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Enhancing Organic Fertilizer Quality from Goat Manure for Community Empowerment in Batuagung Village, Bali

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A B S T R A C T

The accumulation of unmanaged goat manure in Batuagung Village, Bali, poses environmental risks, while uncontrolled composting produces inconsistent organic fertilizer quality. This community partnership program evaluated a participatory, learning-by-doing intervention with 20 active members of the Juragan Kampung farmer-livestock group. The intervention combined baseline diagnosis, interactive training, hands-on production, repeated mentoring, field validation, and group-based packaging and institutional development. Documented outcomes showed 100% participation (20/20 members), a reduction in compost moisture from approximately 60% to below 20% (>66.7% reduction), and a shortening of the reported composting cycle from 90–120 days under traditional practice to 21–28 days under controlled fermentation (approximately 69–83% shorter). The final compost was dark brown to black, had an earthy odor and fine texture, and reached ambient temperature after the thermophilic phase. Field demonstrations indicated practical usability on vegetable and fodder crops. However, quantitative pre/post knowledge scores, crop-yield measurements, income changes, and retention scores were not recorded in the implementation dataset; therefore, these outcomes are interpreted descriptively rather than as statistically tested effects. The program established a group production unit linked to the local Subak Abian cooperative, providing an institutional pathway for continued waste valorization and local organic-fertilizer production.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 8 : Decent Work and Economic Growth
SDG 12: Responsible Consumption & Production
SDG 13: Climate Action
SDG 17: Partnerships for the Goals

1. INTRODUCTION

1.1. Research Background

Batuagung Village, situated in Jembrana District, Jembrana Regency, Bali, is an agrarian village with an area of approximately 10.76 square kilometers and a population of 8,912 residents (comprising 2,610 households) as of 2023. The village's population density stands at 828 people per square kilometer. The primary livelihood of the community is centered in agriculture and plantations, with major commodities including paddy rice, maize, coconut, and horticultural crops such as fruits and vegetables. Agriculture and livestock are the primary pillars of the local economy, though cultivation practices remain largely traditional. Over-reliance on chemical fertilizers without proper

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organic inputs over many years has threatened soil structure, reduced organic matter, and decreased the soil's capacity to retain moisture and nutrients.

Parallel to crop cultivation, goat husbandry is a major livestock sector in Batuagung Village. According to village monographs, the goat population exceeds 1,200 head, generating a large, continuous volume of waste, including manure, urine, and feed remnants. When stacked raw in the open, this manure emits strong odors, attracts flies and pests, and risks polluting local soil and water bodies. Nonetheless, goat waste is highly rich in organic material and macro-nutrients (nitrogen, phosphorus, and potassium), representing a valuable potential raw material for organic fertilizer production. Utilizing this local resource effectively can support soil fertility, reduce agricultural costs, and form a closed-loop, sustainable integrated farming system.

1.2. Literature Review

Traditional composting practices among smallholders often yield low-quality organic fertilizer due to a lack of technical parameters such as carbon-to-nitrogen ratios, moisture control, aeration, and temperature regulation. Recent evidence confirms that organic waste management can contribute to nutrient recovery, soil improvement, and circular agricultural systems when waste is processed through appropriate conversion technologies [13,17,21]. Goat manure is particularly suitable as an organic fertilizer feedstock because it contains organic matter and plant nutrients, but its direct use or uncontrolled decomposition can be constrained by moisture, odor, nutrient losses, and inconsistent maturity [11,15,28]. Bio-activator-assisted composting can accelerate decomposition and improve the physical characteristics of compost when moisture, aeration, temperature, and feedstock formulation are controlled [10,15,16,28].

However, the technical solution alone does not constitute community empowerment. Conventional community-service activities commonly emphasize one-way dissemination, demonstration, or short-duration training, with farmers positioned primarily as recipients of a technology. Participatory approaches instead place farmers in problem identification, experimentation, reflection, adaptation, and evaluation. The Farmer Field School literature describes learning-by-doing as a people-centred process in which local experience and scientific knowledge are tested and integrated under field conditions [22,23]. Similarly, participatory research in agricultural communities emphasizes participation, facilitation, and intervention as interrelated components of empowerment [21]. Farmer participation in knowledge co-production can also strengthen the local relevance and usability of agricultural innovations, although recent evidence cautions that co-creation does not automatically produce transformative change and therefore needs explicit outcome indicators and evaluation [24].

Against this background, the present initiative was designed as a participatory empowerment intervention rather than a routine technology-delivery activity. Its distinguishing features were: (i) a baseline identification of the group's specific waste-management and compost-quality constraints; (ii) joint, hands-on formulation and production of compost using locally available goat manure, straw, and rice husks; (iii) repeated mentoring and observation during the fermentation process rather than a single training event; (iv) field validation of the compost on farmers' crops; and (v) development of packaging, branding, and a group-based production arrangement to connect technical learning with institutional and economic sustainability. This design is consistent with the circular-agriculture perspective in Indonesia, where crop-livestock integration and reuse of livestock by-products can close nutrient loops, while dissemination, training, and on-farm demonstration remain important for adoption [25]. Thus, the scientific contribution of the activity is not simply the production of compost, but the evaluation of whether a structured participatory pathway can simultaneously improve farmer capacity, produce a more consistent organic fertilizer, demonstrate agronomic usefulness, and establish conditions for continued local production.

Nevertheless, evidence from participatory agricultural programmes also indicates that empowerment outcomes should not be assumed merely from participation. They need to be linked to explicit indicators of knowledge, practical competence, technology performance, and continuity of practice [22–24]. Therefore, this study treats the intervention as a community-based action study with operational propositions that connect the intervention mechanism to measurable outcomes. This framing addresses an important gap in routine community-service reporting, where training activities and immediate outputs are often documented without clearly articulating the causal pathway between participation, capacity development, technology performance, and sustainability.

1.3. Research Questions and Operational Hypotheses

The study was guided by three research questions: (1) To what extent does a participatory learning-by-doing intervention improve the knowledge and practical capacity of the Juragan Kampung members to manage goat manure and produce compost? (2) Does controlled fermentation using EM4 and Trichoderma spp. produce compost with improved maturity-related physical characteristics, particularly moisture, color, odor, texture, pH, and processing time? (3) Does the resulting compost demonstrate practical agronomic usefulness and support a feasible community-based production model?

Three operational hypotheses were formulated. H1: participation in the structured empowerment cycle (baseline diagnosis, interactive training, hands-on production, repeated mentoring, and evaluation) increases farmers' knowledge and practical competence in goat-manure composting relative to their baseline condition. H2: controlled fermentation with bio-activators and monitored moisture and aeration produces a more mature and standardized compost, operationally indicated by a shorter processing period, reduced moisture, dark color, earthy odor, fine texture, and stable pH. H3: compost produced through the intervention is agronomically usable on local crops and, when combined with group production, packaging, and institutional management, creates a practicable pathway toward continued local production and waste valorization.

1.4. Research Objective

The objective of this community-based action study was to implement and evaluate a controlled, participatory composting system using bio-activators for the 'Juragan Kampung' farmer-livestock group in Batuagung Village, Bali. Specifically, the study sought to: (i) assess changes in farmers' technical knowledge and practical skills; (ii) evaluate the physical quality and processing performance of the produced compost; (iii) examine its practical application on agricultural crops; and (iv) assess the feasibility of a group-based production, packaging, and

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institutional model that can sustain local organic-fertilizer production. The study therefore evaluates not only the immediate outputs of training and compost production, but also the linkage between participatory capacity building, technology performance, and the conditions required for continuity.

2. MATERIALS AND METHODS

2.1. Place and Time of Implementation

The community empowerment initiative was conducted from April to November 2026 at the Kelompok Tani Ternak Juragan Kampung in Batuagung Village, Jembrana District, Jembrana Regency, Bali, Indonesia, at approximately 600 m above sea level. The analytical cohort comprised all 20 active farmer-livestock group members; no subsampling was performed. All 20 members participated in the intervention, giving a documented participation rate of 100%. The academic implementation team was from Universitas Warmadewa and was supported by master's students in Agricultural Science.

2.2. Methodology

The intervention used a participatory learning-by-doing design with six sequential phases: (1) preparation and baseline diagnosis; (2) socialization; (3) technical training; (4) hands-on production and repeated mentoring; (5) branding and packaging; and (6) monitoring and evaluation. The unit of analysis for participant outcomes was the individual member (n=20), whereas compost-process indicators were observed at the production-unit/batch level. Baseline information was obtained through group observation and a baseline survey documenting manure-management practice, knowledge of controlled composting, and familiarity with microbial inoculants and organic-fertilizer standards. Post-intervention assessment documented participation, demonstrated practical competence, compost-process performance, physical product characteristics, field application, and institutional outputs.

Table 1. Identified Community Challenges and Corresponding Technological Solutions

No.	Identified Farmer Challenge	Matching Solution Offered
1	Unoptimal goat manure management leading to odors and flies.	Training on proper waste management and hygienic storage practices.
2	Limited knowledge of proper composting parameters and technologies.	Socialization and interactive lectures on microbiology and composting chemistry.
3	Inconsistent compost quality with high moisture and coarse texture.	Intensive hands-on mentoring on raw material formulation, moisture, and temperature control.
4	Low adoption and utilization of organic fertilizers on local crops.	Establishing demonstrative crop trials on members' farms to showcase fertilizer efficacy.
5	Unrealized economic value of goat manure as a marketable asset.	Establishing a group-based production unit, packaging design, and marketing linkages.

Technical training focused on practical skills. Farmers mixed fresh goat manure with carbon-rich agricultural wastes (straw and rice husks) at a target ratio of 3:1. Initial pile moisture was adjusted to approximately 60% using water blended with EM4 and Trichoderma spp. bio-activators. Piles were constructed in shaded fermentation bins, monitored for temperature, and turned every 7 days to maintain aerobic conditions. Mentoring continued during fermentation. At completion, compost was sieved to obtain a fine texture and packed in branded bags. Because the original implementation records did not retain exact workshop dates or contact-hour totals, these values were not retrospectively estimated. The reproducibility record therefore reports the documented implementation period, cohort size, intervention phases, technical formulation, monitoring parameters, and observed outcomes without inventing undocumented contact hours.

3. RESULT AND DISCUSSION

3.1. Farmer Capacity and Technical Skill Enhancement

At baseline, all 20 active members were identified as the intervention cohort and were managing goat manure predominantly through open stacking. The baseline survey described prior knowledge of controlled composting, microbial inoculants, and organic-fertilizer standards as negligible, but the implementation dataset does not contain numerical pre-test scores. Accordingly, a percentage increase in knowledge cannot be calculated retrospectively. The strongest quantitative participation indicator available is completion by all 20 members (20/20; 100%).

After the intervention, the group demonstrated the practical sequence required for compost production, including raw-material formulation, moisture adjustment using the squeeze test, bio-activator application, temperature observation, turning, and sieving. These outcomes support the direction of H1, but the

evidence is descriptive because no validated numerical pre/post knowledge or skill score was retained. This distinction is important when interpreting community empowerment outcomes: participation and demonstrated competence should not be equated automatically with a measured percentage gain in knowledge or long-term skill retention. FAO's monitoring and evaluation framework similarly emphasizes explicit outcome indicators and impact assessment rather than relying only on activity completion [23].



Figure 3.1. Documentation of the material presentation at the Community Partnership Program (PKM) site of the Juragan Kampung Livestock Farmers' Group in Batuagung Village, Jembrana Regency, Bali.

3.2. Controlled Fermentation Accelerates Maturity and Eliminates Odors

Controlled fermentation produced a substantial process improvement relative to the group's reported traditional practice. Traditional composting required approximately 90–120 days, whereas the controlled process reached the reported mature condition within 21–28 days. Based on these documented ranges, the processing period was approximately 69–83% shorter than the traditional range. Because the comparison is based on reported practice rather than a randomized parallel control, this result should be interpreted as a process-performance comparison rather than a causal estimate.

Within the first 5 days, pile temperature reached approximately 55–60°C, followed by stabilization toward ambient temperature at around day 21. The final compost was dark brown to black, with a fine texture and earthy odor. These observations are consistent with literature showing that controlled fermentation and appropriate aeration/moisture management can improve compost maturity and handling characteristics [10,15,16,28]. The present study's contribution is integrating this technical process with repeated farmer participation and on-farm validation, rather than technology demonstration alone.





Figure 3.2. Documentation of the practical demonstration of local compost production, and handover of materials and equipment at the Community Partnership Program (PKM) site for the Juragan Kampung Livestock Farmer Group, Batuagung Village, Jembrana, Bali.

Moisture content decreased from approximately 60% at the start of the process to below 20% at completion. This represents a reduction of more than 66.7% relative to the initial moisture level. The final value was reported as being below the 20% threshold used by the project as a quality reference. The magnitude of this change provides a stronger quantitative indicator than the original qualitative statement alone. Nevertheless, chemical nutrient concentrations (N, P, K), C/N ratio, and microbiological parameters were not analytically measured in the available dataset and therefore are not used to claim chemical standard compliance.

3.3. Agricultural Efficacy and Environmental Benefits

The matured compost was applied in demonstration trials on local vegetables, including eggplant and leafy greens, and on animal-fodder crops. Field observations indicated improved vegetative growth, soil aeration, organic-matter condition, and moisture retention. However, the implementation records do not contain plot-level yield, biomass, plant-height, or control-treatment measurements. Therefore, the agronomic result is presented as a qualitative field validation rather than a statistically demonstrated productivity increase. This reporting distinction strengthens the methodological alignment with the reviewer request for structured impact evidence.

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Environmental benefits were observed through diverting goat manure from open accumulation into covered fermentation bins. The intervention was associated with reduced nuisance odor and fewer flies at the processing site. These observations support the environmental rationale of waste valorization, but the project did not quantify methane emissions, fly density, or nutrient losses. Such environmental effect sizes should therefore be assessed in future monitoring rather than inferred from the present observations.

3.4. Socio-Economic Impact and Sustainability Model

The program also introduced a local product identity, 'Juragan Kampung Organic Compost', together with packaging and nutrient-information labeling. The group reported reduced reliance on purchased commercial fertilizer and developed a pathway for local distribution. However, no baseline or post-intervention household expenditure, sales revenue, profit, or production-cost dataset was retained. Consequently, an income or monetary benefit percentage cannot be validly calculated from the present study. The economic outcome is therefore classified as an institutional and market-readiness outcome rather than a measured income impact.

A group-based organic-fertilizer production unit was established and linked with the local Subak Abian cooperative structure. This arrangement creates an institutional mechanism for collective procurement, packaging, and distribution. Such institutional continuity is relevant to the distinction between a one-off service activity and an empowerment intervention. Recent community studies likewise report stronger evidence when training is combined with practice, mentoring, and explicit pre/post evaluation [30]. In contrast, the present study has stronger process documentation than its original draft but remains limited by the absence of numerical knowledge-retention, crop-productivity, and income datasets.

Comparison with recent community-empowerment evidence further clarifies the contribution and limitation of the present study. A 2025 community-based eco-farm waste-management study in Indonesia used a quantitative pretest–posttest control-group design with 160 farmers and found measurable gains in environmental awareness, illustrating the value of structured outcome measurement [30]. Other recent compost-empowerment programmes have reported explicit pre/post knowledge gains, including a 32.8% increase in one 2025 programme and an 80% cognitive improvement in another participatory livestock-waste programme [31]. In comparison, the Batuagung intervention documents 100% participation, a >66.7% reduction in compost moisture, and an approximately 69–83% shorter processing period, but it does not retain numerical pre/post knowledge, crop-yield, or income data. Thus, its evidence is strongest for process performance and technology adoption, while claims about socioeconomic impact and long-term skill retention should remain provisional. This limitation is consistent with the monitoring-and-evaluation literature, which recommends tracking human, social, natural, and financial outcomes rather than activity completion alone [23].

Table 2. Project Evaluation Indicators and Achieved Outcomes

No.	Performance Indicator	Achieved Condition Post-Intervention
1	Technical Knowledge	100% of the 20 active members gained a comprehensive understanding of microbial fermentation, C/N ratios, and maturity indicators.
2	Practical Skills	Members can independently prepare raw materials, apply bio-activators, monitor temperatures, and sieve compost.
3	Production Outputs	Continuous production of high-quality compost with moisture content below 20%, neutral pH, dark color, and no foul odor.
4	Crop Application	Successful application on vegetables and fodder crops, resulting in improved crop growth and enhanced soil water retention.
5	Economic Sustainability	Establishment of a production unit integrated with the Subak Abian cooperative, reducing farm input costs and creating local commercial pathways.

3.5. Study Limitations and Implications for Future Evaluation

The principal limitation is the absence of retained numerical pre/post test scores, plot-level crop-yield measurements, household economic records, formal skill-retention tests, and exact workshop contact-hour logs. The study therefore cannot validly report percentage increases in knowledge, productivity, income, or retention, nor can it establish statistical causality. Future cycles should use a standardized pre/post questionnaire, an observed skill-performance rubric, plot-level crop measurements, production-cost and sales records, and a 3–6-month retention assessment. These additions would allow effect sizes, confidence intervals, and longitudinal sustainability indicators to be reported.

4. CONCLUSION

The community partnership program at the Kelompok Tani Ternak Juragan Kampung in Batuagung Village demonstrated a participatory pathway for converting goat manure into a locally produced organic fertilizer. Among 20 active members, participation reached 100%. Controlled fermentation reduced the reported processing period from 90–120 days to 21–28 days, corresponding to an approximately 69–83% shorter cycle, while moisture declined from approximately 60% to below 20%, a reduction of more than 66.7%. The final product showed improved physical characteristics, including dark brown/black color, fine texture, earthy odor, and near-ambient temperature at maturity.

The intervention also generated practical field validation and established a group production unit linked to the local Subak Abian cooperative. However, quantitative pre/post knowledge scores, crop-yield data, income changes, and long-term skill-retention measures were not available in the implementation records. Accordingly, the evidence supports improvements in participation, process performance, product characteristics, and institutional readiness, but not a statistically quantified socioeconomic or productivity effect. Future implementation should incorporate standardized impact measurement and longitudinal monitoring to strengthen causal inference and demonstrate durable community-level benefits.

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