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ADOPTION OF THE PsPSP PACKAGE, PRODUCTIVITY, AND FARM FEASIBILITY OF SMALLHOLDER COCOA IN LUWU, SOUTH SULAWESI

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Abstract

Smallholder cocoa productivity in Indonesia remains low, and the PsPSP cultural-control package (frequent harvesting, pruning, sanitation, fertilisation) is usually evaluated as a single bundle, so adoption of its individual components is rarely reported. This study describes adoption of the PsPSP components and their relationship with productivity and farm feasibility among smallholder cocoa farmers in Luwu Regency, South Sulawesi. Data were collected from 92 respondents across five cocoa-producing sub-districts. The sample was drawn with the Slovin formula from 1,165 mapped cocoa garden polygons, stratified by land cover and land suitability. Distributions are reported as medians with interquartile ranges. Only two components could be quantified, and adoption was uneven: fertilization was almost universal (91.3%) but overwhelmingly inorganic (organic fertilization only 7.6%), whereas pruning was practiced by fewer than half of the respondents (47.8%). Garden sanitation and frequent harvesting could not be quantified because these variables were not recorded. Median productivity was 226 kg/ha/year, less than one third of the smallholder average reported previously. Tree populations fell below the recommendation for 93.4% of respondents, while median stand age was only 11 years, indicating that planting density rather than stand age is the binding constraint. The enterprise is feasible on a cash cost basis (R/C 4.51), but only because reference cash costs are low; with a median garden of 0.44 ha the income actually received had a median of IDR 1.97 million per year, far below the provincial minimum wage. Production figures are self-reported, as 98.4% of producing respondents keep no farm records.

Keywords: Cocoa Pod Borer; Farm Feasibility; Luwu Regency; PsPSP; Smallholder Cocoa

INTRODUCTION

Indonesia produced 617,110 tons of dry cocoa beans from 1.37 million hectares of land in 2024, with approximately 99% of these coming from smallholder plantations (Central Statistics Agency [BPS], 2025). National production continues to decline, with Indonesia now ranked seventh in the world with a supply of 180,000 tons, or 4.0% of global production, in the 2023/24 cocoa year (International Cocoa Organization [ICCO], 2025). Sulawesi remains the core of production, contributing 59.26% to national production in 2023, and South Sulawesi ranks third among provinces with 79,776 tons (Center for Agricultural Data and Information Systems [Pusdatin], 2025). Within the province, Luwu Regency ranks second with 13,137 tons, or 16.47% of provincial production (Luwu Regency Government, 2024). Smallholder cocoa productivity remains far below its potential. Surveys of smallholder cocoa centers recorded dry bean yields of 250–1,375 kg/ha/year, with an average of 706 kg/ha/year, while the genetic potential of planting material reached 1,800–2,750 kg/ha (Muhardi et al., 2020). This low productivity is commonly associated with aging plants, pest and disease pressure, and inadequate cultivation practices (Ariningsih et al., 2020; Muhardi et al., 2020). In South Sulawesi, disease pressure on cocoa plantations has been documented, including dieback, which was recorded in East Luwu in 2015 and then subsequently in Luwu (Asman et al., 2024).

Beyond production issues, the sustainability of smallholder cocoa is now also determined by farmers' readiness to meet global market demands for quality and traceability. Various studies have shown that the benefits of certification and sustainability programs for Indonesian cocoa farmers' incomes are uneven and often limited

(Irfany et al., 2020; Fountain & Hütz-Adams, 2020; Mithöfer et al., 2017). Therefore, assessing the sustainability of smallholder cocoa requires more than just a snapshot of productivity, but also encompasses cultivation practices, farm feasibility, and farmer institutional readiness. The cocoa pod borer (Conopomorpha cramerella) is a major pest that reduces cocoa yields in Southeast Asia. Its larvae develop inside the pod and damage the beans before emerging to pupate (Niogret et al., 2019). One of the recommended cultural control measures in Indonesia is summarized in the PsPSP package, which includes frequent harvesting, pruning, sanitation, and fertilization. Frequent harvesting and sanitation work by breaking the pest's life cycle by harvesting all ripe fruit and collecting and destroying infested fruit before larvae have a chance to pupate, thus suppressing the next generation's population (Wood et al., 1992; Niogret et al., 2019), while pruning and fertilization maintain plant vigor and productivity. Ramut (2025) evaluated this package as a whole and found a relationship with yield and farmer income. A study in Polewali Mandar also linked the adoption of these four components to increased cocoa production (Khaeratih et al., 2021), while trials in North and West Sumatra showed that pruning combined with botanical pesticides suppressed pod borer attacks (Harahap et al., 2022; Luthfi et al., 2023).

Precisely because it is commonly evaluated as a whole, there has been little reporting on how its implementation is disaggregated across components in smallholder cocoa. Yet the effectiveness of the package hinges on its comprehensiveness; if one component is not functioning, the benefits of other components may not be fully achieved. A description of the implementation of each component is therefore necessary to determine which components have become ingrained and to what extent each can be measured in field surveys, a gap that this research addresses. This article aims to (1) describe the level of implementation of each PsPSP component in smallholder cocoa in Luwu Regency, (2) relate this to productivity and farm feasibility, and (3) address the limitations of self-reported data in populations without farm records.

METHOD

Location, Time, and Materials

The research was conducted in Luwu Regency, South Sulawesi Province, in five cocoa-producing sub-districts: Latimojong, West Bajo, Bajo, West Suli, and Suli. Field data collection took place from April to May 2026. Respondents were spread across 11 villages within the five sub-districts. The research materials consisted of primary data from structured interviews with cocoa farmers, as well as a polygon database of smallholder cocoa plantations from field mapping (Ministry of Agriculture & LPP Agro Nusantara, 2025). The tools used were structured questionnaires, field data recording devices, and statistical data processing software.

Respondent Determination

The sample size was determined using the Slovin formula with a 10% margin of error for 1,165 mapped cocoa plantation polygons in five central sub-districts (Ministry of Agriculture & LPP Agro Nusantara, 2025), resulting in 92 respondents. The sample was stratified proportionally according to the land cover and land suitability matrix (Reddy & Khan, 2023) to represent the spatial diversity of cocoa plantations. Respondents were evenly distributed across the five central sub-districts: 19 respondents in West Bajo, 19 in Suli, 18 in Latimojong, 18 in West Suli, and 18 in Bajo.

Variables and Measurement

Data included respondent identity, land ownership, cultivation practices, production inputs, production and marketing outputs, costs and income, and access to support services. Of the four components of the PsPSP package, only two were recorded and quantifiable: pruning and fertilization. Harvest frequency and garden sanitation were not available, so the implementation of the frequent harvesting and sanitation components could not be determined.

Data analysis

Productivity was calculated as the respondent's reported annual production divided by the area of cocoa farm. Farm feasibility was assessed using net income, R/C, and B/C. Because farm costs and selling prices were available as categories, not Rupiah values, revenue was estimated by multiplying respondent-reported production by the market reference price by the form of sale (dry beans Rp50,000/kg, wet beans Rp21,000/kg), while costs were based on the national reference of Rp2,500,000/ha/year, with a range of Rp1,500,000 to Rp3,500,000/ha/year. Because the reference costs represent cash inputs and do not include family labor, all ratios are reported as ratios to cash costs and are model estimates, not farmer-reported figures.

All distributions are reported as medians with quartile ranges, rather than means, due to the highly skewed distribution. For comparison, the average productivity of respondents was 376 kg/ha/year compared to a median of 226 kg/ha/year, so using the average would reflect a better situation than that experienced by most farmers.

Production figures are based on respondents' reports, not on farm records. Almost all respondents lacked farm records, so the production, revenue, and income figures in this article are estimates reconstructed by respondents during interviews. This limitation is reported as is and is discussed separately.

RESULTS AND DISCUSSION

Respondent Profile

Respondents were predominantly male, comprising 63 respondents (68.5%), with 29 respondents (31.5%) female. Educational attainment was considered lower-middle, with 35.9% having completed elementary school and 6.5% not attending school, while only 3.3% had a diploma or higher. Farming was very small-scale, with a median cocoa plantation area of 0.42 ha, and land tenure security was weak, with only 7 respondents (7.6%) holding a Land Ownership Certificate. Data on age, number of dependents, and household income outside of cocoa were unavailable and therefore not presented. The full profile is presented in Table 1.

Table 1 Respondent profile and cocoa farming land (n = 92)

Variable	n	Mark
Male gender	92	63 (68.5%)
Female gender	92	29 (31.5%)
Elementary school education/equivalent	92	33 (35.9%)
Junior high school education/equivalent	92	18 (19.6%)
High school education/equivalent	92	32 (34.8%)
Diploma education and above	92	3 (3.3%)
Not attending school	92	6 (6.5%)
Area of cocoa plantations (ha), median (Q1-Q3)	92	0.42 (0.14-0.69)
Land status: Girik/SKT/SKGR/Management Rights	92	81 (88.0%)
Land status: Freehold Certificate	92	7 (7.6%)

Source: Analysis of questionnaire data (2026)

Implementation of PsPSP Components

Of the four components of the PsPSP package, only two could be quantified: pruning and fertilization, and both showed uneven implementation (Table 2). Fertilization was nearly universal, with 84 respondents (91.3%), but almost entirely inorganic, as only 7 respondents (7.6%) used organic or mixed fertilizers. Pruning was only applied by 44 respondents (47.8%). The low adoption of pruning is regrettable, as its benefits to yield depend on tree size and the level of inter-stand competition (Tosto et al., 2022), while pruning shade trees in agroforestry systems provides both agronomic and economic benefits (Esche et al., 2023). Frequent harvesting and garden sanitation practices could not be assessed due to unavailable data.

Table 2 Level of implementation of PsPSP package components (n = 92)

PsPSP Components	Implementation	Proportion
Fertilization (all types)	84	91.3%
Organic/mixed fertilization	7	7.6%
Pruning	44	47.8%
Frequent harvest	data not available	-
Garden sanitation	data not available	-

Note: Harvest frequency and garden sanitation are not recorded as separate variables, so the implementation of these two components cannot be quantified. Source: Analysis of questionnaire data (2026)

This study was originally intended to compare the implementation of the four PsPSP components. Data analysis revealed that garden sanitation was not recorded as a separate variable. The absence of sanitation in the tabulations, therefore, does not indicate a lack of practice, but rather a result of measurement limitations. Interpreting this as zero implementation is potentially misleading, especially since technical terms for sanitation may be unfamiliar to respondents, even though the practice is ongoing.

The field context reinforces this caution. Post-infestation sanitation, which involves collecting, cutting, and then burying or burning infected pods to destroy the larvae and pupae inside, is a long-standing practice among cocoa farmers in Luwu Regency, even before the advent of formal extension services. This practice aligns with the biological basis of control outlined previously.

The findings that can be established here are therefore methodological in nature. Sanitation needs to be recorded as a distinct practice with operational explanations familiar to farmers, such as collecting and burying or burning infested fruit, rather than simply a sanitation term, so that its level of implementation can be validly measured in follow-up studies. The same applies to harvest frequency. Throughout this study, the adoption of orchard and harvest sanitation was often not assessed, and no claims were made about it.

Productivity and Standing Condition

Median productivity was 226 kg/ha/year, less than one-third the average of 706 kg/ha/year for smallholder cocoa centers reported by Muhardi et al. (2020). The median plant population was only 349 trees/ha, and 57 of the 61 respondents whose plant population was recorded (93.4%) were below the recommended 1,600 trees/ha for shaded cocoa. The median plant age was 11 years, with 20 respondents (22.0%) cultivating plants older than 20 years (Table 3). The combination of sparse stands with plants that were mostly still in their productive age suggests that plant density, not stand age, is the most prominent constraint to productivity. Experiments on agroforestry cocoa in Sulawesi have shown that stand density does indeed determine growth, root length density, and yield (Saleh et al., 2022). For stands that have passed their productive age, the selected rejuvenation technique also determines the nutrient content and cocoa yield (Meilani et al., 2023), while the application of fertilizer, compost, and dolomite to acidic soils in Sulawesi improves soil properties and productivity in the medium term (Fungenzi et al., 2021).

Table 3 Characteristics of respondents' cocoa cultivation

Cultivation variables	n	Median	Q1-Q3
Plant age (years)	91	11	-
Plant population (trees/ha)	61	349	128-683
Productivity (kg/ha/year, respondents producing)	62	226	102-515

Source: Analysis of questionnaire data (2026)

Farming Feasibility

The median cash cost R/C is 4.51, but this feasibility per hectare does not necessarily translate into high income. Because the median farm size is only 0.44 ha, the estimated net income per respondent is only around Rp1,969,875 per year (Table 4, Figure 1). The very small scale of the farm limits the absolute income that farmers can earn, despite the high feasibility ratio per unit area.

Table 4 Estimates of income, revenue, R/C, and B/C of cocoa farming per hectare per year (n = 62 respondents in production)

Component	n	Median
Productivity (kg/ha/year)	62	226
Income (Rp/ha/year)	62	11,287,008
Net income (Rp/ha/year)	62	8,787,008
R/C on cash costs	62	4.51
B/C on cash costs	62	3.51
Garden area (ha)	62	0.44
Net income per respondent (Rp/year)	62	1,969,875

Note: Each median value is calculated separately for all 62 producing respondents. Because medians are not multiplicative, values between rows cannot be cross-multiplied. Source: Analysis of questionnaire data (2026)

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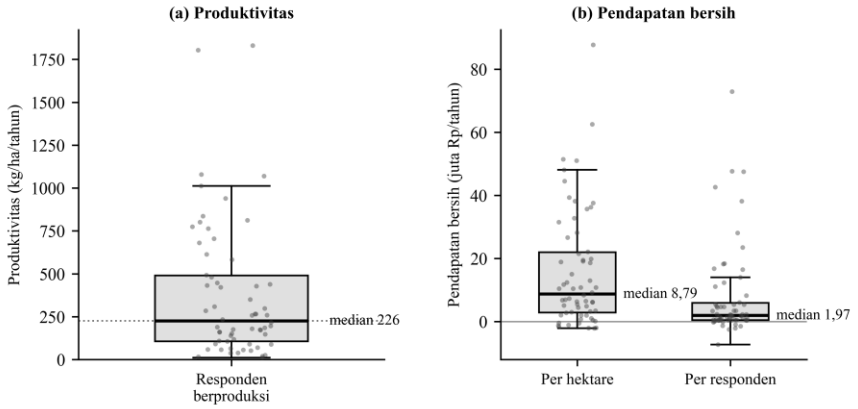

Figure 1 Distribution of (a) productivity and (b) net income among 62 respondents whose gardens are producing. The gray dots are the values for each respondent.

An R/C of 4.51 appears favorable, but this figure is a consequence of the low cash cost benchmark of IDR 2.5 million per hectare per year, not a sign of a productive farm. When family labor is not assessed, the ratio becomes high while real income remains low. Cost-benefit analyses of agricultural practices for smallholder farmers therefore emphasize the importance of incorporating labor inputs to avoid misleading feasibility rankings between practices (Akinyi et al., 2022). Both cocoa farming feasibility studies in North Luwu Regency and Parigi Moutong Regency reported R/Cs above one based on cash costs (Yuniarsih et al., 2021; Tussadia et al., 2021), so this type of feasibility is common and does not necessarily indicate a prosperous farm.

Two metrics need to be distinguished. Per hectare, the median net income is Rp8.79 million per year. However, because the median plantation area is only 0.44 ha, the actual income per respondent is only Rp1.97 million per year. Both are well below the 2025 South Sulawesi Provincial Minimum Wage of Rp3,657,527 per month, equivalent to approximately Rp43.9 million per year, as stipulated in South Sulawesi Governor Decree Number 1423/XII/2024 (South Sulawesi Provincial Government, 2024). While income per hectare is equivalent to approximately one-fifth of the annual minimum wage, farmers' actual income is only approximately one-twenty-second of the annual minimum wage. The significant difference between these two metrics suggests that land ownership, not simply the feasibility ratio, determines the adequacy of livelihoods from smallholder cocoa farming. These findings align with studies that identify land area as a key determinant of achieving a living income in smallholder farming (Marinus et al., 2022), and that show that the pathway to a living income for perennial commodity farmers differs by household type and cannot be achieved solely through increased yields (Waarts et al., 2021). These findings underscore the importance of explicitly stating the cost basis when reporting R/C on smallholder farming, and the low actual income of cocoa farmers aligns with studies that show the economic performance of Indonesian cocoa farmers remains vulnerable despite the high value of the commodity (Irfany et al., 2020).

Table 5 Estimated cocoa farming income according to cropping pattern

Cropping pattern	Respondents (total/production)	Median productivity (kg/ha)	Median net income/ha (Rp)	R/C median	Median net income per respondent (Rp/year)
Monoculture	46/28	258	10,418,587	5.17	3,423,250
Polyculture	46/34	192	7,122,517	3.85	1,627,875

Source: Analysis of questionnaire data (2026)

Based on cropping patterns, respondents using monoculture systems earned higher incomes than those using polyculture systems (Table 5). This advantage stems partly from larger plantation areas, with a median of 0.58 ha compared to 0.38 ha, rather than solely from superior management per unit area. This finding should be read with caution, as comparisons of monoculture and agroforestry in cocoa are not always in favor of monoculture. Agroforestry systems have been reported to provide higher labor rewards than full-sun monocultures (Armengot et al., 2016), and moderate shade can maintain yields while preserving environmental functions (Blaser et al., 2018). However, cocoa yields decline nonlinearly with increasing shade density, so there is always a trade-off between carbon storage and bean yield (Somarriba et al., 2013). On the other hand, the increase in yields in smallholder

agroforestry is not always commensurate with the additional labor and capital (Scudder et al., 2022), while farmers' decisions to adopt it are influenced by many factors beyond yield alone (Kouassi et al., 2023).

Institutions and Marketing

Farmer group membership is quite extensive but not universal, with 67 respondents (72.8%). This membership is not directly proportional to access to services or bargaining power. Support in the form of credit access reached only 4 respondents (4.3%), certified seeds were used by only 15 respondents (16.3%), and for 36 of the 62 respondents in production (58.1%), prices were determined unilaterally by buyers (Table 6). This weak bargaining power aligns with evidence of asymmetric price transmission in the Indonesian cocoa supply chain, where price increases at the top level are passed on to farmers more slowly than price decreases (Ridha et al., 2022).

Table 6 Institutional, service access, and marketing of respondents (n = 92)

Indicator	Amount	Percentage
Joined a farmer group	67	72.8%
Have received production input assistance?	36	39.1%
Have received technical assistance	33	35.9%
Have received training	31	33.7%
Institutional support in the form of credit access	4	4.3%
Using certified seeds/seedlings	15	16.3%
The price is determined unilaterally by the buyer	36 of 62	58.1%
Not recording farming results	61 of 62	98.4%

Note: The last two indicators represent 62 respondents whose gardens are producing. Source: Analysis of questionnaire data (2026)

Data and Research Limitations

A total of 61 of the 62 producing respondents (98.4%) did not record their farming activities. All production figures are therefore estimates from memory, and revenue and income figures are model estimates built on them using reference prices and costs. These two layers of uncertainty should be kept in mind when reading Tables 4 and 5, as the figures represent orders of magnitude, not highly precise values. The lack of record-keeping itself is a finding, as farmers who do not record cannot assess the feasibility of their own farming and cannot meet the traceability demands now required by the global cocoa market. The low use of certified seeds, at 16.3%, reinforces the picture of the still-poor level of traceability readiness. Studies of farmers in Indonesia indicate that farm record-keeping is more determined by mentoring and institutional access than by individual willingness (Wulandari et al., 2023), so strengthening record-keeping requires institutional intervention, not just advice.

The study's scope was limited to five cocoa-producing districts, and its design was descriptive, so the findings are not intended to be representative of all cocoa farmers in Luwu Regency and do not test causal relationships. The most important limitation lies in the scope of variables: age, number of dependents, and non-cocoa household income were not available, so livelihood adequacy can only be assessed from a farming perspective. Adoption of garden sanitation, harvest frequency, and fertilizer and pesticide dosages were not recorded and therefore could not be analyzed. The number of respondents whose gardens were already producing, namely 62 out of 92, limited the accuracy of the feasibility analysis, especially when further stratified by cropping pattern into 28 and 34 respondents, so comparisons between cropping patterns are indicative.

CONCLUSION

In smallholder cocoa in five central districts of Luwu Regency, the two quantifiable components of the PsPSP cultural control package showed uneven implementation. Fertilization was nearly universal (91.3%), but almost entirely inorganic, with only 7.6% using organic fertilizer, while pruning was applied by less than half of respondents (47.8%). Adoption of farm sanitation and harvesting practices often could not be assessed due to unavailable data.

Productivity is relatively low, with a median of 226 kg/ha/year, or less than a third of the average for smallholder cocoa centers reported in previous research, with the main constraint being plant density. A total of 93.4% of respondents cultivate populations below the recommended level, while the median plant age of 11 years indicates that most stands are still within a productive age range. Farming is feasible on a cash-cost basis with a R/C of 4.51, but this feasibility per hectare is not directly proportional to the sufficiency of livelihoods, because with a

median plantation area of only 0.44 ha, the actual income received by farmers is a median of Rp1.97 million per year, far below the provincial minimum wage.

These findings place increasing plant population and expanding business scale as more decisive drivers than stand rejuvenation, while highlighting the need for strengthened farm record keeping as a prerequisite for traceability, as well as the addition of variables to allow for measurable farm sanitation practices, harvest frequency, and cost structure in further studies. Conclusions regarding production and income should be interpreted in light of the self-reported nature of the data.

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