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Factors Affecting the Innovation of Crop-Livestock Integration System (SITT) Adoption in North Minahasa Regency

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ABSTRACT

The adoption of beef cattle crop-livestock integration system (SITT) innovations in North Minahasa Regency still faces various obstacles. As a result, beef cattle development tends to experience a decline in population, productivity, and competitiveness. The purpose of the study was to determine the factors influencing farmers' attitudes and adoption of SITT technology innovations for beef cattle in North Minahasa Regency. Mixed-method research was conducted from March to May 2024, where 25 extension agents and cattle farmers were selected purposively. The variables used were farmer characteristics, extension worker performance, nature of innovation, communication channels, attitudes, and farmer adoption of SITT. Data analysis used the Spearman rank method. The study revealed a strong correlation between extension worker performance and the nature of innovation on farmers' attitudes and SITT adoption. In contrast, communication behavior exhibited a negligible impact. These findings underscore the critical role of extension agents in facilitating technology adoption. To maximize the effectiveness of extension programs, efforts should focus on enhancing extension worker capabilities and creating innovative solutions tailored to farmers' needs.

Keywords: Agricultural Innovation; Crop-Livestock Integration System; Extension Performance; Farmers Attitude; Technological Adoption

INTRODUCTION

The low productivity of beef cattle in the North Minahasa Regency is due to the limited application of technology. This is evidenced by the traditional maintenance system with a scale of livestock ownership between 1-2 heads. In contrast, effective technology implementation requires raising at least 5-7 heads of beef cattle (Wahyuni & Dewi, 2018). To increase productivity, the adoption of technological innovations in crop-livestock integration patterns is necessary.

Beef cattle rearing in North Sulawesi province is still conducted traditionally. Consequently, the population development, including in North Minahasa Regency, has not seen a significant increase (Kalangi et al., 2022; Lenzun et al., 2023). In Indonesia, almost all beef production comes from smallholder farms (78%), with the remaining 5% of beef and 17% of live cattle being imported (Zakiah et al., 2017). This indicates that smallholder farming is the backbone of meeting Indonesia's beef demand. The adoption of crop-livestock integration system (SITT) innovations will impact the development of beef cattle, so their increase should be encouraged. Adoption is determined by various factors, including the innovation itself, communication channels, and the performance of extension workers. The ability of breeders to adopt technological innovations is influenced by their attitude towards these innovations, as attitudes shape their perspective on the introduced technology. The attitude of farmers is a key determinant in whether or not technological innovation is adopted by the main actors.

The process of changing farmers' attitudes is inseparable from the role of extension workers in delivering technological innovations through the use of appropriate media and methods to persuade farmers to adopt these innovations. Extension workers' ability to prepare media and extension methods will influence their performance. Extension performance is measured by counseling preparation, implementation, evaluation, and reporting.

Extension agents play a crucial role in the adoption process by introducing and motivating key actors to influence farmers' attitudes toward adopting technological innovations. Three communication behaviors commonly employed in extension are personal networks, intergroup communication, and mass media. Additionally, the rate of adoption is influenced by the nature of the introduced technological innovations, which includes suitability, relative advantage, complexity, testability, and observability.

North Minahasa Regency holds potential for beef cattle development. The prevalence of livestock rearing without SITT technology presents an opportunity for growth in this sector. The potential for SITT implementation in North Minahasa Regency is hindered by the extensive cattle-rearing practices. Research by Kaemba et al. (2019) indicates that the agricultural sector remains the economic backbone of North Minahasa Regency. The integration of food crops and livestock is a core agricultural subsector in North Minahasa Regency, although the agricultural sector's contribution tends to decline annually, its GRDP continues to increase. Farmers are pivotal to the success of agricultural development in North Minahasa Regency.

It is necessary to adopt technological innovations including applying SITT in accordance with site-specific conditions. The development of the beef cattle population in North Minahasa Regency based on the research results of Lainawa et al. (2024) can be seen in Table 1 below.

Table 1. Development of Beef Cattle Population in North Minahasa Regency

No	Year	Population (tail)	Percentage of Development (%)
1	2019	18,351	0
2	2020	18,627	2.76
3	2021	19,493	4.08
4	2022	19,901	

The low population increase as described in Table 1 is due to the traditional cattle-rearing system, ineffective agricultural extension, limited knowledge and skills of farmers, and poor communication, which in turn affects the attitude and adoption of farmer innovations. Meanwhile, the demand for beef consumption in North Sulawesi province continues to increase along with population growth (Lainawa et al., 2019).

This study aims to determine and analyze the factors that influence farmers' attitudes and adoption of SITT technology innovations in North Minahasa Regency, where the results of this study are useful for evaluating the implementation of programs to accelerate the adoption of SITT innovations. This research is considered very urgent because nationally it is faced with food sovereignty and independence programs, where the production of beef cattle as a provider of meat for the community is important.

LITERATURE REVIEW

Crop-Livestock Integration System (SITT)

Crop-livestock integration is a farming practice that combines agricultural and livestock enterprises. Farmers strategically place and cultivate livestock within crop areas without compromising the productivity of either. In fact, the coexistence of plants and animals can enhance the yield of both. The additional income generated by crop-livestock integration varies, with the coconut-cow integration model yielding the highest livestock income contribution of 75% (Indrawanto & Atman, 2017).

Crop-livestock integration technology often employs the concept of cleaner production, aiming for zero-waste farming. Livestock waste serves as organic fertilizer and energy (biogas) sources, while agricultural byproducts become livestock feed and organic fertilizer. Livestock effectively utilize crop byproducts as feed, and in return, provide organic fertilizers (solid and liquid) for sustainable plant nutrition.

Overall, crop-livestock integration technology seeks to increase crop and livestock productivity, mitigate environmental pollution, improve soil fertility sustainably and cost-effectively, augment farmers' income, and enhance farming efficiency. The Ministry of Agriculture, through the Agricultural Research and Development Agency, is actively promoting technological innovations, particularly SITT (Ilham & Saptana, 2015). SITT is an agricultural system characterized by strong linkages between livestock and crop components within a farm or region. These linkages are instrumental in driving sustainable economic growth within an environmentally friendly, zero-waste framework (Bahri & Tiesnamurti, 2013).

SITT offers substantial economic and ecological benefits. By converting livestock manure into biogas and fertilizer, SITT decreases farmers' production costs while improving their livelihoods (Ruhiyat et al., 2020; Vu et al., 2015). Moreover, crop residues, such as straw, can be utilized as animal feed, optimizing resource use (Musa et al., 2018). As emphasized by Suwarto (2018) and Utami & Rangkuti (2021), SITT's integration of local resources enhances productivity, reduces expenses, and increases farmers' income.

Farmers' attitudes toward technological innovations influence their adoption rates, as these attitudes shape their perspectives on the introduced technology. Farmers' attitudes are a key determinant of technology adoption, as changing farmers' attitudes requires effective extension efforts utilizing appropriate media and methods to persuade farmers to adopt the innovations. Consequently, extension workers' ability to develop media and extension methods impacts their performance. Extension performance is assessed based on preparation, which includes developing agricultural extension programs, creating work plans and schedules for farmer visits, and identifying regional potential. Implementation involves preparing suitable materials and media, conducting outreach activities individually, in groups, and collectively, and providing extension professional development. Evaluation measures extension efficiency and effectiveness.

Extension agents play a crucial role in the adoption process by introducing and motivating key stakeholders to influence farmers' attitudes toward technology adoption. Three primary communication strategies in extension are personal networks, intergroup communication, and mass media. Additionally, the rate of adoption is influenced by the technological innovation's characteristics, including suitability, relative advantage, complexity, testability, and observability (Harta et al., 2021).

Agricultural Innovation

Innovation adoption is a crucial component of agricultural development, involving the acceptance of novel ideas, practices, or technologies to enhance productivity and sustainability. While farmers often exhibit a willingness to adopt innovations, challenges persist. For example, the widespread practice of using cattle waste as manure, although common, poses environmental risks like pollution and odor (Jafar & Awad, 2021).

The widespread adoption of biogas technology is hindered by several factors. A lack of awareness, insufficient technical support, and socioeconomic obstacles present significant barriers to implementation (Roubík & Mazancová, 2020). Inadequate extension services, training, and guidance further compound these issues (Mwirigi et al., 2014). Although the production of biourine offers additional advantages for farmers and aligns with rural lifestyles (Abutani et al., 2011; Nurdayati et al., 2021), addressing the underlying challenges of knowledge dissemination and technical assistance is essential for promoting biogas adoption and maximizing its potential.

Effective innovation communication is vital for driving behavioral change and widespread adoption. To be successful, innovations must be presented in a clear and understandable manner (Syarief et al., 2017). This process, often termed diffusion, involves the dissemination of new ideas through communication channels (Badri, 2022). Clearly communicating the benefits, practices, and technological advancements associated with SITT can stimulate interest and encourage farmer adoption. Tailoring communication strategies to specific target audiences and employing accessible language will facilitate comprehension and knowledge transfer. Ultimately, effective communication channels and persuasive messaging are crucial for driving innovation and behavioral change within the agricultural sector.

Hypotheses Development

The technological components introduced to farmers will influence the adoption of technological innovations. According to Harta et al. (2021), extension worker performance positively impacts adoption, while the nature of innovation has a negative effect. Communication channels, however, have no significant influence on SITT innovation adoption. Furthermore, farmers' attitudes do not mediate the relationship between extension performance, innovation nature, and communication behavior on SITT technology adoption levels. Yet, extension worker performance, innovation nature,

and communication behavior collectively influence farmers' attitudes toward adopting SITT technology innovations, which subsequently impacts SITT technology adoption.

Based on the aforementioned explanation, the following hypotheses are formulated:

H1: There is a relationship between each dimension of extension (extension performance, innovation nature, and communication behavior) and beef cattle farmers' attitudes.
H2: There is a relationship between each dimension of extension agents (extension agent performance, innovation nature, and communication behavior) and SITT technology adoption.
H3: There is no relationship between each dimension of extension agents (extension agent performance, innovation nature, and communication behavior) and beef cattle farmers' attitudes.
H4: There is no relationship between each dimension of extension agents (extension agent performance, innovation nature, and communication behavior) and SITT technology adoption.
H5: There is a relationship between beef cattle farmers' attitudes and SITT technology adoption.
H6: There is no relationship between beef cattle farmers' attitudes and SITT technology adoption.

RESEARCH METHOD

This study applied mixed-methods approach. The research was conducted in North Minahasa Regency from March to May 2024 due to its agricultural potential. Data collection involved both primary and secondary sources. Primary data was gathered through interviews with informants/respondents, while secondary data was obtained from books, journals, the internet, and other relevant materials.

The study population comprised farmers engaged in beef cattle rearing and extension workers involved in beef cattle extension activities within North Minahasa Regency. A purposive sample of 25 farmer households across Dimembe, Kalawat, and Talawaan sub-Regencys was selected to examine the correlation between (1) farmer characteristics, (2) extension worker performance, (3) SITT innovation nature, (4) communication channels, (5) farmer attitudes toward SITT technology innovations, and (6) SITT technology innovation adoption.

Snowball sampling was employed to identify informants through a referral process. A total of 25 participants were involved. Key informants, including village government representatives, agricultural extension workers, and farmer group leaders, provided recommendations for potential participants.

Data analysis encompassed descriptive analysis and Rank Spearman Correlation analysis, guided by Vaus as cited in Lenzun et al. (2023) and visualized in Table 2.

Table 2. Correlation Coefficient Interpretation

No	Coefficient	Relationship Strength
1	0.00	No relationship
2	0.10-0.29	Less meaningful relationship
3	0.10-0.29	Weak relationship
4	0.30-0.49	Moderate relationship
5	0.50-0.69	Strong relationship
6	0.70-0.89	Very strong relationship

7	0.90-0.99	Close to perfect

RESULTS

Characteristics of the Study Area

North Minahasa Regency is administratively divided into 10 sub-Regencys comprising 130 villages. Wori and West Likupang sub-Regencys have the most villages with 20 each, while South Likupang has the fewest with 7. The Regency capital is located in Airmadidi sub-Regency.

According to the Central Statistics Agency of North Minahasa (BPS-Statistics Indonesia North Minahasa Regency, 2024), horticulture is a leading agricultural commodity. Coconut, nutmeg, cloves, cocoa, and areca palm are primary plantation subsector commodities in North Minahasa in 2023. Coconut is the most prominent plantation commodity, covering 36,862 hectares, primarily cultivated in Kauditan, Dimembe, and South Likupang sub-Regencys. Nutmeg is the second largest commodity, with a 2023 production of 555.85 tons, predominantly in Talawaan (124.98 tons) and Dimembe (79.53 tons).

The livestock area, suitable for livestock development with minimal pollution impact, is at least 500 meters from settlements. It covers approximately 27,721.62 hectares, similar to the dryland food crop agricultural area. Primary livestock commodities include cattle, pigs, chickens, and ducks. Beef cattle farming, traditionally practiced as a part-time activity, involves grazing on agricultural and plantation lands with minimal maintenance and feeding. Farmers primarily raise cattle for agricultural labor, food, savings, and emergency income.

A Spearman Rank correlation analysis was conducted to examine and test the significance of the associative hypothesis, with results presented in the following tables.

Relationship Between Extension Worker Performance and Beef Cattle Farmer Attitudes

Table 3. Correlation Between Extension Performance and Farmer Attitudes

Correlations			Extension Performance	Farmer Attitude
Spearman's rho	Extension Performance	Correlation Coefficient	1.000	0.529**
		Sig. (2-tailed)		0.007
		N	25	25
	Farmers' Attitudes	Correlation Coefficient	0.529**	1.000
		Sig. (2-tailed)	0.007	
		N	25	25

Note: ** Correlation is significant at the 0.01 level (2-tailed)

The interpretation of Rank Spearman correlation test output involves three stages: (1) determining the strength of the relationship between variables, (2) identifying the direction of the relationship, and (3) assessing the significance of the relationship.

Table 3 reveals a strong positive correlation coefficient of 0.529 between extension performance and farmers' attitudes toward beef cattle SITT technology. This indicates a substantial relationship, suggesting that improved extension efforts, encompassing preparation, implementation, and evaluation, are associated with more positive farmer attitudes toward SITT adoption.

The p-value of 0.007 is statistically significant, confirming a correlation between extension worker roles and farmer attitudes. Thus, hypothesis H1 is accepted while H3 is rejected. Changing farmers' attitudes is intrinsically linked to extension workers' roles in delivering technological innovations to beef cattle farmers in North Minahasa Regency, employing appropriate media and methods to persuade farmers to adopt SITT technology innovations. Extension workers' ability to prepare and implement media and extension methods impacts their performance, which is measured by extension preparation, implementation, and evaluation.

Effective extension services are crucial for empowering farmers and driving agricultural development. By providing timely information, technical assistance, and capacity building, extension workers can facilitate the adoption of innovative practices and enhance overall productivity (Bahua, 2016).

Relationship Between Extension Performance and Technology Adoption (SITT)

Table 4. Correlation Between Extension Performance and Technology Adoption (SITT)

Correlations			Extension Performance	Technology Adoption (SITT)
Spearman's rho	Extension Performance	Correlation Coefficient	1.000	0.511**
		Sig. (2-tailed)	.	0.009
		N	25	25
	Technology Adoption (SITT)	Correlation Coefficient	0.511**	1.000
		Sig. (2-tailed)	0.009	.
		N	25	25

Note: ** Correlation is significant at the 0.01 level (2-tailed)

Table 4 reveals a strong positive correlation coefficient of 0.511 between extension performance and SITT technology adoption. This indicates a substantial relationship, suggesting that improved extension activities, encompassing preparation, implementation, and evaluation, are associated with higher rates of SITT adoption among farmers.

The statistical significance of this relationship is confirmed by the p-value of 0.009, which is less than the alpha level of 0.05. Thus, hypothesis H2 is accepted, and hypothesis H4 is rejected. The process of adopting SITT technological innovation is inseparable from the role of extension workers in conveying technological innovations to beef cattle farmers in North Minahasa Regency, using appropriate media and methods to persuade farmers to adopt SITT technological innovations. Extension workers' ability to prepare and implement media and extension methods influences extension performance, which is measured by extension preparation, implementation, and evaluation.

Extension workers' performance positively influences SITT technology innovation adoption through active dissemination of SITT technology innovations to farmers, aiming to enhance farmers' knowledge, attitudes, and skills. Extension workers' activities increase farmer involvement in technology applications by strengthening farmer groups (Harta et al., 2021).

Relationship Between Innovation Traits and Attitudes of Beef Cattle Farmers

Table 5. Correlation Between Nature of Innovation and Farmer Attitudes

Correlations			Nature of Innovation	Farmer Attitude
Spearman's rho	Nature of innovation	Correlation Coefficient	1.000	0.699**
		Sig. (2-tailed)	.	0.000
		N	25	25
	Farmers' Attitudes	Correlation Coefficient	0.699**	1.000
		Sig. (2-tailed)	0.000	.
		N	25	25

Note: ** Correlation is significant at the 0.01 level (2-tailed)

Table 5 reveals a strong positive correlation coefficient of 0.699 between the nature of innovation and farmers' attitudes toward beef cattle SITT technology. This indicates a substantial relationship, suggesting that as farmers' understanding of innovation's attributes, including compatibility, relative advantage, complexity, trialability, and observability, increases, their attitudes toward SITT adoption also significantly improve.

The p-value is 0.000, indicating a highly significant relationship, confirming a strong correlation between the nature of innovation and farmers' attitudes toward adopting SITT technology. Thus, hypothesis H1 is accepted, and hypothesis H3 is rejected. The nature of innovation significantly influences changes in farmer attitudes, with a positive correlation. This indicates that farmers perceive SITT technology as highly beneficial, as it can transform the beef cattle rearing system. SITT is a technology that integrates agricultural and livestock enterprises. It also aligns with the concept of cleaner production, aiming for zero-waste technology by utilizing livestock waste as fertilizer for agriculture and agricultural waste as animal feed.

Several advantages arise from implementing crop-livestock integration technology, including (1) diversified use of production resources; (2) reduced risk; (3) efficient use of labor; (4) efficient use of production components; (5) reduced dependence on chemical and biological energy and other external resource inputs; (6) a more sustainable and less polluting ecological system; (7) increased output; and (8) the development of more stable farmer households (Devendra in Indrawanto & Atman, 2017).

Relationship Between Innovation Traits and Adoption of SITT Technology for Beef Cattle

Table 6. Correlation Between Nature of Innovation and Technology Adoption (SITT)

Correlations			Nature of Innovation	Technology Adoption (SITT)
Spearman's rho	Nature of Innovation	Correlation Coefficient	1.000	0.596**
		Sig. (2-tailed)	.	0.002
		N	25	25
	Technology Adoption (SITT)	Correlation Coefficient	0.596**	1.000
		Sig. (2-tailed)	0.002	.
		N	25	25

Note: ** Correlation is significant at the 0.01 level (2-tailed)

Table 6 reveals a strong positive correlation coefficient of 0.596 between the nature of innovation and SITT technology adoption. This indicates a robust relationship, suggesting that as farmers' understanding of innovation's attributes, including compatibility, relative advantage, complexity, trialability, and observability, increases, their likelihood of adopting SITT technologies also rises.

The statistical significance of this relationship is confirmed by the p-value of 0.002, which is less than the alpha level of 0.05. Consequently, H4 is rejected in favor of H2, supporting the claim that there is a significant positive relationship between the two variables.

Harta et al.'s research (2021) suggests that the nature of innovation has a real effect on SITT technology innovation adoption with a negative correlation. This discrepancy arises because the two manifest variables of the nature of innovation, namely relative advantage and level of complexity, do not significantly influence SITT technology innovation adoption. This indicates that farmers perceive SITT technology as less favorable compared to their existing extensive beef cattle farming practices. Farmers also believe that SITT components are challenging to implement due to the required intensive cultivation system.

Relationship Between Communication Behavior and Attitudes of Beef Cattle

Table 7. Correlation between Communication Behavior and Farmer Attitude

Correlations			Communication Behavior	Farmer Attitude
Spearman's rho	Communication Behavior	Correlation Coefficient	1.000	0.136
		Sig. (2-tailed)	.	0.518
		N	25	25
	Farmers' Attitudes	Correlation Coefficient	0.136	1.000
		Sig. (2-tailed)	0.518	.
		N	25	25

Note: ** Correlation is significant at the 0.01 level (2-tailed)

Table 7 indicates a correlation coefficient of 0.136 between communication behavior and farmers' attitudes toward beef cattle SITT innovation in North Minahasa Regency. This suggests a weak positive relationship, implying that while improved communication tends to positively influence farmers' attitudes, the effect is minimal.

The p-value of 0.518 exceeds the significance level of 0.05, indicating no statistically significant relationship between the two variables. Consequently, H3 is accepted, and H1 is rejected. Communication behavior is determined by three components: interpersonal, group, and mass media (internet). Of these, internet media has shown minimal influence due to farmers' limited engagement with online information about SITT technology. This is attributed to factors such as limited human resource capacity in internet media, restricted internet access, and low perceived need for such information.

The effectiveness of information media depends on farmers' motivation to access it. Most farmers in North Minahasa Regency primarily use the internet for entertainment, hindering the innovation adoption process. This is further influenced by limited farmer human resources, insufficient extension workers, and the competence of existing extension workers. Adawiyah, Andriati & Rahmawati, and Mulatmi et al. in Harta et al.

(2021) found that most farmers utilize the internet primarily for entertainment. Additionally, farmers' limited access to information via the internet is due to restricted communication tools, limited farmer human resource quality, insufficient field instructors, and local cultural factors.

Relationship Between Communication Behavior and SITT Ha Technology Adoption

Table 8. Correlation of Communication Behavior with Farmer Attitude

Correlations			Communication Behavior	Technology Adoption (SITT)
Spearman's rho	Communication Behavior	Correlation Coefficient	1.000	0.154
		Sig. (2-tailed)	.	0.461
		N	25	25
	Farmers' Attitudes	Correlation Coefficient	0.154	1.000
		Sig. (2-tailed)	0.461	.
		N	25	25

Note: ** Correlation is significant at the 0.01 level (2-tailed)

Table 8 reveals a correlation coefficient of 0.154 between communication behavior and SITT technology adoption, indicating a weak positive relationship. While there is a slight tendency for improved communication to positively influence adoption, this relationship is not statistically significant. The p-value of 0.461 exceeds the significance level of 0.05, leading to the acceptance of H4 and rejection of H2. The indicators of communication behavior in this analysis are personal networks, group roles, and mass media roles. The process of innovation adoption is slow because these three indicators do not play a significant role, with group and mass media approaches proving inefficient in conveying SITT technology innovations. A more comfortable group atmosphere, characterized by strong relationships, freedom of participation, and a conducive physical environment, fosters higher levels of group dynamism, facilitating the acceptance of technological innovations. Additionally, personal networks, influenced by internet access, limited information, and low information needs, impact adoption rates. Farmers are more likely to adopt new technological innovations if they perceive potential benefits and positive outcomes through communication channels. However, limited communication about SITT has hindered farmer interest, and the underutilization of mass/social media for seeking SITT information further contributes to this issue.

Rahmawati et al. (2023) found that communication channels significantly influence the innovation adoption process. Interpersonal communication channels, including seminars, counseling, and dialogues, are frequently utilized by respondents. However, the use of social media platforms like Facebook, Instagram, Twitter, and Telegram is limited. While WhatsApp is used by some farmers, its usage is not widespread.

Relationship Between Farmer Attitude and Adoption of SITT Beef Cattle Technology Innovation

Table 9. Correlation Between Nature of Innovation and Farmer Attitude

Correlations			Farmer Attitude	Technology Adoption (SITT)
Spearman's rho	Nature of Innovation	Correlation Coefficient	1.000	0.375
		Sig. (2-tailed)	.	0.065

		N	25	25
	Farmer Attitude	Correlation Coefficient	0.375	1.000
		Sig. (2-tailed)	0.065	.
		N	25	25

Note: ** Correlation is significant at the 0.01 level (2-tailed)

Table 9 indicates a moderate positive correlation coefficient of 0.375 between farmers' attitudes and the adoption of Beef Cattle SITT technology, suggesting that a more positive attitude toward specific SITT practices, such as mating management, pregnancy care, and calf rearing, is associated with a higher likelihood of technology adoption.

However, the p-value of 0.065 exceeds the significance level of 0.05, indicating that this relationship is not statistically significant. To test the proposed hypothesis, the author compares the calculated t-value with the t-table value. With a confidence level of 95% (α = 0.05), the calculated significance value of 0.065 is greater than α (0.05). Therefore, the results of this study reject Hypothesis (H5) and accept Hypothesis (H6), indicating that farmers' attitudes do not influence SITT technology innovation adoption. It is assumed that the technology is perceived as less useful, uneconomical, and complex, leading to a cautious attitude among farmers. Additionally, limited communication about SITT has contributed to this outcome. Farmers' attitudes are influenced by direct experiences and perceptions, encompassing both positive and negative aspects. These attitudes are shaped by cognitive, affective, and conative factors. Cognitive factors involve awareness of SITT technology, affective factors pertain to attitudes and opinions about SITT, and conative factors relate to behavioral tendencies influenced by knowledge, motivation, and business scale. Education level, motivation, and business size impact farmers' attitudes toward innovation. Farmers are more likely to adopt innovations with visible and tangible benefits. Rahmawati et al. (2023) found that 7.5% of farmers adopted innovations, 28.3% were hesitant, and 47.2% chose not to adopt innovations.

DISCUSSION

Relationship Between the Role of Extension Workers, Farmer Attitudes, and SITT Technology Adoption

Based on the analysis, all respondents were receptive to adopting the SITT innovation for their beef cattle-rearing businesses. This is primarily due to its potential to provide relative advantages, including reduced production costs and the efficient utilization of all plant and livestock components for economic, social, and ecological benefits.

Crop-livestock integration technology offers several advantages: (1) diversified resource utilization; (2) risk reduction; (3) labor efficiency; (4) efficient component use; (5) decreased reliance on chemical and biological energy and external inputs; (6) a more sustainable and environmentally friendly ecological system; (7) increased output; and (8) the development of more stable farming households (Devendra in Indrawanto & Atman, 2017). Despite these advantages, certain challenges and obstacles require attention: (1) cattle grazing can damage plants; (2) significant capital is needed to purchase livestock; and (3) the optimal integration of crops and livestock, such as utilizing straw or fermentation waste for animal feed, has not been fully achieved.

Extension plays a crucial role in conveying SITT innovation to breeders. Extension agents, as field implementers of innovation, contribute to changing breeders' knowledge, attitudes, and skills to adapt to the SITT program. As educators, disseminators, facilitators, consultants, advocates, and supervisors, extension workers must possess

adequate competencies, including communication skills, positive attitudes, abilities, subject matter expertise, and socio-economic and cultural understanding.

Extension workers must effectively and systematically implement SITT innovation in the field, encompassing planning, implementation, and evaluation. Their contributions should span the introduction, demonstration, and assessment stages. While being an extension worker is essential, it is insufficient to merely reach the socialization phase. The ultimate goal is to achieve SITT innovation adoption among breeders.

Extension worker performance, innovation nature, and communication behavior differentially influence farmers' attitudes and SITT technology adoption. Performance and innovation nature have significant impacts, while communication behavior does not. This indicates that the development of beef cattle SITT technology in North Minahasa Regency through extension channels encountered substantial obstacles in communication behavior, particularly regarding personal networks, group dynamics, and mass media.

The results of research by Harta et al. (2021) indicate that extension worker performance positively influences the adoption of SITT technology innovations. Extension workers actively disseminate SITT technology innovations to farmers, aiming to enhance farmers' knowledge, attitudes, and skills. However, the same research revealed that the nature of innovation negatively impacts SITT technology innovation adoption. The relative advantage and level of complexity, two key components of innovation, do not significantly influence adoption. Farmers perceive SITT technology as less favorable compared to traditional extensive beef cattle farming and find the implementation of SITT components challenging due to the required intensive cultivation system.

Factors influencing farmers' adoption of technological innovations include their perception of the innovation's relative advantages (economic and simplicity) and the extension methods used to deliver SITT technology innovations. The research findings indicate that innovation suitability, relative advantage, complexity, testability, and observability significantly influence farmers' attitudes and the rate of SITT innovation adoption. Therefore, extension workers must enhance their skills through demonstrations, training, and participatory approaches.

The low communication effectiveness of extension workers is caused by the availability of inaccurate data technology (Rizqi & Pradana, 2018; Zis et al., 2021). Therefore, extension workers in North Minahasa Regency must go to the field more often to collect as much data as possible. This will better accommodate the needs of farmers, ensuring that extension activities are targeted accurately. It is crucial to consider the characteristics of extension workers, as these characteristics significantly impact the performance of extension programs. Socio-economic characteristics such as education, age, length of service, number of family dependents, income, and expenditures affect the success of agricultural extension workers in fulfilling their duties.

Effective and efficient extension work requires extension workers with strong characteristics. The success of these workers in developing beef cattle farming in North Minahasa Regency depends largely on their performance from preparation and implementation to evaluation. This success is supported by good characteristics, including social factors like productive age, education, experience, number of family dependents, and economic factors such as income/wages and expenses. Length of service is particularly important, as it correlates with an extension worker's ability to understand the situation. The longer the period of service, the better the extension

worker's ability to communicate, choose the appropriate extension methods, and adapt to farmers as the target audience.

Therefore, strategic planning related to strengths, weaknesses, opportunities, and threats is essential. This planning should focus on providing extension workers with various supportive characteristics to ensure the success of government programs aimed at developing beef cattle farming in North Minahasa Regency using the SITT concept.

Innovation Adoption and Influencing Factors

Innovation Adoption Theory in extension is often defined as a mental process in which an individual receives new ideas and decides whether to accept or reject them. This process is influenced by many factors, including the characteristics of the innovation, the traits of potential users, the decision-making process, the channels or media used, and the qualifications of instructors. Farmers primarily consider the profitability of adopting an innovation as a benchmark, observing and evaluating it in comparison with other types. If they perceive that the advantages outweigh the disadvantages, they will adopt it. Before adopting an innovation, farmers also consider the required costs, as their limited economic capacity often means they prioritize household needs. Thus, innovations should be offered with consideration of the farmers' financial capabilities. Complexity or simplicity is another crucial factor, given the generally low education level of farmers. Simpler methods are more likely to be adopted, whereas complex innovations may have a lower adoption rate. Farmers will adopt innovations that are compatible with their physical environment, as those that could cause environmental problems, such as pollution, are likely to be rejected. Additionally, innovations must align with the cultural practices of farmers. Changing long-established habits requires a persuasive and repeated approach; otherwise, farmers will stick to traditional methods. Innovations should also be easy to communicate and understand. If an innovation is considered difficult to comprehend, it will hinder adoption. Farmers will adopt innovations that do not require excessive time and effort, considering their diverse main jobs and varying ages, which limit their time and energy to invest in new practices. Innovations should be broken down into manageable parts that are easy for farmers to understand and implement. If an innovation cannot be divided into simpler steps, it is less likely to be accepted.

The process of changing farmers' attitudes depends heavily on the role of extension workers, who must use appropriate media and methods to convince farmers to adopt technological innovations. Their performance, measured by their preparation, implementation, and evaluation of extension activities, is crucial. Extension workers play a vital role in introducing and encouraging farmers to adopt new technologies. Effective communication behaviors, including personal networks, intergroup communication, and mass media, are essential in this process. Additionally, the nature of technological innovations, such as their suitability, relative advantage, complexity, ease of testing, and observability, influences the adoption rate.

North Minahasa Regency has significant potential for developing beef cattle farming. However, the lack of SITT technology application in livestock rearing presents both a challenge and an opportunity for development. The potential for implementing SITT in North Minahasa is constrained by extensive cattle-rearing practices. Despite the agricultural sector's decreasing contribution to the economy, it remains a crucial part of North Minahasa's economy, with the integration of food crops and livestock being a key sub-sector. Farmers play a vital role in this development, and their involvement is essential for the success of agricultural development in the region. To address these challenges, strategic planning is essential. It should focus on leveraging the strengths and opportunities while addressing weaknesses and threats. Providing extension workers with supportive characteristics is crucial for the successful implementation of

government programs aimed at developing beef cattle farming in North Minahasa using the SITT concept.

The nature or characteristics of prospective users are crucial to consider because several communication barriers can occur when delivering messages or innovations to targets in extension activities. These barriers include the ability to communicate, which is essential for receiving and conveying information, the low level of knowledge of the target, where prospective users often have limited understanding of the innovations offered, the attitude of the target, which may be less accepting due to the heterogeneous nature of the group (differing in age, occupation, education levels, and emotional characteristics), and the socio-cultural background of the target.

When making innovation adoption decisions, attention should be given to several factors: (1) knowledge, which involves being aware of the innovation and understanding how it functions; (2) persuasion, which determines whether the target likes or dislikes the innovation; (3) decision, which involves activities leading to choosing whether to accept or reject the innovation; and (4) confirmation, which seeks reinforcement for the decisions previously made.

The channels or media used in transferring knowledge and innovation can be divided into interpersonal media and mass media. Interpersonal media includes intrapersonal communication, which occurs within an individual through processes such as thinking, contemplating, and remembering, and interpersonal communication, which is direct communication between individuals. Mass media can be grouped into several types based on information dissemination techniques, including print media, magazines, newspapers, tabloids, electronic media, and online media.

Extension qualifications refer to the attributes that an extension agent must possess for the extension process to be effective and align with the initial objectives. These qualifications, or requirements, include communication skills, knowledge about the content of the message or innovation, a good attitude, and the ability to adapt to the socio-cultural conditions of the target audience. These elements are crucial in changing the behavior of the target, as effective communication, knowledge, attitude, and adaptability are key determinants in influencing and modifying the behavior of the target audience.

It is through effective communication, knowledge, attitudes, and adaptability that the target audience can be influenced to change in terms of knowledge, attitudes, and skills. This transformation aims to shift breeders from being unwilling to willing and from being incapable to capable. Achieving the objectives of extension is challenging if an extension worker does not meet the necessary qualifications, as their task involves the significant challenge of altering the knowledge, attitudes, and skills of farmers. Unfortunately, this difficult task is often not accompanied by adequate support from related agencies, such as efforts to improve the abilities of extension workers through training, specialization according to their field of knowledge, and organizing or participating in seminars. Although these initiatives exist, they are not fully supported.

The successful adoption of innovations or behavioral changes among users is the ultimate goal of the entire series of innovations for the development of agricultural and livestock businesses undertaken by farmers in North Minahasa Regency. The long process of producing innovations, disseminating them, and reaching the adoption stage, which involves many components, is expected to result in business improvements. If it does not, the energy, costs, and time invested will be wasted. The accumulation of these resources due to the lengthy journey from generating SITT technological innovations to

the adoption stage will be justified if the target users effectively utilize them to support the development of beef cattle farming.

SITT represents a highly efficient integrated farming enterprise that has become part of the farming culture of Indonesian communities. This local wisdom needs to be developed and nurtured to increase farmers' income.

CONCLUSION

The findings demonstrate that extension worker performance and the nature of innovation significantly impact farmers' attitudes toward and adoption of SITT technology in North Minahasa Regency. Conversely, communication behavior does not exhibit a significant influence on farmer attitudes. These results highlight the importance of effective extension services and innovative practices in driving technology adoption. Furthermore, the study reveals that farmers' attitudes play a crucial role in the adoption process, emphasizing the need for targeted communication and behavior change strategies.

The theoretical implication of this research is that it can enrich applied research in the field of agricultural development extension, especially in adopting technological innovations in SITT by measuring the performance of extension workers. The practical implications of this research are (1) the key to success lies with farmers as the main actors of beef cattle development in North Minahasa Regency, (2) farmers' decision to adopt SITT technology innovation is influenced by innovation characteristics, and (3) communication behavior of innovations before, during, and after the extension program is necessary for the sustainability of the adoption of SITT technology innovations in beef cattle farmers.

Therefore, to achieve the objectives of the SITT program, it is necessary to evaluate (1) the performance of extension workers, including extension preparation, implementation, and evaluation, (2) the nature of the innovation, including suitability, relative advantage, complexity, testability, and observability, and (3) communication behavior, which includes personal networks, the role of groups, and the role of mass media.

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