**Research Article**

# Application of System Dynamics Modelling in Evaluating Sustainability of Beef Cattle Production and Business System in Smallholder Farmers in South Sumatera, Indonesia

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**Abstract** | Beef cattle production and business model as a complex and dynamic concept requires understanding from a production, nutrition, and economic perspective. This study aims to analyze production systems, evaluate smallholder beef cattle businesses, and stimulate business development scenarios to increase income for sustainable business corporations with a dynamic system approach. Data were collected through interview methods to obtain data on production systems and business models, reproductive and economic parameters, and feed applications to obtain production parameters at the Field Station-School for Smallholder Community (FS-SSC) Maju Bersama, Musi Banyuasin Regency in 2021. The feed application experimental design used a factorial 3x2 Randomized Block Design (RBD) with 10 replications. A descriptive analysis was conducted to evaluate the corporate model's production system and business management. Production analysis was analyzed using ANOVA and data were processed using R studio software version 4.1.2. Furthermore, the observed parameters include average daily gain (ADG), dry matter intake (DMI), pregnancy rate, the ratio of male and female calf births, mortality rates, production costs and income. A business feasibility analysis is calculated by the value of net present value (NPV), benefit/cost (B/C ratio), and internal rate of return (IRR). Vensim software and powersim studio version 10 were used to compile causal loop (CLD) and flow chart diagrams, followed by dynamic system analysis. Based on the simulation results, the existing production model has not been declared feasible as a business with an NPV value of IDR. 683,350,309.27. The simulation results with improved feed and increased marketing showed that the best scenario in corporate business development is semi-intensive breeding. Intensive fattening cattle are given an additional marketing frequency concentrate twice with an interest rate of 6%. The feed application experimental design used a factorial 3x2 Randomized Block Design (RBD) with 10 replications. A descriptive analysis was conducted to evaluate the corporate model's production system and business management. Production analysis was analyzed using ANOVA and data were processed using R studio software version 4.1.2. Furthermore, the observed parameters include average daily gain (ADG), dry matter intake (DMI), pregnancy rate, the ratio of male and female calf births, mortality rates, production costs and income. A business feasibility analysis is calculated by the value of net present value (NPV), benefit/cost (B/C ratio), and internal rate of return (IRR). Vensim software and powersim studio version 10 were used to compile causal loop (CLD) and flow chart diagrams, followed by dynamic system analysis. Based on the simulation results, the existing production model has not been declared feasible as a business with an NPV value of IDR. 683,350,309.27. The simulation results with improved feed and increased marketing showed that the best scenario in corporate business development is semi-intensive breeding. Intensive fattening cattle are given an additional marketing frequency concentrate twice with an interest rate of 6%. It was concluded that the beef cattle business in smallholder farming system was feasible with improved feed, increased marketing and a maximum interest rate of 6% per year. It was concluded that the beef cattle business in smallholder farming system was feasible with improved feed, increased marketing and a maximum interest rate of 6% per year.

**Keywords** | Cattle business, Dynamic model, Financial feasibility, Sustainability

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## INTRODUCTION

For centuries, livestock farming has become a source of livelihood for people in developing countries (Nkadimeng et al., 2022). In Indonesia, beef cattle have an important role in accelerating economic growth and income distribution with large market potential (Rusdiana and Talib, 2019). Data from the Ministry of Agriculture of the Republic of Indonesia (2021) stated that although the livestock sector's Gross Domestic Product (GDP) decreased by 0.33% in 2020, there was an increase in the volume of exports by 14.45% with a workforce absorption of 2.40%, namely 4.6 million people. The current reorientation of livestock development policies on a macro basis is in favor of the people, and there is a delegation of responsibilities, changes in structure, and community empowerment (Mayulu and Daru, 2020). Livestock development is intended as a sustainable and professional business by utilizing technological innovation to improve business efficiency (Hamdi et al, 2016). Minister of Agriculture Regulation No. 18/2018 concerning the development of livestock areas based on breeder corporations is a form of the government's commitment to improving the economy of farmers. The ultimate goal of implementing livestock corporations is to increase added value, productivity, and welfare of farmers (Soetrisno, 2010). Meanwhile, the development focus is smallholder farmers because more than 90% of beef cattle are raised on smallholder farms (Priyanti et al., 2012). However, most farmers are still on a small business scale, have low ownership, subsistence maintenance, and are not yet business-oriented (Sugeng et al., 2006). This condition affects business profits (Yaqin et al., 2022). Meanwhile, business capital is still a limiting factor for obtaining maximum profits (Rusdiana dan Praharani, 2019). Farmers have obstacles to gaining access to capital due to their limited collateral (Sodiq et al., 2017). By being in corporations, they can run their businesses in groups to become entrepreneurs and have governance on a more efficient scale to obtain easy access to capital (Kartadjumena et al., 2022). However, the decision to increase capital in the context of business development is based on previous experience. Farmers will increase investment when the business is profitable (Maart-Noelck and Musshoff, 2013). Therefore, they should understand their production system to plan or decide on profitable business management (Widiati and Widi, 2016).

Bali cattle (*Bos javanicus*) are native Indonesian cattle with the highest percentage of the total beef population in Indonesia at 32.31% (Setiawan et al., 2018; Zulkharnaim and Noor, 2010). Ministry of Agriculture of the Republic of Indonesia (2021) reported that the total beef population in 2021 was 17.4 million, and the population of Bali cattle was estimated at 5,621,940 heads. Bali cattle have been spread evenly in several regions, including South Sulawesi, West Nusa Tenggara, East Nusa Tenggara, South Sumatra, Lampung, Bengkulu, and Central Kalimantan (Purwantara et al., 2012). As native livestock, Bali cattle have good adaptability to marginal environments (Syaiful et al., 2020), a high fertility rate ranging from 80%-82% (Kocu et al., 2019), and a low calf mortality rate (Gunawan et al., 2011). Based on market information, Bali cattle have a higher selling value per kg live weight than imported cattle (Diwyanto, 2002). They have good production potential, genetically capable of achieving a growth rate of 0.85 kg/day (Panjaitan et al., 2014). However, these cattle kept by smallholder farmers are usually only given feed in the form of forage or waste without additional concentrate. The practice is also carried out in several regions in Southeast Asia, which has negative implications for productivity (Mayberry et al., 2021). Therefore, fulfillment strategies are needed through various studies to obtain information on quality feed sources at economical prices, specifically with the use of local feed (Mayberry et al., 2021; Lisson et al., 2010). Feed prices greatly affect production costs (Lim et al., 2018), and marketing is the key to increasing business profits (Harborth et al., 2009).

In livestock system management, there is a link between production and economic components. Productions are maintenance practices, feed, reproduction, and economic components concerning price, costs, interest rates, and markets. The analysis of these two aspects often has limitations because the assessment between components is carried out separately (McDonald et al., 2019; Brown et al., 2017). Meanwhile, the production system is characterized by complexity and resource connectivity (Setianto et al., 2019). Therefore, it should be pursued by examining the problem holistically since assessment with a systems approach is relevant (Lampert et al., 2020; Sutrisna and Yhani, 2016). Using a dynamic system approach, it is possible to model by considering the interaction between subsystems and their feedback (Schaffernicht, 2010). The dynamic model built analyzes the management of the corporate model of the Bali cattle business in smallholder farmers. This study aims to analyze the production system, evaluate smallholder beef cattle businesses, and stimulate business development scenarios to increase income for sustainable business corporations with a dynamic system approach.

## MATERIALS AND METHODS

### Study area

This study was conducted at the Field Station-School for Smallholder Community (FS-SSC) (FS-SSC) Maju Bersama, Sungai Lilin District, Musi Banyuasin Regency, South Sumatra Province (Figure 1) in March-September 2021. The location for my research was determined using a purposive sampling approach. The location determination was adjusted to the study objectives, and the business has been carried out for at least one year.

**Figure 1:** The study area in Sungai Lilin District, Musi Banyuasin regency, south Sumatra Province, Indonesia.

Rainfall conditions were 200-300 mm or above normal, with the number of rainy days around 10-20 days. The average temperature was 28.1°C, with a relative humidity of 85% and a wind speed range of 1-11 knots (Meteorological, Climatological and Geophysical Agency, Climatology Station, 2021).

### Research material

The experimental animals used were 60 heads of Bali feeder cattle owned by FS-SSC Maju Bersama and 333 respondents. The improved feed was given in the form of forage and concentrate with a ratio of 30:70%, with nutrient content as presented in Table 1. The ratio was 3% of cow body weight in dry matter (DM). The concentrate consists of rice bran (50 %), oil palm meal (48.5%), salt (0.5%), $CaCO_3$(0.7 %), and molasses (0.3%). Castration was done by cutting the caudal testis. The technical coefficients of production, reproduction, and economy were taken through cooperating farmers.

**Table 1:** Composition nutrient of grass and concentrate.

| Parameters | Forage | Concentrate |
|---|---|---|
| Dry matter (%)* | 21.30 | 90.62 |
| Crude protein (%)* | 10.77 | 14.67 |
| Crude fiber (%)* | 39.49 | 24.26 |
| Crude fat (%)* | 1.37 | 3.54 |
| Ash (%)* | 8.68 | 13.04 |
| NNFE (%)* | 39.69 | 44.49 |
| TDN (%)** | 48.69 | 63.01 |

NNFE, Non-nitrogen free extract; TDN, total digestible nutrient. *: The results of the proximate analysis conducted at the Laboratory of the Center for Quality Testing and Certification of Feed (BPMSP), Bekasi (2021). ** calculated by the formula %TDN = 70.6%+0.259%crude protein +1.01%crude fat-0.76% crude fiber+0.0991%BETN (Sutardi T 2001).

### Research methods

The research focused more on efforts to illuminate the behavior of the beef farming system. This research used interview methods to obtain data on production systems and business models, reproductive and economic parameters, and feed applications to obtain production parameters Interviews were conducted with member breeders of the corporation. The feed application experimental design used a factorial 3x2 Randomized Block Design (RBD) with 10 replications (Table 2). Initial body weight was at $P_1K_1$ 238.2-280 kg/head, $P_1K_2$ 271.9-316 kg/head, $P_2K_1$ 233.8-279.9 kg/head, $P_2K_2$ 267.4-311 kg, $P_3K_1$ 262.2-280 kg/head, $P_3K_2$ 302-315.4 kg/head. Forage and concentrate samples were then dried and analyzed in the laboratory.

**Table 2:** Study design of bali feeder cattle.

| Treatment | Group | |
|---|---|---|
| | K1 | K2 |
| $P_1$ | $P_1K_1$ | $P_1K_2$ |
| $P_2$ | $P_2K_1$ | $P_2K_2$ |
| $P_3$ | $P_3K_1$ | $P_3K_2$ |

Information: $P_1$: Improvement of feed and non-castration; $P_2$: Improvement of feed and castration; $P_3$: control cattle (100% forage without concentrate and non-castration); $K_1$ = 18-24 months age; $K_2$= 24-30 months age.

### Data collection

### Research parameters

The observed variables include average daily gain (ADG), dry matter intake (DMI), reproductive parameters including pregnancy rate, the ratio of male and female calf births and mortality rates and economic parameters including production costs and income. The parameters obtained are tabulated into technical coefficient data. This technical coefficient applies at the time the research is conducted.

### Laboratory analysis

The analysis of nutritional content in grass and concentrate was carried out in the laboratory of the Center for Quality Testing and Certification of Feed Bekasi-Indonesia, using the Association of Official Analytic Chemistry (AOAC) method.

### Statistical analysis

The mean value was computed, and the production parameters were examined using three ways repeated measure analysis of variance (ANOVA). Furthermore, data were processed using the R studio software version 4.1.2. Average daily gain (ADG) was calculated with the equation:

$$ADG = \frac{weight\ at\ finisihing\ state\,(kg) - weigh\ at\ initial\ state\,(kg)}{observation\ days\ (day)}$$

The dry matter intake (DMI) of the feed was calculated with the equation:

$$\mathrm{DMI} = \frac{DM}{100} \times \text{feed intake (kg)}$$

Economic parameters were analyzed by calculating the B/C ratio, net present value (NPV), and internal rate of return (IRR), with the formula:

$$\text{B/C ratio } = \frac{\sum_{t=1}^{n} \frac{Bt - Ct}{(1+i)^t}}{\sum_{t=1}^{n} \frac{Ct - Bt}{(1+i)^t}}$$

B/C ratio = net benefit cost ratio; Bt = benefit of the proposed project; Ct = total cost of the proposed project i=discount rate; n = project economic time.

$$NPV = \sum_{t=1}^{n} \frac{Bt - Ct}{(1+i)^t}$$

NPV = net present value; Bt = Benefit; Ct= cost; i= discount rate; t = time of the cash flow.

$$\mathrm{IRR} = i' + \frac{NPV'}{NPV' - NPV''} x\ i'' - i'$$

i'= lower discount rate chosen; i''= higher discount rate chosen; NPV'= NPV at i'; NPV''= NPV at i''

The parameters obtained were arranged for causal relationships and analyzed using the Vensim program and Powersim Studio version 10 program with a dynamic system approach. Validation model using AME (Absolute Means Error) and AVE (Absolute Variance Error) (Barlas, 1996), with mathematical models.

$$AME = \frac{\hat{S} - \bar{A}}{\bar{A}} \times 100\%; \hat{S} = \Sigma Si/N\ ;\ \bar{A} = \Sigma Ai/N$$

$$AVE = \frac{Ss - Sa}{Sa} x\ 100\%;\ Ss = (\Sigma(Si - \hat{S})^2)/N\ ;\ Sa = (\Sigma(Ai))/N\ x\ 100\%$$

Where; S= simulated value; A= actual value; N= observational time interval value; Ss =simulated standard deviation value; Sa=actual standard deviation value.

The acceptable deviation limit is a maximum of 10%

## RESULTS AND DISCUSSION

### Bali cattle production system

Field Station-School for Smallholder Community (FS-SSC) is a community of smallholder farmers established by IPB University. FS-SSC Maju Bersama, located in Musi Banyuasin Regency, South Sumatra, Indonesia, was formed in 2013. This district is one of the livestock areas in South Sumatra Province, Indonesia. The community is an example of a livestock group that has carried out the corporate concept for 3 years in one of its activities. Corporate agriculture is a combination of capital jointly managed by farmers in one management (Musthofa and Kurnia, 2018). In analyzing the production system of the breeder corporations, several components have been collected, including population structure, reproduction management, maintenance management, marketing, business capital, and profit sharing. Bali cattle are the breed of cattle that breeders mostly keep. The total population of Bali cattle at FS-SSC is 1,277 heads (Sari et al., 2020). The production system used is breeding and rearing, while it is breeding and fattening in the corporate group. The production system in FS-SSC breeders is also carried out by smallholder farmers, where the differences are unclear because cattle are sold according to their needs (Lestari et al., 2014). Maintenance uses a semi-intensive system for breeding and an intensive for fattening in the corporate group. Caged cattle are fattening daily with forage feeding without additional concentrate. Business capital is obtained from financial institutions using a corporate social responsibility, namely an interest rate of 3% per year. Furthermore, group members receive livestock from the core group in the form of ready to breed or pregnant mothers to produce weaning calves. Meanwhile, weaning calves are reared until they become feeder cows or prospective broodstock. The feeder cattle are fattened until sold, while the prospective brood stocks are returned to the population to increase the availability. Marketing is conducted once during religious holidays. Profit sharing is carried out with a system where 60% and 40% of the profits are given to members and the core group. From the results of interviews, each piece of information is compiled and visualized in a causal loop diagram (CLD) (Schaffernicht, 2010) presented in Figure 2.

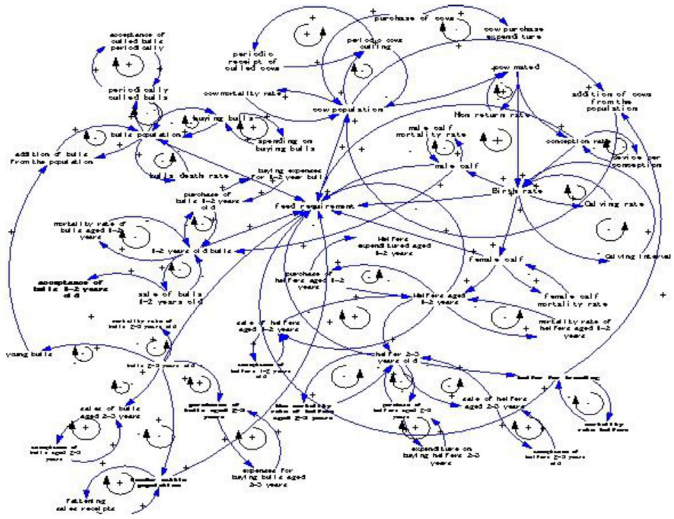

**Figure 2:** Causal loop diagram bali cattle production system.

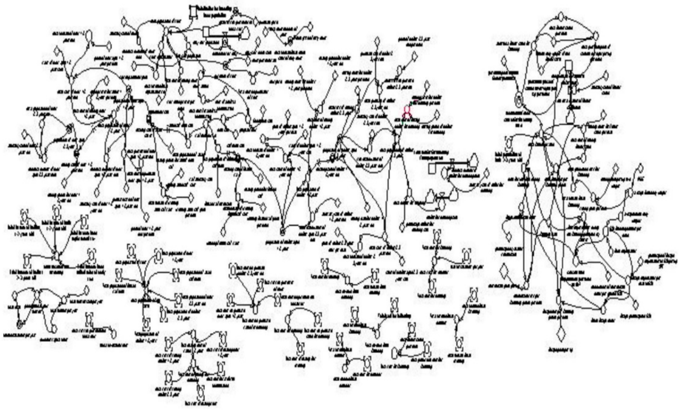

**Figure 3:** The dynamic model structure of the existing Bali cattle production system.

## Dynamic model structure production system of Bali cattle

Based on the identification of causal loop diagrams interpreted in the flow chart input and output or dynamic models using the powersim studio 10 programs, shown in Figure 3. The dynamic model structure is a translation of the CLD and the requirements to achieve the goal, which is an assessment of production systems and business development scenarios. The model's structure gives the shape and the characteristics that influence behavior. The complexity of system behavior is simplified into a basic structure, namely input, process, output, and feedback mechanisms (Habaora et al., 2019).

The Bali cattle production system model comprises breeding and the fattening submodel, composed of population, feed, and economic components. The dynamic model of the system presented in Figure 3 has a causal and feedback relationship between the submodels. A decrease in the performance of one submodel will affect the overall performance of the production model. The components that make up the production system model consist of the population, feed, and economy. The components of the existing production model are breeding submodel and fattening submodel presented in Figures 4 and 5.

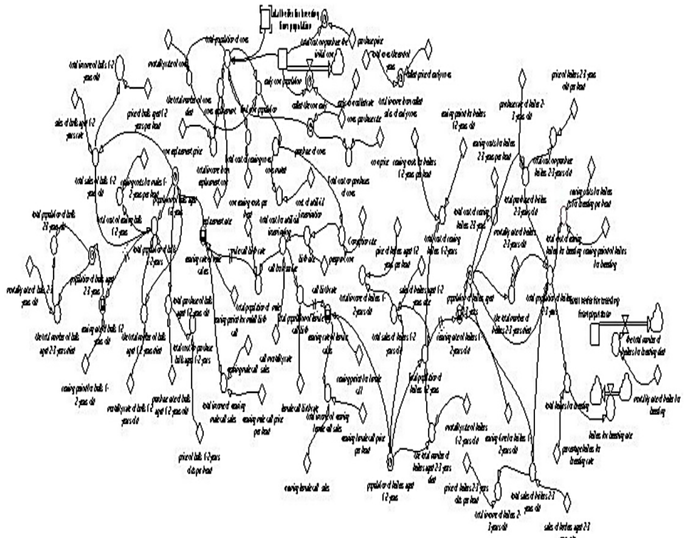

**Figure 4:** Structure of the existing Bali cattle breeding submodel.

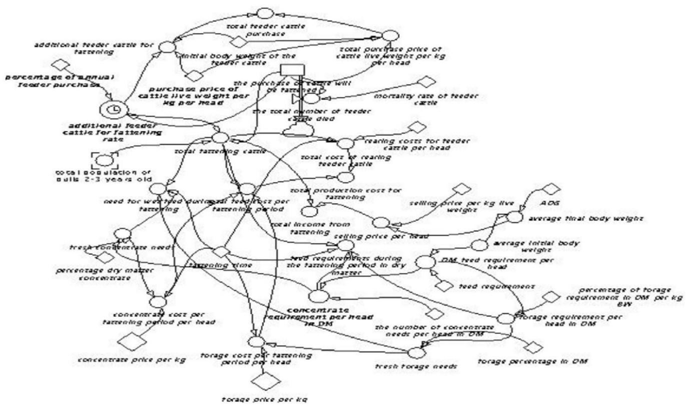

**Figure 5:** Structure of the existing Bali cattle fattening submodel.

Semi-intensive breeding is carried out in most smallholder livestock industries in Indonesia (Mohd-Azmi et al., 2021). Cattle are grazed using natural forage and agricultural waste as feed (Dung et al., 2019). Farmers mostly conduct this breeding system by grazing their livestock in a controlled manner (Matondang and Talib 2015). Mating can be performed by artificial insemination (AI) to save more on labor costs for cattle care. Good forage potential and nutrition among oil palm plantations support broodstock's reproductive performance in producing calves yearly. The productivity of natural forage that grows under mature oil palm can provide feed for 0.37-0.47 UT and immature oil palm of 1.56 UT with the dominant forage species *Colopogonium muconoides, Neprolepis bisserata, Paspalum conjugatum, Spermacoce alata, Centrosema pubescens, Asystasia gangetica, Pennisetum purpureum schumachrenosis, Scleria sumatrens aciculatus,* and *Native aciculatus* with a crude protein content of 5.45-19.74% DM (Susanti et al., 2022).

Bali cattle fattening was carried out in groups with an intensive system for 9 months. The feed is in the form of forage without the addition of concentrate. Marketing is only performed once a year with this system. The business scale is still in the small category, with 20 heads for breeding and 75 heads for fattening. Therefore, the breeding results cannot meet the needs of fattening feeders. Breeders buy feeders from group members of FS-SSC Maju Bersama, where from the total population of beef cattle in 2021, 1036 heads consisting of 553, 290 calves, and 193 feeder cattle are predicted to meet the needs of the next 10 years (Figure 6).

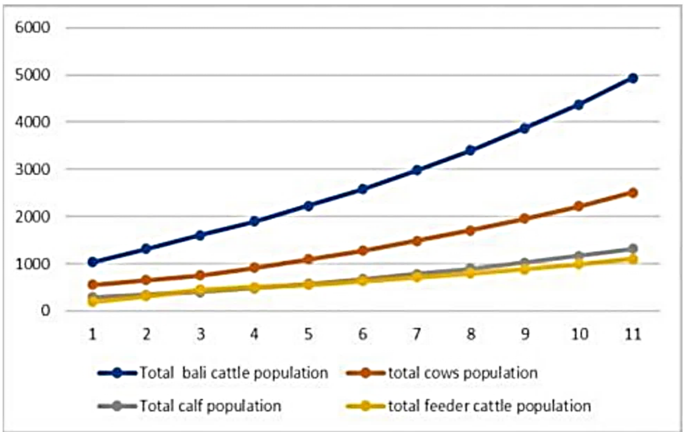


**Figure 6:** Population structure of Bali cattle.

The highest population is 50.08% originating from the addition of prospective parents. In terms of breeding with the current system, which is to maintain 90% of females as potential broodstock, population growth will experience an increasing trend. It is predicted that in 2031, the number of feeder cattle available will be 1103 heads.

## Model consistency

To ensure the model's consistency, model validation was carried out for this research. The validation process is crucial because it can determine whether a model accurately represents the system it is intended to replicate (Bellocchi et al., 2011). The two sub models were compared to the historical data in this research to validate the model. From the acceptable deviation limit (AME and AVE) of 5-10%, a model that has a deviation value below 5% or valid.

## Feed improvement strategies to increase productivity

Livestock productivity can be improved through genetic quality, feed, management, and environmental modification (Anggraeni and Mariana, 2016). Feed is a production factor taken as a variable to be simulated in business development. This is because the success of raising beef cattle is largely determined by feed. The provision in smallholder farms has not paid attention to the needs and is rarely given additional feed such as concentrate (Fatah et al., 2012). Feeding that lacks quality and quantity for a long time can negatively impact to livestock productivity. Feed is a source of energy for livestock growth, hence, the better the quality and the sufficient quantity, the greater the energy stored in the form of meat (Prabowo et al., 2008). Similar to a business, the time of effort is one of the determinants of obtaining optimal profits by accelerating cattle growth, increasing reproduction, and reducing mortality (Burrow, 2019). Feed improvement simulations with the addition of concentrate were carried out on the fattening sub-model to increase the appearance of cow production with the ratio of grass and concentrates of 30%: 70%. Additional feed in the form of concentrate is given together with grass feeding. The concentrate is formulated with balanced nutritional levels (Budiari et al., 2020) to increase the body weight gain process of fattening cows (Supriyantono et al., 2020). Meanwhile, changes in daily body weight as a production variable were obtained by applying several treatments and age grouping to obtain the required technical coefficients. The treatment was carried out by improving feed and castration practices, while the age group was divided into 2 categories, namely 18-24 months and 24-30 months. The results of the analysis showed that the treatment and the group have a significant effect on weight gain, but there is no interaction between the treatment and the group (Table 3).

**Table 3:** Effect of treatment and age group.

| | F-value | p-value | Sig |
|---|---|---|---|
| Treatment | 13.485 | 2.12 x 10-6 | Significant |
| Group | 118.757 | < 2 x 10-16 | Significant |
| Treatment × Group | 0.303 | 0.739 | Not significant |

Analysis results showed a difference in average daily gain (ADG) between cattle treated with and without improvement in feed. However, there was no significant difference between castration and non-castration treatments. Changes in body weight were also significantly different between groups in each treatment. This difference can be seen from the Dry Matter Intake (DMI) and TDN in Bali cattle that were given an improved feed of 8.2±0.55 kg/head/day and 4.71±0.26 kg/head/day while in cattle without improved feed 6.68±0.41 kg/head/day and 2.71 ± 0.41 kg/head/day. This illustrates that the feeding is only in the form of forage, the consumption of DM is sufficient, but the total energy derived from the feed consumed by the cows is still below the standard recommended by Kearl (1982), that consumption recommendation for bulls weighing 250-300 kg with ADG 0.5kg/head/day, that are 6.2–7kg DMI/head/day and 3.2-3.7kg TDN/head/day. The provision of grass as a single feed has not been able to provide an optimal increase in body weight. Dry matter consumption tends to increase until energy requirements are met but body weight gain increases with increasing concentrate in the ration (Quigley et al., 1986). The balance of forage and concentrate determines the substrate available for microorganisms in the rumen. Rumen microbes are a key factor in the utilization of the feed given (Russell et al., 2009). The higher the concentrate content in the ration, the higher the digestibility of organic matter in the rumen (Suryani et al., 2018). One indication that can be measured is the ADG of cattle (Table 4).

**Table 4:** Effect of treatment on daily body weight gain.

| Treatment | | p-value | |
|---|---|---|---|
| $P_1$ | $P_2$ | 0.765 | No significant different |
| $P_1$ | $P_3$ | 0.0000348 | Significant different |
| $P_2$ | $P_3$ | 0.000000292 | Significant different |

P1: Improved feed and non-castration; P2: Improved feed and castration; and P3: control cattle (100 % forage and non-castration).

The Table 4 shows that the castration practice does not affect increasing body weight in post-pubertal Bali cattle. The growth rate of bulls castrated after puberty will experience a slowdown due to the cessation of the hormone testosterone (Fisher et al., 2001) and higher stress response (Dawn, 1998). The body weight of castrated bulls tends to decrease with age (Bretschneider, 2005). In South Africa, most bulls are castrated at 2-6 months of age, and some castrate at 7 days after birth (Meaker and Liebenberg, 1982). ADG of existing cattle is 0.20–0.26 kg/head/day, similar to the study's results on cows fed only dry grass, giving weight gain of about 0.15 – 0.32 kg/head/day. Meanwhile, cattle with improved feed gave ADG of 0.58-0.63 kg/head/day. The feeding strategy for fattening should provide more concentrate than forage and feed given at least 3% body weight based on dry matter, with 9% crude protein elements, 6% crude fat, 15-20% crude fiber, 10% ash, and 60% total digestible nutrient (TDN) (Umiyasih and Antari, 2010).

### Financial feasibility model simulation

The dynamic model simulation of the existing Bali cattle production system is used to determine the behavioral trend pattern. The results are the basis for designing improvement scenarios based on model structure analysis. The simulation is carried out by entering the technical coefficients of production, reproduction, and economy presented in Table 5.

**Table 5:** Research technical coefficients of production, reproduction, and economy.

| Technical coefficient | Unit |
|---|---|
| Ratio of male calves: female calves | 36:64 % |
| Concerption rate | 84 % |
| Calf mortality | 5 %/year |
| Heifers and bulls mortality | 2 %/year |
| Cows mortality | 2 %/year |
| Sales of heifers aged 1-2 years rate | 30% |
| Sales of heifers aged 2-3 years rate | 50% |
| Total cost for fattening except feed | Rp5,110.00/head/day |
| Total cost of rearing cows | Rp6,919.00/head/day |
| Total cost of rearing heifers | Rp6.210,00/ head/day |
| Purchase price of cattle live weight per kg per head | Rp59.273,00 |
| One-time cost of artificial insemination | Rp100.000,00/head |
| Concentrate price | Rp2.000,00/kg |
| Forage price | Rp250,00/kg |
| Business capital loans; loan interest rate per year | Rp1.500.000.000,00; 3% |
| Selling price per kg live weight in on Eid al-Adha | Rp65.000,00/kg |
| Selling price per kg live weight | Rp61.000,00/kg |
| Price of heifers 1-2 years | Rp7.500.000,00/head |
| Price of heifers 2-3 years | Rp9.000.000,00/head |
| Culled price of early cows | Rp6.125.000,00/head |
| Average initial body weight of fattening cattle < 2 year | 180 kg/head |
| Average initial body weight of fattening cattle > 2 year | 228 kg/head |
| Average daily gain without concentrate | 0.26 kg/head |
| Average daily gain with concentrate | 0.61 kg/head |

**Table 6:** Simulation of the financial feasibility of the existing bali cattle production model.

| Parameter | **Unit** |
|---|---|
| Total farmer members of the corporation | 20 people |
| Total beeding cows | 20 head |
| Total fattening cattle | 75 head |
| Total cost for breedlot | 15,791,586,239,37 IDR |
| Total cost for breeding | 2,632,369,994,61 IDR |
| Total cost for fattening | 11,434,216,244,76 IDR |
| Loan plus interest | 1,725,000,000,00 IDR |
| Total income from breedlot | 15,263,351,746,95 IDR |
| Total income from breeding | 1,444,632,186,18 IDR |
| Total income from fattening | 13,818,719,560,77 IDR |
| Total revenue from breedlot | -528,234,492,42 IDR |
| NPV | - 683,350,309,27 IDR |
| B/C Ratio | - |
| IRR | - |
| Sales frequency | 1 time |

Keterangan: NPV: Net Present Value, B/C: Benefit/Cost, IRR: Internal Rate of Return.

From the existing model obtained, the simulation results of the feasibility of breeding and fattening for the next 10 (ten) years are presented in Table 6.

From the simulation, information is obtained that the existing production model has a negative NPV value. Based on Table 6, the income from the breeding business is minus. Beef cattle breeding requires large capital due to the costs of feed, seeds, labor, health, marriage, and other supporting facilities (Riszqina et al., 2011). Income from the fattening subsystem also has not provided maximum benefits. The rate of body weight gain of beef cattle is still low, presumably because the feed provided is only sufficient for the basic needs of life. Feed is a source of energy for livestock growth, hence, the better the quality and the sufficient quantity, the greater the energy stored in the form of meat (Prabowo et al., 2008). It was added that single feeding in the form of forage for fattening male Bali cattle would result in high consumption of dry matter, crude protein, and organic matter but low digestibility (Tahuk et al., 2021). The sale of fattening cattle is only carried out on the day of qurban with a length of maintenance of nine months. Therefore, the largest income is only once a year which is used to cover operational costs and loan installment payments.

## Financial feasibility simulation through business development scenarios

Development scenarios were created based on the simulation findings of the existing model, which indicated a lack of commercial viability. Business development is carried out by improving technical aspects and other supporting facilities (Priyanto, 2011). The study of feed therapy showed that the improvement in non-castrated Bali cattle gave the best results. The development simulation tests the sensitivity with parameters of 2 interest rates, namely 6% and 10% for the People's Business Credit (KUR) and commercial interest rate. Scenario models are made as follows:

**Table 7:** Dynamic model simulation results based on scenarios 1, 2, 3 and 4.

| **Parameter (Unit)** | **Scenario** | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| Total farmer members of the corporation (people) | 20 | 20 | 20 | 20 |
| Total beeding cows (head) | 20 | 20 | 20 | 20 |
| Total fattening cattle (head) | 75 | 75 | 150 | 150 |
| Total cost for breedlot (IDR) | 19,803,271,638,11 | 20,103,271,638,11 | 31,206,580,486,69 | 31,506,580,486,69 |
| Total cost for breeding (IDR) | 2,688,903,280,61 | 2,688,903,280,61 | 2,688,903,280,61 | 2,688,903,280,61 |
| Total cost for fattening (IDR) | 15,176,644,273,71 | 15,176,644,273,71 | 26,567,677,206,08 | 26,567,677,206,08 |
| Loan plus interest (IDR) | 1,950,000,000,00 | 2,250,000,000,00 | 1,950,000,000,00 | 2,250,000,000,00 |
| Total income from breedlot (IDR) | 20,550,689,352,67 | 20,550,689,352,67 | 35,493,107,926,63 | 35,493,107,926,63 |
| Total income from breeding (IDR) | 1,600,884,339,59 | 1,600,884,339,59 | 1,600,884,339,59 | 1,600,884,339,59 |
| Total income from fattening (IDR) | 18,949,805,013,08 | 18,949,805,013,08 | 33,892,223,587,04 | 33,892,223,587,04 |
| Total revenue from breedlot (IDR) | 747,417,714,56 | 447,417,714,56 | 4,286,527.439,94 | 3,986,527,439,94 |
| NPV (IDR) | 116,546,687,06 | -695,894,370,65 | 2,803,928,229,93 | 1,017,218,584,23 |
| B/C Ratio | 1,61 | - | 17,63 | 4,69 |
| IRR (%) | 8 | - | 83 | 57 |

Description: NPV: Net Present Value; B/C: Benefit/Cost; IRR: Internal Rate of Return.

Scenario 1. Intensive fattening cattle are given an additional one-time marketing frequency concentrate with an interest rate of 6% when breeding is conducted semi-intensively. Scenario 2. Intensive fattening cattle are given an additional one-time marketing frequency concentrate with an interest rate of 10% when breeding is done semi-intensively. Scenario 3. Intensive fattening cattle are given an additional marketing frequency concentrate twice with an interest rate of 6% when breeding is done semi-intensively. Scenario 4. Intensive fattening cattle are given an additional marketing frequency concentrate twice with an interest rate of 10% when breeding is done semi-intensively.

Based on the business development with these four scenarios (Table 7), scenario 2 has not provided financial feasibility with a negative NPV, while the other three showed business feasibility. This is because it has an NPV value of more than zero, a net B/C value of more than one, IRR of more than the discount factor (DF) used. The simulation results showed that the interest rate of KUR imposed by the government, namely 6%, provides the highest profitability. Government regulations are needed for breeders by simplifying banking procedures, reducing interest rates, and providing subsidies for breeders who carry out breeding businesses (Hamdi et al., 2016). The advantage of applying this scenario is that the addition of concentrate will accelerate the rate of body weight gain of cattle and shorten the maintenance time.

## CONCLUSION

The Bali cattle production model carried out by corporate breeders, namely semi-intensive breeding, intensive fattening with a single feed in the form of forage, and marketing conducted once a year, has not provided business benefits. The business development scenario performed by improving feed provides an increase in the body weight gain of male Bali cattle by 0.63 kg/head/day to increase marketing frequency. Meanwhile, this model obtains optimal business feasibility at an interest rate of 6%.

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## NOVELTY STATEMENT

This research has the objective to analyze production systems, evaluate smallholder beef cattle businesses, and stimulate business development scenarios to increase income for sustainable business corporations with a dynamic system approach. In the future, the system dynamic approach used in this study will be useful in analyzing the development of the beef cattle business, not only in Indonesia, but also in other developing countries.

## AUTHOR'S CONTRIBUTION

AES, RP, M, DAA, LC contributed to the design and implantation of the research, to the analysis of results and to the writing of the manuscript.

### Ethical approval

All treatments in this study have been approved by the Experimental Animal Welfare Commission of the Agricultural Research and Development Agency with registration number; Balitbangtan/BPTP Sumsel/Rm/01/2021.

### Conflict of interest

The authors have declared no conflict of interest.

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