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Optimization Model of Sustainable Income of Sheep-Corn Farm Integration in Banten Province, Indonesia

Viktor Siagian*[1], Ratna Ayu, Mahmud Thoha, Tuti Ermawati, Sigit Setiawan, Wawan Eka Putra, I Gusti Ayu Putu Mahendri, Ragimun, Benny Rachman[2], Valeriana Darwis, Chairul Muslim, Alvi Yani[3], Basri Abubakar[4], Abdul Azis, Idawanni, Novia Chairuman, Musfal, Palmarum Nainggolan[5], Sortha Simatupang, Rijanto Hutasohit[6], Dwi Priyanto, Wisri Puastuti, Supardi Rusdiana, Lokot Zein Nasution[7], Mutaqin[8]

Abstract

Corn crops and sheep farming have a mutualism symbiosis that has not been integrated optimally. The research aims are: 1) to analyze the socio-economic performance of a sustainable sheep-corn farm, 2) to analyze the household income of farmers-breeders in Serang Regency, and 3) to optimize household incomes for sustainable sheep-corn integration. The study method used is the survey method.. The analysis method uses B/C ratio analysis and linear programming (LP). The number of respondents was sampling purposively as many as 85 farmers. The scope is limited to the integration of farming corn and sheep livestock in Banten province. The results of the study were: 1) Corn crop productivity in Rainy Season (RS) 2020/2021 was 3.63 tons dry shelled/ha and in Dry Season-I (DS-I) 2020 2.65 tons dry shelled/ha with B/C ratio values of 1.7 and 0.4 respectively. The income from sheep farming in RS is IDR. 1,023,138 with a B/C ratio of 2.1, while in DS-2021 the income from livestock business is IDR. 214,937. 2) Farmer/breeder household income is IDR. 24,167,466.3/year which consists of non-farm income which is IDR. 14,462,558.1/year (59.8%) and on-farm income IDR. 9,704,908.1 /year (40.2%). 3) The optimum value of income for sheep farmers is IDR. 53,214,370 which is obtained from the RS 2020/2021 rice planting area of 1.53 ha and sheep farming business of 35.3 heads.

Keywords: *integrated farming, sheep-corn, income, socio-economic, linear programming*

1.0. Background

Corn is the second-largest food crop in Banten Province. In 2019, the corn production in Banten Province reached 119,206 tons, covering a harvested area of 22,346 hectares, (CBS 2020). A comparison with the figures from 2008 reveals a notable increase, with the harvested area expanding by 21.8% (from 27,725 ha) and production rising by 39.7% (from 90,048 tons),

[1] Center for Research in Macroeconomics and Finance, National Research and Innovation Agency (BRIN), Jl. Gatot Subroto No.10, Jakarta, Indonesia.12710., *E-mail: viktor.siagian@brin.go.id
[2] Research Center for Behavioral and Circular Economics, BRIN, Jakarta, Indonesia. 12710.
[3] Reseach Center for Agroindustry, National Research and Innovation Agency (BRIN), Cibinong-Bogor. Indonesia, 16911.
[4] Research Center for Food Crops, National, Research and Innovation Agency, Cibinong-Bogor, Indonesia 16911.
[5] Research Center for Horticulture and Estate Crops, National Research and Innovation Agency, Cibinong-Bogor , Indonesia 16911.
[6] Research Center for Animal Husbandary, National Research and Innovation Agency, Cibinong-Bogor, Indonesia 16911
[7] Research Center for Cooperative, Corporation, and People's Economy, National Research and Innovation Agency, Jakarta, Indonesia 12710.
[8] Research Center for Industrial Economics, Services, and Trade, National Research and Innovation Agency (BRIN), Jakarta, Indonesia. 12710.

indicating a substantial growth in both harvested area and production during this period (CBS 2009).

The primary corn cultivation centers in Banten Province are situated in the Regency of Pandeglang and Lebak, contributing to harvested areas of 15,412 ha and 4,685 ha, respectively. The production figures for these regions are 82,359 tons and 24,534 tons. It is noteworthy that corn cultivation in Lebak Regency is predominantly practiced in dry land and rice fields.

To date, corn has been cultivated in Banten Province for animal feed, either supplied to feed mills or for farmers' use. In the Province of Banten, there were 466,161 sheep in 2019. The distribution of sheep is found throughout the province of Banten. According to its administration, the Pandeglang Regency has the most sheep (209,654 heads; 45.0%), followed by Serang Regency (141,298 heads; 30.3%) and Lebak Regency (82,946 heads; 17.8%) (CBS 2020).

Along with market demands, the production of corn continues to increase. In addition to direct consumption, the corn processing industry is also growing due to various commodities and processing products from corn, such as corn starch (carbohydrates), corn flour, corn oil, and artificial sweeteners (Rozi et al. 2023). The corn plant has a whole section, from pill corn to oilcake, which can produce various processed products such as animal feed, food industry raw materials, energy, and protein sources (Wang, Wu, and Li 2013; Yang et al. 2021).

In some situations, corn waste generated from processing can be mixed with other materials to make animal feed, including sheep, which is full of nutrients. These ingredients can include bone meal, fish meal, or soybean meal (Rosentrater et al.2005). One of the efforts to develop livestock is the provision of inexpensive feed and easily available throughout the year. One of the potential materials is corn plant waste. Waste refers to material discarded from human activities or natural processes lacking current economic worth and even have very small economic value. Corn crop waste is forage left over after harvesting corn. The most corn waste is corn stalks with a low level of digestibility. In contrast, corn husk is a waste with the smallest amount but has the highest digestibility compared to other corn wastes. Corn crop waste is harvested as soon as possible after the grain is removed before the residue loses water. Corn is considered a vital commodity in providing a source of carbohydrates for food, which will also be closely related to the development of the domestic livestock industry which is currently being pursued (Ardiana, Widodo, and Liman 2015).

Sheep farming is a traditional livestock business for farming communities in Banten and Indonesia and a side business that is useful as a source of income when farmers or the community need cash to fulfil household needs (Rusdiana and Praharani 2015). According to Gustimulyanti, Kuswaryan, and Hasni (2016), the mean annual income derived from sheep farming is IDR 7,148,375.10, involving an ownership scale of 11 mixed population or 8.11 Adult Sheep Equivalent (SDD). The proportion of income contributed by sheep farming to the overall income of farmers is 29.15%.

Sheep farming technology is an important factor that determines success in raising sheep, including feed technology, mating, health, and so on. One of the most relevant technologies developed in Banten is the integration of sheep and corn. The integration system for corn and sheep farming is a mutually beneficial farming and livestock system for corn and sheep. Corn plants can be used as feed for goats and sheep due to their leaf sheaths, fruit seeds, and husks. Corn cobs can be converted into biochar to increase soil fertility. Meanwhile, sheep manure and urine can be used as manure for corn plants. The study conducted by Kustyorini,

Krisnaningsih, and Santitores (2020) in Malang, East Java, indicated that administering sheep urine twice daily to hydroponic corn plants yielded optimal results in terms of plant height, leaf count, and the fresh yield of hydroponic corn fodder (Zea mays). The composition of sheep urine includes nitrogen (N), phosphorus (P), and potassium (K) with respective content percentages of 1.35%, 0.5%, and 2.10%. In a study conducted by Khan et al. (2017) on the impact of sheep manure on the vegetative and generative growth of corn in Pakistan, it was found that the application of 5 tons per hectare of sheep manure, administered 15 days before planting, led to a noteworthy enhancement in pre-tassel growth (stems and leaves) as well as physiological maturation processes (stems, leaves, cobs, and seeds). This also influenced dry matter partition, and there was a notable improvement in the harvest index. The founds from the research conducted by Arwinsyah, Tafsin, and Yunilas (2019) demonstrated that utilizing fermented corn cobs along with bio-activators had a substantial impact on the levels of crude protein and crude fibre, as well as on feed performance and digestibility.

The findings from the research conducted by Kusumastuti, Sarim, and Masyhuri (2015) in Deli Serdang Regency, North Sumatra, revealed that factors such as the quantity of mother sheep and goats, feed that got from oil palm plantations and intercrops, the type of livestock, and the l location exerted a significant influence on livestock productivity. The resulting manure output from sheep/goats amounted to 240 grams per unit of livestock per day or 87.6 kg per unit of livestock per year. In comparison, the demand for manure in corn cultivation is approximately 12 tons per hectare per year.According to Van de Vyver, Beukes, and Meeske (2014), focusing on Merino sheep in South Africa, providing silage diets with 20% and 50% dry content led to a greater dressing percentage compared to both the control diet and the 70% silage diet. This led to the conclusion that incorporating silage into sheep feed can be effectively implemented.

Linear Programming (LP) is a mathematical modelling approach extensively used for optimize the allocation of limited resources among competing demands, aiming to achieve optimal objectives (Asmara et al., 2019). The study of optimization models to support integration activities of sheep and corn crops is very important. This needs to be known so that policymakers can see the initial socio-economic conditions of farmers, the performance of corn farming and livestock and corn businesses, and the technological status of the farmers before the activities are carried out. Optimizing farmers' income using existing productivity and resource constraints.

1.1. Objective of study

The objectives of this study are: 1) to analyze the socio-economic performance of sustainable site-specific sheep-corn farming in Anyer District, Serang Regency, Banten Province, 2) to analyze the current income of farmers-breeders of corn-sheep in Anyer District, Serang Regency, and 3) to optimize the household income of farmers-breeders through the optimization of sustainable integration of sheep and corn.

2.0.Methodology

2.1. Data collection method, location, and time of study

The method used in this study is a survey method for primary data collection. Primary data collection at the farmer-breeder level was conducted by interviews using structured questionnaires. Sampling was carried out purposively to 85 respondents in Anyer District,

Serang Regency, Banten Province. This is because of the limited number of all sheep farmers in Anyer District as many as 208 people and corn farmers as many as 18 people (Singarimbun and Effendi, 1989). The site selection was carried out purposively because of the research activity "Optimization of Sustainable Site-Specific Sheep-Corn Integration Areas in Banten Province located in Anyer District which was chosen purposively . (Siagian et al. 2021)

In addition to the survey method, literature studies were also carried out through browsing the internet, as well as books and reports related to this research. Meanwhile, secondary data collection was obtained from agencies such as the Agriculture and Livestock Office of Banten province, the relevant District Agriculture Office, and the Central Bureau of Statistics of Banten Province. The study period is for eight months from May to December 2021. The scope of research is limited only to sheep and corn livestock and only in Serang Regency, Banten Province.

2.2. Analysis Method

The analysis of the data used both qualitative and quantitative methods. Descriptive statistics were utilized for qualitative analysis, while quantitative analysis involved B/C ratio analysis and LP. According to Devani (2012), the LP model incorporates two types of functions: the objective function and the constraint function. The objective function defines the goals in linear programming issues, aiming for an optimal allocation of resources to achieve maximum profit or minimum cost. Typically, the value to be optimized is denoted as Z. Linear programming (LP) is appropriate for designing resource optimization with a singular objective. As outlined by Siswati and Nizar (2012) and Nasendi and Anwar (1985), the LP approach comprises three quantitative elements: the objective function, the processes aimed at achieving the goal, and the constraints imposed by limited resources.The objective function is a mathematical representation that delineates the goals associated with the optimal allocation of resources, aiming for either maximum benefits or minimum costs. The typical format is expressed as follows (Noormalasari, Ikhsan, and Ferrianta 2020; Srilatha et al. 2022; Hemanatha, Jayasuriya, and Romy 2018; Supranto 1988; Mustapha, Hashim, and Hassan 2014).

$$Maximize: Z = \sum_{j=1}^{i} C_j X_j \quad (1)$$

$$with\ constraint: \sum_{i=1}^{r}\sum_{j=1}^{n} a_{ij} X_j \le b_i \quad (2)$$

$$and\ non-negative\ constraints\ X_j \ge 0 \quad (3)$$

for i	**=**	**1, 2, 3, …, r**
$and\ X_j > 0\ for$ j	=	1, 2, 3, …, n
or	$a_{11}X_1 + a_{12}X_2 + \cdots + a_{1j}X_j \le b_1$	(4)
	$a_{21}X_1 + a_{22}X_2 + \cdots + a_{2j}X_j \le b_2$	(5)
	$a_{i1}X_1 + a_{i2}X + \cdots + a_{ij}X_j \le b_j$ (6)	
Where:		
Z	=	Value to be optimized (Objective Function)
X_j	=	The decision or activity variable (which will be searched for, which is unknown)

for i	**=**	**1, 2, 3, …, r**
C_j	=	Coefficient of decision-making variables in the objective function (for this case is the value of income/ha for each farm and livestock)
a_{ij}	=	Technological coefficient of decision-making variables (activities that concerned with the constraint i)
b_i	=	Limited resources (example availability: land, seeds, fertilizers, pesticides, herbicides, labour, forages, vaccines, medicines)
$X_1, X_2, X_3 \ldots X_j$	> 0	(7)

For this case, the details are as follows:

Objective function: maximizing the income of sheep farmers:

$$Z = C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4 + C_5X_5 + C_6X_6 \quad (8)$$

With constraints:

$a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 + a_{15}X_5 + a_{16}X_6 \leq b_1$ ..... 9)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_2$ ..... 10)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_3$ ..... 11)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_4$ ..... 12)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_5$ ..... 13)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_6$ ..... 14)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_7$ ..... 15)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_8$ ..... 16)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_9$ ..... 17)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_{10}$ ..... 18)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_{11}$ ..... 19)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_{12}$ ..... 20)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_{13}$ ..... 21)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_{14}$ ..... 22)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_{15}$ ..... 23)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_{16}$ ..... 24)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 \leq b_{17}$ ..... 25)
and $X_1, X_2, X_3, \ldots Xj, \geq 0$ ..... 26)

In farming analysis, to calculate or evaluate the benefits of each cost incurred, Benefit Cost (B/C) ratio analysis is used. The farm is considered profitable when the B/C ratio exceeds 1, as indicated by Soekartawi (2002) and Suratiyah (2006). The equation is outlined as follows:

$$B/C = \frac{\Pi}{TC} \quad (27)$$

The value can be calculated as follows:

$$\Pi = TR - TC \quad (28)$$

$$TR = P_x * X \quad (29)$$

$$TC = P_i x Q_i \quad (30)$$

Where:

Π	=	**Farm income (IDR)**
TC	=	Total cost of farming (IDR)
TR	=	Total return of farming (IDR)
P_X	=	Price of farming output (IDR/kg)
X	=	Total farming output (kg)
P_i	=	Price of goods from the i-th input (example: Price of Urea, SP-36, etc.)
Q_i	=	The quantity of items used from the i-th input (example: amount of Urea, SP-36, etc.).

The available data underwent computerization for tabular analysis, and the B/C ratio was calculated using Excel software. Additionally, LP analysis was conducted using the QM for Windows 5.3 program.

3.0. Results and Discussion

3.1. Characteristics of respondent farmers and farming patterns

According to the findings from the survey, the respondents' average age is 46.8 years. The age spectrum ranges from a minimum of 20 years to a maximum of 80 years, with the majority falling within the 34.5–60 years bracket. The average household size is 4.3 individuals, with the range 1 person until 8 persons. The average formal education duration is 8.5 years, equivalent to grade 8, and the range extends from a minimum of 4 years to a maximum of 12 years.

Based on the area of arable land, the average area of cultivated land is 1.21 ha consisting of irrigated rice fields 0.47 ha, rainfed rice fields 0.42 ha, uplands 0.13 ha, plantations 0.18 ha, and yards 0.018 ha.

In general, the planting pattern in the typology of rainfed rice fields is rice–fallow (planting in January/February and harvesting in April/May). In contrast, the planting pattern in irrigated paddy fields adheres to a rice–rice–fallow sequence. The prevalent rice varieties include Inpari-32, Ciherang, Pandanwangi, and others, with a productivity range of 3-5 tons per hectare.On dry land, the planting pattern is corn–fallow. The corn planted area in 2020 is ± 150 ha and about 90% is cultivated by Panca Puri Company. The dominant corn varieties are NK-007, NK-212, among others, with a productivity of 1.25–5 tons of dry shells. The selling price of corn during the survey was IDR 5,000/kg and currently IDR 6,100/kg (factory price). Based on data from the Anyer Agricultural Extension Center (AEC), the total number of corn farmers is 18 people.

The number of sheep in Anyer District in 2021 is 1,300 heads from 208 breeders, while in Mekarsari Village there are 683 heads from 108 breeders. The sheep is entirely local/bean lamb. Maintenance by way of being released in the open (twisted). The price of sheep on Eid al-Adha ranges from IDR. 1.5 to 2 million for adults, IDR. 700,000 for juveniles and IDR. 250,000-400,000 for lamb. Sheep disease is generally diarrhoea and never treated. The ownership of sheep is relatively small, range 2-35 heads/household (HH). The feed consumed is generally local grasses and a small portion of forage (cultivated elephant grass).

3.2. Analysis of corn and sheep farming

As per the data in Table 1, the productivity of corn is 3,636.3 kg/ha, indicating a lower level of 31.0% decrease in comparison to the average productivity of Banten Province, which stands at 5.3 tons/ha (CBS 2020). The selling price of corn is relatively good, namely Rp. 3,636.6/kg dry shelled. Revenue IDR. 12.28 million so the income is IDR. 7.71 million/ha and the B/C ratio is 1.7, which means that corn farming is profitable. Cultivated corn land is generally on dry land. The dominant varieties are NK-212 and BISI-8. The area of corn cultivated in the 2020/2021 Rainy Season (RS) is 0.06 ha.

Table 1. Analysis of corn farming on RS 2020/2021 in District of Anyer, Serang Regency

No.	Input/Output Type	Amount	Price/unit (IDR/unit)	Value (IDR)
1	Seeds (kg)			
	a. certified seeds	41.7	531.8	22,158
2	Fertilizers(kg):			
	a. Urea	111.7	3,344.4	373,458
	b. SP-36	20.0	2,300	46,000
	d. ZA	10.0	3,000	30,000
	e. NPK Ponska	170.0	1,134.3	192,831
	f. Manure (kg)	46.7	16,639.3	776,501
	h. Organic fertilizer (ltr)	48.3	1,606.4	77,643
	g. other fertilizers (kg)	1.7	45,454.5	75,758
3	Solid Insecticide (kg)	3.3	3,874.3	12,914
4	Solid Herbicide (kg)	1.7	43,448.3	72,414
5	Others:			193,798
6	Labour Costs:			
	a. Hired labour (WMD)	10.7	58,727.273	625,969
	b. Family labour (WMD)	24.3	46,215.139	1,124,031
	c. Wage of Tractor service (IDR)	3.5	188,888.9	658,915
	d. Cost of Family Tractor (IDR).	0.6	500,001.13	29,0698
7	Total Cost			4,573,087.7
8	Revenue	3,636.6	3,377.6	12,282,945.7
9	Income			7,709,858.0
10	R/C			2.7
11	B/C			1.7

Source: Primary data that has been processed in 2021
Note: n = 85 respondents.

Corn productivity in Dry Season-I (DS-I) was 2,651.5 kg/ha, 27.1% lower than productivity in RS 2020/2021. The return generated from corn cultivation in the DS amount to IDR 9.77 million, while the total cost of IDR 6.9 million. Consequently, the income stands at IDR 2.85 million, and the B/C ratio of 0.4 indicates that this farming not profitable financially. The relatively small area of cultivated land for corn and the small number of farmers who cultivate it is the reason, because the area of land cultivated is limited, which is generally for lowland rice, most of the corn that is cultivated is on dry land/moor. In DS, farmers are generally given rainfed rice fields, left for sheep and buffalo grazing. The average arable area in the 2021 DS-I is 0.06 ha/family.

The current price of concentrate is IDR 3,000/kg at the farm level. The price of goat's milk is IDR. 12,000/bottle/200 ml. As can be seen in Table 3, the average sheep ownership was 5.4 heads/HH with a range of 0-18 heads last year with an average value of IDR 0.85 million/HH, and the current average ownership is 4.9 heads with a range of 0-59 heads and a selling price of IDR. 1.01 million/head. The whole sheep are local sheep or Javanese sheep. Sheep are generally released into grazing fields, namely fallow land for rice farming and dry land.

In more detail, the total adult male sheep managed last year was an average of 1.21 heads/ HH consisting of 1.18 heads of own and 0.03 heads of goats/HH. Meanwhile, the current number has been reduced to 0.85 head/HH, due to being sold. The selling value of adult rams is an average of IDR 1.62 million/HH.

The total adult ewes last year averaged 2.42 heads/HH consisting of 2.3 heads of own and 0.12 tails/HH. The current total of female adult sheep is 1.83, consisting of 1.81 owned by self and 0.02 head of the row. The selling value of an adult female sheep is IDR 2.1 million/HH.

The average number of sheep ownership is 5.4 heads/household with a value of IDR 4.31 million. The total expenditure for breeding sheep is IDR 484,000 which consists of expenses for feed (52.1%), medicine and AI (0.0%), and labour (43.9%). The revenue from sheep farming comes from the sale of breeding sheep, which is IDR. 1.51 million/RS and the income is IDR. 1.02 million/RS and the value of a B/C ratio of 2.1, each additional IDR 1 expenses cost in sheep livestock business is increase in an income of IDR 2.1. This indicates that the sheep livestock business is profitable financially (see detail in Table2).

Table 2. Analysis of sheep livestock in Anyer District, Serang Regency on Rainy Season (RS) 2020/ 2021

No	Input/Output Type	Sum	Price/Unit (IDR/Unit)	Value (IDR)
1	Livestock Ownership:			
	a. adult ram	1.2	1,349,221.6	1,632,558.1
	b. Sheep	2.5	690,365.4	1,691,395.3
	c. Young Ram	0.6	581,407.2	343,030.2
	d. Young Ewe	0.8	557,543.2	434,883.7
	e. Male lamb	0.4	335,548.2	117,441.9
	f. Sheep cub	0.4	265,780.7	93,023.3
	Sheep Total	5.4	801,548.8	4,312,332.6
2.	Expenditure:			
3.	Animal feed			
	a. Forage	566.5	95.8	54,282.4
	b. Concentrate	1.5	121,833.3	182,117.6
	c. Other plants	2.9	5,487.8	15,882.4
4.	Medicines			
	a. Vitamins	0.02	50,000	1,162.8
	b. Medicines	0.01	500,000	5,813.95
	b. Vaccination	0.03	75,000	2,616.28
	c. Others			1,162.8
	d. Breeding tools			2,383.7
5.	Artificial Insemination	0.01	500,000	5,882.35

No	Input/Output Type	Sum	Price/Unit (IDR/Unit)	Value (IDR)
6.	Rent Labour Cost	17.0	12,524.0	21,261.3
7.	Total expenditure on breeding Sheep			483,921
8.	Revenue			
	A. Sales of female adult breeding sheep	0.2	1,892,105.3	422,941.2
	B. Sales of male adult breeding sheep	0.4	2,366,666.7	835,294.1
	C. Sales of young ewe breeding sheep	0.11	550,000.0	58,235.3
	D. Sales of young ram breeding sheep	0.14	1,041,666.7	147,058.8
	E. Sales of sheep breeding female	0.04	383,333.3	13,529.4
	F. Sales of male lamb-breeding sheep	0.05	63,7500	30,000
9.	Total revenue			1,507,058.8
10.	Income			1,023,138.3
11.	R/C			3.1
12.	B/C			2.1

Source: Primary data processed, 2021
Note: n = 85 respondents.

From the analysis of livestock businesses with the same sheep ownership, namely 5.4 heads/HH. The total expenditure was lower at IDR. 208,600. This is because there are no costs for medicines, namely vitamins, medicines, vaccines, AI, and forage feeds. During the corn harvest season, by-products such as straw and corn husks can be used as feed. Corn biomass can be fed directly as fresh forage or processed to increase digestibility and shelf life. The utilization of corn biomass will reduce production costs and increase income. The total revenue was lower at IDR. 423,529, which came from the sale of male adult breeding sheep ,and total expenditure of sheep breeding is IDR. 208,592. The income from this livestock business is IDR. 214,937.1 with a B/C ratio of 1.0, meaning that the sheep slag business is profitable.

As stated by Bahar (2016), the management of corn straw to serve as ruminant animal feed has the potential as an alternative source of feed other than grass, especially in areas with a dry climate with a long dry season. In addition, corn cobs that are processed simply by using silage or ammonia methods can be applied to increase feed sources, especially during the dry season when forage production decreases. Ammonified corn cobs can replace the provision of fresh elephant grass to sheep as indicated by an increase in body weight gain and an improvement in FCR (Yulistiani, Puastuti, and Wina 2021). The utilization of corn biomass will reduce production costs and increase income. The total revenue was lower at IDR. 423,529, which came from the sale of male adult breeding sheep. The income from this livestock business is IDR. 214,937.1 with a B/C ratio of 1.0, meaning that the sheep livestock business is profitable.

3.3. Farmer/Breeder Household Income

Farmer/breeder household (HH) income comes from income from farming/livestock business (on-farm), income from outside the farm but still within the scope of agriculture (off-farm), and non-farm. The total income of farmers/breeders in the survey area is IDR. 24,167,466.3/year which consists of non-farm income accounted IDR. 14,462,558.1/year (59.8%), and income on the farm of IDR 9,704,908.1/year (40.2%). The detailed analysis of the household income of farmers/breeders is showcased in Table 3.

Table 3. Analysis of farmer/breeder household income in Anyer District on 2021 year

Type of Business	Revenue (IDR)	Total Cost (IDR)	Income (IDR)	% Total Income
On-farm Income:				
Corn farming_RS	736,976.7	202,674.4	534,302.3	
Corn farming_DS-I	587,209.3	348,000.0	239,209.3	
			773,511.6	3.2
Rice farming_RS	7,537,864.0	1,429,419.6	6,108,444.3	
Rice farming_DS-I	1,059,418.6	243,604.8	815,813.8	
			6,924,258.2	28.6
Other faming_RS	0.0	0.0		
Other farming_DS-I	295,639.5	13,953.5	281,686.0	1.2
Total income from Farming			7,979,455.9	33.0
Sheep breeding business_RS	423,529.4	207,764.7	215,764.7	
Fattening sheep business_RS	1,930,588.2	688,458.8	1,242,129.4	
Sheep breeding and fattening business_DS	203,488.4	51,162.8	152,325.6	
Total income from livestock	2,134,076.6	739,621.6	1,610,219.7	6.7
Total Income from farming and livestock			9,589,675.6	
Total Income of farming labour			115,232.6	
Total income on the farm			9,704,908.1	40.2
Non-farm Income:				
Vendors			13,008,837.2	53.8
Non-farm laborer			1,453,720.9	6.0
Total income non-farm			14,462,558.1	59.8
Household total income			24,167,466.3	

Source: Primary data processed, 2021

The largest non-farming income was from the trading business, which was IDR. 13,008,837.2/year (53.8% of total income) and the rest was from non-agricultural workers, which was IDR. 1.45,3720.9/year (6.0% of total income). This trading business is carried out by respondents, especially on Sundays and holidays in the tourist area of Anyer Beach which is only 0 – 11.6 km from the survey location. Meanwhile, non-agricultural workers are generally construction workers and motorcycle taxis.

The income from farming is IDR. 7,979,455.9/year which consists of rice farming of IDR. 6,924,258.2/year (28.6% of total household income) and the second is corn farming of IDR. 773,511.6/year (3,2%) while the smallest of other farming businesses such as cucumbers, beans, etc. is IDR. 281,686/year (1.2%). The livestock business provides an income of IDR. 1,610,219.7/year (6.7%) which is the second largest income from on-farm income.

3.4. Income optimization model for sustainable corn and sheep farmers in Banten Province

Linear Programming (LP) is one way to generate optimization. The model used for maximizing the income of farmers in Serang Regency, Banten Province is described in Table 4.

Table 4. Income maximization model for farmers in Serang Regency, Banten Province

,	X_1	X_2	X_3	X_4	X_5	X_6	RHS
Maximize	534,302.3	239,209.3	610,844 5	815,813.8	215,764.7	1,242,129	
Constraint 1	114	57	901.1	150.2	0.05	0.05	1,381
Constraint 2	41.7	37.5	0	0	0	0	10,050
Constraint 3	0	0	25	25	0	0	45,000
Constraint 4	0	0	0	0	2.5	2.5	2,000
Constraint 5	111.7	139.3	123	166.9	0	0	300,000
Constraint 6	20	18.3	42.7	106.9	0	0	17,100
Constraint 7	10	9.3	3.4	18.7	0	0	8,550
Constraint 8	170	106.9	65.3	83.5	0	0	244,460
Constraint 9	48.3	38.9	25.2	46.5	0	0	8,550
Constraint 10	46.7	28.5	104.8	261.1	0	0	42,750
Constraint 11	10.7	61.6	7.6 9.4 0	9.8 17.8	17 0	17 0	405,540
Constraint 12	24.3 0	19.4 0 0	0 0 0 0	0 0 0 0 0	566.5	566.5	0
Constraint 13	0 0 0 0	0 0 0			1.5 0.02	1.3 0	405,540
Constraint 14					0.01 0.1	0.01 0.1	0
Constraint 15							20,000
Constraint 16							3,700 5
Constraint 17							5 25

Source: Primary data processed, 2022.

The explanation of Table 6 is as follows:

$$Maximum: Z = 534{,}302.3\,X_1 + 239{,}209.3\,X_2 + 6{,}108{,}445\,X_3 + 815{,}813.8\,X_4 + 215{,}764.7\,X_5 + 1{,}242{,}129\,X_6$$

The Z value is the optimum value of the income of the farmers-breeders to be sought.

Description of the objective function as follows:

a.	X_1	**:**	**the value of IDR 534,302.3/ha is obtained from corn farming income in Rainy Season (RS) 2020/2021**
	X_2	:	the value of IDR 239,209.3/ha is corn farming income in Dry Season-I (DS-I) 2021
	X_3	:	the value of IDR 6,108,445/ha is lowland rice farming income in RS 2020/2021
	X_4	:	the value of IDR. 815,813.8 is lowland rice farming income in DS-I 2021
	X_5	:	the value of IDR. 215,764.7 is the income of the sheep breeding business in RS 2020/2021
	X_6	:	the value of IDR. 1,242,129 is income from livestock business fattening sheep on RS 2020/2021

With constraint (bi):

b_1	:	**Availability of land (Ha)**
		$114X_1 + 57X_2 + 901.1X_3 + 150.2X_4 + 0.05X_5 + 0.05X_6 \leq 1381$
		▪ The value of 114 ha is the planted area of corn in RS 2020/2021 in Anyer District, Serang Regency
		▪ The value of 57 ha is the planted area of corn in DS-I 2021 in the Anyer District
		▪ The value of 901.1 ha is the planted area of lowland rice in RS 2020/2021 in Anyer District
		▪ The value of 150.2 ha is the planted area of rice fields in DS-I 2021 in Anyer District
		▪ The value of 0.05 ha is the area of the sheep pen on RS 2020/2021 in Anyer District
		▪ The value of 0.05 ha is the area of the sheep shed in the DS-I 2021 in the Anyer District
		▪ Value of 1,381 ha is land availability or Right-Hand Side (RHS)
b_2	:	Availability of corn seeds (kg)
		$41.7X_1 + 37.5X_2 \leq 10{,}050$
		▪ The value of 41.7 kg is the average use of hybrid corn seeds per ha in RS 2020/2021
		▪ The value of 37.5 ha is the average use of hybrid corn seeds in DS-I 2021
		▪ The value of 10,050 is the availability of corn seeds (RHS), obtained from a planted area of 201 ha and use of seed 50 kg/ha
b_3	:	Availability of rice seeds (kg)
		$25.0X_1 + 25.0X_2 \leq 45{,}000$
		▪ The value of 25 kg is the average use of paddy rice seeds per ha in RS 2020
		▪ The value of 25 kg is the average use of paddy rice seeds per ha in DS-I 2021
		▪ The value of 45,000 kg is the availability of rice seeds (RHS), obtained for the assumption of the planting area of 1200 ha in 2021 with an average seed use of 37.5 kg/h
b_4	:	Availability of lamb seeds (tail)
		$2.5X_5 + 2.5X_6 \leq 2{,}000$
		▪ The value of 2.5 heads is the average ownership of female ewes in RS 2020/2021
		▪ The value of 2.5 heads is the average ownership of female ewes in DS-I 2021
		▪ The value of 2,000 heads is the value of the availability of sheep seeds (RHS), it is assumed that there are sufficient sheep seeds for 208 farmers
b_5	:	Availability of Urea fertilizer (kg)
		$111.7X_1 + 139.3X_2 + 123X_3 + 166.9X_4 \leq 300{,}000$
		▪ The value of 111.7 kg is the average use of Urea/ha fertilizer in corn farming in RS 2020/2021
		▪ The value of 139.3 kg is the average use of Urea in corn farming in DS-I 2021
		▪ The value of 123 kg is the average use of Urea in lowland rice farming in RS 2020/2021
		▪ The value of 166.9 kg is the average use of Urea in lowland rice farming in DS-I 2021
		▪ The value of 300,000 kg is the value of Urea availability (RHS) because non-subsidized Urea fertilizer is available in the required quantity assuming a maximum use of 250 kg/ha for the area planting 1,200 ha
…….		
b_{17}	:	Availability of sheep farming land (ha)
		$0.1X_5 + 0.1X_6 \leq 25$
		▪ The value of 0.1 ha is the area of barn land from the average livestock ownership of 5.4 sheep/family in RS 2020/2021 (from survey results)
		▪ The value of 0.1 ha is the area of barn land from the average livestock ownership of 5.4 sheep/head in DS 2021 (from survey results)
		▪ The value of 25 ha is the availability of sheep cattle land (RHS) from the survey results

From the findings in Table 5, it can construe that the optimal household income for farmers and breeders in the Serang Regency is IDR 53,214,370 per year which is obtained from the planting area of lowland rice in RS 2020/2021 covering an area of 1.53 ha and sheep farming as much as 35.3 heads.

Table 5. Results of maximizing the income of farmers-breeders in Banten Province

	X_1	X_2	X_3	X_4	X_5	X_6	RHS
Maximize	534,302.3	239,209.3	6,108,445	815,813.8	215,764.7	1,242,129	
Constraint 1	114	57	901.1	150.2	0.05	0.05	1,381
Constraint 2	41.7	37.5	0	0	0	0	10,050
Constraint 3	0	0	25	25	0	0	45,000
Constraint 4	0	0	0	0	2.5	2.5	2,000
Constraint 5	111.7	139.3	123	166.9	0	0	300,000
Constraint 6	20	18.3	42.7	106.9	0	0	17,100
Constraint 7	10	9.3	3.4	18.7	0	0	8,550
Constraint 8	170	106.9	65.3	83.5	0	0	244,460
Constraint 9	48.3	38.9	25.2	46.5	0	0	8,550
Constraint 10	46.7	28.5	104.8	261.1	0	0	42,750
Constraint 11						17 0	405,540
Constraint 12					17 0 566.5	566.5	405,540
Constraint 13					1.5 0.02	1.3 0	20,000 3,700
Constraint 14	10.7 24.3 0	61.6 19.4 0	7.6 9.4 0 0	9.8 17.8 0	0.01 0.1 0	0.01 0.1	5 5 25
Constraint 15	0 0 0 0	0 0 0 0 0	0 0 0 1.53	0 0 0 0 0		35.3	53,214,370
Constraint 16							
Constraint 17							
Solution							

Source: Primary data processed, 2022.

Based on Zenis, Supian, and Lesmana (2018), the results of the analysis showed that 135,314 hectares of land were used for rice fields, 11,798 hectares for corn, 2,290 hectares for soybeans, and 2,818 hectares for peanuts, with farmers' income of 2,682,020,000,000 per year.

Based on Table 6, which is to find out which resources are used optimally or not yet optimally, only land resources (slack $1/b_1$) and forage resources (Slack $13/b_{13}$) have been fully utilized (not excessive), other than that they are still in excess. Corn seed resources (Slack 3) are still over 10,050 kg, Urea fertilizer resources (Slack 5) are still over 299,811.5 kg, and so on.

Table 6. Optimization of resources/inputs used for sheep-corn business integration

Variable	Status	Value
		0 0 1.53 0 0 35.3 0
X_1 X_2 X_3 X_4 X_5 X_6 Slack 1 Slack 2	Non-Basic Non-basic Basic Non-	10,050 44,961.69
Slack 3 Slack 4 Slack 5 Slack 6	Basic Non-Basic Basic Non-Basic	1,911.74 29,9811.5
Slack 7 Slack 8 Slack 9 Slack 10	Basic Basic Basic Basic Basic	17,034.56 8,544.79
Slack 11 Slack 12 Slack 13 Slack	Basic Basic Basic Basic Basic	299,899.9 8,511.38
14 Slack 15 Slack 16 Slack 17	Basic Non-Basic Basic Basic Basic	42,589.39 404,838.2
Optimal Value (Z)	Basic	405,435.6 0 3,654.1 5
		4.65 21.47 53,214,370

Source: Primary data processed, 2022.

3.5. Sensitivity analysis

The analysis is used to determine the extent of the sensitivity of a model to changes that occur in the coefficient of the objective function (variables $X_1, X_2, X_3, X_4, X_5, and\ X_6$ and resource capacity. If the change is still within the lower boundary and the upper boundary, it is not a problem because it does not change the optimal value (Z) and vice versa.

Based on Table 7, it is known that corn farming income in RS 2021/2021 (X_1) decreases to infinity and increases to IDR. 772,791.9, it will not affect the optimum value (Z) which is IDR. 53.21 million. Likewise, corn farming income in DS-I 2021 (X_2), which is IDR. 239,209.3, if it decreases to infinity and increases to IDR. 386,395.9, it will not affect the optimum income (Z). In lowland rice farming income in RS 2020/2021 (X_3), which is IDR. 6108445, if it decreases to IDR. 4894340.0 and increases to infinity, it will not affect the optimum value (Z) or optimum income. In lowland rice farming income in DS-I 2021 (X_4), if it decreases to infinity and increases to IDR. 1018187.0, it will not affect the optimum income. The income value of breeding sheep in RS 2020/2021 (X_5) if it decreases to infinity and increases to a maximum of IDR. 1,242,129, then the optimum income value (Z) does not change. The value of sheep fattening business income in RS 2020/2021 (X_6) decreased to IDR. 215764.7 and increased to infinity, the optimum income value of IDR. 53.21 million did not change.

In the constraint of land resources, namely 1,381 ha, if the area decreases to 1.77 ha and increases to 305,732.1 ha it will not affect the optimum value. In the corn seed resource, which is 10,050 tons, if it decreases to 0 ha and increases to infinity, it will not affect the optimum value (Z). Likewise, the availability of concentrate resources (constraint 14) is 3,700 kg, if it decreases to 45.9 kg and increases to infinity, it will not affect the optimum value (Z). The details are described in Table 7.

Table 7. Sensitivity analysis of integration optimization of sheep-corn farming in Serang Regency on the 2021 year

Ranging Variable	Value	Reduced	Original Value	Lower Boundary	Upper Boundary
			534,302.3		772,791.9 386,395.9
			239,209.3		Infinity
		238,489.5 147,186.6	6,108,445	-Infinity -Infinity	1,018,187.0
		0 202,373.3	815,813.8	4,894,340.0 -	1,242,129 Infinity
	0 0 1.53 0 0	1,026,364.0 0	215,764.7	Infinity -Infinity	Upper Bound
X_1 X_2 X_3 X_4	35.3 Dual	Slack/Surplus 0	1,242,129	215,764.7 Lower	305,732.1 Infinity
X_5 X_6 1 2 3	Value	10,050 44,961.73	Original Val	Bound 1.77 0	Infinity Infinity
4 5 6 7 8 9 10	6,778.88 0 0 0	1,911.74 299,811.8	1,381 10,050	38.27 88.26	Infinity Infinity
11 12 13	0 0 0 0 0 0 0 0	17,034.64 8,544.8	45,000 2,000	188.25 65.36 5.2	Infinity Infinity
14 15 16 17	2,192.04 0 0 0	299,900.1 8,511.43	300,000 17,100	99.94 38.57	Infinity Infinity
	0	42,589.59 404,838.2	8,550 300,000	160.41 611.81	Infinity Infinity
		405,435.6 0 3,654.1	8,550 42,750	14.38 0 45.9 0 .35	141625 Infinity
		5 4.65 21.47	405,450	3.53	Infinity Infinity
			405,450 20,000		Infinity
			3,700 5 5 25		

Source: Primary data processed, 2022.

The Reduced Cost value shows the magnitude of the reduction in income if one of the variables is forced to work. If the value of lowland rice farming in RS 2020/2021 (X_3) and fattening

sheep in RS 2020/2021 (X_6) is added to one unit, it will not reduce income. If the value of corn farming in RS 2020/2021 is added by one unit, it will reduce income by IDR. 238489.5/ha. Also, if the value of corn farming in DS-I 2021 (X_2) is added by one unit, the value of corn farming income is reduced by IDR. 147186.6. Likewise, if the value of rice farming income in DS-I 2021 (X_4) is added by one unit, the value of income will be reduced by IDR. 202373.3/ha. The same is true for the value of the sheep breeding business in RS 2020/2021 (X_5) plus one unit, the income value of the breeding sheep business will be reduced by IDR. 1,026,364/RS.

The value shows the optimal combination of lowland rice planting area in RS 2020/2021 which is 1.53 ha and the number of fattening sheep in RS 2020/2021 which is 35.3 heads to obtain optimum income. Based on the research results of Hemanatha, Jayasuriya, and Romy (2018) in Nepal the optimal combination of livestock integration with food crops (rice and corn) obtained for small farming is rice 0.17 ha, corn 0.22 ha, feed crops 0.04 ha, buffalo 1 LU (Livestock Unit), goat 4 LU (16 individuals), with a Gross Return of 53,059.50 NRs. While for medium farming are rice 0.28 ha, corn 0.5 ha, feed crops 0.08 ha, buffalo 2 North Latitude, goats 4 South Latitude with a Gross Return of 66,711.84 NRs. The study of Igwe and Onyenweaku (2013) in Abaia State, Nigeria determined that the optimal income of 374,850.80 Naira was obtained from the production of a mixture of exactly 0.31 hectares of cassava/corn/melon, 0.33 hectares of cassava/corn/cocoyam and 1.30 hectares of cassava/corn/melon/mucuna floanei while 0.14 of 500 (70.00) of broiler II, 0.11 of 1000 (110.00) of fish II and 0.07 of 15 pigs (1.05).

Conclusions

The corn crop productivity in RS 2021 was 3.63 tons of dry shelled/ha and in DS-I 2020 2.65 tons of dry shelled/ha with B/C ratio values of 1.7 and 0.4, respectively. The dominant varieties are NK- 007, NK-21, and BISI-8. The average arable area for RS and DS is 0.06 ha/family. The average number of sheep ownership last year was 5.4 heads/HH and this year is 4.9 heads/HH. The income from sheep farming in RS is IDR. 1,023,138/RS with a B/C ratio of 2.1, while in DS-2021 the income from livestock business is IDR. 214,937/DS.

Farmer/breeder household income IDR. 24,167,466.3/year which consists of non-farm income, which is IDR. 14,462,558.1/year (59.8%) and on-farm income IDR. 9,704,908.1/year (40.2%). The income from non-livestock farming is IDR. 7,979,455.9/year which consists of rice farming of IDR. 6,924,258.2/year (28.6%) and the second is corn farming of IDR. 773,511.6/year (3.2%) while the smallest of other farming businesses such as cucumbers, beans, etc., is IDR. 281,686,0/year (1.2% of total household income). The livestock business provides an income of IDR. 1,610,219.7/year (6.7%) which is the second largest income from farming income (on farm).

The optimum value of income for farmers-breeders is IDR. 53,214,370 which is obtained from the rice planting area of RS 2020/2021 of 1.53 ha and sheep livestock of 35.3 heads. Based on sensitivity analysis if the income of lowland rice farming in RS 2020/ 2021 (X_3), decreases to IDR 4,894,340 and increases to infinity will not affect the optimum value (Z). Likewise, if the income value of the fattening sheep business in RS 2020/2021 (X_6) decreases to IDR. 215,764.7 and increases to infinity, the optimum income value does not change.

Limitations

This study has several limitations, namely the number of corn farmers, the area of cultivation, and the number of sheep ownership is relatively small. The scope is also limited, namely in Anyer District, Serang Regency, Banten Province. In future research, it is expected to be examined on the theme of plant integration with livestock (corn with goats and cows) with a wider scope, namely the province or country, especially from the Collaborative Innovative Research and Development project carried out in 2021.

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