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Harvesting Quota and Financial Feasibility of Timor Deer Captive Breeding in Sadhana Arifnusa East Lombok, Indonesia

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ABSTRACT

Timor deer breeding activities have been widely carried out in Indonesia as animals with economic value. However, management in the form of determining harvest quotas that affect the feasibility of business is still minimal in various captive timor deer populations in Indonesia. The objectives of this study were to determine the harvest quota of Timor deer and the financial feasibility of captive breeding for Sadhana Arifnusa. The harvest quota, which is conducted once a year, is determined based on the calculation of the break-even point (BEP). The scenario of harvesting twice a year was based on the growth and population harvesting rates. Financial feasibility is measured based on investment appraisal criteria, namely, net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR), and payback period. The results revealed that the harvest quota, which is carried out once a year, is five individuals, and the population size that must be available at the time of harvest is 48 individuals. Meanwhile, the harvest quota that is carried out twice a year from year 1 to year 3 comprises two individuals. Based on the financial value of the scheme without slaughter and the scheme with slaughter, it can be said that the Timor deer captive business is potentially profitable and feasible to develop with NPV values of IDR 428,748,935 and IDR 934,136,423, respectively; BCR values of 1.66 and 2.46; IRR values of 28.89% and 32.89%, respectively; and the ability to return investment after 4.6 and 5.1 years, respectively.

Introduction

Timor deer (*Rusa timorensis*) is a native Indonesian deer protected under Government Regulation No. 106/2018 concerning protected wild plants and animals. The Conservation Status of Timor deer on the IUCN Red List is Vulnerable, and the population in its natural habitat, namely Jawa and Bali Island, has declined over the past few decades as a result of hunting, habitat degradation, and the spread of invasive plant species [1]. This form prevents the decline of the Timor deer population in its natural habitat by implementing ex-situ conservation in the form of captive breeding [2]. Deer breeding as an animal species with economic value has been widely practiced in Indonesia, while still paying attention to the purity of the species up to the first generation (F1) [3].

Timor deer have good prospects in terms of improving people's welfare because, in addition to consumable meat, Timor deer velvet can also be used as medicine [4]. The consumption rate of venison by restaurant consumers in the DKI Jakarta area was 84.21%, and 60% of interviewed meat sellers were interested in selling venison [5]. However, the availability of Timor deer is still limited, and thus, the fulfillment of venison needs is obtained by imports [6]. This is because deer abroad have developed as livestock [7]. One of the ideal areas for conserving the Timor deer as an introduced animal in ex-situ conservation efforts in West Nusa Tenggara is because drier areas, such as West and East Nusa Tenggara, are more suitable than other areas in Eastern Indonesia [8].

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One of the parties conducting captive Timor deer is Sadhana Arifnusa on Lombok Island, West Nusa Tenggara. Captivity is still relatively new and aims to become one of the institutions providing Timor deer seeds from captives in a professional manner to preserve germplasm, educational and research facilities, recreation, and commercial use, while still adhering to the principle of sustainable use in accordance with the conservation principles that apply in Indonesia. An important factor determining the success of management is highly dependent on the harvest effort undertaken and the time of harvest [9]; therefore, the question that needs careful and scientific study by the manager is the number of animals that can be harvested from the population each year [10]. Therefore, research that focuses on the aspect of determining the harvest quota for Timor deer is considered important and necessary. Another important aspect of this study is the financial analysis of the captive-breeding business. This is important because it can provide an overview of breeding from the economic aspect of whether the business is feasible and considered capable of providing benefits in the form of return on investment capital to the breeder. Based on this, this study aims to 1) determine the quota for the Timor deer harvest based on population sustainability in captivity and the break-even point (BEP) value and 2) analyze the financial feasibility of the Sadhana Arifnusa captive breeding scheme without and with slaughter.

Method

Study Area

This research was carried out from August – September 2022 in Sadhana Arifnusa Timor deer (*Rusa timorensis*) captivity, East Lombok. Sadhana Arifnusa's timor deer captivity is a breeding unit built in 2020 providing timor deer seeds from professional breeding for the purpose of preserving germplasm, educational and research facilities, recreation and commercial utilization while still adhering to the principle of sustainable use in accordance with applicable conservation principles in Indonesia (Figure 1). The number of individuals of timor deer (*Rusa timorensis*) until September 2022 is 38 individuals consisting of 19 males and 19 females (1:1). Not all adult timor deer (*Rusa timorensis*) are produced from births in Sadhana Arifnusa captivity, but there are some individuals who are deliberately imported from outside the captivity. This aims to prevent inbreeding and reduce the risk of defects in future offspring.

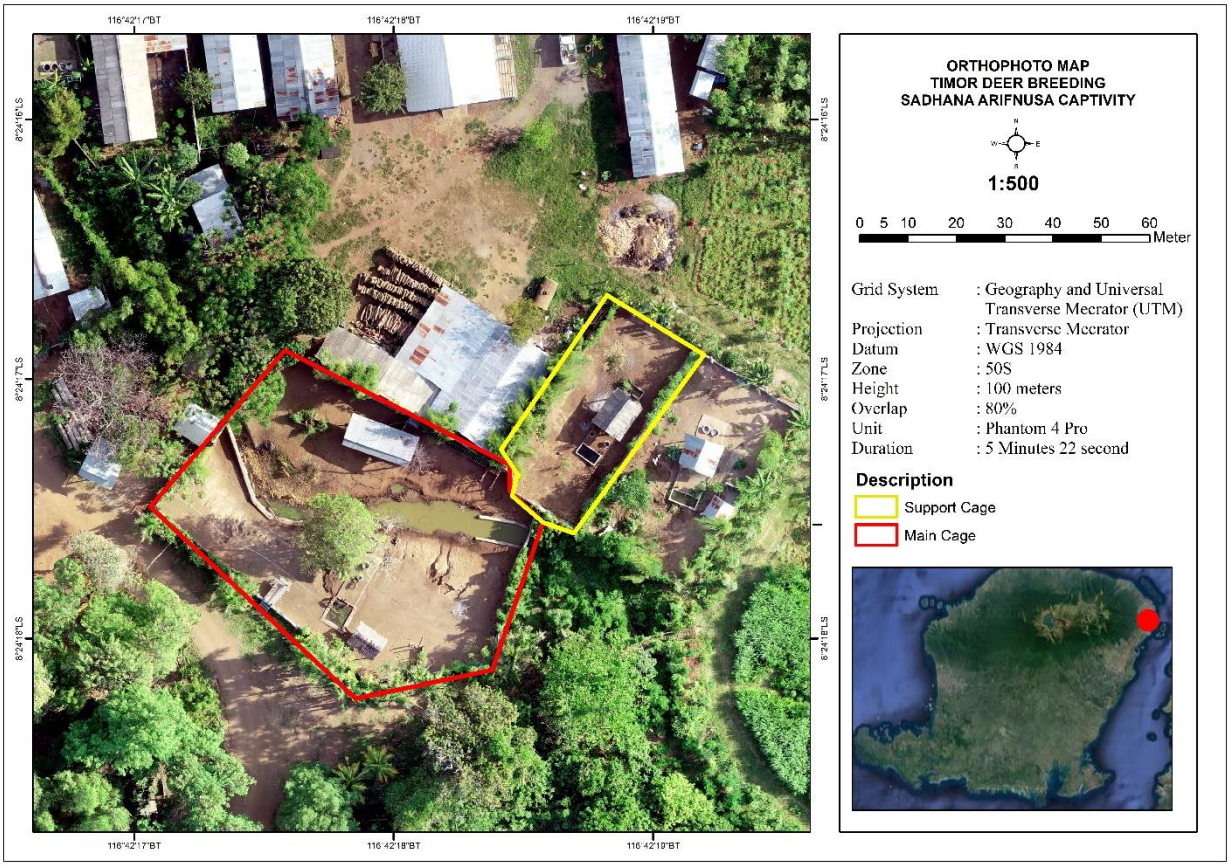

Figure 1. Research location map.

Data Collection

The data collected in this study consisted of primary and secondary data. Primary data includes the components of captive breeding costs (investment costs, fixed costs, and variable costs), population size, growth rates, harvesting rates, and revenue data from Timor deer utilization. Furthermore, the secondary data collected is supporting data for research results, which include population development, feed consumption levels, and estimation of captive area needs. The tools used in this study include one unit of Phantom 4 Pro drone to document and map the food garden and breeding cages, digital camera to document activities and objects of research, stationery to record the data obtained, tape measure to measure facilities and facilities in captivity, interview guide and questionnaire for cage officers and managers, as well as spring balance and rope to weigh the weight of feed and body weight of timor deer before measuring feed consumption.

Data collection techniques to analyze harvest quotas in this study included observation or direct observation in the field, interviews with managers and animal keepers, and literature studies. Data collection through direct observation in the field to obtain data and information on population size at the time of the study Interviews with managers and animal keepers were conducted to obtain data and information on the initial population at the start of captive breeding, which is expressed as N(0), and the cost components consisting of investment costs, fixed costs, and variable costs. Literature study to obtain data and information regarding individual economic selling prices and Timor deer derivative products, growth rates, harvesting rates, and populations that must be available at the time of harvesting activities. Literature sources are obtained from various related sources, such as journals, research results, and other scientific works.

Data collection techniques to analyze financial feasibility in this study include interviews with managers and literature studies. Interviews are needed to obtain data and information on investment costs, fixed costs, variable costs, and the benefits of captive breeding. The components of investment costs include development costs, captive breeding support facilities and infrastructure, and fixed costs in the form of operational costs for captive breeding activities each year. The variable costs obtained are maintenance costs for each individual timor deer per year. Data and information regarding profits are obtained from the difference between income and expenses each year. Meanwhile, the literature study was used to determine the prevailing interest rate in Indonesia at the time of the study, which was then included in the interview data to find the discount factor when analyzing the financial feasibility of captive breeding.

Data Analysis

Harvest Quotas

Harvest quotas based on population sustainability (SY) in captivity, where harvesting activities are carried out twice a year, are obtained by calculating the growth rate (r), population harvesting rate (h), and population size in the last year of captivity expressed as N(t). While the size of the harvest quota is based on the calculation of the break-even point (BEP), which is expressed as Qt, where harvesting activities are carried out once a year using the equation with components that include fixed costs (F), variable costs (V), and the economical selling price of individual timor deer (P) [11]. The results of the harvest quota use in equation 1.

$$r = ln\left(\frac{Nt}{N0}\right) \quad h = 1 - [(e)]^{-r}) \quad SY = \left(\frac{h}{2}\right).Nt \quad Qt = \frac{F}{(P-V)} \quad \boldsymbol{N0} = \frac{Nt}{e^{r.t}} \tag{1}$$

Explaination:

N0 : Initial population size (individuals)

Nt : Population size in the last year of captivity (individuals)

r : Exponential growth rate

e : Euler's number (e = 2.718281…)

h : Population harvesting rate

SY : Harvest quotas based on population sustainability (individuals)

Qt : Harvest quotas based on break-even point (individuals)

Financial Feasibility

Financial feasibility is measured based on investment appraisal criteria, namely NPV (Net Present Value), BCR (Benefit Cost Ratio), IRR (Internal Rate of Return), and PP (Payback Period) [12]. While, The BCR method is a comparison between income and costs as well as material for validating the NPV value (equation 2), where a

business is said to be feasible if the BCR value is > 1 (equation 3). The IRR value indicates the ability of a project to generate the level of profit it will achieve. The amount resulting from this calculation is in percentage units (%). A business is said to be feasible if the IRR value is greater than the Discount Rate (DR) or the applicable interest rate (equation 4). The PP value is a complementary method in financial analysis. This calculation method is carried out to calculate how fast the rate of return on capital of a business. The faster the rate of return on investment, the more interested investors will be in investing in the business. The equation for determining the PP as expressed in equation 5.

$$NPV= \sum_{t=1}^{n} \frac{Bt-Ct}{(1+i)^t} \quad (2)$$

Note: NPV: Net present value; Bt: Annual gross income; Ct: Annual fee; n: Project economic life; t: Project year;

$$BCR = \frac{\sum_{t=1}^{n} \frac{Bt}{(1+i)^t}}{\sum_{t=1}^{n} \frac{Ct}{(1+i)^t}} \quad (3)$$

$$IRR = DFP + \left[\frac{NPV}{(PVP - PVN)}(DFN - DFP)\right] \quad (4)$$

Note: DFP: Discounting factor, used to produce a positive present value; DFN: Discounting factor, used to produce a negative present value; PVP: Present value positive; PVN: Present value negative.

$$Payback\ Period = \frac{Total\ investment\ cost}{Net\ income\ per\ year} \quad (5)$$

Result and Discussion

Harvest Quotas

The initial population of Timor deer in captivity periodically shows that in 2021 (N0), there will be 34 individuals, and in 2022 (N1), there will be 38 individuals, so the value of the growth rate is 0.11 and the population harvesting rate is 0.105. Based on the results of interviews with managers, the total fixed costs are IDR 54,201,500 per year, including the cost of maintaining facilities and infrastructure, electricity payments, transportation, and employee salaries. Meanwhile, variable costs are IDR 487,145 per year per individual, including intensive feeding, additional feed, health care, eartag, and legality. Therefore, the harvest quota in Sadhana Arifnusa captivity is explained in the following chapter.

Harvest Quota Based on Break Even Point (BEP)

Harvest quotas based on the break-even point (BEP), where harvesting activities are carried out once a year, are a reflection of total revenue equaling total expenditure. The determination of BEP in this study is only based on the sale of one type of product (single product), namely living individuals, where the BEP calculation is based on total fixed costs and variable costs. The two cost components have different impacts on the calculation of the BEP, that fixed costs in the management of deer captivity are costs incurred to support the implementation of captive breeding activities but not directly related to sales volume [13]. While variable costs are costs that are directly related to all the needs needed to maintain an individual deer and sales volume. If the sales volume changes, the direct variable cost will also change.

The selling price of live adult deer in the Dramaga Research Forest in 2013 was IDR 7,500,000 per individual [3]. The individual price of Timor deer life is IDR 10,000,000 [12]. Therefore, the increase in the economic price of individual live deer in this study is 6% per year at a price of IDR 12,671,092 in 2022. Based on fixed costs, variable costs, and the selling price per individual, a minimum harvest quota can be obtained as presented in Table 1.

Table 1. Harvest quota based on BEP.

No	Type of cost	Total
1	Fixed cost (IDR/year)	IDR 54,201,500
2	Variable cost (IDR/individual/year)	IDR 487,145
3	Selling price per Individual	IDR 12,671,092
4	BEP/minimum harvest quota per year	4.45 = 5 individuals

The results of calculations according to the BEP listed in the table above show that the minimum harvest quota every year so that captive breeding activities can continue is five individuals. An important factor that determines the value of BEP besides fixed costs is the unit contribution margin or the difference between the selling price and the variable cost per unit of product. The greater the unit contribution margin, the smaller the BEP value [14]. The effect of fixed costs and unit contribution margin on BEP values is strengthened in captive Dramaga Research Forest in an intensive system with a fixed cost of IDR 185,238,831, variable costs of IDR 6,680,100, and a selling price of IDR 7,500,000 [13]. Based on these values, the BEP was obtained for 33 individuals, where this value was greater than the BEP value in this study.

The population size that must be available at the time of harvest (Nt) is 48 individuals. The timing of harvesting activities in this study shows that when referring to harvest quotas based on BEP, the number of populations that must be available at the time of harvest, and the initial population numbers that are known and fulfilled, the time of harvesting activities can be carried out in the 3rd year since captive breeding was held, namely on the year 2024. Calculation of harvesting time is done by entering the value of the growth rate (r) for the appropriate time (t) into the previously known exponential equation with the following details (Table 2).

Table 2. Timing of harvesting activities and population size must be available based break-even point.

*t	0	1	2	3	4	5	6	7	8	9	10
**N(t)	34	38	43	48	53	59	66	74	82	92	103

*t: year, **N(t): 48 individuals.

Given the condition of the deer population, which is all in one ranch model cage and not all of them have been tagged, which results in individuals in the second generation (F2) is difficult to ascertain, so the timing of harvesting activities is considered based on the mature age of male and female timor deer (*Rusa timorensis*). The adult age of timor deer (*Rusa timorensis*) in captivity in various literatures varies; for the Nusa Tenggara region, the minimum breeding age for male Timor deer is 11 to 12.67 months and 10 to 15.25 months in male deer. As for the Java region, male deer in captivity show their lust at the age of 15 to 16 months, and female deer become pregnant at the age of 16 to 18 months. The gestation period for Timor deer is 8.3 to 8.5 months. The age of the first birth is 20 to 25 months, and the interval between the first and second births is 13.25 to 13.75 months. The percentage of births in Indonesia ranges from 45 to 75% [15].

Based on the consideration of averaging the adult ages of male and female timor deer, individuals that can be harvested are second-generation individuals (F2) that are 15 months old [13]. Because the gestation period for adult deer is 8.5 months, the second generation of timor deer (F2) individuals can be harvested as early as four years after the initial population size is available.

Harvesting Quota Based on Sustainability in Captivity

Determining harvest quotas based on sustainability in captivity is based on the population growth rate and harvesting rate, where harvesting activities are carried out twice a year. Therefore, it was found that the harvest quota was two individuals. The quota for harvesting twice a year is then calculated based on the predicted population size in the following year with an exponential model (Table 3). The harvest quota which is carried out twice a year has the same amount until the 3rd year, namely two individuals. The total number of individuals harvested by harvesting twice a year is smaller than once harvesting a year. This is because the harvest quota twice a year is based on the principle of sustainable harvesting, where the BEP factor is not taken into account. In addition, this is also based on the principle of harvesting as a form of population increase [16] in unlimited environmental conditions so that it grows exponentially [17] with harvest quotas not exceeding the population growth rate [18].

Table 3. Biannual harvest quotas with an exponential model.

Time	Total population (N)	Year	Harvest
2021	34	0	0
2022	38	1	2
2023	42	2	2
2024	48	3	2

Financial Feasibility

The financial feasibility analysis in this study uses a discount rate of 4.75%, referring to the Bank Indonesia deposit rate in December 2022. Meanwhile, all cost components are assumed to remain unchanged until the 10th year of captive breeding. Based on the results of data collection through in-depth interviews with captive management and literature studies, information regarding investment costs, fixed costs, variable costs, and income assumptions is obtained in detail in the following discussion.

Investment Costs

Investment costs for captive timor deer (*Rusa timorensis*) written down are all costs incurred since the breeding was established, including the cost of building pens and their facilities, offices and information centers, operational equipment, water and electricity installations, facilities and infrastructure, and feed gardens. The total investment cost incurred is IDR 214,215,000.

Fixed Costs

The fixed costs incurred consist of the components of labor wages, transportation facilities, infrastructure maintenance, and electricity costs. The total fixed costs incurred per year amount to IDR 54,201,500.

Variable Costs

Variable costs incurred include costs for feed, medicine, transportation, and administration. Feed costs consist of three components: intensive feed, additional feed in the form of rice bran concentrate, and additional corn feed. The total variable costs incurred for one individual timor deer (*Rusa timorensis*) amounted to IDR 487,145.

Since the Sadhana Arifnusa Timor Deer Breeding Center was built in 2020, there has been no utilization, so the value of the income is unknown. Therefore, the amount of income earned and the economical price of deer, including their derivative products, is assumed and refers to previous studies with an estimated life span of 10 years. Acceptance and financial feasibility analysis are divided into two schemes, namely based on acceptance without and with slaughter.

Financial Feasibility Based on Revenue Without Being Slaughtered

Live Individuals

The selling price of live adult deer has increased by 6% per year, where the economical selling price of live individual deer in 2022 is IDR 12,671,092. The assumption of income from the sale of live individual deer starting in the 4th year of captivity is formed with the number of sales of 5 individuals per year according to the harvest quota based on the BEP.

Velvet

The price of velvet per head refers to [3] of IDR 4,700,000 where one individual male deer produces velvet aged ± 60 days weighing 0.5 kilograms per head in fresh form. The assumption of income from the sale of young hornbills (velvet) is obtained from the total harvest quota based on the BEP, namely five adult male individuals with harvesting of young hornbills (velvet) twice a year per individual.

Tourism Object

Acceptance of captive timor deer (*Rusa timorensis*) as a new tourist attraction in East Lombok Regency based on the number of visitors is assumed with an average of 20 people per day [3]. While the rates for captive tourism for Timor deer (*Rusa timorensis*) in this study are assumed where the ticket selling price is IDR 5,000 per person [12]. The assumption of revenue from ticket sales is obtained from the opening of the captive tourism object for one full year, namely 365 days. The financial value of the first captive Timor deer (*Rusa timorensis*) in Sadhana Arifnusa with a total cost of IDR 761,101,447 is presented in Table 4.

Calculation of the financial analysis of the first scheme based on NPV shows that captive breeding activities are feasible to develop because they have an NPV ≥ 0, namely IDR 428,748,935. This is consistent with that if the NPV ≥ 0 means the project is quite profitable because the NPV illustrates the investment program's ability to generate profits at a certain interest rate [19].

The result of calculations with the BCR method up to 10th year are 1.66 or > 1; this means that captive breeding activities are feasible to be developed in the future. Calculation of financial feasibility using the IRR method yields a value of 28.89% which means that captive breeding activities are also feasible to develop because of the prevailing IRR > I (4.75%). Meanwhile, the payback period for investment costs is 4.6 years.

Table 4. Financial value of breeding Timor deer first scheme sadhana arifnusa.

Year	Reception	Profit	NPV (IDR)	BCR	IRR (%)	PP
0	36,500,000	(177,715,000)				
1	74,100,000	19,411,355				
2	74,100,000	19,411,355				
3	74,100,000	19,411,355				
4	149,557,367	94,868,722				
5	154,084,809	99,396,164	428,748,935	1.66	28.89	4.60
6	158,883,897	104,195,252				
7	163,970,931	109,282,286				
8	169,363,187	114,674,542				
9	175,078,978	120,390,333				
10	181,137,717	126,449,072				

*NPV ≥ 0, *BCR > 1, *IRR > I, *PP: payback period.

Financial Feasibility Based on Slaughter Revenue

Venison

The quality of venison is highly preferred because, in addition to its distinctive taste, the texture is also soft and has fine fibers. The fat and cholesterol content are relatively lower, while the protein and iron are quite high compared to some conventional meats [20]. States that the fat content in venison is 3.30% lower than that contained in beef 9.76%, lamb meat 7.62%, and pork 10.64%, the venison cholesterol content of 66 mg/100 grams is also lower than that contained in beef 92 mg/100 grams, pork 101 mg/100 grams, or lamb meat 83 mg/100 grams [21]. Meanwhile, in terms of protein content, the protein content of venison was 23.36% higher than that found in pork which was 21.32%, or beef, which was 19.61% [22]. It was also reported that the content of omega-3 and omega-6 in venison is higher than that contained in pork and beef. Even though the price of venison is expensive, it is quite sought after by people because 50 to 55% of the fat is polyunsaturated or not saturated fat [15]. In addition, the low fat and cholesterol content in venison is more suitable for a dietetic menu [23].

Venison is several times more expensive than beef. The venison weight of an adult deer is assumed to be 60% of body weight, and the average weight of an adult deer is 70 kg [24]. The standard price of venison is 2 to 2.5 times higher than the price of beef [25]. Beef prices experienced a marked growth of between 24% and 37%, with an average increase of 30% per year [26]. The average price of beef in the research year (2022) is IDR 133,600 per kilogram. Therefore, it can be seen that the economic price of venison from legal breeding in 2022 ranges from IDR 267,200 to IDR 334,000 per kilogram. The assumption of income from the sale of deer carcasses in this study is the slaughter of five adult deer individuals as a harvest quota based on the BEP and the time of the first harvesting activity, with an initial price (1st year) of IDR 300,600 per kilogram obtained from averaging prices in the 2022 range mentioned earlier. It refers to the lowest beef price growth rate of 24% per year.

Deer Antlers

The potential for the utilization of deer antlers is also high, considering the large number of male deer in the study area. The hard antlers in their intact form can be used as souvenirs, such as those sold in tourist parks and zoos, with prices ranging from IDR 250,000 to IDR 750,000 [3]. Meanwhile, the price of deer antlers in several places in Bogor City is IDR 300,000 [24]. The price assumption for antler deer in this study refers to the highest price of IDR 750,000 [3] per head of adult male individual with a harvest quota of five antlers per year based on the BEP and the time of the first harvest without any price changes until the year the 10 captive activities carried out.

Leather

The price of deer skin is higher than goat skin per sheet, the price of goat skin reached IDR 150,000 per sheet, and deer skin reached IDR 250,000 and then increased to IDR 275,000 [3]. This research assumes that the price of deerskin until the 10th year is the same, namely IDR 275,000 per sheet.

Tourism Object

Acceptance of captive Timor deer (*Rusa timorensis*) as a new tourism object in East Lombok Regency is the same as the no-slaughter scheme. The financial value of captive Timor deer (*Rusa timorensis*) in the second scheme at Sadhana Arifnusa with a total cost of IDR 761,101,447 in the second scheme is presented in Table 5. Financial analysis calculations based on NPV show that captive breeding activities are feasible to develop because they have NPV ≥ 0, which is IDR 934,136,423. Meanwhile, the BCR value > 1, which is 2.46, and the IRR value is 32.89%, with a payback period of 5.1 years.

Table 5. Financial value second scheme of sadhana arifnusa.

Year	Reception	Profit	NPV (IDR)	BCR	IRR	PP
0	36,500,000	(177,715,000)				
1	36,500,000	(18,188,645)				
2	36,500,000	(18,188,645)				
3	36,500,000	(18,188,645)				
4	161,982,547	107,293,902				
5	190,868,358	136,179,713	934,136,423	2.46	32.89	5.10
6	226,686,764	171,998,119				
7	271,101,587	216,412,942				
8	326,175,968	271,487,323				
9	394,468,200	339,779,555				
10	479,150,568	424,461,923				

*NPV ≥ 0, *BCR > 1, *IRR > I, *PP: payback period.

Conclusion

The harvest quota based on the BEP carried out once a year is five individuals with a population size of 48 individuals from the initial population size of 34 individuals. While the harvest quota is based on sustainability in captivity with the intensity of harvesting activities twice a year in 2022, 2023, and 2024 for each of the two individuals. Good population management can help improve the quality and selling value of captive-bred deer with several strategies, including setting the sex ratio and the harvesting rate must be maintained so that the desired age structure can be available at the time of harvest and health care and reproduction are checked more routinely.

The financial analysis results are based on revenue without being slaughtered (first scheme) and by being slaughtered (second scheme); it is known that the Sadhana Arifnusa Timor deer breeding business is feasible to develop. Parties can use this as a reference in carrying out captive breeding activities if it has a commercialization purpose, provided that the principles of efficiency are still being implemented, such as minimizing excessive expenses. The NPV value of the first scheme is IDR 428,748,935, and the second scheme is IDR 934,136,423. The BCR values were 1.66 and 2.46, respectively. The IRR values are respectively 28.89% and 32.89%. While the payback period for investment costs in the first and second schemes is 4.6 years and 5.1 years, respectively. The results of the financial analysis of the Shadana Arifnusa deer captivity are said to be feasible for development.

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