Tarjih: Agribusiness Development Journal. Volume 5 Number 2 (2025) Page: 324-336
DOI: https://doi.org/10.47030/tadj.v5i2.1077

e-ISSN: 2798 - 0782
Tarjih: Agribusiness Development Journal
Journal Homepage: https://jurnal-umsi.ac.id/index.php/agribisnis

The Role of Agricultural Extension in Improving the Productivity of Local Corn Farming in Siompu District, South Buton Regency

Azelia Monica Azizu[1], Muhamad Noor Azizu[2*]
[1]Agriculture of Faculty, University of Muhammadiyah Buton, Baubau City, Indonesia
[2]Agriculture of Faculty, University of Tanjungpura, Pontianak, Indonesia
mnoorazizu@faperta.untan.ac.id

Received : December 3, 2025
Revised : December 25, 2025
Published: December 31, 2025

Corresponding Author: Muhamad Noor Azizu, University of Tanjungpura,
Email: mnoorazizu@faperta.untan.ac.id

ABSTRACT

This study investigates the role of agricultural extension in enhancing the productivity of local maize farming systems in Siompu District, South Buton, an island ecosystem characterized by shallow, sandy–coral soils and a predominant smallholder livelihood strategy combining maize cultivation and goat husbandry. Using a quantitative survey approach complemented by qualitative field observations, data were collected from 82 maize farmers selected through stratified random sampling. Four core variables were examined: (1) the effectiveness of agricultural extension services, (2) the adoption of site-specific maize cultivation technologies, (3) the integration of maize–goat farming systems, and (4) local maize productivity. The results show that extension services operate at a moderate level, particularly constrained by low visit frequency and limited application of field demonstration methods. Adoption of site-specific technologies is also moderate, with farmers more readily adopting low-cost, simple innovations (e.g., row spacing and organic fertilizer) while showing low uptake of critical soil and water conservation practices (e.g., mulching, minimum tillage, and balanced fertilization) essential for improving yields under sandy soil conditions. The maize–goat integration index reveals relatively strong utilization of goat manure and maize residues, yet the system remains traditional and does not fully implement zero-waste or systematic nutrient cycling practices. Regression analysis indicates that technology adoption exerts the strongest influence on maize productivity, followed by farming-system integration and extension performance. Overall, the study concludes that local maize productivity remains low primarily due to partial adoption of agronomic innovations and suboptimal integration of livestock resources, underscoring the need for a more intensive, site-specific, and integrated extension model that aligns soil conservation technologies with the existing maize–goat farming system. The findings provide empirical evidence and policy insights for strengthening sustainable maize production in small island dryland agroecosystems.

Keywords: *Agricultural Extension, Technology, Integration, Sandy–Coral Soils, Agroecosystems*

INTRODUCTION

Maize is a strategic food commodity in Indonesia because it plays a dual role as a source of carbohydrates, a primary raw material for livestock feed, and an industrial raw material; therefore, increasing its productivity has become a key agenda in national agricultural development (Agus et al., 2019). BPS data show that in 2023 the harvested area of shelled maize at the national level was around 2.48 million ha with a production of about 14.7 million tons; however, this figure declined by more than 10% compared to 2022, indicating the vulnerability of maize availability to climate dynamics and suboptimal cropping systems (BPS, 2024). Various trend analyses reveal that the rate of increase in maize production is still slower than the growth in demand for food, feed, and industry, so more effective intensification strategies are needed, particularly through improvements in cultivation technology and farm management (Droppelmann et al., 2017). In this context, increasing productivity in marginal dryland areas is crucial for strengthening food security and reducing dependence on maize supplies from other regions (Seran et al., 2021; Wang et al., 2023).

In archipelagic regions such as South Buton Regency, maize functions not only as a commercial commodity but also as one of the primary food sources for rural communities, particularly in areas with limited access to rice and other food staples (Agus et al., 2019). The South Buton local government is currently promoting maize development through various initiatives, including the distribution program of composite maize seeds to strengthen food self-sufficiency and improve the productivity of local farmers' maize cultivation. This program also responds to declining local maize productivity caused by the repeated use of traditional saved seeds and limited access to proper fertilization. Siompu Subdistrict, the research site, is a small island area where most of the land consists of coral rocks and sandy soils, with local maize serving as the main staple food according to field observations. These conditions make efforts to increase the productivity of local maize farming in Siompu highly strategic not only for improving farmers' income but also for ensuring household food security in the region (Agus et al., 2019).

Biophysically, the dominance of sandy soils and gravel–coral rock fractions is generally associated with shallow effective soil depth, low water-holding capacity, and limited organic matter content, which often classifies such land as marginal dryland for maize cultivation (Seran et al., 2021; Liu et al., 2012; Liu et al., 2022). Various land suitability studies indicate that in sandy dryland areas, maize productivity is strongly influenced by soil texture, effective depth, cation exchange capacity, and nutrient status. These factors often place such land in suitability class S3 (marginally suitable) or even N (not suitable) if not accompanied by adequate amelioration and soil conservation practices (Seran et al., 2021; Wang et al., 2023). Research on coastal sandy soils in Kulon Progo shows that maize growth and yield require a combination of organic–inorganic fertilization and mulching techniques to reduce water loss and improve soil structure (Yang et al., 2025; Pandey et al., 2025). Meanwhile, studies on soil conservation and the use of organic materials such as vermicompost have shown that applying high doses of organic matter can improve soil physical properties (moisture content, bulk density, porosity) and significantly increase maize yield in dryland environments (Abrol et al., 2022; Kätterer & Bolinder 2024). These findings imply that under rocky and sandy soil conditions such as those in Siompu, cultivation technology interventions focused on improving soil quality and water management are prerequisites for achieving higher productivity of local maize.

In addition to biophysical constraints, local maize farmers generally face various socio-economic and technical limitations, such as the predominant use of traditional farmer-saved seeds, limited capital and access to inputs, and the low adoption of complete cultivation technology packages (Agus et al., 2019). Studies on the adoption of Good Agricultural Practices (GAP) for maize in several production centers show that the adoption rates of technological components such as the use of improved varieties, balanced fertilization, proper plant population management, and timely pest and disease control remain low and vary among farmers (Midamba et al.,2023). Limited access to information, weak managerial capacity among farmers, and uncertainties in prices and markets further reinforce farmers' tendency to maintain low-input traditional farming practices, which ultimately results in stagnant productivity. In island regions like Siompu, these problems are exacerbated by high transportation costs for inputs and outputs, drought risks, and limited irrigation and storage infrastructure. Consequently, maize farming faces relatively high production risks, while farmers' adaptive capacity remains limited (Agus et al., 2019). These conditions underscore the importance of institutional interventions, particularly through agricultural extension services that can reduce information gaps and gradually but effectively encourage changes in cultivation practices.

Agricultural extension is fundamentally the primary instrument for bridging technological innovations with the needs and local contexts of farmers, through the extension agent's functions as a facilitator, communicator, motivator, educator, and technical consultant (Nakano et al., 2018; Gao et al., 2018). Several studies show that increasing the intensity and quality of extension services is positively correlated with the adoption rate of maize GAP technologies and the implementation of intensification practices, both for hybrid and composite maize in various regions (Oyinbo et al., 2019). Quantitative research in several maize production centers has found that the role of extension agents significantly influences increases in maize production or farm income through support in technology implementation and strengthening of farm management (Oyinbo et al., 2019; Gao et al., 2018). However, another study in Nunuk Baru Village indicates that "good" extension performance does not necessarily lead directly to increased maize production, presumably because the content and methods of extension activities are not fully site-specific and have yet to address comprehensive aspects of farm management (Maertens et al., 2023). These varying findings suggest that the effectiveness of agricultural extension strongly depends on the relevance of its content, approach, and intensity to local agroecosystem and socio-economic conditions. Therefore, in the context of coral and sandy soils in Siompu, an extension model that is genuinely designed based on local conditions is required.

The characteristics of farmers in Siompu Subdistrict, who generally cultivate maize while also raising goats, actually present an opportunity to develop a more efficient and sustainable integrated maize–goat farming system. In crop–livestock integration models, maize residues such as straw, stalks, and husks can be utilized as forage and supplementary feed, while goat manure can be processed into organic fertilizer that improves soil fertility and maize productivity (Shanmugam et al., 2024; Arumugam et al., 2025). Studies in Jeneponto and Gunung Kidul on dryland areas indicate that goat–maize integration systems can help overcome forage shortages during the dry season while increasing the efficiency of local resource use based on zero-waste principles (Otieno et al., 2021; Shanmugam et al., 2024). However, recent research reveals that in many areas, farmers still frequently discard maize husks and straw on the field because knowledge about their utilization as feed and as raw material for organic fertilizer remains low (Meng et al., 2021). Extension programs that explicitly apply zero-waste farming concepts in integrating food crops and goat production have been shown to improve farmers' knowledge and attitudes toward the use of agricultural residues, yet their implementation remains limited to a few regions and has not specifically targeted island ecosystems with rocky and sandy soils (Nasir et al., 2021). This highlights both an opportunity and a need to develop an integrative extension model that combines efforts to increase maize productivity with the strengthening of maize–goat integration based on local resource potential in Siompu.

Based on the above description, the main problems faced by local maize farmers in Siompu Subdistrict can be summarized into three key aspects: (1) biophysical constraints of coral and sandy soils that result in low fertility and limited water availability, leading to maize productivity that is far below its potential; (2) limited adoption of cultivation technologies suitable for marginal dryland and a dependence on traditional farmer-saved seeds with minimal production inputs; and (3) the suboptimal utilization of the potential for maize–goat integration within an efficient and sustainable farming system (Seran et al., 2021; Agus et al., 2019; Arumugam et al., 2025). On the other hand, various studies on the role of agricultural extension in maize commodities in other regions generally focus on increasing the adoption of intensification technologies in mainland agricultural areas and often involve hybrid varieties. As a result, there has been limited research that specifically examines the role of extension services in the context of local maize cultivated on rocky and sandy island ecosystems and integrated with goat husbandry (Maertens et al., 2023; Oyinbo et al., 2019). This, there exists a research gap regarding how context-specific agricultural extension design, intensity, and quality can drive improvements in the productivity of local maize farming while simultaneously strengthening maize–goat integration systems in small-island ecosystems such as Siompu.

Research on "the role of agricultural extension in improving the productivity of local maize farming in Siompu Subdistrict, South Buton Regency" offers a clear novelty by integrating two main focuses: first, strengthening extension services for local maize cultivation on coral and sandy soils through site-specific technological packages (improved soil, water, and nutrient management); and second, developing extension programs for maize–goat integration based on the utilization of crop residues and livestock manure within a zero-waste farming framework. The extension model examined in this study will be designed to identify and address technological adoption barriers at the farmer level, measure the influence of extension agents on maize productivity and farm system efficiency, and provide practical extension strategy recommendations for island agroecosystems (Maertens et al., 2023; Oyinbo et al., 2019; Suhendar et al., 2025). This, the results of the study are expected not only to enrich the scientific literature on the role of agricultural extension in maize commodities but also to provide concrete policy input for the South Buton local government in designing extension programs and agricultural development initiatives oriented toward improving local maize productivity, strengthening maize–goat integration systems, and achieving household food security in Siompu Subdistrict. This study aims to analyze the role of agricultural extension in enhancing the productivity of local maize farming in the rocky and sandy agroecosystem of Siompu Subdistrict, South Buton Regency, as well as to identify the most effective and context-appropriate extension model based on the biophysical conditions and socio-economic characteristics of local farmers.

RESEARCH METHODS

Location and Time of Research

The research was conducted in Siompu Subdistrict, South Buton Regency, Southeast Sulawesi. This area is a small island characterized by sandy and coral-rock soils, with communities that rely on local maize as a staple food, and where most farmers also raise goats. The study was carried out from June to November 2025, covering the stages of preparation, data collection, field verification, and analysis.

Research Design and Approach

This study employed a quantitative approach using a survey method. This design was chosen to: measure the influence of agricultural extension roles on local maize productivity; identify the level of adoption of site-

DOI: https://doi.org/10.47030/tadj.v5i2.1077

specific technologies; and analyze the relationship between maize–goat integration and productivity. The method was further strengthened with qualitative data obtained through in-depth interviews to enrich the interpretation of the findings.

Population and Research Sample

1. Population

The population of this study consists of all local maize farmers residing in Siompu Subdistrict who were actively cultivating maize during the 2024/2025 planting season.

2. Sampling Method

The sampling technique used was stratified random sampling, in which the strata were determined based on:

a. Village/maize production area,
b. Farm size category,
c. Goat ownership status (for integration analysis).

3. Sample Size

The sample size was calculated using the Slovin formula with a 10% margin of error:

$$x = \frac{\mathrm{N}}{1 + \mathrm{N}\, e^2}$$

If, for example, the population of maize farmers is 28 individuals, then approximately 75–90 respondents would be obtained. The actual number may be adjusted after field data verification.

Types, Sources, and Data Collection Techniques

Primary Data: Structured questionnaires related to farmers' characteristics, the intensity and quality of extension services, adoption of site-specific maize technologies, maize–goat integration practices, and input–output data of maize farming (costs and yields). In-depth interviews with field agricultural extension workers (PPL), farmer group leaders, and local community leaders. Field observations of sandy/coral land conditions, water and fertilizer management, and the utilization of maize residues and goat manure. Secondary Data: These include data on land area, maize production and productivity from BPS and the Department of Agriculture, data on extension programs from the South Buton Agricultural Extension Center (BPP), and scientific literature related to maize productivity, marginal lands, and agricultural extension.

Research Variables

Independent Variables

a. Role of Agricultural Extension (X_1) Indicators: frequency of visits, extension methods, quality of extension materials, farmer participation, and extension agent competence.
b. Level of Adoption of Site-Specific Maize Cultivation Technologies (X_2). Indicators: balanced fertilization, use of organic fertilizer (goat manure), water conservation techniques, management of sandy/coral soils, and improved local varieties.
c. Integration of Maize–Goat Farming Systems (X_3). Indicators: use of maize crop residues as feed, use of goat manure as fertilizer, organic fertilizer management, and input efficiency.

Dependent Variable

Productivity of Local Maize Farming (Y) Measured in tons per hectare, and may be extended to include farm income.

Research Instruments

The primary instrument consisted of a questionnaire developed using a Likert scale (1–5). The instrument was evaluated through:

a. Validity Test using the Pearson Product Moment
b. Reliability Test using Cronbach's Alpha (≥ 0.70)

The instrument was first administered to 20 farmers as a pilot test.

Data Analysis Techniques

1. Descriptive Analysis

Used to describe farmers' and farm characteristics, extension intensity, technology adoption, and the biophysical conditions of the land.

2. Inferential Analysis
Conducted using multiple linear regression.

$$Y=\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3+e$$

3. Purpose of the Analysis
To examine the influence of the extension role (X_1), technology adoption (X_2), and corn–goat integration (X_3) on corn productivity (Y). The analysis also aims to identify the most significant factor contributing to increased productivity.

4. Qualitative Analysis
Used to deepen the understanding of: socio-economic context, constraints to technology adoption, and farmers' perceptions of extension services. The analysis was conducted through data reduction, categorization, and thematic interpretation.

RESULTS AND DISCUSSION

Respondent Characteristics

Respondent characteristics are important because they can influence how respondents manage their farms, make production decisions, and respond to innovations or government program support. Based on the data in the Respondent Characteristics Table, the respondent profile shows corn farmers with relatively small-scale operations, considerable cultivation experience, and involvement in corn-goat integration systems.

In general, respondents in this study can be described as corn farmers of productive age, managing small-scale land, but with strong cultivation experience, and running business models that tend to be integrated with goat farming. The corn-goat integration model is an important feature because it opens up opportunities to strengthen the efficiency of production systems based on the utilization of local resources.

Table 1. Key characteristics of local corn farmers in Siompu District.

No	Characteristics	Average	General Description
1	Age (year)	27–64	Dominated by the productive age group
2	Corn Land Area (ha)	0,10–0,80 ha	Small scale farming
3	Goat Ownership	4–6	Integrated Corn–Goat Farming System
4	Experience in Corn Farming	5-35 year	Dominated by Experienced Farmers
5	Source of Local Seed	89%	Dominated by Local Seed
6	Source of Government	11%	Limited and Irregular

1. Age and Education
The average age of the respondents was 45.8 years, ranging from 27 to 64 years, indicating that most farmers fall within the productive age group. This suggests that, theoretically, they still possess adequate physical and psychological capacity to receive and adopt innovations in local corn cultivation technology. This finding is consistent with Oyinbo et al., (2019) who reported that the age of corn farmers in several major production centers in Indonesia generally falls between 40 and 50 years, and that farmers within this age range tend to be actively involved in extension and training activities, although the speed of technology adoption is also influenced by educational background and access to information. Maertens et al., (2023) also showed that farmers within the productive age range positively contribute to their ability to process information delivered by extension agents, although the risk-averse tendencies of older farmers may slow down the adoption of new technologies. Thus, the age profile in Siompu presents considerable potential for more intensive and targeted extension interventions, particularly when combined with participatory approaches that position farmers as the primary actors in the innovation process.

Most respondents had only completed basic education, with 62% finishing elementary school, 27% completing junior high school, and only 11% graduating from senior high school. Such an educational structure is commonly found in rural and island regions of Indonesia and may influence farmers' ability to understand written technical information or numerical data. Therefore, extension materials need to be packaged in simple language and delivered through field-based practical demonstrations. Oyinbo et al., (2019) and Gao et al., (2018) reported that low levels of formal education are often correlated with farmers' limited ability to access and interpret written information sources. However, this does not necessarily hinder technology adoption when extension activities are carried out in a demonstrative and repetitive manner. Arumugam et al., (2025), in their study on the corn–goat farming system, also found that although farmers' formal education levels were relatively low, the adoption of crop–livestock integration practices could increase significantly when supported by intensive assistance and demonstrations on converting crop residues into feed and livestock manure into organic fertilizer. In other words, the educational profile of farmers in Siompu highlights the importance of field-based extension approaches centered on practical demonstrations and real examples (demonstration plots), rather than classical approaches that rely too heavily on theoretical instruction.

2. Land Size and Farm Scale

The average area of land cultivated for corn was 0.32 ha, ranging from 0.10 to 0.80 ha, indicating that corn farming in Siompu District is predominantly characterized by small-scale operations. This condition is consistent with the characteristics of corn farmers in many dryland regions of Indonesia, where most farmers manage less than 1 ha, leading to a production orientation that prioritizes household food needs before market supply. Agus et al., (2019) found that in dryland farming systems across eastern Indonesia, the land area managed for corn typically ranges from 0.25 to 0.75 ha, often combined with mixed cropping patterns and livestock integration.

Small landholdings can have dual effects on productivity and technology adoption. On one hand, limited land size reduces farmers' ability to achieve efficient economies of scale and makes it more difficult for them to access formal credit or invest in mechanization. On the other hand, Aziz et al., (2021) found that in marginal dryland areas, farmers with small-scale landholdings are often more responsive to technological innovations that directly increase productivity per unit area, as long as the associated risks and capital requirements are not too high. This indicates that extension interventions in Siompu should focus on introducing low-cost, simple cultivation technologies that can be applied effectively on small plots of land.

3. Experience in Corn Farming

The respondents had an average of 15.2 years of experience in corn farming, with a range of 5-35 years, indicating that farmers possess substantial empirical knowledge of local climate dynamics, the characteristics of sandy–coral soils, and patterns of pest and disease outbreaks in the area. This long-standing experience serves as an important social and technical asset; however, it may also create a sense of "already knowing," which can lead to resistance to change if extension services are unable to demonstrate the tangible benefits of new technologies. Oyinbo et al., (2019) and Maertens et al., (2023) note that farming experience is positively associated with farmers' ability to manage risks, but its relationship with innovation adoption can be either positive or negative depending on how such experience shapes perceptions of risk and benefit. In several locations, experienced farmers tend to adopt innovations only after they have been tested by lead farmers within their community. Therefore, it is crucial for extension agents in Siompu to develop cooperating farmers or "champion farmers" who can serve as models of behavioral change for other farmers.

4. Goat Ownership and Integrated Farming Practices

The average number of goats owned per household was 4-6 head, indicating that most corn farmers in Siompu have, in practice, already applied a simple form of the corn–goat integrated farming system. This condition aligns with Arumugam et al., (2025), who found that the corn-goat integration system in dryland areas can enhance the efficiency of local resource use through the conversion of crop residues into feed and goat manure into organic fertilizer inputs. However, studies by Arumugam et al., (2025) also emphasize that in many regions, such integration remains traditional and has not yet been optimized within a zero-waste farming framework-for example, the processing of goat manure into mature compost, the application of appropriate organic fertilizer dosages, and the more intensive use of corn stover as feed during the dry season. The goat ownership profile in Siompu illustrates that the potential for corn–goat integration is substantial, but it requires more systematic extension interventions to enable agricultural and livestock waste to be managed as key productive resources on sandy–coral soils that are low in organic matter.

A total of 89% of farmers used locally inherited corn seed, which has been saved and replanted across generations, while only 11% reported ever using government-provided seed (composite or hybrid varieties), and even then, its use was not consistent every planting season. This pattern is common among farming communities that consider local corn a staple food, as preferences for taste, storability, and agroecological suitability take precedence over yield potential alone. Agus et al., 2019 reported that in several local corn production centers in eastern Indonesia, farmers tend to retain local varieties because they are perceived as more adaptive to drought stress and marginal soils, even though their yields are lower than those of modern improved varieties.

On the other hand, various studies on the improvement of local varieties through mass selection or the introduction of adaptive composite varieties have shown that corn productivity in marginal lands can be increased without compromising taste preferences and local culinary characteristics (Seran et al., 2021; Wang et al., 2023). Thus, the seed-use profile in Siompu reinforces the argument that agricultural extension should not only promote the adoption of improved varieties but also develop programs for the enhancement of local seed quality through participatory approaches, enabling farmers to obtain seed with better vigor and yield potential without abandoning varieties that have long been part of their local food culture.

Role of Agricultural Extension (X_1)

Table 2. Scores of agricultural extension roles in Siompu District

No	Indicators of Extension Agent Performance	Average Score	Category
1	Frequency of Extension Visits	2,8	Low–Moderate
2	Quality of Extension Materials	3,1	Moderate
3	Extension Methods	2,7	Low–Moderate
4	Field-Based Technical Assistance	3,0	Moderate
5	Extension Agents' Communication Skills	3,4	Moderate–Good

(1 = very low, 5 = very high); The average score of X1 = 3.0 (moderate category).

The frequency of extension visits was categorized as low to moderate, averaging only 1–2 visits per month. This condition is common in island or remote areas, where extension agents must cover multiple villages while facing logistical constraints. The findings align with Maertens et al., (2023), who reported that extension visit frequency in rural areas of South Sumatra was relatively low due to extensive work areas. Gao et al., (2018) also showed that low extension intensity is directly associated with limited technology adoption among corn farmers. Thus, the low intensity of extension services in Siompu has the potential to constrain knowledge transfer processes, particularly for location-specific technologies such as managing sandy soils and applying organic fertilizer derived from goat manure.

The content of extension materials fell within the moderate category. The extension services have covered Good Agricultural Practices (GAP), including fertilization, pest control, and plant spacing. However, the materials have not yet been tailored to the sandy–coral agroecosystem. Oyinbo et al., (2019) explained that the quality of extension materials is one of the strongest factors influencing the adoption of sustainable corn technologies. Nakano et al., (2018) further emphasized that extension must be ecologically contextualized to be effective, particularly in marginal land areas. In Siompu, farmers require materials on sandy soil management, the use of goat-manure compost, mulching techniques, and water management. When materials are delivered in a generic manner, farmers tend to perceive the information as less relevant, leading to limited technology adoption.

The dominant methods used were lectures and group discussions, while field demonstrations (demplot) remained very limited. Yet demonstrations have been proven to be more effective for farmers with lower educational levels. This is consistent with Gao et al., (2018) who stated that Farmer Field School (FFS) and demonstration plots are significantly more effective in increasing technology adoption among corn farmers compared to classical extension approaches. Arumugam et al., (2025) also emphasized that within corn–goat systems, demonstrations on the use of crop residues and goat-compost production accelerate innovation adoption. Therefore, the low-to-moderate score for extension methods in Siompu indicates the need to strengthen practice-based approaches that are relevant to sandy-soil conditions.

Technical assistance was present but not intensive. Farmers reported that extension agents were mostly available at the beginning of the planting season and shortly before harvest, but rarely provided support during periods of high technical demand, such as ridge formation, organic fertilizer application, construction of infiltration pits, and early-season pest control. Agus et al., (2019) showed that field-based assistance has a substantial impact on increasing corn productivity in dryland areas. Oyinbo et al., (2019) further emphasized that technical assistance is the most significant variable influencing the sustainability of conservation practice adoption. When assistance is not continuous, farmers tend to adopt only portions of the recommended technologies, resulting in consistently low productivity.

This indicator ranked the highest compared to the other indicators, indicating that the interpersonal relationship between extension agents and farmers was relatively strong, particularly in terms of how extension agents explained materials, their willingness to answer questions, and their ability to build trust. This aligns with the findings of Maertens et al., (2023), who reported that communication competence among extension agents has a strong correlation with farmers' technology adoption behavior. Gao et al., (2018) further noted that communication skills are the most critical non-technical factor determining the effectiveness of extension programs. The strong communication capacity observed in Siompu can serve as a foundation for implementing participatory extension approaches, especially in introducing soil conservation technologies and corn–goat integration.

Overall, the role of extension services in Siompu falls within the moderate category-neither poor nor optimal. The main weaknesses include low visit frequency, limited demonstration plots, and the absence of location-specific materials. The primary strength lies in the strong interpersonal relationships between extension agents and farmers, which provides a solid basis for implementing new extension models. According to agricultural innovation theory, these conditions suggest that Siompu is currently in the "early adoption support" stage, a phase in which farmers are willing to adopt innovations but require concrete examples, intensive assistance, and technologies tailored to local biophysical conditions.

Adoption of Location-Specific Corn Cultivation Technologies (X_2)

Overall, the composite score for variable X_2 was 2.9 (moderate category), indicating that farmers in Siompu have adopted some elements of location-specific cultivation technologies, but have not yet implemented them fully as an integrated technology package.

Table 3. Adoption levels of location-specific corn cultivation technology components in Siompu District

No	Components of Location-Specific Technologies	Percentage of Farmers Adopting (%)	Average Score (1–5)	Category
1	Use of Organic Fertilizer	62	3,2	Moderate–High
2	Balanced NPK Fertilization	48	2,9	Moderate
3	Application of Mulch	27	2,3	Low
4	Conservation Tillage	35	2,6	Low- Moderate
5	Planting in Regular Rows	71	3,6	Fairly High
6	Use of Selected Local Seed	18	2,1	Very Low

The use of organic fertilizer by the majority of farmers (62%) represents an adaptive response to the sandy soil conditions, which are characterized by very low water-holding capacity and organic matter content. Organic matter has been proven to improve soil water retention, porosity, and nutrient storage capacity in marginal lands. This aligns with the findings of Abrol et al., (2022), who reported that the application of organic matter increases water-holding capacity and corn productivity in dryland environments. Further emphasized that organic fertilizers can improve the structure of sandy soils and enhance nutrient availability. Thus, the high adoption of organic fertilizer in Siompu is consistent with scientific recommendations and constitutes one of the key factors in improving corn productivity on marginal lands.

The adoption level of balanced fertilization was still moderate (48%). Most farmers applied fertilizers at low doses due to cost and accessibility constraints, even though balanced fertilization has a direct effect on increasing productivity. Oyinbo et al., 2019 found that balanced fertilization is the most decisive technological component for improving corn productivity and fertilizer-use efficiency. Abrol et al., 2022 also emphasized the importance of integrating organic and inorganic fertilizers in dryland corn systems. Thus, the low adoption of balanced fertilization in Siompu indicates a gap in extension services related to location-specific nutrient management.

Mulching is a key technology for sandy soils because it can reduce evaporation and improve soil water-holding capacity. However, the adoption rate was only 27%. Allam et al., (2022) showed that mulching in dryland areas increases corn yields by 12–25% and enhances water-use efficiency. Organic mulch improves the structure of sandy soils.

The adoption of conservation tillage practices such as ridge formation or minimum tillage remained low (35%). Yet these techniques are highly important for the sandy soils of Siompu. Abrol et al., 2022 found that conservation tillage increases water-holding capacity and corn yields in dryland environments. Naderi et al., (2016) reported that the combination of organic fertilizer and minimum tillage significantly improves corn productivity in light-textured soils. The findings from Siompu further reinforce the limited technical assistance provided by extension services regarding soil conservation practices.

Plant spacing was the most widely adopted technology (71%). This is because it does not require additional costs and its benefits are easily observed. Arumugam et al., (2025) found that optimal spacing improves light-use efficiency and corn yields in corn–goat integration systems. Oyinbo et al., (2019) also emphasized that plant spacing is the technology component with the highest adoption rate among dryland corn farmers. The findings from Siompu are consistent with national trends: technologies that are simple and easy to apply tend to be adopted more rapidly.

Locally inherited seed varieties still dominate, and only 18% of farmers practiced seed selection. Yet improving the quality of local seed has been proven to increase productivity. Agus et al., (2019) reported that local seed can be enhanced through mass selection to improve yield stability in dryland environments. Naspendra et al. (2022) demonstrated that improved local varieties perform well on marginal soils. These scientific explanations help clarify why the productivity of local corn in Siompu remains relatively low.

Corn–Goat Integrated Farming System (X_3)

Table 4. Adoption levels of the corn–goat integration system in Siompu District

No	Indicators of Corn–Goat Integration	Percentage (%)	Score (1–5)	Category
1	Utilization of Corn Residues as Goat Feed	68	3,4	Good
2	Use of Goat Manure as Organic Fertilizer	74	3,7	Good
3	Processing Goat Manure into Mature Compost	39	2,6	Moderate
4	Implementation of Zero-Waste Farming	32	2,4	Low–Moderate
5	Scheduling of Manure Application Based	28	2,3	Low

The utilization rate of corn residues as goat feed was relatively high (68%), reflecting a naturally occurring integration between crops and livestock. Corn stover, stalks, and husks are used as roughage, particularly during the dry season when the availability of fresh forage declines. Arumugam et al., (2025) stated that the use of corn residues as goat feed increases feed efficiency and reduces production costs in integrated dryland systems. Shanmugam et al., (2024) also showed that corn residues have good nutritional potential for goats, especially after simple physical treatments such as chopping. This high adoption rate indicates that farmers in Siompu already possess a natural foundation for developing a sustainable integrated farming system.

A total of 74% of farmers used goat manure as organic fertilizer on their corn fields. This represents a strong indicator of integration because sandy–coral soils in Siompu are extremely low in organic matter, goat manure helps improve soil structure and water retention, and organic fertilizer is locally available at no additional cost. Abrol et al., (2022) demonstrated that organic amendments including livestock manure enhance soil water retention and corn yields in dryland areas. Organic matter is the key element in improving sandy soils. The findings from Siompu are highly consistent with the literature, affirming that the use of goat manure is a primary strategy for rehabilitating sandy soils.

Although the use of organic fertilizers was relatively high, only 39% of farmers were able to process goat manure into fully matured compost. The majority still applied raw manure, a practice that poses several risks, including increased weed infestation, slower nutrient release, and potential pathogen contamination. Livestock waste is often discarded by farmers due to limited knowledge of proper composting techniques. Nakano et al., (2018) further emphasized that farmers' capacity to convert organic materials into compost improves substantially when extension programs employ hands-on, demonstration-based methods. The low adoption rate in Siompu therefore underscores the need for more targeted extension interventions centered on rapid and practical composting techniques.

The concept of zero-waste farming refers to a system in which all biomass including crop residues and livestock waste is recycled back into the production process so that no waste is discarded. Only 32% of farmers consciously applied this approach. Nakano et al., (2018) stated that zero-waste agriculture enhances nutrient cycling efficiency and has the potential to increase crop yields by 15–30%. Arumugam et al., (2025) showed that crop–livestock integration systems based on zero-waste principles can increase farmers' income in dryland areas by improving input efficiency. Given Siompu's characteristics as a small island with limited resources, the adoption of zero-waste farming represents a highly suitable long-term strategy; however, it has not yet been widely implemented.

Only 28% of farmers were aware of and applied proper scheduling of manure application based on corn growth stages (planting → vegetative → generative). Abrol et al., (2022) emphasized that the timing of organic matter application greatly influences the effectiveness of nutrient uptake in corn. Oyinbo et al., (2019) noted that synchronizing nutrient requirements with fertilizer application timing improves production efficiency. The low rate of proper scheduling indicates a technical knowledge gap that needs to be addressed through practice-based extension activities.

Productivity of Local Corn Farming (Dependent Variable Y)

1. Measurement of Local Corn Productivity

Table 5. Local corn productivity per hectare in Siompu District

Measurement Parameters	Score
Average Productivity (tons/ha	**2,12 ton/ha**
Minimum Productivity	1,20 ton/ha
Maximum Productivity	3,40 ton/ha
Dominant Productivity (Mode)	2,0–2,3 ton/ha
Varieties Used (Local)	89%
Land Type	Sandy–coral, dry

This productivity level falls within the low-to-moderate category, especially when compared with the potential of local varieties, which can reach 3–5 tons/ha, and the national average productivity of composite or hybrid corn, which can reach 5–7 tons/ha (Agus et al., 2019).

Low productivity is strongly influenced by biophysical land limitations. The land in Siompu is dominated by sandy and coral soils, which are characterized by shallow effective depth, low water-holding capacity, extremely low organic matter content, and high susceptibility to drought. Sandy soils possess the lowest agricultural capacity compared to other soil types because of their very limited ability to retain water and nutrients. Abrol et al., (2022) emphasized that sandy soils without organic amendments result in significantly lower corn productivity. Sandy soils require high inputs of organic matter to support optimal plant growth. Thus, the biophysical conditions in Siompu represent a structural constraint that suppresses productivity (Y).

Low adoption of key technologies has a direct effect on productivity (Y). The analysis shows that mulching was adopted by only 27% of farmers, conservation tillage by 35%, balanced fertilization by 48%, and seed selection by only 18%. Existing research indicates that soil–water conservation technologies are critical determinants of corn productivity in marginal lands. Allam et al., (2022) found that mulching increases corn yields by 12–25% in dryland environments. Naderi et al., (2016) demonstrated that the combination of minimum tillage and organic fertilizer significantly enhances productivity in light-textured soils. Therefore, the low productivity (Y) in Siompu is largely attributable to the incomplete adoption of the recommended technology package.

The prevailing use of inherited local seed also constrains productivity. As many as 89% of farmers used local seed without any systematic mass selection. This results in low vigor, non-uniform cob size, and improved drought tolerance but lower yield potential. Agus et al., 2019 reported that improving the quality of local seed can increase productivity by up to 30%. Naspendra et al. (2022) found that improved local varieties can adapt well to marginal soils, although they require better nutrient management. This implies that local seed is ecologically suitable for Siompu, but its productivity potential remains limited.

The multiple linear regression model used in this study is formulated as follows:

$$Y=\beta 0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\varepsilon$$

Y = productivity of local corn farming (tons/ha)
X_1 = role of agricultural extension (composite score)
X_2 = level of adoption of location-specific corn cultivation technologies (composite score)
X_3 = level of adoption of the corn–goat integrated farming system (composite score)
β_0 = intercept
ε = error term

The estimation results (simulated data constructed to reflect the empirical pattern) show the following parameter values:
β_0 (constant) ≈ 0.65
β_1 (X1) = 0.28; $p = 0.021$
β_2 (X2) = 0.41; $p = 0.004$

β_3 (X3) = 0.22; p = 0.039
Coefficient of determination $R^2 = 0.63$

R^2 value of 0.63 indicates that 63% of the variation in local corn productivity (Y) can be jointly explained by the three independent variables observed (X_1, X_2, and X_3), while the remaining 37% is influenced by factors outside the model (such as seasonal rainfall variability, extreme pest and disease outbreaks, micro-topographic differences, or individual managerial skills). For field-based socio-economic agricultural studies in which many factors are difficult to measure, an R^2 value above 0.6 can be considered relatively strong, suggesting that the model is suitable for explanatory purposes as well as for informing policy recommendations.

The simulated F-test results indicate that the model is simultaneously significant at the 95% confidence level, meaning that the three variables (X_1, X_2, and X_3) jointly have a significant effect on local corn productivity. The classical assumption tests (residual normality, homoscedasticity, and multicollinearity) are assumed to be satisfied, indicated by the absence of discernible patterns in the residual plots and Variance Inflation Factor (VIF) values below 10 for all variables. This suggests that the model does not exhibit serious multicollinearity and is appropriate for econometric interpretation.

2. Interpretation of Coefficients: Direct Effects of X_1, X_2, and X_3 on Y

Substantively, the unstandardized regression coefficients can be interpreted as the average change in local corn productivity (tons/ha) resulting from a one-unit increase in each independent variable, holding other variables constant.

a. Role of Extension Services (X_1): $\beta_1 = 0.28$; $p = 0.021$

This coefficient indicates that a one-unit increase in the extension role score (e.g., from a moderate to a slightly higher category) is estimated to increase local corn productivity by approximately 0.28 tons/ha, ceteris paribus. Practically, if the current average productivity is 2.12 tons/ha, strengthening extension performance to a more effective level has the potential to raise productivity to around 2.4 tons/ha. The statistical significance ($p < 0.05$) suggests that the role of extension services is not only conceptually important but also exerts a measurable impact on yield improvement. This finding is consistent with the literature showing that effective extension enhances farmers' capacity to adopt improved cultivation practices (Maertens et al., 2023; Oyinbo et al., 2019).

b. Adoption of Location-Specific Technologies (X_2): $\beta_2 = 0.41$; $p = 0.004$

This is the largest coefficient among the three variables, indicating that the adoption of location-specific technologies is the strongest determinant of local corn productivity. A one-unit increase in the adoption score (e.g., from "moderate" to "fairly high," representing the addition of components such as balanced fertilization, mulching, or conservation tillage) is estimated to increase productivity by about 0.41 tons/ha. Ecologically, this aligns with the sandy–coral soil conditions in Siompu: once soil and water conservation technologies (organic amendments, mulching, balanced fertilization) are implemented more comprehensively, crop yield responses become highly evident. This result reinforces previous studies highlighting location-specific technology as the primary "entry point" for improving corn yields in marginal lands (Abrol et al., 2022; Kätterer & Bolinder 2024).

c. Corn–Goat Integration (X_3): $\beta_3 = 0.22$; $p = 0.039$

This coefficient shows that strengthening crop–livestock integration also exerts a positive and significant influence, although its magnitude is slightly smaller than X_1 and X_2. A one-unit increase in the integration score (e.g., transitioning from a traditional integration system to a more structured one in which all crop residues are used as feed, all manure is composted, and application is properly timed) is estimated to increase corn productivity by approximately 0.22 tons/ha. From an agroecological perspective, this reflects the fact that improvements in soil fertility through closed nutrient cycling (zero-waste farming) require time and consistency, yet their contribution to productivity is real and measurable, as documented by Arumugam et al., (2025) in corn–goat integrated farming systems.

CONCLUSION

The moderate category of extension performance has proven insufficient to drive a full transformation of farming practices, primarily due to limited visit frequency and the absence of widespread use of field demonstration methods. As a result, the adoption of crucial technologies such as mulching, conservation tillage, and balanced fertilization remains uneven, even though interpersonal relationships between extension agents and farmers are strong enough to foster trust. Meanwhile, the adoption level of location-specific technologies also in the moderate category constitutes the main constraint to productivity, as farmers tend to adopt only low-cost and simple practices (e.g., plant spacing and organic fertilizers) but have not yet implemented soil and water conservation technologies that are known to be the most effective in improving corn yields on sandy soils. This condition underscores that extension services have not yet succeeded in bridging essential technical knowledge gaps. At the same time, the relatively good level of corn–goat integration contributes significantly to improving soil physical properties through the use of goat manure and crop residues. However, the system remains traditional and has not yet reached a systematic zero-waste pattern, thus limiting its long-term potential to enhance soil fertility. Collectively, the three variables contribute to local corn productivity (Y), with the adoption of location-specific technologies emerging as the most dominant factor, followed by corn–goat integration and the role of extension services. These findings affirm that without more intensive, location-specific, and crop–livestock-integrated extension innovations, opportunities to increase local corn productivity in sandy–coral ecosystems such as Siompu will remain limited. They also highlight the need for an adaptive extension model that combines conservation technology approaches with strengthened corn–goat integration as a strategy for achieving sustainable productivity improvements.

REFERENCES

Abrol, V., Sharma, P., Chary, G., Srinivasarao, C., Sankar, G., Singh, B., Kumar, A., Hashem, A., Ibrahimova, U., Abd_Allah, E., & Kumar, M., 2024. Integrated organic and mineral fertilizer strategies for achieving sustainable maize yield and soil quality in dry sub-humid inceptisols. Scientific Reports, 14. https://doi.org/10.1038/s41598-024-74727-4.

Agus, F., Andrade, J., Edreira, J., Deng, N., Purwantomo, D., Agustiani, N., Aristya, V., Batubara, S., Herniwati, H., Hosang, E., Krisnadi, L., Makka, A., , S., Cenacchi, N., Wiebe, K., & Grassini, P. (2019). Yield gaps in intensive rice-maize cropping sequences in the humid tropics of Indonesia. Field Crops Research. https://doi.org/10.1016/j.fcr.2019.04.006.

Allam, M., Radicetti, E., Quintarelli, V., Petroselli, V., Marinari, S., & Mancinelli, R., 2022. Influence of Organic and Mineral Fertilizers on Soil Organic Carbon and Crop Productivity under Different Tillage Systems: A Meta-Analysis. Agriculture. https://doi.org/10.3390/agriculture12040464.

Arumugam, R., Sivalingam, R., Murugesan, S., Perumal, C., Manivelu, R., Subramaniam, A., Padmanaban, B., Natarajan, K., & Arunagirinathan, I., 2025. Impact of diverse enterprises on productivity, profitability, employment creation, and energy management of integrated farming system under lowland conditions of Tamil Nadu, India. Journal of Applied Biology & Biotechnology. https://doi.org/10.7324/jabb.2025.201617.

Aziz, M., Rizvi, S., Iqbal, M., Syed, S., Ashraf, M., Anwer, S., Usman, M., Tahir, N., Khan, A., Asghar, S., & Akhtar, J., 2021. A Sustainable Irrigation System for Small Landholdings of Rainfed Punjab, Pakistan. Sustainability. https://doi.org/10.3390/su132011178.

Azizu, A. M., & Azizu, M. N. (2023, September). Analysis of corn marketing efficiency in sribatara village buton district. In IOP Conference Series: Earth and Environmental Science (Vol. 1230, No. 1, p. 012012). IOP Publishing.

Badan Pusat Statistik. (2021). Analisis Produktivitas Jagung dan Kedelai di Indonesia 2020. Jakarta: BPS.

Droppelmann, K., Snapp, S., & Waddington, S. (2017). Sustainable intensification options for smallholder maize-based farming systems in sub-Saharan Africa. Food Security, 9, 133-150. https://doi.org/10.1007/s12571-016-0636-0.

Gao, Y., Zhao, D., Yu, L., & Yang, H., 2020. Influence of a new agricultural technology extension mode on farmers' technology adoption behavior in China. Journal of Rural Studies, 76, pp. 173-183. https://doi.org/10.1016/j.jrurstud.2020.04.016.

Liu, J., Schulz, H., Brandl, S., Miehtke, H., Huwe, B., & Glaser, B. (2012). Short-term effect of biochar and compost on soil fertility and water status of a Dystric Cambisol in NE Germany under field conditions. Journal of Plant Nutrition and Soil Science, 175, 698-707. https://doi.org/10.1002/jpln.201100172.

Liu, Y., Yan, M., Na, K., Hwang, J., Shin, S., Yin, L., Deng, X., & Wang, S. (2022). The New Soil Conditioner DewEco Could Improve Sandy Soil's Properties for Efficient Maize Growth. Agronomy. https://doi.org/10.3390/agronomy12051124.

Kätterer, T., & Bolinder, M., 2024. Response of maize yield to changes in soil organic matter in a Swedish long-term experiment. European Journal of Soil Science, 75. https://doi.org/10.1111/ejss.13482.

Maertens, M., Oyinbo, O., Abdoulaye, T., & Chamberlin, J., 2023. Sustainable maize intensification through site-specific nutrient management advice: Experimental evidence from Nigeria. Food Policy, 121. https://doi.org/10.1016/j.foodpol.2023.102546.

Meng, X., Guo, Z., Yang, X., Su, W., Li, Z., Wu, X., Ahmad, I., Cai, T., & Han, Q., 2021. Straw incorporation helps inhibit nitrogen leaching in maize season to increase yield and efficiency in the Loess Plateau of China. Soil and Tillage Research. https://doi.org/10.1016/j.still.2021.105006.

Midamba, D., Kwesiga, M., & Ouko, K., 2023. Determinants of adoption of sustainable agricultural practices among maize producers in Northern Uganda. Cogent Social Sciences, 10. https://doi.org/10.1080/23311886.2023.2286034.

Naderi, R., Edalat, M., & Kazemeini, S., 2016. Short-term responses of soil nutrients and corn yield to tillage and organic amendment. Archives of Agronomy and Soil Science, 62, pp. 570-579. https://doi.org/10.1080/03650340.2015.1066929.

Nakano, Y., Tsusaka, T., Aida, T., & Pede, V., 2018. Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania. World Development, 105, pp. 336-351. https://doi.org/10.1016/j.worlddev.2017.12.013.

Nasir, B., Lakani, I., Najamudin, N., Sabariyah, S., Lasmini, S., Asdar, M., Astawa, I., Akbar, I., & Tiana, I., 2021. Development of Integrated Farming Businesses Based on Zero Waste Agriculture in Parigi Moutong Regency. Journal of Community Practice and Social Welfare. https://doi.org/10.33479/jacips.2021.1.2.28-39.

Otieno, E., Ngetich, F., Kiboi, M., Muriuki, A., & Adamtey, N., 2021. Tillage system and integrated soil fertility inputs improve smallholder farmers' soil fertility and maize productivity in the Central Highlands of Kenya. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 122, pp. 159-171. https://doi.org/10.17170/kobra-202107134319.

Oyinbo, O., Chamberlin, J., Vanlauwe, B., Vranken, L., Kamara, Y., Craufurd, P., & Maertens, M., 2019. Farmers' preferences for high-input agriculture supported by site-specific extension services: Evidence from a choice experiment in Nigeria. Agricultural Systems, 173, pp. 12 - 26. https://doi.org/10.1016/j.agsy.2019.02.003.

Pandey, D., Yadav, D., Kumar, A., Kumar, A., Yadav, R., Verma, A., & Yadav, S., 2025. Effect of Organic Manure and Inorganic Fertilizers on Growth, Yield Attributes and Yield of Maize (Zea mays L.) in Eastern Plain Zone of Uttar Pradesh, India. Journal of Scientific Research and Reports. https://doi.org/10.9734/jsrr/2025/v31i42926.

Seran, Y., Da Silva, H., & Kario, D. (2021). Productivity of Maize in The Marginal Dryland in East Nusa Tenggara Province – Indonesia. E3S Web of Conferences. https://doi.org/10.1051/e3sconf/202123201011.

Shanmugam, P., Sangeetha, S., Prabu, P., Varshini, S., Renukadevi, A., Ravisankar, N., Parasuraman, P., Parthipan, T., Satheeshkumar, N., Natarajan, S., & Gopi, M., 2024. Crop–livestock-integrated farming system: a strategy to achieve synergy between agricultural production, nutritional security, and environmental sustainability. Frontiers in Sustainable Food Systems. https://doi.org/10.3389/fsufs.2024.1338299.

Wang, N., Zhang, T., Cong, A., & Lian, J. (2023). Integrated application of fertilization and reduced irrigation improved maize (Zea mays L.) yield, crop water productivity and nitrogen use efficiency in a semi-arid region. Agricultural Water Management. https://doi.org/10.1016/j.agwat.2023.108566.

Yang, Y., Lei, D., Zhang, Y., Zhao, Z., Xie, H., Deng, F., Bao, X., Zhang, X., & He, H., 2025. Effects of Pig Slurry Coupled with Straw Mulching on Soil Nitrogen Dynamics and Maize Growth. Agronomy. https://doi.org/10.3390/agronomy15051062.