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Research

Buffalo agribusiness and rural household income: Mediating effects of Farmer characteristics in Lindu district, Indonesia

Sayekti Handayani ^{*)1)}, Suparmin Fathan ²⁾, Haerani Maksum ¹⁾, Afandi ¹⁾, Hasnadia ¹⁾, Siti R. Machieu ²⁾, Ramlan Mustapa ²⁾, Safriyanto Dako ²⁾, Delvi Suleman ²⁾

¹⁾ Universitas Tadulako, Central Sulawesi, Indonesia

²⁾ Universitas Negeri Gorontalo, Gorontalo, Indonesia

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ABSTRACT

Buffalo farming is an important part of agribusiness activities that play a role in supporting the economy of rural livestock families. Buffalo farming contributes to family income beside providing a source of food and labor. Buffalo farming agribusiness needs to be continuously optimized with the hope of optimizing the capital and competency aspects of farmers in order to optimize the economy and family income. The study aims to determine (1) the contribution of buffalo agribusiness to family income, and (2) analyze the influence of land area (capital factor) and farmer experience (competence) on family income through livestock agribusiness. The research used a Mixed Method Sequential Explanatory approach. The data source in this study was primary data from questionnaires distributed to 85 livestock farmers, followed by interviews, observation, and documentation. Data analysis used descriptive statistics, path analysis, and Sobel test. Research results showed that Buffalo agribusiness contributed an average of 44.09% to family income, with the lowest contribution of 2.23% and the highest 98.48%. Path analysis showed that land area and livestock farmer experience did not have a significant direct effect on family income, with land area being more influential than farmer experience. However, the Sobel test showed that land area and livestock farmer experience had a positive and significant effect when using buffalo agribusiness income as a mediating variable, farmer experience was the most dominant influence in indirect effect. Income from buffalo agribusiness plays a strategic role in increasing the influence of capital and livestock farmer competency on household economic well-being. These results emphasize the importance of strengthening an integrated, land-based, and experience-based buffalo agribusiness system, policy interventions in the form of capacity-building training for farmers, optimal utilization of land resources, and institutional support to enable buffalo agribusiness to become a primary pillar in strengthening family economic resilience.

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^{*)} Corresponding Author

INTRODUCTION

Economic growth in rural areas is closely linked to communities' ability to manage local resources effectively. The livestock sector, particularly buffalo, is a critical sector in supporting the local household economics. It plays an important role in the integrated farming system and serves as the primary or secondary source of income for livestock farming families (McDermott et al., 2010). In Lindu District, Sigi Regency, buffalo are raised not only for consumption and labor but also as an important component of the developing local agribusiness system. Farmers' characteristics have a significant impact on the performance and productivity of buffalo farming enterprises. Education level, age, farming experience, access to knowledge and technology, and land ownership are the most important factors in good livestock management and enhancing family income (Lalljee et al., 2019). Previous research has found that farmers with greater levels of education are more likely to adopt better innovations and management approaches, which has a direct impact on production and revenue (Wong et al., 2018).

Buffalo agribusiness management includes various activities, including production, product processing, and marketing. The agribusiness strategy enables farmers to gain additional value from livestock products, such as meat, milk, or other processed products. This creates substantial opportunities to improve household income when managed properly (Escarcha et al., 2020). Buffalo farming can help to increase food security and improve community welfare. Rosairo (2023) highlighted that integrating agribusiness with the appropriate farmer characteristics can improve farmer families' economic stability. On the other hand, many constraints such as restricted access to financing, volatile markets, and inadequate technology are frequently the primary impediments to optimizing this industry (Bhandari, 2022). The value chain-based approach recognizes the relevance of agribusiness in accelerating the influence of farmer characteristics on family income. This method emphasizes the mutual support of production, processing, distribution, and markets (Kumar et al., 2020). In order to develop an inclusive and sustainable agricultural environment, local institutions, livestock cooperatives, and government backing are required.

Lindu District has geographical and biological possibilities for buffalo farming. The abundance of natural grasslands, as well as the community's socio-cultural patterns associated with livestock rearing, are significant sources of social capital. However, this potential has not been completely realized due to inadequate access to technical knowledge and institutional strengthening (Saqib et al., 2025). As a result, measures to strengthen livestock farmers' capacities through training, technical assistance, and market access are critical. Optimizing family income through buffalo farming is about more than just production efficiency; it also involves environmental and social sustainability. Alexander et al. (2018) found that a well-

managed local livestock system can strike a balance between resource use and environmental protection. This technique is appropriate for sensitive sites such as Lindu, which are located in a conservation buffer zone. In terms of economic empowerment, buffalo farming affects the participation of vulnerable groups such as women and youth in their family's economy. Priscilla et al. (2024) stated that this group's participation in cattle agribusiness contributes significantly to income diversification and poverty reduction in rural areas.

Technological support has been critical in expediting the impact of farmer income characteristics. Fermented feed, superior breeding, and digital marketing and financial management apps have all been found to improve farmer efficiency and profitability (Escarcha et al., 2018). However, technology adoption remains a challenge in many communities, especially Lindu District, due to low digital literacy and inadequate infrastructure. Furthermore, the contemporary agribusiness system includes a focus on animal health and livestock product safety. Duncan et al. (2013) stated that high-quality animal products not only provide higher selling prices, but also improve market confidence in local products. As a result, in order to maximize family income from buffalo livestock, all sanitary standards, proper livestock management, and access to veterinary services must be prioritized. Buffalo farming plays a significant role in supporting rural economic development. Soliman (2018) describes this sector as a pillar of sustainable agricultural development capable of creating jobs, reducing inequities, and strengthening food security. Lindu District has an ideal chance to make buffalo farming a strategic tool in its community's economic development, taking into account local potential and existing obstacles. Thus, the importance of this study lies in the need to understand the extent to which the features of livestock farmers and agribusiness management influence family income in the area. The study's findings are expected to give data-driven suggestions for policymakers, supporting institutions, and corporations attempting to construct flexible, inclusive, and sustainable agribusiness development strategies at the local level. This study intends to investigate the contribution of livestock businesses or buffalo agribusiness to family income and examine the influence of land area (capital factor) and livestock farmer experience (competence) on family income through livestock agribusiness. The hypotheses in this study consist of descriptive hypotheses and associative hypotheses, i.e. (1) it is suspected that the contribution of buffalo livestock or agribusiness makes a significant contribution to family income, and (2) it is suspected that buffalo livestock agribusiness is able to significantly increase the influence of land area (capital factor) and livestock breeder experience (competence) on family income.

Existing literature has primarily focused on the direct effects of various factors, with only a small number of studies investigating the role of buffalo agribusiness income as a mediating

variable. This gap is particularly evident in the context of Eastern Indonesia, notably in Sulawesi, where evidence remains scarce. The current study aims to address this gap by providing a theoretical contribution that synthesizes capital, competence, agribusiness income, and family welfare into a comprehensive mediation model. This approach not only enhances understanding of the interrelationships among these elements but also sheds light on their collective impact on agribusiness dynamics in the region.

METHOD

The research was conducted in Lindu District, Sigi Regency, to assess the potential for livestock and buffalo agribusiness in the area. The research considered ethical considerations by ensuring that all respondents provided informed consent before participating in the survey and interviews. Ethical approval was obtained from the Animal Research Ethics Committee of Tadulako University (No. 1711/UN28.16/AL.04/2025). Respondent determination was primarily driven by self-selection, where participation was entirely optional and respondents' identities were kept anonymous. Furthermore, this research received institutional clearance from the relevant authorities (the Sigi Regency government, the sub-district administration, and the village governments of Lindu sub-district) to ensure conformity with ethical norms for social research.

The Mix Method Sequential Explanatory technique is used in this study, which prioritizes quantitative aspects first, followed by qualitative factors. This study includes four variables, as mentioned below:

1. Family income

Family income is defined as the total economic income earned by all family members during a certain time period, from both livestock and non-livestock activities. Family income is frequently derived from a combination of livestock agribusiness income (the sale of buffalo, milk, or byproducts) and other sources, such as farming or informal jobs. Livestock revenue helps to shape livestock households' income structures. In fact, in many areas, livestock activities, such as buffalo farming, are the principal source of income for rural communities.

2. Buffalo agribusiness income

Buffalo agribusiness income refers to the amount of money earned by farmers from buffalo farming activities during a given period. This value comprises the sale of live livestock, dairy products, and other processed items such as dadiah (milk slurry) and manure-based fertilizer. Income in the livestock agribusiness is frequently stated in terms of nominal business earnings. Buffalo agriculture is especially beneficial as a principal economic source in locations with substantial grazing land (Hedge, 2019).

3. Land area

Livestock business capital includes all of the initial resources required to establish a livestock business, including physical capital (pens, equipment), financial resources, and natural assets such as land. Farmers can run their companies at a minimal cost by using local land and natural resources. Capital defines as financial, social, and ecological. Land area is often measured in hectare (ha), which is directly related to feed production capacity and livestock management efficiency. The Land Carrying Capacity Index (LCI) is also used to assess a region's potential for ruminant livestock expansion.

4. Farmer experience

Farmer experience is the collection of information, abilities, and professional attitudes that a farmer possesses while managing his livestock business. Long and continuous work experience in the cattle sector is a significant factor in demonstrating competency. Prolonged experience typically leads to enhanced skills in livestock management, disease prevention, and marketing. A positive correlation between farmer experience and livestock agribusiness efficiency and productivity has been found.

Data Collection and Variable Measurement

Data were collected using questionnaires, interviews, observations, and documentation. The population of this study was 85 livestock farmers, and using the saturated sample approach, an 85-person sample was determined. The validity and reliability of this study were not examined because it employed an open-ended, numerical questionnaire. Land area was assessed in hectares, livestock farmer experience was measured in years of working in livestock farming, family income was measured using nominal family income, and agribusiness income from livestock farming was calculated using nominal agribusiness income.

Data Analysis Technique

1. Contribution Analysis

Contribution analysis is a method for measuring and evaluating the extent to which a component, variable, or action contributes to specific outcomes or goals in financial, economic, organizational, and social contexts. In this context, it assesses how much livestock companies contribute to household income. The contribution analysis formula is:

$$\% \text{ Buffalo Contribution} = (\text{Buffalo Livestock Income}) / (\text{Family Income}) \times 100\%$$

2. Path Analysis

Path Analysis is a statistical technique for determining the causal relationship between variables in a model, either directly or indirectly. Because the base is linear regression, a precondition analysis is performed prior to route analysis, which includes normality, autocorrelation, multicollinearity, and heteroscedasticity. To conduct path analysis, family and buffalo agribusiness income data were converted to natural logarithms (LN) and standardized to utilize the beta coefficient as the path coefficient. The equations used in this research are:

$$Y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 Z_i + \varepsilon_i$$

$$Z_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \varepsilon_i$$

Description:

Y : family income

Z : buffalo agribusiness income

X1 : land area

X2 : farmer experience

α : Constant

β : Regression Coefficient

After the data from equation 1 and equation 2 are obtained, the results of the indirect influence are determined through Sobel analysis. The Sobel test is used after path analysis to statistically confirm the significance of an indirect effect (mediation effect). While path analysis indicates the strength of relationships between variables, the Sobel test specifically evaluates whether a mediator variable significantly carries the influence of an independent variable to a dependent variable, with the following formula:

$$Sab = \sqrt{b^2 \cdot Sa^2 + a^2 \cdot Sb^2 + Sa^2 \cdot Sb^2}$$

$$Z_{value} = \frac{ab}{Sab}$$

Description:

Sab = The size of the standard error of the indirect effect

a = The path of the independent variable (X) with the intervening variable (Z)

b = The path of the intervening variable (Z) with the dependent variable (Y)

Sa = Standard error of the coefficient a

Sb = Standard error of the coefficient b

RESULTS AND DISCUSSION

Description Statistical Analysis

Descriptive statistics in this research aims to provide an overview of the value of variables that are more focused on the contribution of buffalo agribusiness income to family income. The results of descriptive statistics of the research variables are shown in Table 1.

Table 1. Descriptive Statistics of Research Variables

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Land area (m ²)	85	.50	4.00	2.1647	.94219
Livestock Experience (year)	85	2.00	39.00	17.0235	10.07351
Buffalo Agribusiness Income (IDR)	85	14.66	18.62	16.8407	.94614
Family Income (IDR)	85	15.96	20.23	18.0715	1.07472
Valid N (listwise)	85				

Source: SPSS 21 Processed Data, 2025

The average area of livestock land in Lindu sub-district, Sigi district was 2.16 hectares with the lowest value of 0.5 hectares and the highest 4.00 hectares. This condition shows that the majority of livestock farmers were small to medium land owners, which has the potential to limit the scale of their livestock business. According to Indrayani et al. (2023), land area has a significant positive relationship with the income of buffalo farmers because it has an impact on the availability of natural feed and maintenance intensity. In addition, Devendra (2012) emphasized that optimizing land use in a mixed livestock system is an important factor in increasing agribusiness income. Then for the average livestock farmer experience, it is 17.02 years with the lowest experience of 2 years and the highest 39 years. This figure shows a fairly mature level of experience, which reflects the skills and knowledge that have been accumulated. Based on research by Syarifuddin et al. (2024), livestock experience has a significant impact on the efficiency of livestock management and business sustainability. Sowmya (2023) also showed that farmers with more than 15 years of experience tend to have a stronger scientific and economic orientation in buffalo farming.

The average income of buffalo livestock agribusiness was LN 16.84 or IDR 30,447,518 with the lowest value was LN 14.66 or IDR 2,328,000 and the highest value was LN 18.62 or IDR 122,145,000. This range indicates productivity inequality between livestock farmers. Tenrisanna & Kasim (2021) stated that factors of business scale, number of livestock, and market access greatly influence the variation in livestock income in Indonesia. Likewise, research by Sowmya (2023) found that farmers with higher incomes have a good combination

of land resources, training, and institutional support. The average family income was LN 18.07 or IDR 122,059,318 with the lowest value was LN 15.96 or IDR. 8,535,500 and the highest value was LN 20.23 or IDR 610,545,000. This illustrates that some livestock families are able to access more than one source of income, strengthening household economic resilience. Rohaeni et al. (2023) emphasized the importance of diversifying income sources in livestock agribusiness to ensure the sustainability of the family economy. In addition, Indrayani et al. (2023) found that total family income increased significantly when livestock was combined with the agricultural and service sectors. Meanwhile, the results of the analysis of the contribution of buffalo agribusiness income to family income are shown in Table 2.

Table 2. Contribution of Buffalo Agribusiness Income to Family Income Results Analysis

Aspect	Contribution of Buffalo Agribusiness Income (%)
Lowest	2.23
Highest	98.48
Average	44.09

Source: Excel Processed Data, 2025

The contribution of buffalo agribusiness income to family income analysis measures how much a household's net earnings from rearing buffaloes increase their total available income. The average contribution of income from buffalo agribusiness to the total income of livestock farmers in Lindu District was 44.09%, indicating that more than a third of the economic structure of livestock farmers' households depends on this sector. With variations in contributions ranging from 2.23% to 98.48%, this indicates an imbalance in the level of involvement and success of buffalo farming businesses between farmers.

This finding was in line with the study by Saxena et al. (2017), which emphasized that the buffalo sector is able to contribute up to 67% of total agricultural income in several rapidly developing zones of India. Islam et al. (2018) in Bangladesh also showed that income from buffalo farming can be the mainstay of the household economy. These findings supported by Phumchantuk et al. (2024) in Thailand that has socio-cultural elements are almost the same as Indonesia that Buffalo raised by smallholder farmers play important roles for agricultural. Devendra (2012) noted that buffalo have high economic value because they are multifunctional, both as producers of milk, meat, and labor, which ultimately supports food security and the income of small farmers. Cruz (2007) even highlighted that the economic role of buffalo in Asia has increased drastically along with global demand for its derivative products. Parthasarathy & BIRTHAL (2008) underlined how buffalo productivity directly contributes to rural poverty reduction. Tenrisanna & Kasim (2021) emphasized that buffalo farming is an alternative agribusiness venture that provides high profit margins and short-term regular

income for small farmers. Indrayani et al. (2023) also added that the contribution of buffalo farming to livestock household income can reach significant figures when accompanied by access to markets and efficient reproductive technology.

Path Analysis

Classical Assumptions

The summary of the results of the classical assumptions in the study are shown table 3. The data in this study were normally distributed because the significance value for the buffalo agribusiness income and family income variables was greater than alpha 5%. For autocorrelation, it was met because the Watson durbit value was on the criteria $du < dw < (4 - du)$. The multicollinearity test was in moderate correlation (VIF values < 5), and the heteroscedasticity test was met because the significance value for the buffalo agribusiness income and family income variables was greater than alpha 5%. Therefore, because all classical assumptions were met, the path analysis test which was a development of multiple regressions can be carried out.

Table 3. Classical Assumption Results

Prerequisites	Value	Criteria
Normality	Asymp. Sig. 0.734 (Buffalo Agribusiness Income); 0.870 (Family income)	Normally Distributed
Autocorrelation	Durbin Watson 2.180	Fulfilling Autocorrelation
Multicollinearity	VIF = 1.663 (Land area), 2.097 (Livestock Experience), 1.948 (Buffalo Agribusiness Income)	Moderate Correlation
Heteroscedasticity	Significance 0.096	Fulfilling Heteroscedasticity

Source: SPSS 21 Processed Data, 2025

Results of Direct Influence Testing

The direct influence of land area and livestock breeder experience on buffalo agribusiness income was presented in table 4. The equation for path analysis uses the Standardized Coefficients value, namely $Z = 0.238X_1 + 0.529X_2 + e$. This shows that the area of land and the experience of farmers have a positive influence on the income of buffalo livestock agribusiness in Lindu District, Sigi Regency. The results of the hypothesis testing for this were:

Table 4. Direct Effect of X_1 and X_2 on Z and Y

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
Z	(Constant)	15.478	0.190		81.558	.000
	Land area	0.239	0.099	0.238	2.415	0.018
	Livestock Experience	0.050	0.009	0.529	5.362	0.000
Y	(Constant)	11.073	2.438		4.541	0.000
	Land area	0.170	0.145	0.149	1.171	0.245
	Livestock Experience	0.002	0.015	0.018	0.124	0.902
	Buffalo Agribusiness Income	0.392	0.157	0.345	2.503	0.014

Source: SPSS 21 Processed Data, 2025

The Effect of Land Area on Buffalo Agribusiness Income

The probability value of land area was 0.018 which is smaller than the alpha value of 5% and indicates that land area has a positive and significant effect on buffalo agribusiness income in Lindu District, Sigi Regency. The results of the positive and significant effect mean that the larger the area of the farmer's land, the greater the capital of the farmer which ultimately provides positive benefits in increasing buffalo agribusiness income. Farmers with larger land have a greater capacity for providing natural feed, diversifying activities, and intensive livestock management. According to Lambertz et al. (2012), buffalo farmers with larger land ownership have a more productive business scale and more stable income than those with narrow land.

Devendra (2012) emphasized that land area in a mixed farming system plays an important role in production efficiency and household economic resilience of farmers. Cruz (2007) noted that the expansion of the buffalo production base is directly correlated with an increase in income volume. Parthasarathy & Birthal (2008) explained that extensive land-based livestock systems provide production flexibility, increase efficiency, and strengthen agribusiness resilience. Nanda & Nakao (2003) stated that adequate land allows for independent feed management, reducing external input costs. Gerber et al. (2005) stated that spatially intensive livestock production increases the economic value of land units. This is reinforced by Thomas et al. (2002), who stated that integration between land expansion and improved agribusiness management results in increased income in livestock systems.

The Influence of Farmer Experience on Buffalo Livestock Agribusiness Income

The probability value of farmer experience was 0.000 which is smaller than the alpha value of 5% and indicates that farmer experience has a positive and significant effect on buffalo livestock agribusiness income in Lindu District, Sigi Regency. These findings indicate that the more experienced the farmer, the more adequate the competence of the farmer, which will ultimately be able to increase buffalo livestock agribusiness income. Farmers who have long experience tend to understand the reproductive cycle, feed management, and disease management effectively. According to Lambert et al. (2012), livestock experience is strongly correlated with the efficiency of buffalo livestock businesses in Thailand and supports household economic success.

Devendra (2012) emphasized that long-term experience allows for optimal adoption of local technology in livestock agribusiness systems. Meanwhile, Paris (2002) stated that experience contributes to efficient resource utilization, which increases the profitability of livestock businesses. Hedge (2019) noted that experienced farmers have higher resilience to climate and market fluctuations. Indrayani et al. (2023) showed that the experience variable was significant in the buffalo income regression model. Tenrisanna & Kasim (2021) added that experience had a significant impact on increasing the value of livestock businesses in Sulawesi. Nanda & Nakao (2003) stated that experience affects technical competence in buffalo production, which is important for the sustainability of livestock agribusiness.

The direct influence of land area, livestock farmer experience and buffalo agribusiness income on family income was presented in table 4. The equation for path analysis using the Standardized Coefficients value was $Y = 0.149X_1 + 0.018X_2 + 0.345Z + e$. This shows that land area, livestock farmer experience and buffalo agribusiness income have a positive effect on the income of livestock farmers' families in Lindu District, Sigi Regency.

Effect of Land Area on Family Income

Land area did not significantly influence household income ($\beta = 0.149$, $p = 0.245$), suggesting that land ownership alone may not be sufficient to improve household welfare of livestock farmers' families in Lindu District, Sigi Regency. The results of the insignificant positive effect mean that although there was a tendency for income to increase along with the increase in land area, the contribution was not strong enough which is thought to be caused by the dominance of income from the non-agricultural sector or low intensification of land use. Shankar et al. (2019) showed that land ownership is not the only determinant of increasing welfare, but human capital and business diversification factors play a much bigger role. Yamauchi (2021) stated that large areas of land are not always productive if not accompanied

by good technology and management. The study by Datta & Behera (2024) also stated that the integration of land, forestry, and livestock is more effective than land expansion alone in improving farmer welfare. Swain & Teufel (2017) added that urbanization patterns make farmers oriented towards alternative income rather than relying on land optimization. Udo et al. (2011) concluded that the livestock intensification approach on a small land scale is actually more effective in improving the welfare of livestock households.

The Effect of Farmer Experience on Family Income

The probability value of livestock experience was 0.902, which is greater than the alpha value of 5%, which shows that livestock experience has a positive but insignificant effect on the income of livestock families in Lindu District, Sigi Regency. The results of the insignificant positive effect mean that although experience can enrich technical and managerial knowledge, it is not enough to produce a consistent increase in household income. Paris (2002) stated that farmer experience contributes to input efficiency, but does not guarantee an immediate increase in financial well-being if not supported by external factors such as market access. Khumairoh et al. (2024) showed that experience in an integrated farming system has an uneven effect on income if not accompanied by diversification. Salman et al. (2022) also found that farmer experience does not necessarily increase income in climate-prone areas because environmental factors are more dominant. Toiba et al. (2024) noted that experience is only significant in groups of farmers who are members of cooperatives, not in general. Winaya et al. (2022) concluded that experience is not significant for the interest in adopting new technology in livestock farming without formal training support.

The Effect of Land Area on Buffalo Farming Agribusiness Income

The probability value of buffalo farming agribusiness income was 0.014, which is smaller than the alpha value of 5%, indicates that buffalo farming agribusiness income has a positive and significant effect on the income of livestock farmers in Lindu District, Sigi Regency. The results of a positive and significant effect mean that every increase in the value of buffalo farming has a direct impact on household income growth. Rohaeni et al. (2023) stated that the net income of buffalo farmers can contribute more than 50% to the total family income in rural areas of Indonesia, especially when the production system is carried out sustainably. Devendra (2012) stated that buffalo have an important contribution to the integrated farming system in Southeast Asia, because they are multifunctional as a source of meat, milk, and labor. Lambertz et al. (2012) showed that buffalo farming is the main source of income for small households with limited land. Cruz (2007) added that strengthening buffalo agribusiness not only increases income but also improves household food security. Paris (2002) concluded that

integration between livestock and crop activities in agribusiness can improve the welfare of livestock farmers.

Results of Indirect Effect Testing

The results regarding the mediation effect of buffalo livestock agribusiness income on the influence of land area on family income are:

$$\begin{aligned}
 Sab &= \sqrt{b^2.Sa^2 + a^2.Sb^2 + Sa^2.Sb^2} \\
 Sab &= \sqrt{0,392^2.0,099^2 + 0,239^2.0,157^2 + 0,099^2.0,157^2} \\
 Sab &= \sqrt{0.0015052 + 0.0014020 + 0.0002403} \\
 Sab &= \sqrt{0.0031475} \\
 Sab &= 0.0561024 \\
 Z_{count} &= \frac{ab}{Sab} \\
 Z_{count} &= \frac{0.392 \times 0.239}{0.0561024} \\
 Z_{count} &= \frac{0.094}{0.0561024} \\
 Z_{count} &= 1,670 \\
 Probability Z_{count} &= 0,047
 \end{aligned}$$

Based on the calculation above, the result shows that the Z-count values for the land area variable was 1,670. When compared to the Z-table value of 1,645, then the Z-count obtained was much greater than the Z-table value. The significance value of the land area was smaller than alpha 5%. So that the land area through the income of buffalo livestock agribusiness has a positive and significant effect on the income of livestock farmers' families in Lindu District, Sigi Regency. The results of a positive and significant effect mean that the income of buffalo livestock agribusiness was able to be a good intervening variable in increasing the influence of land area on family income, which is also evidenced by the direct effect of land area on family income was not significant, but after the mediation effect of buffalo livestock agribusiness income becomes significant. This means that income from buffalo agribusiness is an effective intervening variable, strengthening the indirect relationship between land area and family income (Nainggolan et al., 2019; Tullo et al., 2019; Ezeaku et al., 2015; Jeerat et al., 2022; Kaniaska, 2016; Bhagat et al., 2024).

In this context, buffalo agribusiness facilitates the optimization of land use through an integrated farming system that increases farmers' productivity and income (Bijttebier et al., 2018; Lubis et al., 2020; Sertoglu et al., 2017). This shows that the integration of the crop and livestock sectors not only has an impact on food security and preservation of local culture, but

is also significant in rural development strategies (Jovovic et al., 2017; Saragi et al., 2021; Han, 2020; Herrero et al., 2013).

Then the results regarding the mediation effect of buffalo agribusiness income on the influence of livestock farmers' experience on family income are:

$$\begin{aligned}
 Sab &= \sqrt{b^2.Sa^2 + a^2.Sb^2 + Sa^2.Sb^2} \\
 Sab &= \sqrt{0,392^2.0,009^2 + 0,050^2.0,157^2 + 0,009^2.0,157^2} \\
 Sab &= \sqrt{0.0000132 + 0.00000605 + 0.0000021} \\
 Sab &= \sqrt{0.0000757} \\
 Sab &= 0.0087022 \\
 Z_{count} &= \frac{ab}{Sab} \\
 Z_{count} &= \frac{0.392 \times 0.050}{0.0087022} \\
 Z_{count} &= \frac{0.019}{0.0087022} \\
 Z_{count} &= 2,236 \\
 Probability Z_{count} &= 0,013
 \end{aligned}$$

Based on the calculation above, the result shows that the Z-count value for the variable of farmer experience was 2,236. When compared with the Z-table value of 1,645. Then the Z-count obtained was much greater than the Z-table value. The significance value of farmer experience was smaller than alpha 5% means that the experience of farmers through buffalo agribusiness income had a positive and significant effect on the income of farmer families in Lindu District, Sigi Regency.

The results of a positive and significant effect mean that buffalo agribusiness income can be a good intervening variable in increasing the influence of farmer experience on family income, which is also evidenced by the direct effect of farmer experience on family income was not significant, but after the mediation effect of buffalo agribusiness income becomes significant. Nainggolan et al. (2019) showed that experience does not immediately increase family income, but when supported by productivity and income from the buffalo agribusiness system, the effect becomes significant. This is reinforced by Lambertz et al. (2012) who stated that farmer experience will have more impact when integrated with a structured system. Similarly, a study by Grünbühel & Williams (2016) confirmed that practical knowledge of farmers requires mediation from agribusiness support systems to create increased household welfare. Buffalo agribusiness income acts as an intervening variable that links experience to family income. Studies by Sertoglu et al. (2017) and Bonis-Profumo et al. (2021) showed that the

livestock integration system with farming businesses can increase productivity and diversification of household income. Muatip et al. (2024) in the Indonesian context also confirmed that the capacity of small farmers can be significantly increased by strengthening the integrated agribusiness model.

CONCLUSION

Buffalo livestock industry significantly contributes to the income of livestock farmers' households in Lindu District, Sigi Regency, Indonesia. Quantitatively, the average contribution of 44.09% demonstrates that the buffalo livestock business was not just an add-on but also the primary component of the livestock farmer's family economy. The contribution range of 2.23% to 98.48% reveals an imbalance in farmer productivity and capacity, which is determined by capital factors, experience, and resource availability. Farmer experience and land area have no direct impact on family income. However, income from buffalo livestock agribusiness serves as a mediating variable and has a favorable and considerable impact. This indicates that income from buffalo farming provides a strategic link (an intervening variable) between the effectiveness of capital factors (land area) and competence (experience). Successful application of land and experience in a buffalo livestock agribusiness led to a significant rise in revenue for livestock farmers' families. These findings highlight the significance of an integrated land-experience-productivity agribusiness approach for improving the welfare of livestock farming families. Policy interventions should focus on improving livestock farmers' capacity to manage buffalo businesses, not just in terms of farming technology, as well as in market access, business training, and institutional assistance.

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Sayekti Handayani & Suparmin Fathan: Idea and design. **Afandi, Hasnadia, Ramlan Mustafa, Safriyanto Dako, Haerani Maksum & Delvi Suleman:** Survey, correspondence interview & data analysis. **Sayekti Handayani, Suparmin Fathan & Siti R. Machieu:** Write the manuscript. **Sayekti Handayani:** Revision

CONFLICT OF INTEREST STATEMENT

No potential conflict of interest relevant to this article was reported.

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