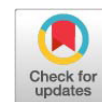


Research Article



Catalyst Factors for the Effectiveness of the Artificial Insemination Programs Based on Breeders' Internal Dynamics and External Support in Bone Bolango Regency

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Abstract | Artificial insemination (IB) is one of the reproductive technologies applied in the livestock sector to improve the population and genetic quality of beef cattle. The effectiveness of artificial insemination programs is influenced by various internal and external factors that can determine the success of its implementation in the field. Therefore, this study aims to analyze the influence of internal factors (characteristics of breeders and social capital of livestock breeders) as well as external factors (performance of livestock extension workers and competence of inseminators) on the effectiveness of artificial insemination programs for beef cattle in Bone Bolango Regency. This study uses a quantitative approach with a survey method. Data was collected through questionnaires, observations, documentation and interviews. The number of samples was 72 breeders. The data analysis technique used is multiple linear regression. The results of the study showed that simultaneously, the characteristics of breeders, social capital of livestock breeders, the performance of livestock extension workers, and the competence of inseminators had a significant effect on the effectiveness of the artificial insemination program. Partially, the social capital of livestock breeders, the performance of livestock extension workers, and the competence of inseminators have a positive and significant influence on the effectiveness of artificial insemination programs. However, the characteristics of breeders show a negative and insignificant influence on the effectiveness of artificial insemination programs. This indicates that improving the quality of human resources of breeders, both through increasing knowledge and skills, needs to be the main concern in optimizing the artificial insemination program. Based on the findings of the study, breeders in Bone Bolango Regency are advised to enhance their awareness and knowledge of artificial insemination through continuous education and outreach. The Bone Bolango Regency Government, especially livestock extension workers and inseminators, should strengthen technical competence and provide sustainable mentoring. At the provincial level, the Gorontalo Government is encouraged to provide funding, infrastructure, and facilities, while universities are expected to contribute through research, innovation, and training programs that enhance the capacity of breeders and technical staff.

Keywords | Insemination, Breeder, Social capital, Performance, Competence, Bone Bolango

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The livestock sector has a strategic role in national economic development, especially in the provision of animal protein, improving the welfare of breeders, and creating jobs. According to the Ministry of Agriculture (2020), this sector contributes to national food security by increasing meat and dairy production to meet the increasing needs of the community. So that by optimizing the livestock sector, it will have an impact on various aspects of people's lives nationally and locally. One of the districts that has made livestock a priority sector and is in line with the development aspirations of President Prabowo is Bone Bolango Regency, where in this district the livestock sector, especially beef cattle farming, is one of the leading sectors that supports the local economy.

The development of the livestock sector focuses not only on increasing the number of livestock population, but also on improving its quality and productivity. Various programs have been developed by the government to support this sector, one of which is the artificial insemination (IB) program which aims to improve the population and genetic quality of beef cattle. The effectiveness of the artificial insemination program is greatly influenced by various factors, both internal and external. Therefore, the analysis of these factors is important to ensure the success of the artificial insemination program in increasing the productivity and welfare of breeders (Saragih *et al.*, 2020; Siregar *et al.*, 2021). The national food security program emphasizes the importance of beef self-sufficiency as part of national strategic policies in creating economic independence. Beef cattle farming is one of the priority sectors because it has great potential in meeting the community's animal protein needs.

The government continues to encourage various efforts to increase livestock population and beef productivity through innovative programs such as artificial insemination. This program aims to improve the genetic quality of cows, increase the birth rate, and accelerate the growth rate of the livestock population. However, the effectiveness of this program is highly dependent on various factors such as the readiness of breeders, the role of extension workers, and the competence of inseminators. Therefore, research on the influence of internal and external factors on the effectiveness of artificial insemination programs is very important to support the achievement of national food security.

One of the main strategies in increasing the population and productivity of beef cattle is through the implementation of artificial insemination programs. This program allows the improvement of the genetic quality of cows by using semen from superior males that have been carefully selected.

According to Rahayu *et al.* (2019), artificial insemination has been shown to increase the pregnancy rate of female cows compared to natural mating methods. The artificial insemination program in Bone Bolango Regency has been implemented to increase the population of quality beef cattle. However, the success of this program still faces various challenges, such as lack of understanding of artificial insemination procedures, limited access to technology, and lack of support from inseminators and livestock extension workers. Therefore, an in-depth analysis of the factors affecting the effectiveness of artificial insemination programs is needed so that it can be optimized to support the growth of the livestock sector.

Artificial insemination is an artificial reproductive technique that is carried out by inserting semen from superior males into the reproductive tract of females using special tools without going through a natural mating process (Li *et al.*, 2018; Firmiaty *et al.*, 2023). This method has many advantages, such as accelerating the genetic improvement of livestock, reducing the risk of spreading infectious diseases, and increasing the birth rate of beef cattle (Widiyanto and Setiadi, 2020). The urgency of implementing artificial insemination in beef cattle farming is increasing in line with the increasing demand for beef in the domestic market. In addition, artificial insemination is also a solution for breeders to increase the productivity of their livestock efficiently without having to have their own males. However, the success of artificial insemination is influenced by several factors such as the readiness of breeders to accept this technology, the quality of the semen used, the skills of inseminators, and the support of livestock extension workers. Therefore, it is important to identify the factors that contribute to the effectiveness of artificial insemination so that the program can run optimally and provide maximum benefits for breeders.

The effectiveness of the artificial insemination program in beef cattle is influenced by various factors, both internal and external. In this study, internal factors include the characteristics of breeders and social capital of livestock breeders, while external factors include the performance of livestock extension workers and the competence of inseminators. The selection of these four factors is based on the consideration that the effectiveness of artificial insemination programs is influenced not only by technical aspects but also by breeders' internal conditions and external support. Breeder characteristics and social capital reflect their readiness and participation, while the performance of extension workers and inseminator competence are crucial for successful field implementation. Thus, these factors represent the integration of individual and institutional dimensions that directly affect program effectiveness. The characteristics of breeders include various aspects, such as education level, breeding experience, business scale, and

knowledge and skills in livestock reproduction technology. Breeders with higher levels of education tend to have a better understanding of artificial insemination programs, so they are able to implement more appropriate practices in managing their beef cattle. In addition, livestock farming experience also affects the success of artificial insemination, because more experienced breeders tend to be more sensitive in detecting signs of insemination in cows, which is a key factor in the success of artificial insemination (Takanjanji and Kaka, 2022). The scale of the business also affects the effectiveness of artificial insemination, where breeders with a larger number of livestock are generally more motivated to implement artificial insemination optimally. Therefore, the characteristics of breeders are a factor that cannot be ignored in assessing the effectiveness of artificial insemination programs (Rahman *et al.*, 2019).

The social capital of livestock breeders plays an important role in the success of artificial insemination programs because it includes aspects such as trust, social norms, and social networks. Trust between breeders and extension workers can increase the acceptance and application of artificial insemination technology, while evolving social norms within the breeder community can encourage active participation in the program. Social networks also play a role in sharing information and experiences related to artificial insemination, which can ultimately increase the success rate of the program. Breeders who have high social engagement are more likely to accept innovation and apply it in their livestock practices (Putri *et al.*, 2021; Alfani *et al.*, 2022).

Livestock extension workers have a strategic role in disseminating information and providing technical guidance to breeders related to artificial insemination. Good extension worker performance is characterized by the frequency of regular visits, a communicative approach, and the ability to convey information clearly and easily understand. Active and competent extension workers can help improve breeders' understanding of the benefits and techniques of artificial insemination, thereby encouraging higher adoption rates. In addition, support from extension workers can also help breeders overcome various obstacles that may be faced in the implementation of artificial insemination, such as difficulties in detecting birahi or optimal management of cow nutrition (Hasibuan *et al.*, 2022).

Inseminator officers have the main responsibility in the implementation of artificial insemination, so their competence greatly determines the success of this program. Inseminator competencies include technical skills in handling cows, understanding the reproductive cycle, and the ability to perform artificial insemination procedures appropriately and hygienically. A well-trained inseminator

can increase the chances of successful conception in beef cattle, which ultimately has an impact on the increase in the livestock population. In addition, officers who have good communication with breeders can provide more effective education related to cow care after artificial insemination, thereby increasing the success of the program (Yunus *et al.*, 2023).

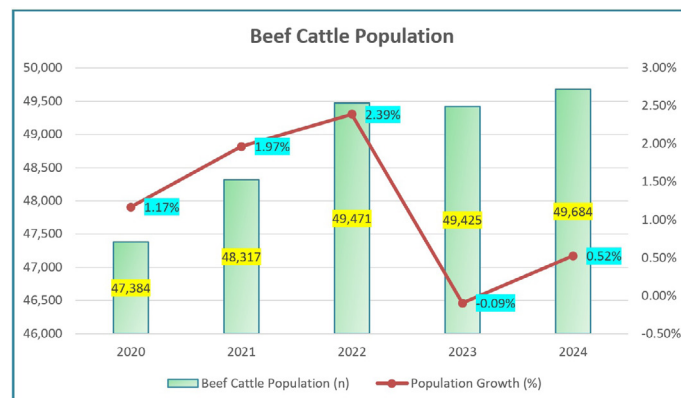


Figure 1: Beef Cattle Population in Bone Bolango Regency.

Based on Figure 1, which illustrates the beef cattle population in Bone Bolango Regency, it can be interpreted that the beef cattle population in Bone Bolango Regency between 2020 and 2024 shows a generally upward trend, though marked by fluctuations in growth rates. In 2020, the population was recorded at 47,384 heads with a growth of 1.17%, which continued to rise in 2021 to 48,317 heads (1.97%) and reached 49,471 heads in 2022 with the highest growth rate of 2.39%. However, in 2023 the population slightly decreased to 49,425 heads, reflecting a negative growth of -0.09%, before experiencing a modest rebound in 2024 with 49,684 heads and a growth rate of 0.52%. These variations suggest that the sustainability of population growth has not yet achieved stability and remains influenced by internal factors such as characteristics of breeder and social capital of breeder, along with external factors including extension workers performance and inseminator competency. This indicates that the artificial insemination program has not fully optimized consistent growth, highlighting the need for stronger synergy between breeders' capacities and institutional support to enhance program effectiveness in the future.

To achieve maximum effectiveness in the artificial insemination program, it is necessary to optimize the internal and external factors that play a role in the success of this program. From an internal perspective, increasing the capacity of breeders through training and education is very important so that they can better understand the benefits and techniques of implementing artificial insemination. Social capital must also be strengthened through the formation of breeder groups that can share information and experience with each other. From the external side,

increasing the capacity of livestock extension workers and inseminator officers must be a priority. With competent extension workers and well-trained inseminators, artificial insemination programs can run more effectively and produce a higher success rate. Therefore, this research is expected to contribute to the development of more productive and sustainable beef cattle farming in Bone Bolango Regency.

MATERIALS AND METHODS

This study uses five variables consisting of four independent variables and one dependent variable. The operational definition of these variables is:

EFFECTIVENESS OF ARTIFICIAL INSEMINATION PROGRAMS

Artificial insemination is a reproductive technique that involves collecting sperm from superior males and then injecting them into the reproductive tract of females manually, with the aim of improving reproductive efficiency and genetic quality of livestock (Sutiyono and Widiastuti, 2017; Kewilaa and Umarella, 2023). Indicators to assess the effectiveness of artificial insemination programs are Service-per-conception (S/C) (Yohana *et al.*, 2018; Mwangi *et al.*, 2023; Susilawati *et al.*, 2023). The formula for Service-per-conception (S/C) is:

$$S/C = \frac{\text{Number of Artificial Inseminations}}{\text{Number of Pregnant Cows}}$$

CHARACTERISTICS OF LIVESTOCK BREEDERS

Breeder characteristics include various aspects such as age, education level, and livestock experience with information and technology. These factors play an important role in determining the ability of breeders to adopt innovation and effective management practices (Rahman and Siregar, 2019). Indicators of breeder characteristics are (1) age, (2) level of education, and (3) experience (Win *et al.*, 2019; Nail *et al.*, 2024).

SOCIAL CAPITAL OF LIVESTOCK BREEDERS

Breeder social capital is a network of social relationships, norms, and beliefs that facilitate cooperation and coordination between breeders and between breeders and other parties, such as agricultural extension workers and government agencies (Handayani and Kurniawan, 2020). Indicators of breeders' social capital consist of (1) social networks, (2) social beliefs and (3) social norms (Handaka *et al.*, 2015; Linawati and Solikin, 2020; Azzahra and Sulandjari, 2022).

PERFORMANCE OF LIVESTOCK EXTENSION WORKERS

The performance of livestock extension workers is the level

of achievement of duties and responsibilities carried out by extension workers in an effort to empower breeders in conducting a good livestock business (Refiswal, 2016). This includes the effectiveness of extension workers in developing livestock extension programs and artificial insemination, disseminating agricultural technology information, and increasing the capacity and independence of breeders. The performance indicators of livestock extension workers are (1) the quality of work, (2) the quantity of work and (3) the punctuality of work (Julia *et al.*, 2022; Gurning *et al.*, 2023; Dewi *et al.*, 2024).

COMPETENCE OF INSEMINATORS

The competence of inseminators includes knowledge, skills, and work attitudes in conducting artificial insemination so that they are able to understand the anatomy and physiology of animal reproduction, technical skills in carrying out artificial insemination procedures, and the ability to identify the right time of estrus in females (Wahyuni *et al.*, 2018; Hidayat and Lestari, 2021). Indicators of inseminator competence are (1) knowledge, (2) skills and (3) work attitude (Dradjat *et al.*, 2016; Suteki and Dwatmadji, 2023; Solikin *et al.*, 2023).

This research was carried out for 6 months, namely July-December 2024 with the target being beef cattle breeders in Bone Bolango Regency. This study uses a quantitative approach with a survey method. This study employs a survey method as it is considered most appropriate for exploring breeders' perceptions, characteristics, and internal dynamics, along with external support that influence program effectiveness, particularly the effectiveness of artificial insemination measured through service-per-conception.

The total population is 257 breeders and the sample calculation in this study uses the Slovin formula:

$$n = \frac{N}{1 + N \cdot e^2}$$

Information: n = sample size; N = population size; e = Tolerable inaccuracy violations, 10%

$$\begin{aligned} &= \frac{257}{1 + (257 \cdot 0,1^2)} \\ &= \frac{257}{1 + (257 \cdot 0,01)} \\ &= \frac{257}{3,57} = 71.99(72) \end{aligned}$$

Based on the calculation of the Slovin formula, a sample of 72 breeders was obtained whose sample selection used probability sampling, especially simple random sampling.

Data collection in this study uses observation, documentation, interviews and questionnaire methods. The questionnaire in this study used a likert scale questionnaire consisting of 4 options. The data analysis used is Multiple Linear Regression. The multiple Regression equation is as follows:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Information: Y= effectiveness of artificial insemination programs; α = Constant; β = regression coefficient; X1= characteristics of livestock breeders; X2= social capital of livestock breeders; X3= performance of livestock extension workers; X4= competence of inseminators; ε = error rate (error).

Before testing the hypotheses, a classical assumption test was conducted, which consisted of normality, multicollinearity, and heteroscedasticity tests. In the normality test, particularly using the normal probability plot method, the data are considered normally distributed if the points follow the diagonal line. Meanwhile, in the Kolmogorov-Smirnov normality test (K-S test), the data are deemed normal if the significance value of the Kolmogorov-Smirnov test is greater than the alpha value of 5% (Sugiyono, 2020). For the multicollinearity test, the assumption is fulfilled, or no multicollinearity occurs, if the VIF value is below 10 or the tolerance value is above 0.10 (Sugiyono, 2020). Furthermore, in the heteroscedasticity test using the Scatter Plot method, the assumption is met if the scatter plot points are randomly distributed and spread both above and below the zero point on the Y-axis. In addition, using the Glejser method, the assumption is fulfilled if the significance value of the Glejser test is greater than the alpha value of 5% (Sugiyono, 2020).

Hypothesis testing consists of a partial test (t test) and a simultaneous test (F test) with a significance level of 5% which is also supported by the value of the partial determination coefficient and the simultaneous determination coefficient.

RESULTS

CLASSIC ASSUMPTION TESTING

DATA NORMALITY

Based on Figure 2, it can be seen that the data (points) spread around the diagonal line and follow the direction of the diagonal line. So that the data in this regression model meets the assumption of data normality. From Table 1, it can be seen that the data normality test (*Kolmogorov smirnov*) found that the residual value has a smaller Kolmogorov Smirnov (KS) value of 0.849 compared to the Z value of table 1.96 (standard Z). As well as a probability of 0.467 which is greater than 0.05 so that the data in this study

meets the Normality test (Normally distributed data).

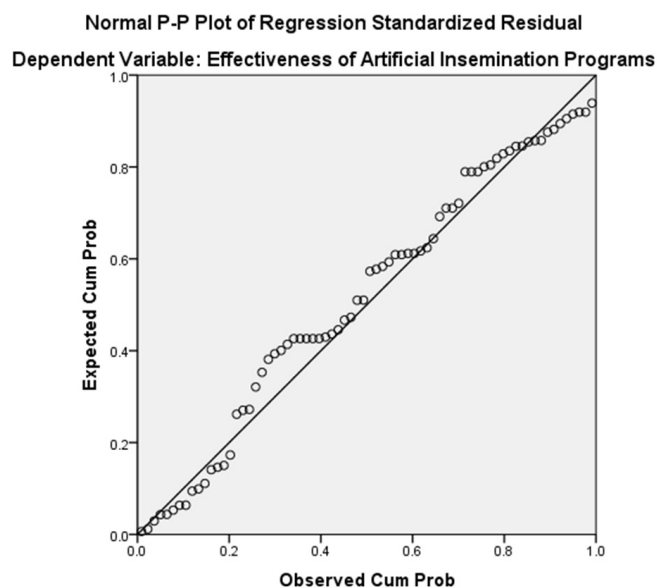


Figure 2: Normality Test (Normal Probability Plot).

Table 1: Results of the normality test of one sample of Kolmogorov Smirnov.

		Unstandardized residual
N		72
Normal parameters ^{a,b}	Mean	0.0000000
	Std. Deviation	0.14093310
Most extreme differences	Absolute	0.100
	Positive	0.061
	Negative	-0.100
Kolmogorov-Smirnov Z		0.849
Asymp. Sig. (2-tailed)		0.467

Source: SPSS 21, 2025 data processing.

Table 2: Multicollinearity testing.

Type	Collinearity statistics	
	Tolerance	VIF
(Constant)		
Characteristics of livestock breeders	0.963	1.038
Social capital of livestock breeders	0.333	3.003
Performance of livestock extension	0.286	3.498
Competence of inseminators	0.272	3.674

Source: SPSS data processing 21, 2025.

MULTICOLLINEARITY TESTING

Based on the results in Table 2, it can be seen that the variable of breeder characteristics has a VIF (Variance Inflation Factor) value of 1.038. The social capital of the breeder has a VIF value of 3.003. The performance of livestock extension workers has a VIF value of 3.498. Then the inseminator competency is 3.674. The VIF value is less than the standard number of 10. So that in this study there were no symptoms of multicollinearity or compliance with

the multicollinearity test of the research data.

DATA HETEROSCEDASTICITY TESTING

Based on Figure 3, it can be seen that the dots are randomly spread and scattered both above and below the zero number on the Y axis. Therefore, it can be concluded that the regression model does not occur Heteroscedasticity. To strengthen these results, it is necessary to conduct a Heteroscedasticity test using the *Glejser* test method. Based on Table 3, it can be seen that the significance value or *Probability value* (P-value) is 0.553. The significance value of the test is greater compared to the alpha value of 0.05. So, it is concluded that the regression model does not have a Heteroscedasticity problem.

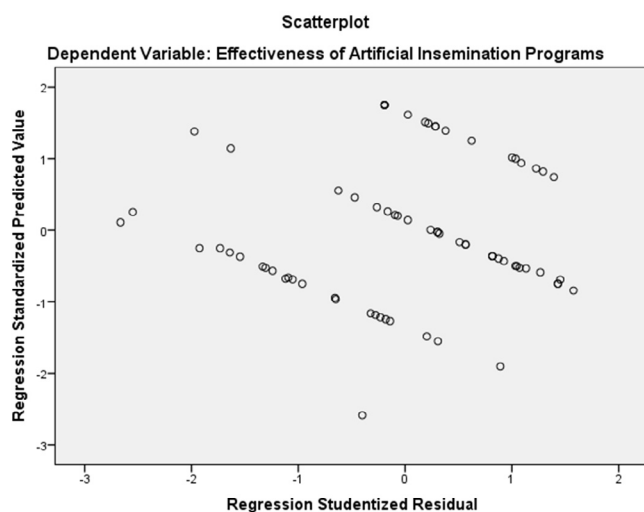


Figure 3: Heteroscedasticity Test (Scatterplot).

Table 3: Glejser heterokedastistas test results.

Type		Sum of squares	Df	Mean square	F	Sig.
1	Regression	0.022	4	0.005	0.763	0.553b
	Residual	0.474	67	0.007		
	Total	0.495	71			

Source: SPSS 21 processed data, 2025

MULTIPLE REGRESSION ANALYSIS RESULTS

MULTIPLE REGRESSION EQUATIONS

Based on the results of the analysis in Table 4, the model of the multiple linear regression equation is:

Table 4: Regression analysis results.

Type	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.006	0.255		11.791	0.000
Characteristics of livestock breeders	-0.031	0.027	-0.075	-1.134	0.261
Social capital of livestock breeders	0.014	0.006	0.247	2.189	0.032
Performance of livestock extension	0.021	0.008	0.305	2.507	0.015
Competence of inseminators	0.023	0.008	0.369	2.961	0.004

Source: Processed data SPSS 21, 2025.

$$Y = 3.006 - 0.031X_1 + 0.014X_2 + 0.021X_3 + 0.023X_4 + \varepsilon$$

Based on the multiple regression equation model, the following things can be interpreted:

INTERPRETATION OF CONSTANT VALUES

The constant value of 3.006 is a fixed value of the variable of the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency and Bone Bolango Regency if there is no influence from the characteristics of the breeder, the social capital of the breeder, the performance of the livestock extension worker and the competence of the inseminator.

INTERPRETATION OF BREEDER CHARACTERISTIC COEFFICIENT VALUE

The value of the regression coefficient of the variable X_1 (breeder characteristics) is -0.031, showing that every change in the variable of the breeder's characteristics by 1 unit will decrease the effectiveness of the artificial insemination program of beef cattle by -0.031 times the unit with the provision of other variables in a constant state (*Ceteris paribus*).

INTERPRETATION OF THE VALUE OF THE BREEDER'S SOCIAL CAPITAL COEFFICIENT

The value of the regression coefficient of the variable X_2 (Breeder's social capital) is 0.014, showing that every change in the breeder's social capital variable of 1 unit will increase the effectiveness of the artificial insemination program for beef cattle by 0.014 times the unit with the provision of other variables in a constant state (*Ceteris paribus*).

INTERPRETATION OF THE VALUE OF THE PERFORMANCE COEFFICIENT OF LIVESTOCK EXTENSION WORKERS

The value of the variable regression coefficient X_3 (Performance of livestock extension workers) is 0.021, showing that every change in the performance variable of livestock extension workers by 1 unit will increase the effectiveness of the artificial insemination program for beef cattle by 0.021 times the unit with the provision of other variables in a constant state (*Ceteris paribus*).

Table 5: Partial test results.

It	Variable	Calculation	P-value	t table	Information
0	(Constant)	11.791	0.000		
1	Characteristics of livestock breeders	-1.134	0.261	1.996	Not significant
2	Social capital of livestock breeders	2.189	0.032**	1.996	Significant
3	Performance of livestock extension	2.507	0.015**	1.996	Significant
4	Competence of inseminators	2.961	0.004**	1.996	Significant

** Significant at the 0.05 level (2-tailed)

Source: Processed data SPSS 21, 2025.

INTERPRETATION OF THE VALUE OF THE INSEMINATOR COMPETENCY COEFFICIENT

The value of the regression coefficient of the variable X_4 (inseminator competence) is 0.023, showing that every change in the inseminator competency variable of 1 unit will increase the effectiveness of the artificial insemination program for beef cattle by 0.023 times the unit with the provision of other variables in a constant state (*Ceteris paribus*).

PARTIAL TEST RESULTS (T-TEST)

After deriving the regression equation model, the subsequent step is hypothesis testing. This study applies a 95% confidence level, meaning the significance threshold (α) is 5%. To evaluate the significance of the effects within the regression model, the t-test is employed. The testing criteria are established by comparing the obtained t-count with the t-table. If the t-count exceeds the t-table, the null hypothesis (H_0) is rejected; conversely, if the t-count is smaller than the t-table, H_0 is accepted. According to Sarwono (2007), whether the result is positive or negative only indicates the direction, not the magnitude. Thus, in comparing t-counts with t-tables, the negative sign does not affect the interpretation. Prior to the comparison, the t-table value was determined at a 5% significance level with degrees of freedom (df) = $n - k - 1 = 72 - 4 - 1 = 67$, resulting in 1.996.

Based on the results of the analysis in Table 5, the results of partial testing in this study can be described:

INTERPRETATION OF PARTIAL TEST OF BREEDER CHARACTERISTIC VARIABLES

The analysis shows that the t-count for breeder characteristics is -1.134, while the t-table is 1.996. Since the t-count is smaller than the t-table ($-1.134 < 1.996$), the alternative hypothesis (H_{a1}) is rejected. The significance value of 0.261 is greater than 0.05 ($0.261 > 0.05$). So that the characteristics of breeders have a negative and insignificant effect on the effectiveness of the artificial insemination program of beef cattle in Bone Bolango Regency.

INTERPRETATION OF THE PARTIAL TEST OF BREEDERS' SOCIAL CAPITAL VARIABLES

The t-count for social capital of livestock breeders is 2.189 compared to the t-table value of 1.996. Because the t-count exceeds the t-table ($2.189 > 1.996$), H_{a2} is accepted. The significance level of 0.032 is less than 0.05 ($0.032 < 0.05$). So that the social capital of livestock breeders has a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency.

INTERPRETATION OF PARTIAL TEST OF PERFORMANCE OF LIVESTOCK EXTENSION WORKERS VARIABLES

For the performance of livestock extension workers, the t-count is 2.507, which is higher than the t-table of 1.996 ($2.507 > 1.996$). The corresponding significance value is 0.015, smaller than 0.05 ($0.015 < 0.05$). Thus, H_{a3} is accepted, showing that the performance of livestock extension workers has a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency.

INTERPRETATION OF PARTIAL TEST OF INSEMINATOR COMPETENCY VARIABLES

The t-count for inseminator competency is 2.961, greater than the t-table value of 1.996 ($2.961 > 1.996$). The significance value of 0.004 is also below 0.05 ($0.004 < 0.05$). Therefore, H_{a4} is accepted, which means the competence of the inseminator has a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency.

SIMULTANEOUS TEST RESULTS (TEST F)

Based on Table 6, the F-count value of this study is 42.372 with a significance value or probability of 0.000. Meanwhile, the F value of the table at the significance level of 5% and df_1 is $k = 4$ and df_2 is $N - k - 1 = 72 - 4 - 1 = 67$ is 2.509. If these two F values are compared, then the F-count value obtained is much larger than the Ftable. Then the probability value obtained from the test is less than the alpha value of 0.05. So that the characteristics of breeders, social capital of livestock breeders, the performance of livestock extension workers and the

competence of inseminators together have a significant effect on the effectiveness of the artificial insemination program of beef cattle in Bone Bolango Regency.

Table 6: Simultaneous test results.

Type	Sum of squares	Df	Mean square	F	Sig.
Regression	3.567	4	0.892	42.372	0.000b
Residual	1.410	67	0.021		
Total	4.978	71			

Source: SPSS data processing 21, 2025

COEFFICIENT OF DETERMINATION TESTING

Based on the results of the determination coefficient analysis in Table 7, the magnitude of the determination coefficient or R square number is 0.717. This value shows that 71.70% of the variability of the effectiveness of the artificial insemination program of beef cattle in Bone Bolango Regency can be explained by the characteristics of the breeder, the social capital of the breeder, the performance of the livestock extension officer and the competence of the inseminator, while the remaining 28.30% can be explained by other variables that are not examined in this study such as cow health and reproduction, reproductive status, and body condition score (BCS); quality and handling of semen, environmental factors and cleanliness of the cage.

Table 7: Coefficient of determination.

Type	R	R square	Adjusted R square	Std. error of the estimate
1	0.847a	0.717	0.700	0.14508

Source: SPSS 21 processed data, 2025

Based on the results of the determination coefficient analysis in Table 8, it can be explained for the influence of each variable as follows:

CHARACTERISTICS OF BREEDERS

Based on the calculation above, the value of the determination coefficient which results is 0.005. So that 0.50% of the ability of the breeder characteristic variable in influencing the effectiveness of the artificial insemination program of beef cattle in Bone Bolango Regency.

Table 8: Partial determination coefficient.

Type	Standardized coefficients	Correlation	Determination	
			Value	%
Characteristics of livestock breeders	-0.075	0.070	-0.005	-0.50%
Social capital of livestock breeders	0.247	0.763	0.188	18.80%
Performance of livestock extension	0.305	0.784	0.239	23.90%
Competence of inseminators	0.369	0.799	0.295	29.50%
Simultaneous determination coefficient			71.70	71.70%

Source: SPSS 21 processed data, 2025.

BREEDER SOCIAL CAPITAL

Based on the calculation above, the value of the determination coefficient which results is 0.188. So, that 18.80% of the ability of the social capital variable of breeders in influencing the effectiveness of the artificial insemination program of beef cattle in Bone Bolango Regency.

PERFORMANCE OF LIVESTOCK EXTENSION WORKERS

Based on the calculation above, the value of the determination coefficient which results is 0.239. So, that 23.90% of the ability of the performance variables of livestock extension workers in influencing the effectiveness of the artificial insemination program of beef cattle in Bone Bolango Regency.

INSEMINATOR COMPETENCIES

Based on the calculation above, the value of the determination coefficient is 0.295. So, that 29.50% of the ability of the inseminator competency variable in influencing the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency.

The findings indicate that inseminator competency exerts the greatest effect (29.50%) because technical skills, procedural accuracy, and field experience are crucial for successful fertilization. Livestock extension workers' performance also contributes strongly through continuous guidance and knowledge transfer. In contrast, breeder characteristics have the weakest influence (0.50%), since individual traits and demographic backgrounds do not directly ensure insemination success. Social capital shows a moderate effect, as cooperation among breeders supports participation but still relies heavily on technical support from professionals.

DISCUSSION

Breeder characteristics, breeder social capital, livestock extension worker performance, and inseminator competencies together have a significant influence on the effectiveness of the artificial insemination (IB) program in beef cattle in Bone Bolango Regency, with a determination coefficient of 71.70%. This shows that these factors

contribute greatly to the success of the artificial insemination program. Breeder characteristics, such as education level, breeding experience, and skills in livestock reproductive management, affect the level of adoption and optimal utilization of artificial insemination technology. Breeders' social capital, which includes trust, social norms, and networks between breeders and with extension workers and inseminators, supports the effectiveness of the program through information dissemination and good cooperation. The performance of livestock extension workers is very important in providing education, training, and assistance for breeders to understand the benefits and procedures of artificial insemination thoroughly. On the other hand, the competence of the inseminator, including technical skills, accuracy in determining the time of insemination, and understanding of livestock reproductive health, greatly determines the success rate of cow pregnancy. When these four factors run optimally and support each other, the effectiveness of the artificial insemination program can increase, so that the population and productivity of beef cattle in Bone Bolango Regency also increases.

However, although these factors contributed 71.70%, there were still 28.30% of other factors that also affected the effectiveness of the artificial insemination program but were not studied in this study. These factors include cow health and reproduction, reproductive status, and body condition score (BCS), which greatly determine the success of pregnancy after the insemination process. Cows with good health conditions, optimal reproductive status, and appropriate body condition scores will have a higher chance of pregnancy. In addition, the quality and handling of semen is also an important factor because low-quality or poorly handled semen can reduce the success rate of artificial insemination. Environmental factors, such as temperature, humidity, and stress due to unsanitary or uncomfortable enclosure conditions, can also affect the effectiveness of the program. Therefore, although the characteristics of breeders, social capital, extension worker performance, and inseminator competence are very influential, the success of the artificial insemination program also requires attention to aspects of livestock health, cage management, and environmental factors to increase the chances of pregnancy and productivity of beef cattle in Bone Bolango Regency.

The results partially found that the characteristics of breeders had a negative and insignificant effect on the effectiveness of the artificial insemination program of beef cattle in Bone Bolango Regency. The negative influence means that the characteristics of the breeder have not been able to have a good impact on the increasingly effective artificial insemination program of beef cattle, which is because older breeders tend to maintain traditional methods in raising livestock and are less open to new

technologies such as artificial insemination. This is due to long-established habits and experiences, so the adoption of modern technology is a challenge for them (Razak *et al.*, 2021). In addition, higher levels of education are not always directly proportional to the application of artificial insemination, as highly educated breeders often have business diversification that reduces the focus on beef cattle.

The negative influence of breeder characteristics on the effectiveness of artificial insemination programs can also be caused by a lack of knowledge and skills in applying the technology. Breeders who lack understanding of the benefits and techniques of artificial insemination are often reluctant to adopt it, so the effectiveness of the program is hampered. In addition, the experience of raising livestock that is dominated by traditional methods makes breeders feel comfortable with the old way and are reluctant to switch to more modern methods (Hamdamy *et al.*, 2019). Therefore, an appropriate educational approach is needed to improve the understanding and skills of breeders in implementing artificial insemination.

To overcome these obstacles, the role of livestock extension workers is very important in providing information and training to breeders about the benefits and techniques of artificial insemination. A persuasive and educational approach can help change breeders' perception of this technology. In addition, a training program that is ongoing and tailored to the needs of breeders can improve their skills and confidence in implementing artificial insemination. Thus, it is hoped that the effectiveness of the artificial insemination program in beef cattle can increase along with the improvement of breeders' knowledge and skills (Nikmah *et al.*, 2023).

Breeders' social capital has a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency. The positive influence means that the better the social capital of the breeder, the more effective the artificial insemination program of beef cattle will be. Social capital includes elements such as trust, social networks, and norms that apply within the farming community. Trust between breeders and between breeders and extension workers or inseminators facilitates the exchange of information and knowledge about artificial insemination techniques, thereby increasing the adoption of the technology. Additionally, a strong social network allows breeders to share experiences and resources with each other, which in turn increases the success of artificial insemination programs. According to Sari *et al.* (2020), good social capital in the beef cattle farming community contributes significantly to the effectiveness of artificial insemination programs.

Shared norms and values within the farming community also play an important role in supporting the effectiveness of artificial insemination programs. Norms that encourage cooperation and mutual assistance between breeders create an environment conducive to the application of new technologies such as artificial insemination. When breeders feel supported by their communities, they are more motivated to try and adopt the innovations offered. A study by [Fitrimawati and Iskandar \(2017\)](#) shows that social capital in the form of cooperation and solidarity between breeders has a positive effect on the adoption of artificial insemination technology and the development of beef cattle farming business.

Increasing social capital can be done through the formation and strengthening of livestock breeder groups, which function as a forum for breeders to interact, share information, and support each other. Active involvement in breeder organizations or groups increases breeders' access to resources, training, and information related to artificial insemination. In addition, solid breeder groups can be strategic partners for the government and related institutions in the implementation of livestock productivity improvement programs. Research by [Alfan \(2022\)](#) indicates that the social capital of livestock breeder groups plays a significant role in the development of beef cattle assistance programs in Central Lombok Regency.

The performance of livestock extension workers has a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency. The more optimal the performance and role of livestock extension workers in providing motivation to breeders, the more effective the artificial insemination program for beef cattle will be. Extension workers act as facilitators in the transfer of knowledge and technology to breeders, thereby increasing their understanding and skills in implementing artificial insemination. A study by [Tulong et al. \(2019\)](#) shows that the active role of extension workers in providing artificial insemination learning to cattle breeders in West Kawangkoan District contributes significantly to the success of the program. Thus, optimizing the performance of extension workers is the key to increasing the effectiveness of the artificial insemination program in this area.

The motivation provided by extension workers to breeders also plays an important role in encouraging the adoption of artificial insemination technology. Extension workers who are able to build good relationships and provide positive encouragement can increase breeders' interest in trying and implementing artificial insemination in their livestock business. Research by [Radjab et al. \(2021\)](#) indicates that the role of extension workers in motivating breeders in Totikum District affects the adoption process

of feed technology innovations, which in turn can increase the beef cattle population. This shows that the motivation of the extension worker is a crucial factor in the success of the artificial insemination program.

In addition, extension workers who are competent in mastering artificial insemination materials and techniques can provide effective guidance to breeders, thereby improving their skills in conducting artificial insemination independently. The ability of extension workers to convey information clearly and practically makes it easier for breeders to understand and apply artificial insemination technology. According to research by [Dali et al. \(2017\)](#), the good performance of field agricultural extension workers is closely related to the success of beef cattle breeders in Kwandang District in adopting artificial insemination technology. Therefore, improving the competence and performance of extension workers is a strategic step in optimizing the effectiveness of the artificial insemination program in Bone Bolango Regency.

The competence of the inseminator has a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency with a partial determination coefficient of 29.50%. The higher the level of competence of the inseminator officer, the better and more effective the artificial insemination program for beef cattle will be. These competencies include technical knowledge, practical skills, and experience in carrying out artificial insemination procedures. According to [Amidia et al. \(2021\)](#), the internal characteristics of the inseminator such as the duration of work and the intensity of training have a significant effect on the success of artificial insemination. The longer the working period and the higher the intensity of the training followed, the higher the success rate of artificial insemination achieved.

In addition, external factors such as the availability of supporting facilities and the condition of artificial insemination posts also contribute to the effectiveness of artificial insemination programs. Inseminators who work with complete equipment and in a conducive work environment tend to be able to carry out their duties more efficiently and accurately. A study by [Amidia et al. \(2021\)](#) shows that supporting facilities and good conditions of artificial insemination posts have a positive effect on the success of artificial insemination in Kerinci Regency. Thus, increasing the competence of inseminators must be accompanied by the provision of adequate facilities and infrastructure to achieve optimal results.

Improving the competence of inseminators can be done through continuous training and structured certification programs. The training not only focuses on the technical

aspects, but also covers reproductive management and accurate sex detection. According to Waluyo (2018), achievement motivation and inseminator competence have a significant effect on their performance, which in turn affects the service-per-conception (S/C) figure. Therefore, investment in human resource development, especially inseminators, is a strategic step to increase the effectiveness of artificial insemination programs.

CONCLUSIONS AND RECOMMENDATIONS

Characteristics of breeders, social capital of livestock breeders, performance of livestock extension workers and inseminator competencies together have a significant effect on the effectiveness of the artificial insemination program of beef cattle in Bone Bolango Regency with a determination coefficient of 71.70%. While the remaining 28.30% can be explained by other variables that were not studied in this study such as cow health and reproduction, reproductive status, and body condition score (BCS); quality and handling of semen, environmental factors and cleanliness of the cage. The partial results found that (1) the characteristics of breeders had a negative and insignificant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency, (2) the social capital of livestock breeders had a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency, (3) the performance of livestock extension workers has a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency, (4) the competence of the inseminator has a positive and significant effect on the effectiveness of the artificial insemination program for beef cattle in Bone Bolango Regency.

Based on the study results, it is recommended that breeders in Bone Bolango Regency strengthen their awareness and knowledge regarding the importance of artificial insemination through continuous participation in socialization and education programs. For the Bone Bolango Regency Government, particularly livestock extension workers and inseminators, there is a need to further enhance service quality by improving technical competencies, providing timely assistance, and ensuring sustainable mentoring to breeders. At the provincial level, the Government of Gorontalo Province is encouraged to allocate greater support in terms of funding, infrastructure, and facilities that can facilitate the success of artificial insemination programs across the region. Meanwhile, universities and academic institutions are expected to contribute actively through research, innovation, and training programs that provide practical solutions and

capacity-building for breeders, extension workers, and inseminators, thereby creating a strong synergy to increase the effectiveness of beef cattle artificial insemination programs in Bone Bolango.

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NOVELTY STATEMENT

The novelty in this study is the success or effectiveness of the artificial insemination program based on internal and external factors that focus on socioeconomic factors. Then the next novelty is novelty in the results of research which found that the characteristics of breeders have a negative effect on the effectiveness of artificial insemination programs because older breeders and dominant experience in traditional methods tend to make breeders maintain traditional methods in raising animals and are less open to new technologies such as artificial insemination and there is also a phenomenon that breeders with a higher level of education tend to diversifying farming and livestock businesses so that they pay less attention to beef cattle that have been artificially inseminate.

AUTHOR'S CONTRIBUTION

SYP and LOS: Conceptualization, methodology, data curation, supervision, writing original draft, writing review and editing.

FZ, SRM, UAR and HS: data curation, formal analysis, writing original draft, writing review and editing.

GENERATIVE AI AND AI-ASSISTED TECHNOLOGY STATEMENT

The authors declare that no Generative AI was used in the creation of this manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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