoidable loss (Islam et al., 2024; Kaur et al., 2024; Marzouk et al., 2024). Indonesian integrated crop-management research similarly demonstrates that improved varieties must be combined with appropriate crop and nutrient practices to narrow yield gaps and improve profitability (Erythrina et al., 2021). Fertilizer timing, source, dose, and the water condition at application are therefore essential variables in an operational assessment.

Recent studies have evaluated individual interventions such as improved varieties, water-saving irrigation, nutrient management, and farmer adoption, but they rarely examine how a complete routine management sequence at an Indonesian experimental farm is documented and whether that evidence supports sustainability claims (Erythrina et al., 2021; Chang et al., 2024; Yao et al., 2024). Operational field reports commonly record what was done while omitting measured yield, water input, soil fertility, pest abundance, explicit scoring rules, and uncertainty. The resulting gap is not merely a lack of description; it is the absence of a transparent method for separating implemented practices, derived indicators, and verified outcomes. This distinction is necessary because operational completeness cannot be treated as proof of productivity, resource-use efficiency, or environmental impact.

The novelty of this study is a traceable evidence-conversion workflow that transforms non-replicated operational records into a crop-management timeline, agronomic input indicators, a literature-anchored qualitative contribution matrix, and an evidence-strength map without fabricating unobserved outcomes. The study addressed three questions: (1) which management components, timings, and input rates were documented for Inpari 32 cultivation at Mojosari; (2) how do those components align with agronomic functions and sustainability objectives; and (3) which missing measurements prevent causal or impact inference? The objectives were to reconstruct the field protocol, calculate transparent plot- and hectare-level indicators, interpret the package against recent rice-management literature, and specify the measurements required for future replicated validation.

## Materials and Methods

This study used an observational, non-replicated case-study design based on operational field records rather than a researcher-established field experiment. It was conducted at Mojosari Experimental Farm of Balai Penerapan Modernisasi Pertanian Jawa Timur, East Java, Indonesia, during the professional field-practice period from 23 June to 22 August 2025. The focal crop was Inpari 32 lowland rice grown on a one-hectare paddy field divided into eight operational plots of approximately 1,250 m2. No randomized treatments, experimental control, or biological replicates were established. The unit of description was therefore the managed field and its activity records, and all analyses were descriptive or derived. Activities unrelated to the rice objective, including hydroponic vegetables and pot trials, were excluded.

Evidence consisted of direct field observation, daily operational participation, field photographs, interviews with field supervisors and technicians, and activity-log reconstruction. Ten prespecified management stages were coded: land preparation, nursery management, transplanting, irrigation, fertilization, weeding, roguing, pest management, harvest, and postharvest drying. Extracted variables included field area, plot division, seed rate, seedling age, planting geometry, fertilizer source and dose, application timing, weeding and roguing dates, irrigation regime, pest-control materials, harvest age, and drying target. The field records mentioned the trade products Virtako and Applaud. Their active ingredients were identified as thiamethoxam plus chlorantraniliprole and buprofezin, respectively; however, formulation, application dose, spray volume, and number of applications were not recorded and were therefore not quantified.

Table 1. Reconstructed field protocol and agronomic function of Inpari 32 rice management at Mojosari Experimental Farm

| Stage | Timing | Operational parameter | Agronomic function | Data status |
|---|---|---|---|---|
| Land cleaning and bund repair | Before tillage | Brush cutter, manual removal of weeds and hard vegetation, bund construction of 30-50 cm | Reduced weed competition; improved water control; facilitated access | Observed/ recorded |
| Pre-flooding and primary tillage | 1-2 days before transplanting | 2-5 cm water layer; tractor tillage at 20-25 cm depth | Softened soil, buried weeds, improved puddling readiness | Observed/ recorded |
| Secondary puddling and leveling | Before transplanting | Hand tractor puddling, molluscicide application, final leveling | Produced homogeneous mud layer and reduced golden apple snail risk | Observed/ recorded |
| Wet nursery and transplanting | 18 DAS and 0 HST | 40 kg seed ha-1; 2-3 seedlings hill-1; jajar legowo 2:1 with a 40-cm alley, 20-cm paired-row spacing, and 10-cm within-row spacing | Improved establishment and field accessibility | Observed/ calculated |
| Irrigation | 0-100 HST | Macak-macak early stage, weekly irrigation, 5-7 cm water layer, drying near harvest | Maintained moisture and supported water-saving orientation | Observed; not metered |
| Fertilization | 10, 24, 38 HST | 300 kg urea + 300 kg Phonska Plus ha-1 split equally | Synchronized nutrient supply with establishment, tillering, and reproductive transition | Observed/ calculated |
| Weeding | 14, 25, 40 HST | Manual weeding using sickle before topdressing | Reduced nutrient and light competition | Observed/ recorded |
| Roguing | 30 HST, 50-60 HST, pre-harvest | Removal of off-type plants | Maintained varietal purity and seed quality | Observed/ recorded |
| Pest control | Monitoring based | Virtako (thiamethoxam + chlorantraniliprole) and Applaud (buprofezin) mentioned; formulation and dose not recorded | Reduced pest pressure while avoiding inappropriate application timing | Observed; pest density not measured |
| Harvest and drying | 110-120 HST | Manual cutting, threshing, sun drying to 10-12% moisture | Maintained grain quality and storability | Observed/ recorded |

DAS = days after sowing; HST = days after transplanting. Data status distinguishes observed field records from indicators calculated from recorded parameters. Product names are reported for traceability and do not imply endorsement.

Derived indicators were calculated only where the source records provided sufficient denominators. In the jajar legowo 2:1 geometry, a 60-cm module comprised a 40-cm alley and two planted rows separated by 20 cm; hills within each row were spaced 10 cm apart. Two planted rows per 0.60-m module, multiplied by 10 hills m-1 of row, yielded an estimated 33.3 hills m-2 or 333,333 hills ha-1. Nutrient equivalents were calculated from 300 kg urea ha-1 and 300 kg Phonska Plus ha-1. Urea was treated as 46% N and Phonska Plus as a 15-15-15 compound fertilizer, giving 183 kg N, 45 kg P2O5, and 45 kg K2O ha-1. Per-plot allocations were obtained by dividing hectare values by eight. These are arithmetic indicators, not measured plant uptake, soil nutrient balance, or fertilizer-use efficiency.

Analysis followed four steps. First, activities were ordered relative to transplanting. Second, seed and fertilizer records were converted to hectare-, plot-, and nutrient-equivalent values. Third, eight management components were crossed with six functions—yield formation, water efficiency, nutrient efficiency, pest-risk reduction, varietal purity, and SDG alignment—to form 48 cells. Each cell was scored on a prespecified ordinal rubric: 0 = no documented linkage; 1 = plausible but indirect linkage; 2 = direct, literature-supported linkage whose outcome was not measured; and 3 = direct and central linkage with the relevant practice documented. The rubric was anchored to reported functions of rice establishment, irrigation, nutrient, and pest-management practices (Carrijo et al., 2017; Erythrina et al., 2021; Andryan et al., 2024; Chang et al., 2024; Kaur et al., 2024). The maximum score was 144, and observed totals were reported as points, percentage of the maximum, and mean score per cell.

Each matrix cell was assigned after cross-checking the operational record with the cited functional evidence. The rubric is an author interpretation and was not validated through independent raters; inter-rater reliability was therefore not estimated. Operational completeness was calculated separately as the number of prespecified stages documented divided by 10 and multiplied by 100. Fourth, management components were mapped to SDGs only when a plausible operational pathway was identifiable. Neither the matrix nor the SDG map represents measured environmental impact. No p-values were generated because replication, randomization, quantitative yield sampling, and a comparison treatment were absent.

## Result and Discussion

The reconstructed sequence covered all 10 prespecified stages, beginning with land preparation and ending with postharvest drying. Land preparation combined weed removal, bund repair, pre-flooding, primary tillage, secondary puddling, golden apple snail control, and final leveling. This sequence can support seedling anchorage, water retention, early root penetration, and weed suppression when implemented uniformly. Pre-flooding to 2-5 cm reduced soil mechanical resistance; primary tillage to 20-25 cm inverted the topsoil; and secondary puddling refined the rooting layer. Final leveling was agronomically important because spatially uneven water depth can create non-uniform establishment, nutrient movement, and weed pressure. These functions are consistent with integrated crop-management approaches that treat field preparation as part of a coordinated production system rather than an isolated operation (Erythrina et al., 2021; Chang et al., 2024). Nevertheless, bulk density, infiltration, puddling intensity, and field elevation were not measured, so improved soil physical condition remains a mechanistic interpretation rather than an observed treatment effect.

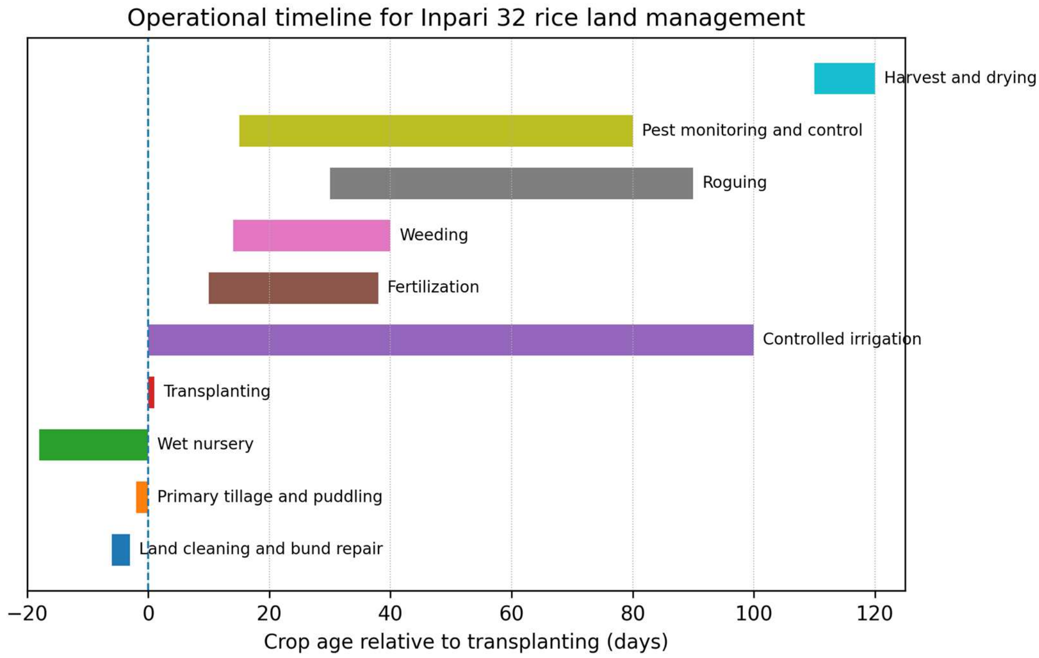


Figure 1. Operational timeline of Inpari 32 rice land management reconstructed from KKP field records

The wet nursery used 40 kg seed ha-1, equivalent to 5 kg per 1,250 m2 operational plot. Seeds were soaked and incubated before sowing, and water was kept shallow during establishment. Transplanting 18-day-old seedlings with three to four leaves was compatible with the use of young seedlings in Indonesian rice trials; Aswidinnoor et al. (2023), for example, transplanted 16-18-day-old seedlings when evaluating elite materials alongside Inpari 32. Using two to three seedlings per hill provided a practical reserve against mortality, although excessive survival could increase within-hill competition. Because seedling height, root length, dry weight, and seven-day survival were not recorded, the present evidence confirms the nursery protocol but not seedling vigor. Future records should link a nursery lot identifier to field plots so that emergence, transplanting damage, and early stand loss can be distinguished.

The jajar legowo 2:1 geometry consisted of a 40-cm alley, 20-cm spacing between the paired planted rows, and 10-cm within-row spacing. This explicit interpretation of the recorded 40 x 20 x 10 cm pattern produced an estimated 333,333 hills ha-1 (33.3 hills m-2), approximately 33% more hills than a 20 x 20 cm square pattern. The alley can improve access for weeding, fertilization, pest scouting, and roguing, while additional border exposure may alter light interception and tiller performance (Andryan et al., 2024). However, calculated density is not equivalent to established stand. Missing-hill percentage, tillers hill-1, panicles m-2, and lodging should be measured because a dense stand may intensify competition and canopy humidity. The observed geometry should therefore be evaluated as one component of an integrated package rather than an independent yield-enhancing treatment (Erythrina et al., 2021).

The density calculation assumes that the full hectare followed the recorded module without deductions for headlands, drains, damaged rows, or missing hills. With two to three seedlings per hill, the initial nominal placement would correspond to about 0.67-1.00 million seedlings ha-1, but that figure should not be interpreted as the effective plant population because survival and subsequent tillering were unknown. This distinction between hills, seedlings, tillers, and panicles is important when comparing planting systems. A future trial should count established hills in fixed quadrats at 7 and 21 days after transplanting, then record productive tillers and panicles per square meter. Whole-plot yield at standardized moisture, as used in multi-environment rice evaluation, could then be related to actual stand components rather than the nominal spacing alone (Aswidinnoor et al., 2023).

Fertilizer was divided equally among applications at 10, 24, and 38 days after transplanting. Each application supplied 100 kg urea and 100 kg Phonska Plus ha-1, or approximately 61 kg N, 15 kg P2O5, and 15 kg K2O ha-1; the seasonal total was 183 kg N, 45 kg P2O5, and 45 kg K2O ha-1. Split timing can synchronize N supply with recovery, tillering, and reproductive transition, but dose adequacy cannot be established without soil and crop measurements. The calculated 183 kg N ha-1 was 52.5% above 120 kg N ha-1 and exceeded the approximately 90-120 kg N ha-1 range (calculated values about 93-120 kg N ha-1) supplied by several East Java fertilizer schedules recalculated from the product compositions reported by Slameto et al. (2024). That comparison is contextual rather than a prescription because soils, varieties, organic inputs, and yield targets differ. Nonetheless, global evidence shows that increasing N rate is a major constraint to agronomic N-use efficiency (Chen et al., 2023), whereas integrated nutrient management can improve rice yield, farm returns, and N-use efficiency (Islam et al., 2024; Kaur et al., 2024). The next trial should use pre-season soil testing, omission or response plots, and leaf color chart readings before topdressing. Grain N uptake, partial factor productivity, agronomic efficiency, and an N balance are required before the present schedule can be described as nutrient efficient.

Table 2 also exposes the input structure at the operational-plot scale. Each 1,250 m2 plot received a seasonal allocation of 37.5 kg urea and 37.5 kg compound fertilizer, equivalent to 22.875 kg N and 5.625 kg each of P2O5 and K2O. On a nutrient-mass basis, the calculated N:P2O5:K2O ratio was approximately 4.07:1:1, showing that the package was strongly N-weighted. This ratio cannot diagnose nutrient imbalance because indigenous soil supply, crop residues, organic inputs, and attainable yield were not measured. It nevertheless identifies a priority for testing: additional N will not translate efficiently into grain if another nutrient or water becomes limiting. Agroecological nutrient management therefore requires soil- and yield-target information rather than a fixed product schedule.

Table 2. Input and nutrient-equivalent budget reconstructed from fertilizer and seed records

| Input or indicator | Per hectare | Per 1,250 m2 plot | Calculation basis | Interpretation |
|---|---|---|---|---|
| Seed | 40 kg | 5 kg | Recorded seed requirement divided across eight plots | Adequate for wet nursery and transplanting reserve |
| Urea | 300 kg | 37.5 kg | Seasonal dose split into three applications | Main synthetic nitrogen source |
| Phonska Plus | 300 kg | 37.5 kg | Seasonal dose split into three applications | Compound N, P, and K source |
| Nitrogen equivalent | 183 kg N | 22.875 kg N | 300 kg urea x 46% + 300 kg Phonska x 15% | High relative to several reported East Java schedules; requires soil and plant diagnostics |
| Phosphate equivalent | 45 kg P2O5 | 5.625 kg P2O5 | 300 kg Phonska x 15% | Supports root growth and energy metabolism |
| Potash equivalent | 45 kg K2O | 5.625 kg K2O | 300 kg Phonska x 15% | Supports osmotic regulation and stress tolerance |
| Estimated hill population | 333,333 hills | 41,667 hills | Legowo 2:1 module: 2 rows per 0.60 m width, 0.10 m within-row spacing | Approximately 33% higher than 20 x 20 cm square spacing |

Phonska Plus was treated as a 15-15-15 compound fertilizer for nutrient-equivalent calculation. The values are derived indicators from operational records, not laboratory nutrient balances

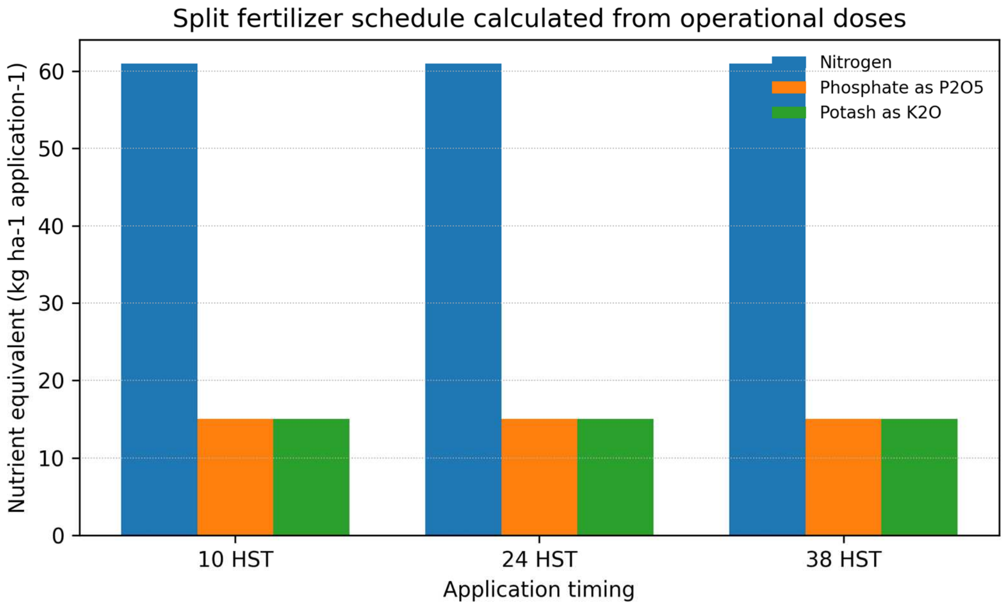


Figure 2. Nutrient-equivalent distribution across three fertilizer applications at 10, 24, and 38 days after transplanting

Water management was controlled rather than continuously flooded: early growth was maintained under macak-macak conditions, irrigation occurred approximately weekly during the first 30 days, 5-7 cm ponding was used when stable moisture was needed, and the field was dried later and before harvest. This sequence points in the direction of water-saving management, but it cannot be classified as alternate wetting and drying because no re-irrigation threshold or below-surface water level was recorded. Meta-analytic and field evidence shows that water savings and yield responses depend on drying severity, rainfall, groundwater, and crop stage (Carrijo et al., 2017; Chen et al., 2024; Yao et al., 2024). Irrigation regime can also alter canopy humidity and grain filling (Chen et al., 2025). Future monitoring should use perforated field-water tubes, flow measurements, rainfall records, and dated irrigation events. Grain yield divided by total irrigation plus effective rainfall could then be reported as water productivity rather than inferred from irrigation frequency.

Water and nutrient management must also be interpreted jointly. The redox condition and depth of ponding at fertilization influence N transformation and loss pathways, whereas N-driven canopy growth changes crop water demand and field humidity. In the Mojosari record, fertilizer dates were available, but irrigation events immediately before and after topdressing were not paired with them. Consequently, the apparent coordination of three N splits with crop stages cannot be extended to a claim of efficient water-nutrient synchronization. Research elsewhere shows that optimizing the two inputs together is necessary to balance yield and greenhouse-gas outcomes (Islam et al., 2024; Yao et al., 2024). A future log should record water-table depth at fertilizer application, the interval to re-irrigation or drainage, and rainfall within the following 48 hours. Those observations, coupled with grain and plant-N measurements, would reveal whether the timing reduced loss or merely divided a high seasonal dose into equal portions. This assessment supports soil- and yield-targeted nutrient management rather than a fixed product schedule (Susanti et al., 2024). The value of weeding before topdressing should be verified through plant nutrient uptake and weed-biomass data.

Manual weeding at 14, 25, and 40 days after transplanting was scheduled before or near fertilizer applications, reducing the likelihood that added nutrients would primarily stimulate weeds. Early weeding protected establishment, whereas later operations reduced competition during tillering and canopy closure. Roguing at vegetative, flowering, and pre-harvest stages added a varietal-purity function: plant type, color, leaf angle, heading time, and panicle appearance could be used to remove off-types before grain mixing. These coordinated operations are consistent with the systems perspective of integrated crop management (Erythrina et al., 2021; Chang et al., 2024). However, weed density, dry biomass, off-type frequency, and labor time were not measured. Recording these variables before and after each operation would permit calculation of weed-control efficiency, roguing intensity, and labor demand, turning a documented schedule into evidence of biological and operational efficacy.

Pest management combined field observation with insecticide use when risk was reported. The trade name Virtako was interpreted as thiamethoxam plus chlorantraniliprole, while Applaud was interpreted as buprofezin. Morning or late-afternoon application was intended to avoid unfavorable spraying conditions.

Naming active ingredients improves traceability, but it does not by itself establish integrated pest management. The records lacked formulation, dose, spray volume, application count, pest density, natural-enemy abundance, economic threshold, and disease incidence; consequently, exposure and control efficacy cannot be assessed. An integrated approach requires diagnosis, threshold-based decisions, non-chemical options where feasible, and evaluation of both pests and beneficial organisms (Andryan et al., 2024; Chang et al., 2024). Future logs should record product, active ingredient, formulation, dose ha-1, target organism, pretreatment count, decision threshold, weather, and post-treatment count. The present result is therefore evidence of a monitoring-oriented intention, not verified pest suppression or reduced pesticide risk.

Interactions among management components are especially important for interpreting pest risk. The estimated high hill density and substantial N input could accelerate canopy closure and increase humidity, conditions that may modify pest or disease pressure. Conversely, the legowo alley improved access for scouting and spraying, while manual weeding and field sanitation reduced alternative hosts and physical obstruction. Irrigation regime can further alter canopy microclimate and crop physiology (Chen et al., 2025). These linkages explain why the matrix assigns several functions to one practice and why a complete package is more informative than an inventory of isolated operations. They remain hypotheses in this case, however, because canopy humidity, pest abundance, disease severity, and crop damage were not recorded. Paired time-series observations of crop stage, weather, canopy condition, and organisms would allow the farm to test whether access-oriented geometry and monitoring actually reduced chemical intervention (Andryan et al., 2024; Chang et al., 2024).

Harvest occurred at approximately 110-120 days after transplanting when panicles had bent and most grains showed yellow-brown maturity. Manual cutting was followed by threshing, sun drying on tarpaulin, and storage under dry, shaded conditions. The recorded 10-12% moisture target is compatible with a storage-quality objective, but moisture-meter readings and postharvest loss were not provided. Crop duration was broadly comparable with the developmental period reported for Inpari 32 in Indonesian multi-environment trials (Aswidinnoor et al., 2023). Journal-level yield evidence requires harvested area, fresh grain mass, subsample moisture, and yield corrected to a common moisture content, preferably from whole plots or prespecified quadrats. Panicles m-2, filled grains panicle-1, thousand-grain mass, harvest index, and drying loss would then clarify whether crop establishment and input management translated into productivity and grain retention. In their absence, no yield claim is made.

Across the results, three evidence levels were deliberately kept separate. Recorded values include the seed and product masses, application dates, seedling age, stated spacing, and harvest window. Derived values include hill density, nutrient equivalents, per-plot allocation, and matrix totals; their equations and assumptions are shown in the methods and tables. Inferred functions include expected effects on rooting, water saving, nutrient efficiency, pest reduction, grain quality, and SDG alignment. This hierarchy strengthens traceability because a reader can distinguish observations from calculations and agronomic interpretation. It also identifies uncertainty: the field area and plot size were approximate, product composition was assumed from recorded labels, and no independent measurements verified application uniformity. Future work should archive source logs, calibrated instrument records, and calculation sheets with versioned plot identifiers so that every reported indicator can be reproduced.

Operational completeness was 10 of 10 prespecified stages (100%), confirming that the management pathway was fully represented in the available records. This metric describes documentation coverage, not the quality or biological effectiveness of each operation. Its main value is auditability: a reader can identify the sequence, timing, and intended function of every major stage. The distinction prevents a complete field log from being misread as evidence of a high-performing production system. Similar caution is needed when operational observations are used to discuss sustainable-practice adoption (Chang et al., 2024).

The contribution matrix totaled 76 of 144 points (52.8%; mean 1.58/3), which is interpreted as moderate cross-functional alignment. Yield formation received 18 of 24 points (75.0%) and SDG alignment 17 of 24 (70.8%); pest-risk reduction received 14 of 24 (58.3%), nutrient efficiency 11 of 24 (45.8%), and both water efficiency and varietal purity 8 of 24 (33.3%). Land preparation and planting geometry contributed strongly to the yield row, irrigation dominated the water row, split fertilization dominated the nutrient row, and roguing dominated the purity row. The values expose which functions are represented in the package; they are not effect sizes, treatment comparisons, or measured sustainability scores.

The matrix also makes the evidence deficit explicit. Its ordinal cells were assigned from one operational case and were not tested for inter-rater agreement or predictive validity. A future study should register the rubric before fieldwork, use at least two independent raters, report agreement, and test whether cell scores correlate with grain yield, water productivity, nutrient-use efficiency, pesticide intensity, and varietal purity. Replicated plots or farms, a comparison practice, and measurements across seasons would be needed for causal inference. Until then, the matrix is a transparent organizing device that adds structure to the field report without creating unobserved data.

Column totals provide a complementary view of the matrix. Land preparation received 12 of 18 possible points, water control 11, planting geometry, nutrient splitting, and weeding 10 each, pest monitoring and postharvest handling 8 each, and roguing 7. A lower column total does not necessarily indicate poor implementation; specialized practices contribute intensively to fewer functions. Roguing, for example, received the maximum score for varietal purity but little or no score for water or nutrient efficiency. Conversely, land preparation touched several functions but was not measured against a physical soil outcome. Reading row and column profiles together therefore avoids ranking practices as universally good or bad. The profile is most useful for study design: high-scoring broad functions require outcome validation, while low-scoring or specialized functions indicate where additional components or more precise indicators may be needed.

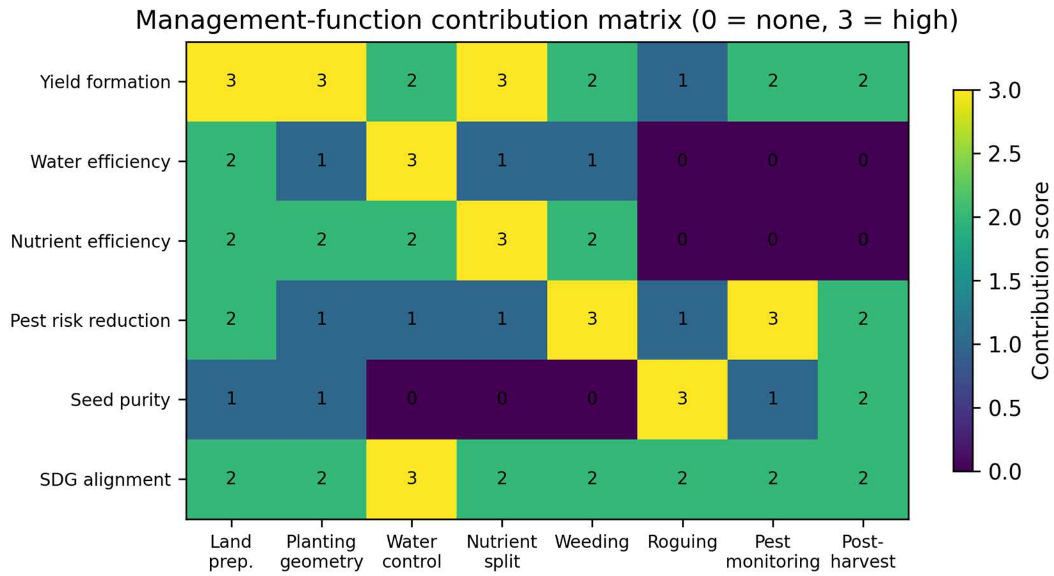


Figure 3. Literature-referenced management-function contribution matrix
(0 = no documented linkage; 1 = indirect; 2 = direct but outcome unmeasured; 3 = direct and central).
Total = 76/144 points (52.8%); values are interpretive indicators, not treatment effects

The SDG map is likewise an operational-alignment analysis rather than a measured impact assessment. Improved crop establishment, input timing, and harvest handling provide a plausible pathway to SDG 2; controlled irrigation is relevant to SDG 6; input scheduling and loss prevention relate to SDG 12; water and N management are potential entry points for SDG 13; and sanitation, monitoring, and roguing relate to SDG 15. Recent experiments show that water and N management can create trade-offs among yield, water use, and greenhouse-gas emissions (Islam et al., 2024; Yao et al., 2024), while adoption reviews emphasize that technical practices operate within farm, institutional, and economic constraints (Chang et al., 2024). The Mojosari records did not measure yield, water balance, nutrient recovery, greenhouse gases, biodiversity, or postharvest loss. Thus, Table 3 identifies relevant mechanisms and the metrics needed to test them; it does not demonstrate achievement of an SDG target.

For experimental-farm management, the practical implication is to embed measurement within routine operations rather than reconstruct it after the season. A standardized digital log should link each plot identifier with date, operator, crop stage, water depth and volume, fertilizer source and rate, leaf color, product and active ingredient, pest and natural-enemy counts, and labor time. Pre-season soil tests and post-season nutrient balances should accompany whole-plot grain yield corrected to a standard moisture content. This minimum dataset would preserve the farm's operational relevance while enabling replicated comparisons, resource-efficiency calculations, and defensible sustainability conclusions in subsequent seasons.

Table 3. Sustainable Development Goals linkage of the reconstructed land-management package

| SDG linkage | Relevant field practice | Mechanism of contribution | Evidence strength in this study | Required future metric |
|---|---|---|---|---|
| SDG 2: Zero Hunger | Improved variety, complete crop establishment, fertilizer scheduling, harvest handling | Supports stable rice production and grain-quality protection | Moderate; management observed but yield not measured | Grain yield corrected to standard moisture; yield components |
| SDG 6: Clean Water and Sanitation | Controlled irrigation and drying before harvest | Potentially reduces continuous flooding and unproductive water loss | Low to moderate; water regime observed but not metered | Irrigation volume, water table depth, rainfall, water productivity |
| SDG 12: Responsible production | Split fertilizer, weeding before topdressing, drying and storage | Improves input timing and reduces grain-loss risk | Moderate; input doses and timing recorded | N-use efficiency, postharvest loss, grain moisture dynamics |
| SDG 13: Climate Action | Water and nutrient management in paddy field | Potential entry point for reducing methane and nitrous oxide risks | Low; emissions not measured | $CH_4$ and $N_2O$ flux, global warming potential |
| SDG 15: Life on Land | Weed control, monitoring-based pest management, roguing | Supports land stewardship, field sanitation, and reduced unnecessary pesticide use | Moderate for practice; low for ecological impact | Pest density, natural enemies, pesticide-use intensity, biodiversity indicators |

SDG contribution is reported as management alignment. Impact claims require additional quantitative indicators in future trials

## Conclusion

This observational, non-replicated case study documented all 10 prespecified stages of Inpari 32 management at Mojosari Experimental Farm. The records supported a 40 kg seed ha-1 rate, an estimated 333,333 hills ha-1, and calculated nutrient inputs of 183 kg N, 45 kg $P_2O_5$, and 45 kg $K_2O$ ha-1. The literature-referenced matrix yielded 76/144 points (52.8%), indicating moderate operational alignment rather than proven productivity or sustainability. The high calculated N input and absence of measured yield, water, soil, and pest outcomes limit inference. Future replicated comparisons should measure grain yield and components, irrigation volume and water productivity, soil-test nutrient balance, leaf color, pest and natural-enemy density, pesticide intensity, and postharvest loss.

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