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Analysis of Dynamic System Toward Governor Policy of Nusa Tenggara Timur about Quota of Beef Cattle Export (Case Study in Plantation Agroecosystem of Timor Island)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors RP, JRR and AY designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BPP, LA and AMF managed the analyses of the study. Author FH managed the literature searches and coresponding author. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of this research is to analyze the influence of the policy of the Governor of Nusa Tenggara Timur regarding the quota of beef cattle exports to areas of a national beef consumer toward the development of the Bali cattle population on Timor Island, East Nusa Tenggara. Determination of the location by purposive sampling based on physical criteria (land area), biology (availability and population of Bali cattle), and socio-culture (policy) so that the sampling locations representing the agroecosystem of plantations in Kupang district. The material used was 57 Bali cattle and involved 107 respondents of Bali cattle farmers. Respondents were interviewed using a

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questionnaire of reproduction status of Bali cattle. In addition to interviews, field observations were also conducted to measure the response of Bali cattle production. This research uses primary and secondary data. Data analysis is done by building a dynamic system using Powersim and interpreting simulation results for the next 30 years.The results showed a significant decrease in the population of Bali cattle over the next 30 years due to the high mortality of calves and female parent, low reproductive status of the female, and the export of cattle from uncontrolled agroecosystems. The results of this study indicate that the beef cattle export quota currently determined by local governments needs to be reviewed. The strategy to improve the quality of Bali cattle production in plantation agroecosystems to support cattle export quotas from Timor Island namely (1) farmers and local governments in striving to increase the population of Bali cattle in the agroecosystem of plantation can be done with a technical approach including prevention of death of cattle to the lowest level (<5% per year) and limitations on cattle exports according to the ability of the region; (2) improving the reproductive quality of Bali cattle through artificial insemination or controlled mating management so that it is more efficient; and (3) the government and stakeholders need to review the policy to determined cattle export quotas and improve the reproductive status of cattle in good breeding practice.

Keywords: Bali cattle; export quota;governor policy; plantation agroecosystem; Timor Island.

1. INTRODUCTION

National beef need centers in Indonesia of 60% are concentrated in the provinces of DKI Jakarta, West Java, and Banten [1]. To fulfill these needs, 750 head of cattle are slaughtered per day which are supplied from Australian imports, East Java, Central Java, Bali, West Nusa Tenggara and Nusa Tenggara Timur (NTT). Bali cattle contribute around 26,92% to the supply of cattle slaughtered, and one of the highest areas of Bali cattle suppliers for slaughter is NTT [2,3,4].

The number of beef cattle exported from NTT between 55.000-63.000 head per year according to NTT Governor Decree Number: 207 / Kep / HK / 2012 concerning Export Quota of Beef Cattle. This number of exports is lower than the quota before the 2000 between 60.000-80.000 head per year [2,3,4,5,6]. A decrease in cattle export quota is intended to prevent degradation of cattle population in NTT, but showed weak scientific studies because the determination of quotas has not taken into account aspects of low cattle productivity in NTT, namely: (1) high calf death (35-40%) [2,3,4,7], (2) female parent mortality is high (>20% per year) [3,8], (3) productive female slaughter in Slaughterhouse reaches> 60% of total cattle slaughter [4,7], (4) limited cattle feed due to the long dry season [3,9,10,6,11], (5) traditional maintenance system with low production input [9,7,12], (6) the endemic occurrence of brucellosis and anthrax with a high prevalence (14,57-40,76%) in the past 10 years [11]; (7) supervision of livestock exports is still weak so that the realization of exports is higher than the specified quota [2,4,5], and (8) there was a decrease in the body weight of cattle exports from 450 kg / head in the 1970-1980s to 275 kg / head from 2015 to the present [2,3,4,10,13,14]. If the NTT Governor's policy regarding beef cattle exports from NTT is not well reviewed it is likely to have problems with the beef cattle population in NTT.

The center of beef cattle production in NTT is Timor Island with a spread of cattle population of 65.97%, of which 593.408 head of cattle are spread on Timor Island of the total cattle population in NTT totaling 899.577 head [15] with the spread of the main types of beef cattle population is Bali cattle [11]. Bali cattle which are exported from NTT are generally cattle that are in plantation agroecosystems [16]. The NTT Governor's policy regarding the determination of the export quota of beef cattle from NTT is believed to be a weak scientific review so that it requires a comprehensive solution. One way to solve the problem of determining the export quota of beef cattle from NTT is to use a dynamic system. Dynamic systems are methods that can describe the process's behavior and complexity in the system [17]. The purpose of this study was to analyze the development of Bali cattle population as the main type of livestock exported from NTT to the national beef consumer area based on the existing conditions of beef cattle farm behavior.

2. MATERIALS AND METHODS

This research was carried out on Timor Island, Nusa Tenggara Timur province from January to December 2019 by purposive sampling based on physical criteria (land area), biology (availability

and population of Bali cattle), and socio-culture (policy) so that the sampling locations representing the agroecosystem of plantations in Kupang district. The material used was 57 Bali cattle and involved 107 respondents of Bali cattle farmers. Respondents were interviewed using a questionnaire on the reproductive status of Bali cattle. In addition to interviews, field observations were also conducted to measure the response of Bali cattle production. This research uses primary and secondary data. Primary data is used to determine the input in the system is built. Secondary data were obtained from related institutions such as the East Nusa Tenggara Animal Husbandry Office and the East Nusa Tenggara Statistics Agency. Data collected consists of: (1) Bali cattle population (male and female), (2) status data of livestock reproduction (pregnant cattle, the female parent of partus, the female parent of lactation, calves ratio, mortality, conception rate, and age of cattle production), and (3) cattle that come out of agroecosystem as export cattle [14]. Data analysis is done by building a dynamic system using Powersim and interpreting simulation results for the next 30 years (2019-2050).

3. RESULTS AND DISCUSSION

3.1 System Conceptualization and Problem Solving

The problem of the analysis of the development of cattle population to the Governor of NTT's policy on the export quota of beef cattle involves many elements such as cattle population (male and female) based on age structure (calf, young, and adult), physiological status of the female parent (pregnant, calving, lactation), a ratio of birth (male calf and female calf), livestock mortality in each structure of cattle population, conception rate, age of production from cattle born go to culling cattle, and cattle sold as export cattle. The development of cattle population structure is influenced by the birth rate of female calves that will grow and develop into a young cattle and continue to adult cattle until the cull. Factors affecting female livestock on the development of cattle population in agroecosystems are conception rate, calving interval, length of cattle weaning, and age of production. The existence of a death fraction in each structure of female cattle population is very significant to the decrease in the population of Bali cattle. The population of male Bali cattle as the main commodity of cattle exports is influenced by the population of male calves that grow and develop into cattle of a young, adult, and culling. Factors affecting are the rate of birth, death and productive age of males. The birth of male cattle is very influenced by the population of females parent giving birth so that there is an increase in the male population. An increase in the male cattle population in the population structure is significant to an increase in the availability of beef cattle in the agroecosystem. Increase or decrease Bali cattle population in agroecosystems very affects the ability of agroecosystems to supply cattle export quotas to produce a policy of beef cattle export quota allocation from NTT. The problems described are very complex, will continue to change and develop over time so that the correct problem solving is to use a dynamic system approach with Powersim [17].

3.2 System Identification and Problem Finishing

System identification is the process of design to produce a picture of the relationship between elements (entities) and the relationship of input and output from the operation of a system [17]. The problem of the analysis of the development of Bali cattle population in Timor Island plantation agroecosystem is highly dependent on the population of female cattle that give birth to female calves for replacement stock and male calf population as preparation for the main commodity of export cattle. Female cattle population with good reproductive capacity influences the increase in Bali cattle population support the availability of superior males [14]. Male calves that grow and develop into young cattle are used as steers to being adult age to be prepared as beef cattle. Female and male cattle that have been cull age are very supportive of increasing the population of Bali cattle as cut cattle in meeting domestic and regional beef needs. Information and data in the analysis of the development of Bali cattle populations in the Timor Island plantation agroecosystem can be seen in Table 1.

3.3 Model Flow Diagram (Model Structure)

The structure of the model will give shape to the system and at the same time give characteristics that influence the behavior of the system. The behavior is formed by a combination of causal loops that make up the structure of the model. All model behaviors, however complex, can be simplified into a basic structure, namely the

mechanism of input, process, output, and feedback (Fig. 1). Fig. 1 explains that in the structure of the main model of Bali cattle population in the Timor Island plantation agroecosystem the main focus is the population of Bali cattle and productivity which has a causal loop with various factors. The structure of the main model is actually derived from the submodel aggregation which consists of 2 sub-models, namely the male population sub-model and the female population submodel (Fig. 2 and Fig. 3).

Fig. 2 explains that the development of female Bali cattle population is very influenced by the birth ratio of female calves that will grow and develop into young females continue to develop into adult females until the cattle are culling. The growth status of female Bali cattle population is influenced by young cattle of pregnancy and pregnant adult cattle when they reach production age. Growth and development of cattle population is very influenced by pregnant female cows who give birth and wean Bali calf cattle (lactation). Pregnancy of a female cow depends on the value of the conception rate, female of partum is influenced by the length of pregnancy, and the female lactation is influenced by the factor of breastfeeding [14]. The female parent (lactation female) returns to being pregnant when she has weaned her offspring. The factor of livestock mortality in every age structure of the population influences the decrease in Bali cattle population. In general, the factors that influence the development of female Bali cattle population consist of livestock births, livestock mortality, age of cattle production, and reproductive status of female Bali cattle.

Table 1. Condition of existing Bali cattle population in 2019

No.	Population Model Data	Gender of Livestock	
		Female	**Male**
1.	**Bali cattle population (tails)**		
	- Calf	114	126
	- Young	356	298
	- Adult	377	291
	- Cull	12	15
	Total	**859**	**730**
2.	**The condition of female reproduction (%)**		
	- Pregnant	13	-
	- Female parent of partum	25	-
	- Female parent of lactation	37	-
3.	**Factor of influence (%)**		
	Calf birth ratio	62,5	37,5
	Mortality		
	- Calf	31,9	27,3
	- Young	15,3	7,6
	- Adult	7,3	5,8
	Conception rate	34,6	-
	Cattle carry out from agroecosystem		
	- Female cull	80,3	-
	- Male cull	-	89,4
	- Steer	-	63,5
	- Adult	-	83,9
4.	**Fraction of production age (month)**		
	- Calf age	6	6
	- Young age	19	21
	- Adult age	62	64
	- Culling age	89	80
	- Calving Interval	12	-
	- Pregnant age	9,2	-

Source: Primary and secondary processed data (2020) and Riwukore et al., [14]

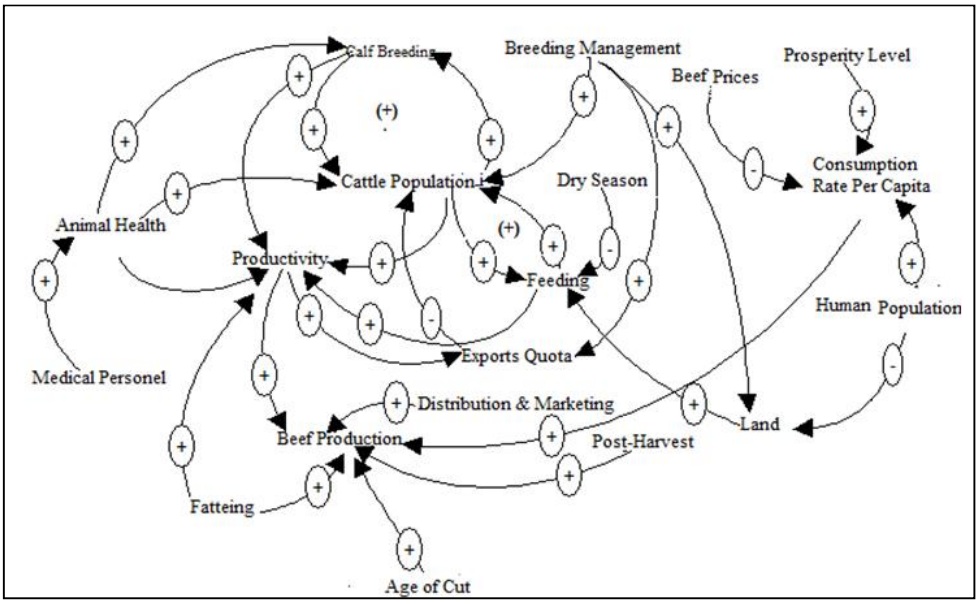

Fig. 1. Structure of Bali cattle population model
Source: Riwukore et al., [14]

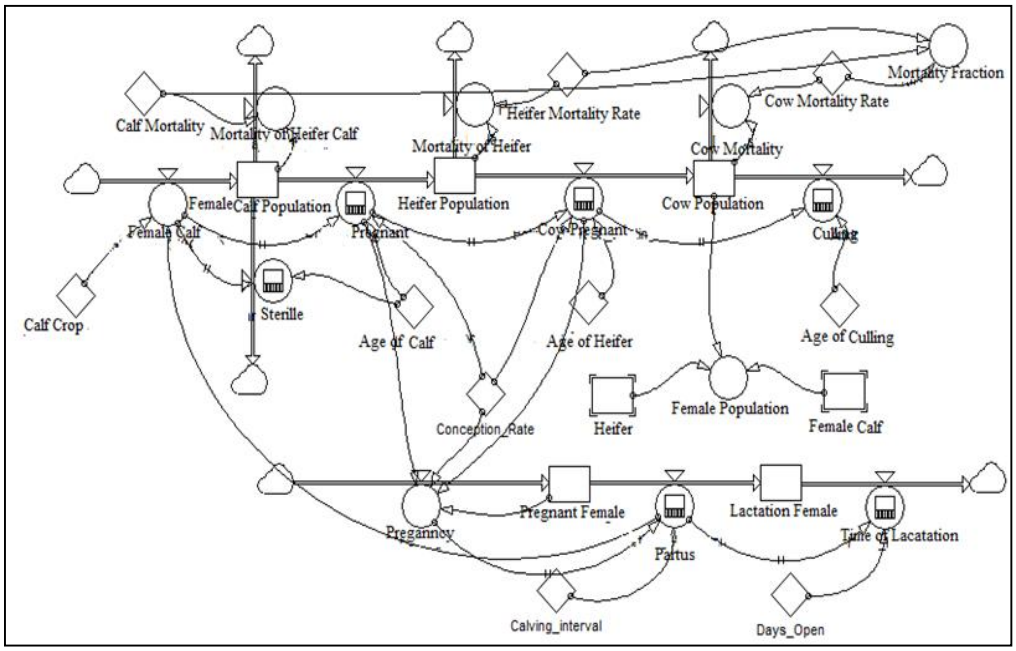

Fig. 2.Submodel of female Bali cattle population
Source: Riwukore et al., [14]

Fig. 3 explains that the growth and development of the male cattle population is very influenced by the ratio of births of a male calf, then grow into young cattle, adult cattle, and cattle of culling. Growth and development of male Bali cattle population is strongly influenced by livestock mortality factors. High cattle mortality in every population structure accelerates the decrease in Bali cattle population. The lower livestock mortality, the rate of decrease in Bali cattle population can be slow and resistance. The decrease in the population rate of male Bali

cattle is also affected by young cattle and adult cattle which are sold as steer or meat producers for the needs of meat consumers. The sale of Bali cattle which does not consider the ability of the region has accelerated the rate of degradation of the Bali cattle population. Utilization of cattle as a fulfillment of meat protein needs is very influenced by the age of livestock production from cattle born to calves that grow to become young cattle (steer), become adult cattle, and be cattle of culling (slaughtered). Increasing the population of male Bali cattle is influenced by the reproductive status of female cattle to give birth to male calves. In general, the factors that influence the growth and development of male cattle population are the birth of a calf, the death of a male cattle in each population structure, the rate of cattle sales toward region capacity, and the reproductive status of female cattle. The better the reproductive status of female cattle influences the increasing number of male Bali cattle population.

3.4 Simulation Results

Dynamic system simulation results using existing condition data show that if farmers and livestock stakeholders continue to engage in cattle activities such as existing conditions, over the next 30 years there will be a decrease of cattle populations towards extinction in the Timor Island plantation agroecosystem. The results of the analysis explain the decrease in the population of a female calf causes a decrease in the population of young female cattle and adult female cattle. The factors that influence the decrease in female Bali cattle population in plantation agroecosystems are (1) mortality of female cattle population in every structure of female cattle population is very high, especially female calf cattle (>31,9%) despite having a fairly high conception rate (34,6%); and (2) Bali cattle have a very long calving interval value of 12 months, where Bali cattle will get pregnant again after 1 year which affects the production period for calf produce. The productivity display of female Bali cattle such as this shows a low performance so that it becomes a major obstacle in developing the Bali cattle population which also contributes to the policy of import quotas for Bali cattle from Timor Island because female cattle are low in producing male cattle as the main commodity of export cattle.

Tanari et al. [18] stated that the low value of natural increase (population growth) of Bali cattle affects the replacement stock and cultivation livestock in an area. The amount of natural increase is determined by the livestock mortality rate in the population where the higher the livestock mortality rate decreases the natural increase value, and vice versa if the low mortality rate increasing the natural increase value [19]. In addition, the value of natural increase is also influenced by the magnitude of the calving interval value. Budiawan et al. [20] states that if there is a long calving interval value due to the length of time the female cattle wean her offspring. Long weaned calves cause the first estrus from the female parent postpartum to be long, farmers mate livestock for a long time so that the weaning is long, the value of service per conception is high, and the female age of conception first cattle is slow.

The results of dynamic system simulation on the female Bali cattle population submodel show that the existing condition of Bali cattle farms in the Timor Island plantation agroecosystem needs to be repaired at the real world livestock system level. The strategy that can be done is to shorten the length of calf cattle weaning and reduce the calving interval value of the female parent and reduce the factors causing mortality of female Bali cattle. Priyanto et al. [21] and Priyanto [13] state that improving the quality and quantity of productivity of Bali cattle can be done by shortening calving interval values and length of calf weaning, saving productive females, delaying the time of slaughtering cattle, and implementing artificial insemination (AI) / controlled mating to increase the conception rate value.

The dynamic system simulation results based on the existing condition of Bali cattle farms in Timor Island plantation agroecosystem show a decrease in male Bali cattle population over the next 30 years. The decrease in the population of male Bali cattle affects aspect of male cattle cultivation as the main commodity of cattle that are exported from the island of Timor or NTT in general. The decrease in male Bali cattle population due to mortality of male Bali calf is very high in the agroecosystem of a plantation which reaches> 27,3% per year. The results of this analysis are consistent with several research reports in NTT that the value of natural increase of Bali cattle on Timor Island or NTT is still low due to high calf mortality (35-40%) and high female parent mortality (> 20%) in the cattle population Bali [4,8,7].

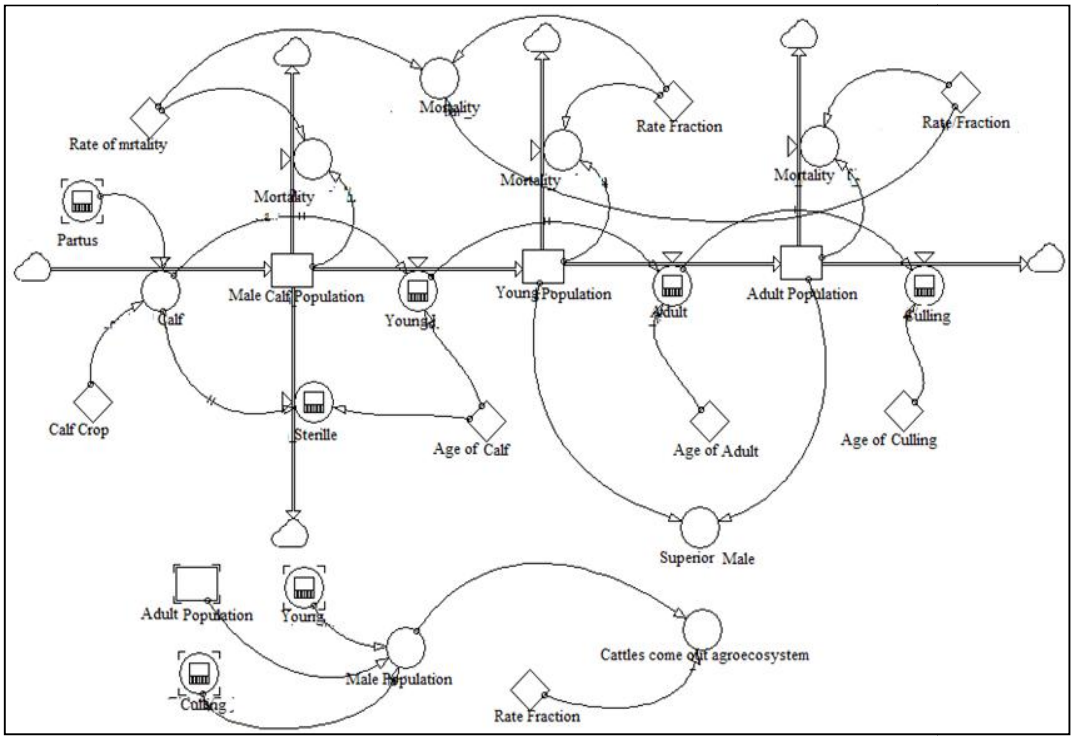

Fig. 3. Submodel of male Bali cattle population
Source: Riwukore et al., [14]

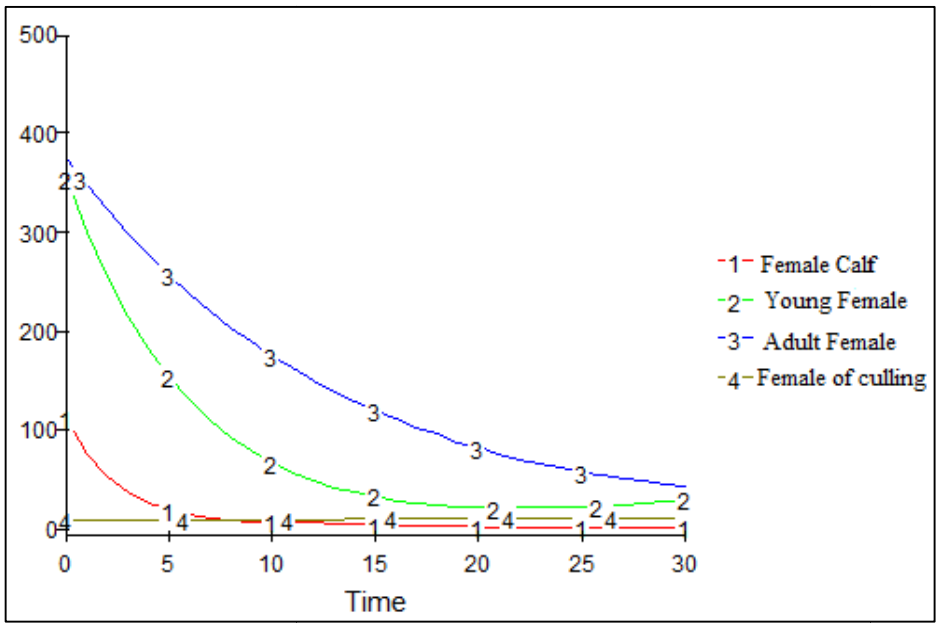

Fig. 4. Simulation diagram of population submodel of female Bali cattle for 30 years

The decrease of the male cattle population in the Timor Island plantation agroecosystem is also influenced by the export of male cattle from an uncontrolled agroecosystem and does not consider agroecosystem capabilities. A display like this will accelerate the degradation in the

value of the natural increase in the population of Bali cattle. A number of researchers state that livestock population size is very closely related to population size (male and female), birth and death of livestock, and uncontrolled expenditure of livestock from agroecosystems [22,20,23,24, 19,25,14,26,27,18]. Birth and death of livestock in an agroecosystem affect the value of natural increase where if the value of natural increase is high, it shows that the agroecosystem has a number of productive female cattle with good management and handling. Conversely, if the mortality rate is high it will reduce the value of natural increase and further decrease the population if the female reproductive status is low. Likewise, livestock expenditure from an agroecosystem that does not take into account the agroecosystem's ability further accelerates the rate of population degradation.

The role of the agroecosystem of Timor Island plantations as one of the supporting area of policies of the Governor of Nusa Tenggara Timur to import Bali cattle out of NTT in fulfilling national beef demand if not considering aspects of Bali cattle population development and regional carrying capacity will cause a significant decrease of Bali cattle population. The current quota of Bali cattle exports from NTT should need to be reviewed again because the region's ability to provide Bali cattle as the main commodity has a low production value.

According to NTT Governor Decree No. 207 / Kep / HK / 2012 concerning the export quota of beef cattle, the number of cattle exported from NTT is between 55.000 to 63.000 per year. This number is lower than the quota before the 2000s which is 60.000-80.000 head per year [2,3,4,28]. Decrease in cattle export quota is intended to prevent degradation of livestock in NTT. The impact of the decrease in the quota was an increase in population during cattle over the past 15 years with a growth of 39%, from 495.052 in 2001 to 899.577 in 2015. However, the increase in the population of Bali cattle is still considered low because it only grows on average of 2,6% per year. The factor of the low productivity of Bali cattle is due to the relatively high death of cattle, the reproductive status of female cattle is relatively low, and the expenditure of cattle that have not taken into account the existing conditions of the region.

Based on the results of dynamic system analysis that repairing the quality of Bali cattle production in plantation agroecosystems needs to be done as one of the areas production beef cattle supporting local government policy in exporting cattle out of Timor Island or NTT. The strategy in improving the quality of Bali cattle production in the Timor Island plantation agroecosystem can be done(1) farmers and local governments in striving to increase the population of Bali cattle in the agroecosystem of plantation can be done with a technical approach including prevention of death of cattle to the lowest level (<5% per year) and limitations on cattle exports according to the ability of the region; (2) improving the

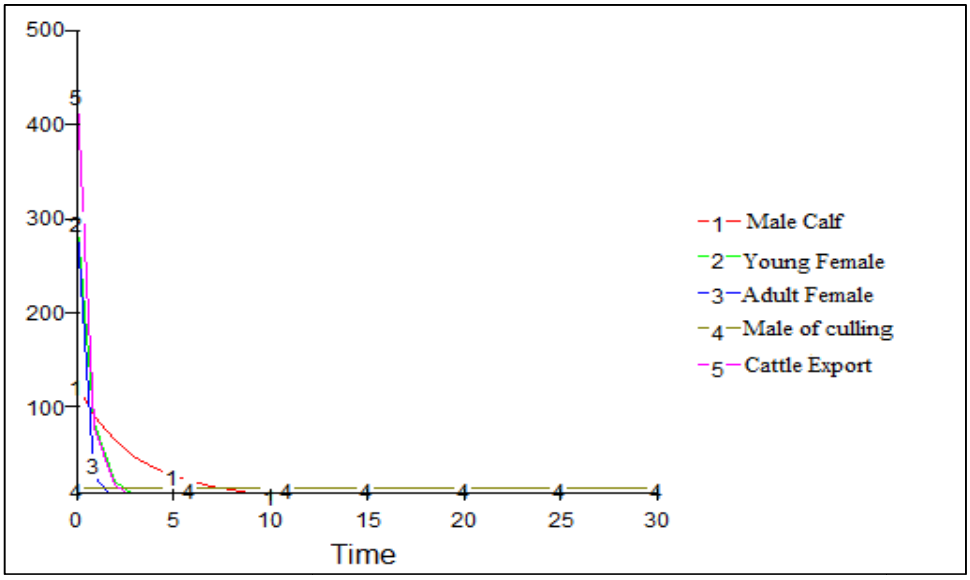

Fig. 5. Simulation diagram of population submodel of male Bali cattle for 30 years

reproductive quality of Bali cattle through artificial insemination or controlled mating management so that it is more efficient; and (3) the government and stakeholders need to review the policy to determined cattle export quotas and improve the reproductive status of cattle in good breeding practice.

4. CONCLUSION

The conclusion is that Bali cattle population in Timor Island plantation agroecosystem shows a trend of population decrease based on dynamic system simulation data for 30 years, due to calf mortality and broodstock mortality is high, reproductive status of broodstock is low, and livestock expenditure from agroecosystem is uncontrolled. For this reason, the beef cattle export quota currently determined by the regional government needs to be reviewed. policy interventions can be done in a way(1) farmers and local governments in striving to increase the population of Bali cattle in the agroecosystem of plantation can be done with a technical approach including prevention of death of cattle to the lowest level (<5% per year) and limitations on cattle exports according to the ability of the region; (2) improving the reproductive quality of Bali cattle through artificial insemination or controlled mating management so that it is more efficient; and (3) the government and stakeholders need to review the policy to determined cattle export quotas and improve the reproductive status of cattle in good breeding practice.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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