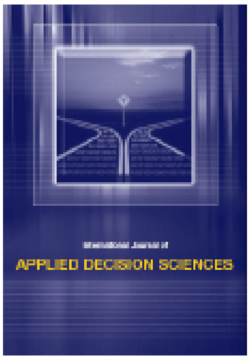

International Journal of Applied Decision Sciences

ISSN online: 1755-8085 - ISSN print: 1755-8077
https://www.inderscience.com/ijads

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DOI: 10.1504/IJADS.2022.10043339

Article History:

Received:	04 May 2021
Accepted:	04 September 2021
Published online:	22 December 2022

Decision support system for the feasibility of investment in the virgin coconut oil agro-industry

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Abstract: The agro-industry faces investment challenges when natural datasets and economic analyses are not taken into consideration. Investing in the processing of coconut to virgin coconut oil (VCO) also represents a substantial opportunity under Agriculture 4.0. This paper presents a decision support system that enables a decision-based investment on new VCO agro-industries. It involves improving the management system, which was observed in several aspects before investing. The method combines natural data with economic analysis, which involves spatial analysis, location quotient, capacity production planning, and financial analysis. Four case studies were used to determine the feasibility of VCO investment, with the selected potential area being Pariaman District, West Sumatera, Indonesia. Despite its shortcomings, this DSS program facilitates accurate and fast decisions for the investor. However, the program is in need of future improvements to be able to become a completely online application without overlays.

Keywords: decision support system; feasible investment; virgin coconut oil; VCO; agro-industry; capacity production planning.

Reference to this paper should be made as follows: Meilizar, Luthvina, R., Oktavia, N. and Putranesia (2023) 'Decision support system for the feasibility of investment in the virgin coconut oil agro-industry', *Int. J. Applied Decision Sciences*, Vol. 16, No. 1, pp.42–66.

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1 Introduction

The coconut is a significant component of the vegetation of the tropics and semi-tropics. Every part of the coconut is processed to make value-added products, like processing the endosperm (kernel) to virgin coconut oil (VCO) (Ignacio and Miguel, 2021; Srivastava et al., 2018). The diversity of coconut populations is identifiable with specific dispersed ethnic especially across Southeast Asia and the Pacific. Hence, the genetic improvement of the coconut by the primary objective to increase oil production and economic profitability of the coconut plantations has begun in the industrial sector. It will enable the farmers and the industry to join hands in sustaining the coconut in the global market (Nair, 2010; Nadaraja et al., 2021).

Headway in science and technology has been making it easy in processing yields of coconut agriculture. Although selecting area, processing, and product marketing should properly be planned before the agro-industry is started. Agriculture 4.0 puts forward four essential requirements: increasing productivity, allocating resources reasonably, adapting to climate change, and avoiding food waste (Zhai et al., 2020; Teixeira et al., 2019; Bueno et al., 2020). Usually, the stakeholders and farmers may encounter difficulties in making proper decisions about agricultural management, and it is challenging for them to transfer these data into practical knowledge (Taechatanasat and Armstrong, 2014). Thus, they need assistance in making evidence-based and precise decisions, which are called DSS. The DSS is a computer-based support system for decision-makers to improve the quality of decisions, collect, process, provide information, and manage decision-making activities based on a computer (Sheng and Zhang, 2009; Terribile et al., 2015; Yazdani et al., 2017). The DSS has been widely applied in agriculture to address complex issues and maintain profitability in crop production (Alenljung, 2008), such as:

1 improve farm management and development of smallholder-oriented policies (Ali et al., 2020; Sofiyuddin et al., 2021)

2 applies crop cultivation management to enhance comprehensive quality (Wang et al., 2021)

3 select a suitable logistic service provider (Sarabi and Darestani, 2021)

4 manage fertilisation for agriculture area (Pahmeyer et al., 2021)

5 agricultural supply-chain management (Gardas et al., 2019).

The agro-industry is necessary to classify the suitable land and crops type. Rank factor and land quality specify appropriate land characteristics with crop requirements (Rossiter, 1996). Specific requirements for the lands' quality associate with geographic phenomena and their attributes. Geographic information system (GIS) is a tool for data input, storage, retrieval, manipulation, analysing and output spatial data (Marble et al., 1984), and the spatial analysis will classify the suitable lands (Esri, 2001). Hence, the stakeholder can interpret soil qualities and site information for agriculture usage and management practices (Rossiter, 2009). Likewise, it protects natural resources by deciding the land use according to its potential. Agriculture land use planning and identification should be analysed and evaluated rationally about soil and land resources (Özkan et al., 2020). Applying the spatial analysis towards crop improvement also help the farmer disseminate varieties for cultivation, and will increase the efficiency of testing and deployment of genotypes (Hyman et al., 2013). Arguably, a land suitability analysis is a prerequisite for sustainable agricultural production (Debesa et al., 2020).

Industrial sector development should predict the potential area of raw material and the percentage of employment (Page and Patton, 1991; Yin et al., 2020). The location quotient (LQ) is a method to make corporations as inter-regional economic parameters by searching high numbers absorb workers locations. Suitable location for corporation development must qualify with LQ > 1. The LQ method can calculate the leading sector to develop an industry (Billings and Johnson, 2012). It may spur and lift the growth of raw materials sectors for the industry (Darmanto et al., 2014).

Moreover, capacity planning can specify the number of tools or equipment size. Of course, people will operate and observe tools and equipment. Therefore, capacity planning is decided by raw material, demand, processing time, and production scheduling (Teerasoponpong and Sopadang, 2021; Hazeltine, 2003). Production planning and supply chain management determine an innovative growth of entrepreneurship in the industry, the possibilities of selling industrial products, and the effectiveness of industrial entrepreneurship (Bogoviz et al., 2021). Production planning may depend on production time with dynamic demands (Han et al., 2019). It is a long-term strategic decision class that seek to meet customer demand at minimum cost/maximum profit (Santander et al., 2020). The planning approach only considers demand items and without capacity requirements. However, improvement in process planning should consider the consumption item that involves a capacity requirement (Jodlbauer and Strasser, 2019; Vazquez et al., 2021). Therefore, the coconut processing capacity estimation aids the future sales policy to support the production planning of the supply chain (Limpianchob, 2017).

The interaction between user and system to obtain feasibility value of industrial business refer to inflow, outflow, and cash flow, which is processed by the financial analysis method. Hence, the decision-making process of every industrial business requires a key role in financial analysis. Valuable information about financial state, performance and changes in the financial state is most necessary. The companies must own financial analysis to evaluate their economic performance to obtain the best conclusion of the past, present and future situation (Shkodra et al., 2011; Trusova et al., 2021). Five financial analysis indicators are presented to evaluate the future financial performance of the new establishing VCO industry, such as:

1 net present value (NPV) is a measure of a project's economic feasibility
2 internal rate of return (IRR) represents profitability potential
3 break-even point (BEP) or the capital turning point
4 payback period (PBP)
5 profitability indicator or B/C-ratio.

The DSS application aids the new VCO industry establishment. It is known as an interactive computer system to facilitate industrial management against the complex decision-making process at the level of the user with experts' knowledge (Druzdzel and Flynn, 2012). The agriculture sector had applied this method to support precision information and provide feedback to stakeholders, including farmers, advisers, researchers and policymakers (Gutierrez et al., 2019). Where, management aspect of land resources utilises the advantage of DSS, which combines with GIS to form a hybrid type of decision support (Li et al., 2020). This research proposes the decision support system for continuity of the new establishing VCO agro-industry. The result shows the feasibility of the newly established VCO industry including business risk indicators. The remainder of this arranging paper is as follows. Section 2 stated the VCO investment decision-making problem. The explanation of an optimising method of DSS for VCO investment is in Section 3. In Section 4, experiment results of the DSS application have been verified and tested with four study cases. Section 5 is result discussion. Finally, the conclusions are in Section 6.

2 Problem statement

VCO is a value-added coconut processing product which is commonly a raw material in the health and cosmetics industries. It promises well for the development of the VCO agro-industry at Pariaman districts with their coconut cultivation. However, the agro-industry supply chain is one of the issues. Investors should evaluate before embarking on VCO agro-industry development efforts. The importance of an integrated decision-making system is due to the complexity and uncertainty in the agro-industry supply chain. Typically, each supply chain stakeholders make decisions, such as farmer decisions on coconut growing acreage, processing industry decisions on the production method, and marketing decisions by marketing players.

Generally, the financial analysis method calculates feasibility investment. And the investment profitability is analysed utilising NPV and BCR to verify the performance and cost evaluation of a power plant (Abdelhady, 2021). Then, Reniers et al. (2016) use IRR and PBP for safety investment. Likewise, Pranadi et al. (2019) use the NVP and IRR method for economics analysis of selected feeder optimum location. Instead, the investment in agro-industry is affected by the plantation area for raw material availability, worker, process production and profit (Qian, 2021). Therefore, this paper adopted spatial analysis, LQ method, capacity planning, production planning, and financial analysis methods to enhance the performance of IDSSVCO.

As a result, developing the VCO agro-industry requires a decision-making framework involving site selection through profit calculation in VCO marketing. This approach of decision-making is crucial for encouraging investors to invest in the VCO agro-industry's development. This system will include:

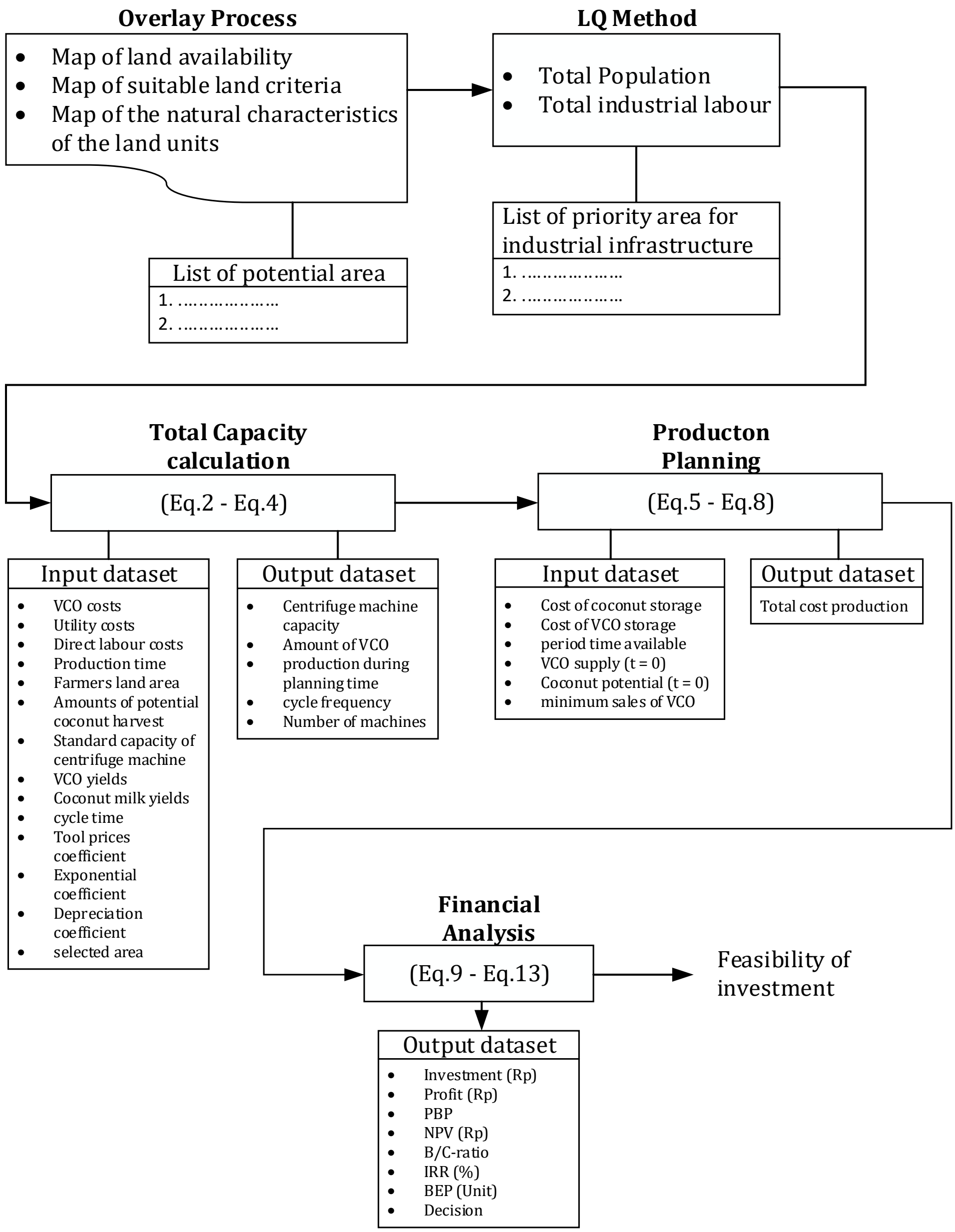
1. the selection of feasible land, which will involve a field study
2. the positioning of industrial infrastructure can absorb a considerable amount of labour (Nolte and Ostermeier, 2017)
3. calculate the design capacity based on the area, which calculates the number of machines, processes and products
4. calculate the overall cost of manufacturing concerning the production design
5. assess the financial value of the VCO investment criterion and determine whether the investment is feasible
6. investor decision-making.

The IDSSVCO provides a report on raw materials available throughout the production process. So that investors may perceive the potential for profit on the investment benefits they receive.

3 Optimising decision making to develop new VCO agro-industry

The goals of the DSS was presented in Section 1. Illustration to develop the industrial use of VCO involves several aspects, such as raw data from the credible institution, method and analysis, government policy, and cooperation between farmers and enterprise. Figure 1 shows the DSS framework to develop new VCO industries. The first stage is an overlay process of raw data from the Center for Agricultural Land Resources, Indonesian Ministry of Agriculture (Ritung et al., 2011; Wahyunto et al., 2016; Bapelitbangda, 2019; Government Office of Pariaman, 2019). An overlay process generates data of potential areas for coconut plantations at the Pariaman district of West Sumatera, Indonesia. The second stage decides an infrastructure location for VCO agro-industry by the LQ method, which considers worker availability in that area. The third stage is capacity planning aims to reduce production costs over the machine and raw material. The fourth stage is production planning, which aims seek to meet customer demand. The fifth stage aims to decide and evaluate feasibility of the investment.

Figure 1 The DSS framework for the VCO industrial planning



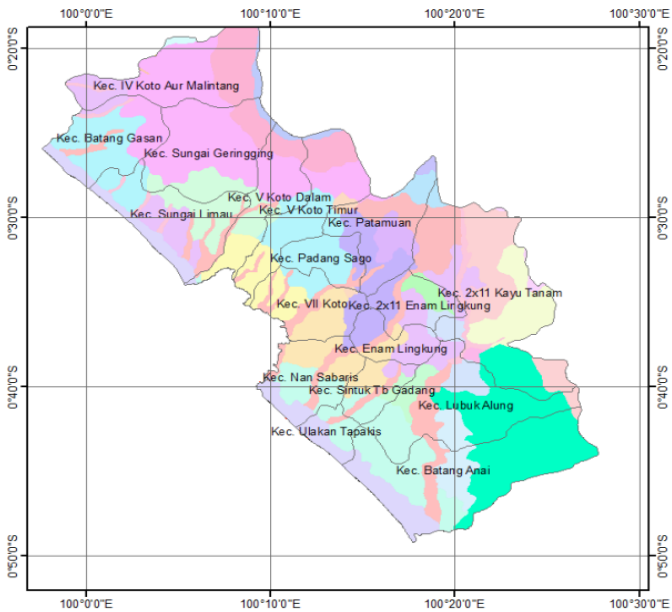
3.1 Material and method

3.1.1 Spatial analysis by using GISs

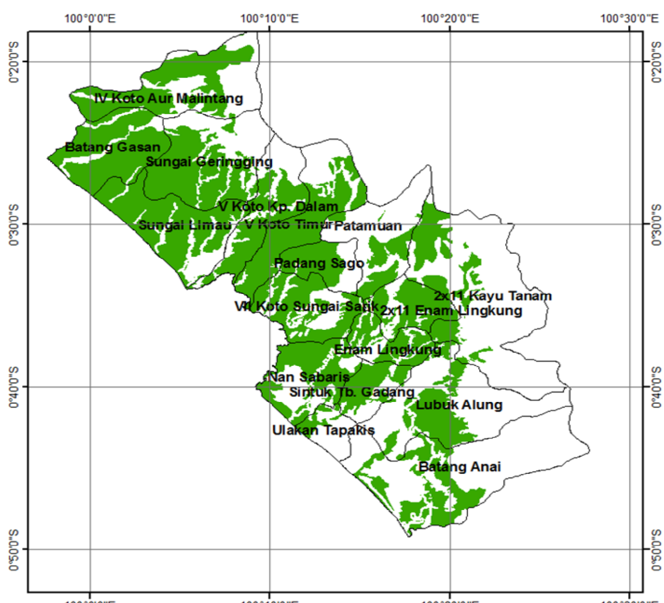
Potential land criteria is an important parameter to specify the plantation area (Agustian and Simanjuntak, 2018). Figure 2 and Table 1 are raw data for the overlay process, which use information from the Center of Agricultural Land Resources recorded using GIS.

Where, biophysical evaluation for the suitable land criteria classify into four classes, namely very suitable (S1), moderately suitable (S2), marginal (S3) and unsuitable (N).

Figure 2 Map of Pariaman districts, West Sumatera, Indonesia, (a) map of the natural characteristics of the land unit (b) map of land availability (see online version for colours)



(a)



(b)

Table 1 Suitable land criteria for coconut crop

Requirements for use of land characteristics	*Suitable class*			
	S1	*S2*	*S3*	*N*
Average temperature (°C)	25–28	28–32 or 23–25	32–35 or 20–23	< 20 or > 35
Humidity (%)	> 60	50–60	< 50	-
Drainage	Good, moderate	Clogged	More subtle	Coarse
Texture	Smooth, few smooth, medium	Few coarse	Very smooth	Coarse
Soil depth	> 100	75–100	50–75	< 50
Peat thickness (cm)	< 60	60–140	140–200	> 200
Nutrient retention (pH)	5.2–7.5	4.8–5.2	< 4.8	-
	-	7.5–8.0	> 8.0	-
Available land nutrient				
P_2O_5 (mg/100 g)	Medium	Low	Very low	-
K_2O (mg/100 g)	Medium	Low	Very low	-
Slope (%)	< 8	8–16	16–30	> 30
Rock outcrop (%)	< 5	5–15	15–25	> 25

The overlay process using spatial analysis was applied to determine the potential land area. It supports coconut harvest improvement by specifying genotypes for the appropriate environment. The blending map of Pariaman districts and available land for plantation also suitable land criteria for coconut becomes datasets of spatial analysis in generating a new map of potential area for coconut plantation.

3.1.2 LQ method

LQ method is widely applied to discuss the economic conditions, likewise, for the establishment of VCO agro-industry. The LQ method is used to specify the establishment location of the VCO agro-industry by referring to labour absorbing. Therefore, LQ value is calculated by the following equation:

$$LQ = \frac{SP_j / SP_T}{VT_j / V_T} \tag{1}$$

where

SP_j amount of labours in the industrial sector at sub-districts of j

SP_T total labours in the industrial sector at districts of Pariaman

VT_j amount of labours at sub-districts of j

V_T total labours at districts of Pariaman.

LQ value of sub-districts area is calculated by equation (1). Priority and non-priority locations are identified based on their LQ value.

3.1.3 Capacity planning

Capacity planning of VCO agro-industry aims to reduce the productions cost of per kg VCO (C_p). In this case, process production uses the centrifuge machine. Achieving maximum profits in production planning may consider centrifuges machine capacity, and capacity planning should seek to select the available machine type and coconut harvesting potential from the farmer's farm. Equation (2) stated modelling of centrifuge machine capacity design (v_p) was limited by available raw material and available production time. Raw material availability must be adequate for the amount of VCO production, which result from *n* times (N_t) rotation [equation (3)] against centrifuge machine capacity compares with coconut milk. Therefore, z_s is a binary variable that is worth one if centrifuge machine capacity sized small (*s*).

$$v_p = \frac{1}{\sum_s \frac{z_s}{v_s}} \tag{2}$$

$$N_t = \frac{Q_t}{m} \sum_s \frac{Z_s}{v_s} \tag{3}$$

The existence of cooperation between farmers and industry has a good impact on production planning. Therefore, the availability of raw material coconut for VCO production is sufficient. Improvement management for coconut plantations considers harvesting potential periodically and selling the coconut harvest to the industry. Where the VCO production is influenced by raw material, price and demand. Hence, the machine capacity planning model is declared as follows:

$$C_p = \frac{(c_b + c_p).Q_t + c_i.N_t + d.a.(v_p).^b}{Q_t} \tag{4}$$

Production cost consists of variable cost and fixed cost. Variable cost is the purchasing of raw material, utility and direct employee cost, while the fixed cost is the depreciation value of tools in a unit of time (*d*). Therefore, the amount of VCO production during the planning (Q_t) involves a raw material cost (c_b), utility (c_p), rotation frequency (N_t), employee cost (c_i), centrifuge machine capacity (v_p), coefficient of tool prices (*a*) and exponential coefficients of tools price (*b*).

3.1.4 Production planning

Production planning is a long-term strategic class decision. This stage aims to fulfil the customer demand at minimum cost/maximum profit (Santander et al., 2020). In this case, VCO production planning should correspond with the planning horizon (*w*) determined by production time (*T*). Each period of the potential of coconut harvest is appropriate for plant life and harvests schedule. Then, the rotate process occurs if the amount of coconut milk has been sufficient requirement of one rotating batch. Hence, total cost production (*TCP*) is defined as follows:

$$TCP = c_b.HP_t + c_i.N_t + c_p.Q_t + h_k.\left(\frac{ITK_{t-1} + ITK_t}{2}\right) + h_p.\left(\frac{IP_{t-1} + IP_t}{2}\right) \tag{5}$$

TCP involves parameters as follows: the cost of coconut stock (HP_t), coconut milk yield towards endosperm (k), coconut milk supply cost (h_k), VCO yields towards coconut milk (m), VCO supply cost (h_p), selling price of VCO (P_t), amount of VCO production (Q_t), amount of coconut milk supply (ITK_t), amount of VCO supply (IP_t), and amount of VCO has to sold periodically (CS_t).

Net profit (*NP*) is obtained by subtracting TCP from the amount of selling product, derived by equation (5) and equation (6).

$$TS = P_t.CS_t \tag{6}$$

$$NP = TS - TCP - d.a.v_p^b \tag{7}$$

Finally,

$$NP = P_t.CS_t - \left[c_b.HP_t + c_i.N_t + c_p.Q_t + h_k\left(\frac{ITK_{t-1} + ITK_t}{2}\right) + h_p\left(\frac{IP_{t-1} + IP_t}{2}\right)\right] - d.a.v_p^b. \tag{8}$$

3.1.5 Financial analysis

Financial analysis aids decision making to evaluates feasibility investment in establishing a new VCO agro-industry. The feasibilities value of the company or industry considers inflow, outflow and cashflow. Financial analysis implements several methods like NPV, IRR, BEP, PBP and B/C-ratio.

NVP shows the value of a project's economic feasibility. The positive-net value represents the feasible projects economically, and the negative-net value conversely. It defines by the cash inflows are subtracted cash outflows. Cash inflows represent annual revenues of selling VCO on the proposed VCO plants (Abdelhady, 2021; Hall et al., 2012). Refer to Pranadi et al. (2019) that the NPV is declared as follows:

$$NPV = \sum_{n=0}^{N} \frac{(B_n - C_n)}{(1+i)n} \tag{9}$$

where n is project-lifetime in years, B_n is a benefit at year n, and C_n is cost at year n. Another profitability indicator is BCR. This method defines the ratio between total profit and the total investment cost (TIC) of the system during its lifecycle. BCR is declared as follow:

$$BCR = 1 + \frac{NPV}{TIC} \tag{10}$$

The IRR defines the discount rate, where the present value for all future cash flows equals the initial investment (NVP = 0). Equation (11) shows the IRR to measure and compare the profitability of investments. Generally, the investment will carry on if the value of investment IRR is higher. So the IRR can be used to rank several possible investment options (Reniers et al., 2016). Where i_1 is discount or interest rate at first year, i_2 is discount or interest rate at second year, NVP_1 is NVP value at first year, and NVP_2 is NVP value at second year.

$$IRR = i_1 + \frac{(NPV_1)}{(NPV_1 - NPV_2)}(i_2 - i_1) \quad (11)$$

The PBP generally refers to the amount of time taken by a project to fully recover initial investment costs. Equation (12) represents a simplified definition of the PBP (Pranadi et al., 2019; Heysel and Filion, 2014).

$$PBP = \sum_{n=0}^{PP} \frac{(Bn - Cn)}{(1+i)n} = 0 \quad (12)$$

The condition of operating results equals the spending capital was called BEP. It means that enterprise run without profit and no loss. Equation (13) explains the BEP as follows:

$$BEP(Q) = \frac{TFC}{P - AVC} \quad (13)$$

where

TFC total fix cost

AVC average variable cost

P product price

Q amount of VCO.

3.2 Web-based application of IDSSVCO

The DSS of the VCO agro-industry had been developed by using a web-based application. This application aimed to simplify the decision making against VCO's agro-industry development, which is designed through the four steps as follows:

Step 1 Perform a necessity analysis: The DSS had created to assist users in persuading investors to engage in VCO's agro-industry in the Pariaman areas. It started by selects the coconut plantation sites, determine capacity and production planning, financial analysis and business feasibility. The requirement planning includes retrieving information, an entry files analysis, preparing reports from innumerable files, and making recommendations or offers the decision.

Step 2 To create a model-based management system (MBMS): The UML diagrams had used to make system analysis and communication easier. Business process diagrams, use case diagrams, and activity diagrams are some of the UML diagrams employed.

In the proposed system, the business process diagram explains the flow of information and the decision-making process. The government will inform potential investors about the VCO agro-industry development opportunity. Then admin enters/updates data on the website till the government can view/print the required reports. Figure 3 depicts this procedure.

The use case diagram displays the functions involves in the development of the VCO's agro-industry. It defines who is responsible, certified, and has access to these functions. As displayed in Figure 4, the activity diagram can represent the business use case's workflow. An admin begins updating data on the system, and the system will determine potential locations, calculating production capacity, the production planning, and financial analysis to obtain reports relevant to VCO agro-industry development. Login, updating data, selecting a potential location, calculating production capacity and planning, evaluating financial data, and seeing a report are all included in an activity diagram.

Figure 3 Business process diagram

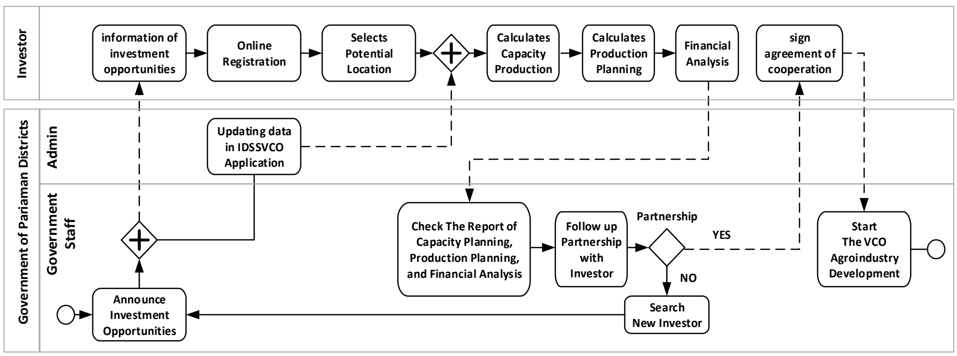
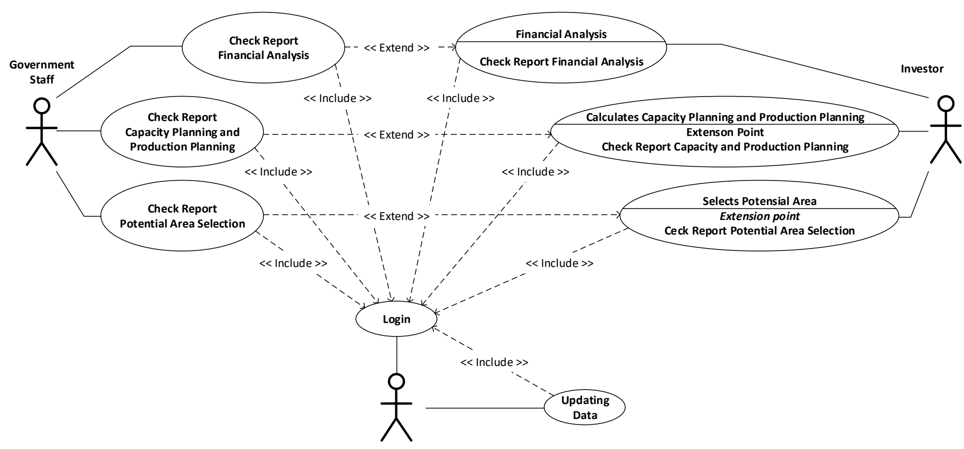


Figure 4 Use case diagram of VCO's agro-industry development



Step 3 Designing a database management system (DBMS): Normalisation data is the first step in the database design process, which involves grouping data properties to create non-redundant, stable and flexible entities. It strives to avoid duplicate data, easy to modify the table structure and reduce the impact of database structure changes. The class diagrams function to describe the link between the data. Existing classes represent the functions of the system following the system requirements analysis. Figure 5 shows the class diagram.

Figure 5 Class diagram for VCO's agro-industry development

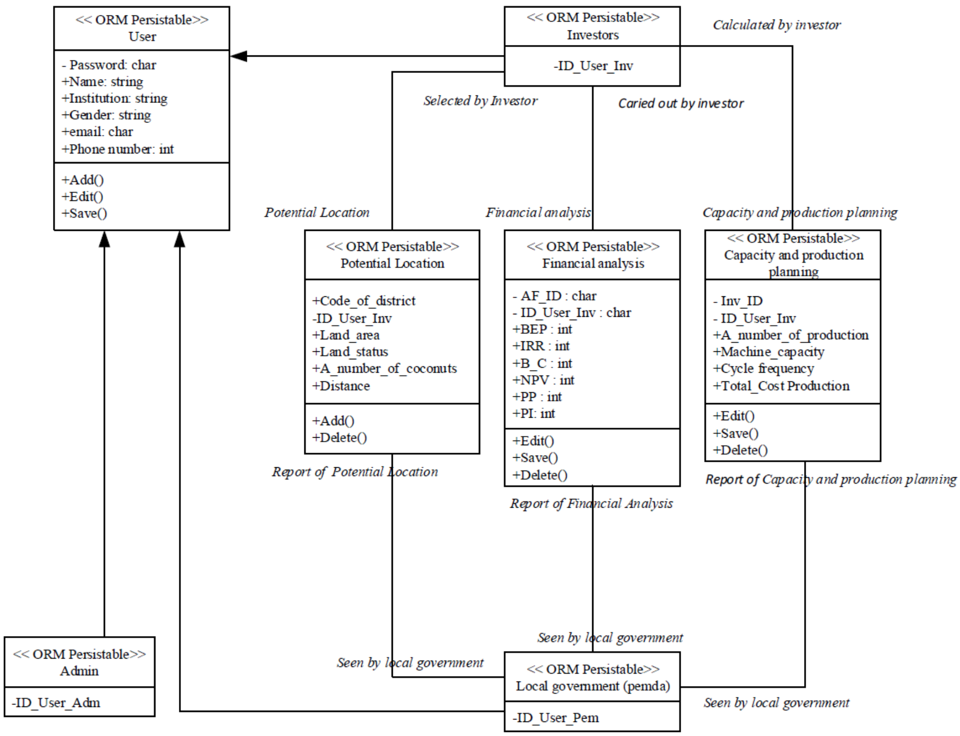
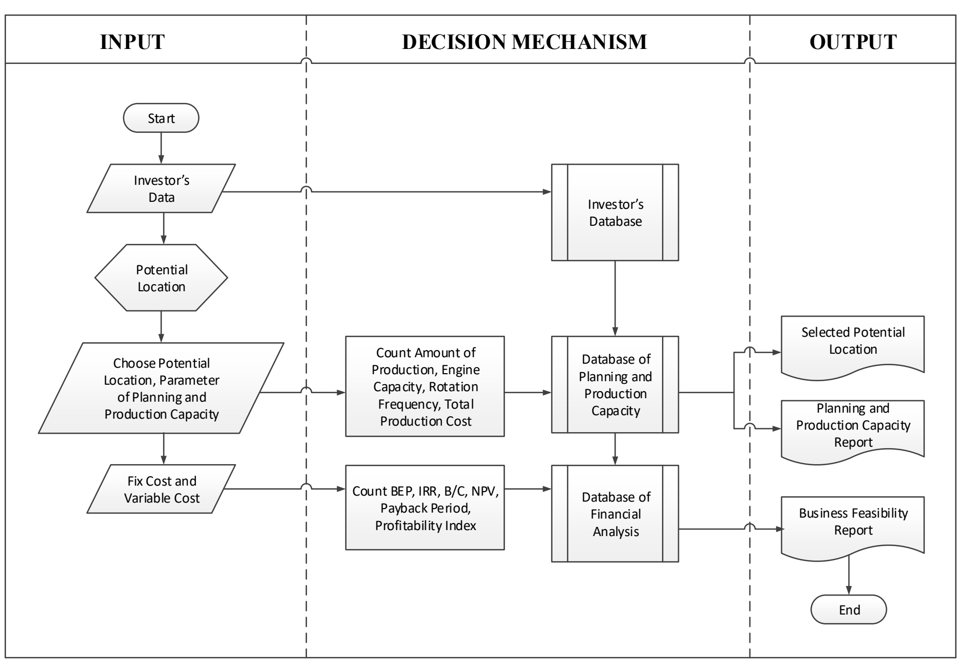


Figure 6 The DSS configuration for VCO agro-industry development



Step 4 The DSS configurations: The DSS flow diagram dataset involves potential location and investor data, which relates to the production process. The illustration of the DSS flow diagram displays in Figure 6. Results show feasibility business, factory location, process planning and capacity planning. The IDSSVCO web system was created by integrating the LQ method, capacity planning, production planning, and financial analysis, which aids the user in the decision making strategy for establishing new VCO agro-industry. IDSSVCO system consists of a DBMS and a MBMS that connects to the centralised processing system.

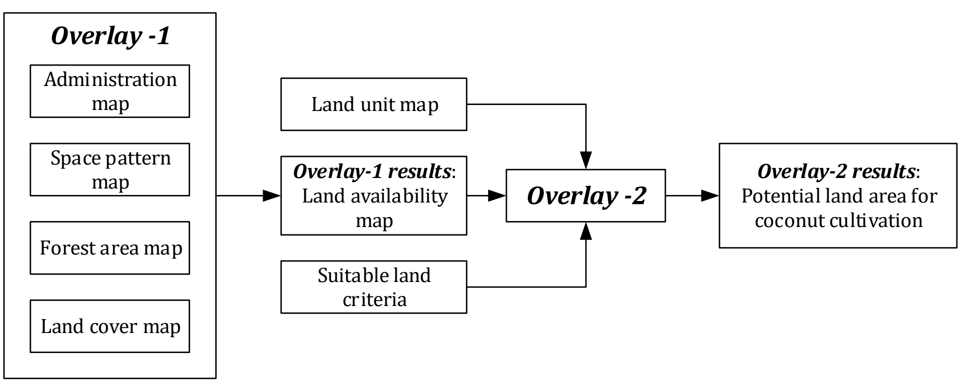
4 Results

4.1 Spatial analysis by using GIS

Pariaman districts have a 132.879 Ha area, which totals 87.298 Ha of the coconut plantation. Besides consuming directly as a cooking ingredient, the coconut may be processed and becomes a value-added product. One of them is the VCO, which is a valuable product for cosmetics, healthy food ingredient, etc. Therefore, IDSSVCO will aid to decide the feasibility of the VCO agro-industry.

IDSSVCO's first stage is a spatial analysis with the GIS method to decide the potential area of coconut cultivation. Therefore, two overlay processes are required to complete these stages, as illustrated in Figure 7. The first overlay process will generate a land availability map displayed in Figure 2(b). The raw data such as the administration map of Pariaman districts, the space pattern map of hamlet and neighbourhood in Pariaman districts, the forest area map, and the land cover map from the Landsat 8 images in 2015 at path 127 and row 60, are used as input data of the first overlay.

Figure 7 The overlay process of spatial analysis



Next, the second overlay process uses data of land availability map as a result of the first overlay, then adds with data of land unit map, and suitable land criteria for coconut cultivations as regulated by the centre for agricultural land resources of Indonesia. These land criteria should fulfil the land requirement characteristics for coconut cultivation by dividing the class into four categories (S1, S2, S3 and N). S1, S2, and S3 classify as potential land with different levels, then N is unsuitable or non-potential land for coconut cultivation. S1, S2, and S3 classify as potential land with diverse soil fertility, then N is unsuitable or non-potential land for coconut cultivation. The N class is recognised as land with an average temperature greater than 35°C or less than 25°C, coarse drainage, coarse texture, less than 50 cm soil depth, peat thickness greater than 200 cm, more than 30% slope, and more than 25% rock outcrop. The S1, S2, and S3 classes are referred to in Table 1. Where S1 class is a medium level with P_2O_5 and K_2O in between 21 to 40 (mg/100 g), S2 class is a low level with P_2O_5 and K_2O in between 10 to 20 (mg/100 g), and S3 is the lowest level with less than 10 (mg/100 g) of P_2O_5 and K_2O.

Figure 8 shows the result of spatial analysis processing to determine the potential area of coconut plantations. The colours represent categories of soil type suitable for coconut plantations. The 17 sub-districts displayed in Table 2 have potential areas for coconut cultivation as a raw material for VCO. The overlay process is carried out outside the IDSSVCO application to keep accuracy in processing GIS data. Determination of potential land for coconut plantations is carried out based on natural characteristics as shown in Table 1, as well as average temperature, rainfall, humidity, drainage, texture, soil depth, peat thickness, soil CEC, pH, P_2O_5 and K_2O levels, slope and rock outcrops. Therefore, 40,755 Ha of class S1 spreads in 17 sub-districts. 2,723 Ha of class S2 spreads in sub-districts of Batang Anai, Lubuk Alung, Ulakan Tapakis, Sintuk Toboh Gadang and Nan Sabaris. Then, 20,347 Ha of class S3 spreads in 17 sub-districts. This stage shows that Pariaman has 139.307 Ha of land units based on natural characteristics, around 105,642 Ha of available land area, and 63,827 Ha potential area for coconut cultivation.

Figure 8 Potential area for coconut plantation (see online version for colours)

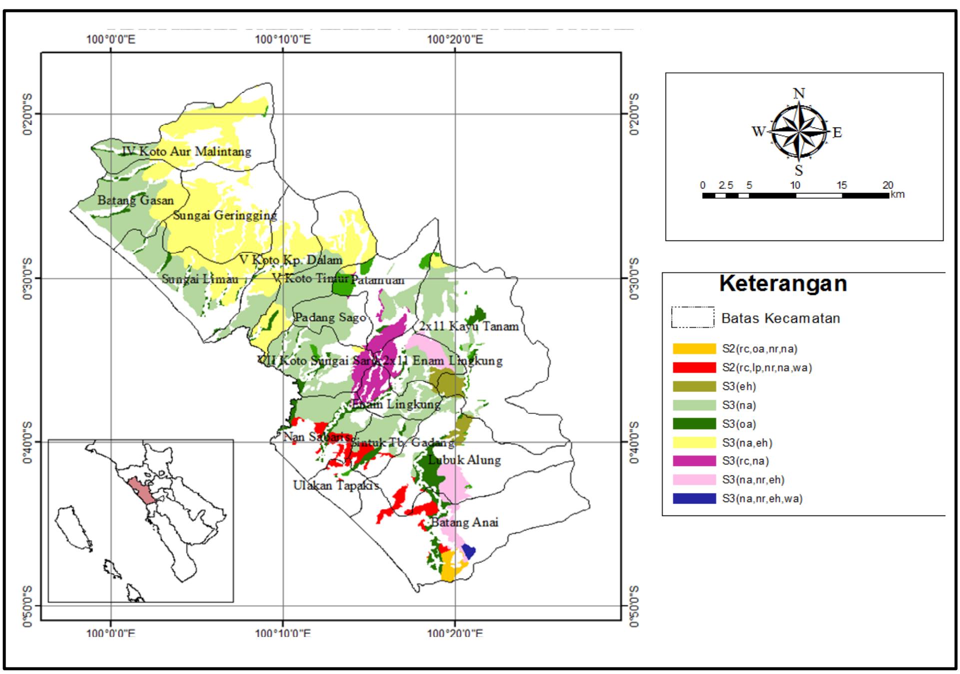


Table 2 Potential land area for a coconut plantation in Pariaman districts

No.	*Sub-districts*	*Potential land area (Ha)*
1	Batang Anai	2,596
2	Lubuk Alung	3,295
3	Sintuk Toboh Gadang	2,154
4	Ulakan Tapakis	209
5	Nan Sabaris	3,212
6	2 × 11 Enam Lingkung	2,968
7	Enam Lingkung	2,311
8	Kayu Tanam	3,570
9	Sungai Sarik	4,208
10	Patamuan	2,863
11	Padang Sago	2,321
12	IV Koto Kampung Dalam	3,900
13	V Koto Timur	5,730
14	Sungai Limau	5,911
15	Batang Gasan	5,962
16	Sungai Geringging	6,511
17	IV Koto Aur Malintang	6,110
Total		*63,827*

4.2 LQ method

Referring to the statistics population of Pariaman shown in Table 3, the number of workers and availability of industrial workers is the determining parameter in selecting the location for VCO company establishment. In this case, The IDSSVCO applies an LQ method. Potential location determined with an LQ value greater than 1. Figure 9 shows that nine potential sub-districts from 17 existing sub-districts in Pariaman. Then, four highest LQ filtered becomes the priority location stated in Figure 10.

Figure 9 Potential area for the location of VCO agro-industry

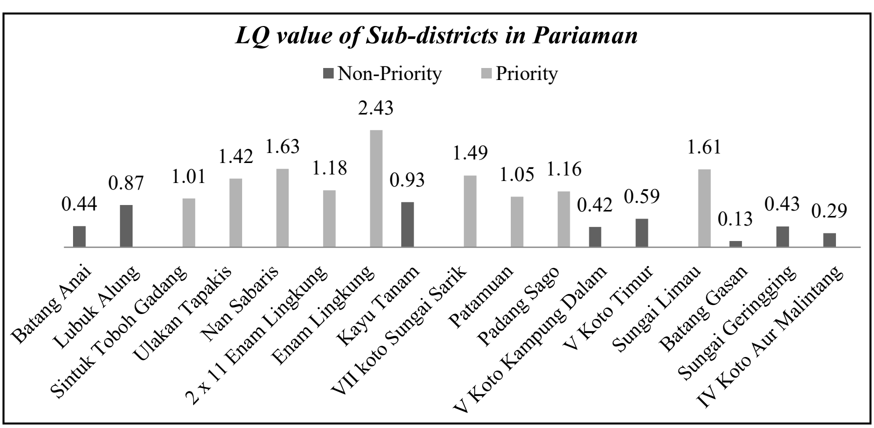
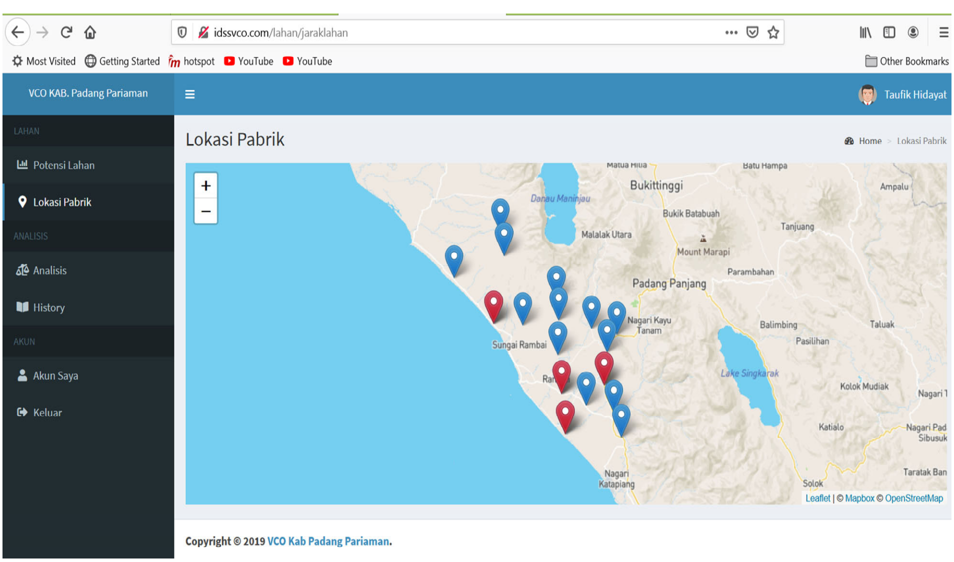


Table 3 The statistic data of Pariaman

Name of sub-districts	*Amount of worker*	*Worker in industrial sector*
Batang Anai	14,905	239
Lubuk Alung	14,438	463
Sintuk Toboh Gadang	6,176	229
Ulakan Tapakis	6,493	338
Nan Sabaris	8,757	522
2 × 11 Enam Lingkung	5,664	246
Enam Lingkung	6,170	549
Kayu Tanam	8,298	284
VII koto Sungai Sarik	10,569	577
Patamuan	5,251	202
Padang Sago	2,431	103
V Koto Kampung Dalam	6,636	102
V Koto Timur	4,230	92
Sungai Limau	8,902	526
Batang Gasan	3,566	17
Sungai Geringging	9,216	147
IV Koto Aur Malintang	6,622	71
	128,324	*4,707*

Figure 10 Priority of potential area for the location of VCO agro-industry (see online version for colours)



4.3 Capacity planning

The stage of capacity planning emphasises the usage of centrifugal machines as processing machines in the VCO industry. Where the parameter listed in Table 4 is applied to calculate the amount of centrifuges machine. The areas were selected by the investor define as the case number. In each case is calculated, evaluated, and decided on the number of its machines. The researcher takes four cases samples that were studied and analysed its capacity planning:

Case 1 VII koto Sungai Sarik, Enam Lingkung, Nan Sabaris and Sintuk Toboh Gadang

Case 2 Kayu Tanam, 2 × 11 Enam Lingkung and Lubuk Alung

Case 3 Sungai Geringging and Sungai Limau

Case 4 Kayu Tanam.

Table 4 Input dataset for centrifuge machine capacity planning

No.	*Parameter*	*Unit*	*Case 1*	*Case 2*	*Case 3*	*Case 4*
1	VCO costs	Rp./kg of VCO	40,000	40,000	40,000	40,000
2	Utility costs	Rp./kg of VCO	250	250	250	250
3	Direct labour costs	Rp./batch	80,000	80,000	80,000	80,000
4	Production time	Hours	8	8	8	8
5	The land area of farmers	Hectares	11,885	9,833	12,422	3,570
6	The total amount of potential coconut harvest	Kg of coconut	1,188,500	983,300	1,242,200	357,000
7	Type of centrifuge machine capacity	Kg coconut milk	100, 150, 200, 250	100, 150, 200, 250	100, 150, 200, 250	100, 150, 200, 250
8	VCO yield	Kg of VCO/kg of coconut milk	0.35	0.35	0.35	0.35
9	Coconut milk yield	Kg of coconut milk/kg coconut flesh	0.56	0.56	0.56	0.56
10	Rotating time	Hours	0.33	0.33	0.33	0.33
11	Coefficient of tool prices		9.34	9.34	9.34	9.34
12	Exponential coefficient		1.785	1.785	1.785	1.785
13	Depreciation coefficient		0.18	0.18	0.18	0.18
14	Districts		4	3	2	1

Following the purpose of capacity planning calculations that reduce production costs and increase profits, it is necessary to select the area of coconuts plantation and configures an efficient centrifuges machine for the production process. The results of four cases capacity planning calculations in different selected areas are displayed in Table 5. Usages different machine types to the number of VCO production and amount of machine become capacity planning results that is important to consider.

Table 5 Capacity planning result of centrifuges machines

No.	*Decision variables*	*Unit*	*Case 1*	*Case 2*	*Case 3*	*Case 4*
1	Centrifuge machine capacity (v_p)	Kg coconut milk	100	150	200	100
2	Amount of VCO production during planning time (Q)	Kg VCO	60.566	50.109	63.303	18.193
3	Rotating frequency (N)	Batch of press	1,730.46	954.46	904.32	225.48
4	Number of machines (R)	Unit	3	2	2	1

4.4 Production planning

Process planning aims to meet customer demand with minimum cost/maximum profit. The emphasis is the optimal and efficient production process relates to the production schedule and time. Table 6 shows the coconut storage cost and VCO storage cost around 200 to 210 and 8,000 to 8,100, respectively, the initial value of VCO supply and coconut potential considers to zero, and the available time per period scheduled 1,200 hours, then the minimum sales of VCO distributed around 95 to 97.5. Referring to equation (5), TCP calculation in four of the study case shows that the lowest value is Case 4 (Table 7). Because Case 4 own the smallest plantation area with the lowest coconut harvesting, which affects VCO production.

Table 6 Input dataset for production planning

Parameter	*Unit*	*Case 1*	*Case 2*	*Case 3*	*Case 4*
Holding cost of coconut	Rp/kg	200	210	220	210
Holding cost of VCO	Rp/kg	8,000	8,100	8,250	8,100
Available time per period	Hours	1,200	1,200	1,200	1,200
VCO supply at $t = 0$	Kg	0	0	0	0
Coconut potential at $t = 0$	Kg	0	0	0	0
The minimum amount of VCO sales	Kg/period	95	96	97.5	96

Table 7 Results of production planning

Parameter	*Unit*	*Case 1*	*Case 2*	*Case 3*	*Case 4*
Total production cost	Rp	729,272,463	605,413,325	766,113,169	219,053,506

4.5 Financial analysis

Financial analysis will evaluate investment decision of business activity. The NPV, IRR, BEP, PBP, and B/C-ratio applied for IDSSVCO. As stated in Table 8, the negative NVP is rising in Case 4 signifying that the projects are infeasible economically. The statement is confirmed by the PBP value of Case 4 showing the long duration.

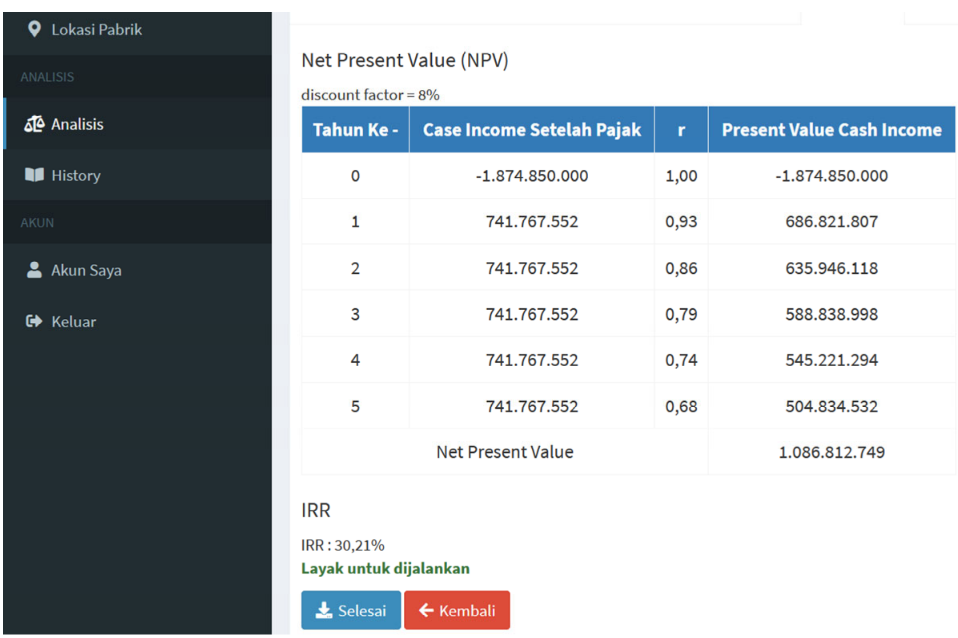
Table 8 The result of financial analysis

No.	*Criteria*	*Case 1*	*Case 2*	*Case 3*	*Case 4*
1	Investment (Rp)	1,874,850,000	1,235,037,046	1,490,608,296	1,769,850,000
2	Profit (Rp)	741,767,552	602,193,433	823,398,376	122,651,139
3	PBP	2 year, 6 months, 10 day	3 year, 0 months, 24 day	2 year, 6 months, 10 day	14 year, 5 months, 4 day
4	NPV (Rp)	1,084,812,749	557,533,762	1,434,740,960	–1,280,139,567
5	B/C-ratio	2,32	1.91	2.61	0.28
6	IRR (%)	30.21%	20.12%	36.28%	0%
7	BEP (unit)	12,812	10,933	10,605	8,962
8	Decision	Feasible	Feasible	Feasible	Not feasible

4.6 *IDSSVCO application*

IDSSVCO are designed based on a web application system to support the government, investor and coconut plantation management (http://idssvco.com). An interaction between investor and the government facilitated with important data which integrates on IDSSVCO. The government also provides the datasets of geographics plantation area that aids investor to select the potential plantation area and location of VCO factory establishment. The economic parameter on VCO factory establishment was noted in detail for every stage, as illustrated in Figure 11.

Figure 11 IDSSVCO illustration for NVP analysis on study Case 1 (see online version for colours)



5 Discussion

Many previous topics have discussed the DSS separately on spatial analysis, selected location of agro-industry, capacity and production planning, and financial analysis. But the proposed DSS have combined this method into a single IDSSVCO application, which can facilitate user, investors, and government. Hence, IDSSVCO may improve the future agro-industry management system. The government can play the role of a good facilitator and policymaker, increase investors confidence to contribute to agro-industry business, then enhance the user confidence to complete the production process with high profit. This application aids an investor with accuracy and fastly in deciding the new investment of VCO agro-industry. Geographical statistics data of plantation and population from the government becomes an input dataset for spatial analysis with results are potentials area for a coconut plantation in Pariaman. Hence, the government or private company is expected to improve policy and plantation management to increase profits. An interested investor to develop the VCO agro-industry may select priority locations for the factory establishment are listed in IDSSVCO.

Four cases study based on investor selected areas were tested and explained. Every case consists of a different combination area of coconut plantation to their production planning. The third case is the largest, with 12,422 hectares of plantation, 1,242,200 kg of coconut harvesting, and 63,303 kilograms of VCO produced. While the first case selects 11,885 Ha of the plantation area, with 1,188,500 kg of coconut harvesting, and produce 60,566 kg of VCO. However, the first case runs in the highest rotating frequency with 1,730.46 pressure batches and three-unit of centrifuges machines. The third case has a rotating frequency of 904.32 pressure batches and two units of centrifuges machines. After a financial analysis process, the third case shows the highest profits are Rp.823,398,376, and the highest NVP are Rp.1,434,740,960, although PBP values have the same duration between the first case and third case. Hence, it concludes that Case 3 is more feasible than the other case.

6 Conclusions

The IDSSVCO application is greatly rewarding to an investor and government in the decision-making of the new VCO agro-industry establishment. Potential land selection for coconut cultivation helps smallholders to harvest with high profits. Nevertheless, crop processing to value-added products may increase profits and upgrade public welfare. Therefore, IDSSVCO plays the role to select priority locations for the new VCO agro-industry establishment. Then, it analyses financially by involving capacity planning and production planning aspects in looking at possibilities of investment in the VCO agro-industry. From the four study cases carried out, only three options are feasible as an investment, excluding Case 4. However, Case 3 shows priority investment with the highest profits and a short period of PBP. Finally, it is concluded that the selection of potential locations, the amount of coconut, the type and amount of machines, and batch scheduling play a role to develop the VCO agro-industry. Although, it should improve in the future because the IDSSVCO still use an overlay process for spatial analysis to select the potential location.

Acknowledgements

This paper was produced as part of the research work funded by SPIRIT Research Grant 2019, Industrial Human Resources Development Agency, Ministry of Industry Indonesia, Grant Number 046/BPSDMI/SPKP/IV/2019. The authors would like to express their appreciation for the support given.

References

Abdelhady, S. (2021) 'Performance and cost evaluation of solar dish power plant: sensitivity analysis of levelized cost of electricity (LCOE) and net present value (NPV)', *Renewable Energy*, Vol. 168, pp.332–342, Elsevier Ltd., DOI: 10.1016/j.renene.2020.12.074.

Agustian, I. and Simanjuntak, B.H. (2018) *Penilaian Status Kesuburan Tanah dan Pengelolaannya, di Kecamatan Karanggede, Kabupatem Boyolali, Jawa Tengah*, pp.255–264, Fakultas Pertanian dan Bisnis UKSW.

Alenljung, B. (2008) *Envisioning a Future Decision Support System for Requirements Engineering – A Holistic and Human-centred Perspective*, PhD thesis, Linköpings universitet, Linköping, Sweden.

Ali, M.F., Aziz, A.A. and Sulong, S.H. (2020) 'The role of decision support systems in smallholder rubber production: applications, limitations and future directions', *Computers and Electronics in Agriculture*, October 2019, Vol. 173, p.105442, Elsevier, DOI: 10.1016/j.compag.2020.105442.

Bapelitbangda (2019) *Rencana Strategis (Renstra) Tahun 2016–2021*.

Billings, S.B. and Johnson, E.B. (2012) 'The location quotient as an estimator of industrial concentration', *Regional Science and Urban Economics*, Vol. 42, No. 4, pp.642–647, DOI: 10.1016/j.regsciurbeco.2012.03.003.

Bogoviz, A.V. et al. (2021) 'Production planning and supply chain management under the conditions of Industry 4.0', *Advances in Mathematics for Industry 4.0*, DOI: 10.1016/b978-0-12-818906-1.00008-5.

Bueno, A., Godinho Filho, M. and Frank, A.G. (2020) 'Smart production planning and control in the Industry 4.0 context: a systematic literature review', *Computers and Industrial Engineering*, August, Vol. 149, DOI: 10.1016/j.cie.2020.106774.

Darmanto, E.B., Pratiwi, Y.S. and Nugroho, H.S.W. (2014) 'The regional analysis of agricultural and non-agricultural employment in Egypt', *Indian Journal of Forensic Medicine & Toxicology*, Vol. 14, No. 1, pp.234–238.

Debesa, G. et al. (2020) 'GIS and remote sensing-based physical land suitability analysis for major cereal crops in Dabo Hana District, South-West Ethiopia', *Cogent Food & Agriculture*, Vol. 6, No. 1, p.1780100, Cogent, DOI: 10.1080/23311932.2020.1780100.

Druzdzel, M.J. and Flynn, R.R. (2012) 'Decision support systems', *Understanding Information Retrieval Systems*, pp.461–472, Taylor & Francis Group, LLC.

ESRI (2001) *ArcGIS TM Spatial Analyst: Advanced GIS Spatial Analysis Using Raster and Vector Data*, December, p.17, New York.

Gardas, B.B. et al. (2019) 'A hybrid decision support system for analyzing challenges of the agricultural supply chain', *Sustainable Production and Consumption*, Vol. 18, No. 1, pp.19–32.

Government Office of Pariaman (2019) *Laporan Akuntabilitas Kinerja Instansi Pemerintah*.

Gutierrez, F. et al. (2019) 'A review of visualizations in agricultural decision support systems: an HCI prospective', *Computers and Electronics in Agriculture*, Vol. 163, No. 1, pp.1–28.

Hall, T.J. et al. (2012) 'A net present value and financial feasibility analysis of converting from plastic pots to degradable paper pots', *Acta Horticulturae*, March, Vol. 930, pp.135–140, DOI: 10.17660/ActaHortic.2012.930.17.

Han, J.H., Lee, J.Y. and Kim, Y.D. (2019) 'Production planning in a two-level supply chain for production-time-dependent products with dynamic demands', *Computers and Industrial Engineering*, May, Vol. 135, pp.1–9, Elsevier, DOI: 10.1016/j.cie.2019.05.036.

Hazeltine, B. (2003) 'Planning and implementation', in Bull, B.H.C. (Ed.): *Field Guide of Appropriate Technology*, 1st ed., pp.17–156, Elsevier Inc, California, DOI: 10.1016/B978-012335185-2/50045-0.

Heysel, C.S. and Filion, Y.R. (2014) 'Estimating the payback period of in-line micro turbines with analytical probabilistic models', *Procedia Engineering*, Vol. 70, pp.815–822, Elsevier BV, DOI: 10.1016/j.proeng.2014.02.089.

Hyman, G., Hodson, D. and Jones, P. (2013) 'Spatial analysis to support geographic targeting of genotypes to environments', *Frontiers in Physiology*, March, Vol. 4, pp.1–14, DOI: 10.3389/fphys.2013.00040.

Ignacio, I.F. and Miguel, T.S. (2021) 'Research opportunities on the coconut (*Cocos nucifera* L.) using new technologies', *South African Journal of Botany*, Vol. 141, pp.414–420, DOI: 10.1016/j.sajb.2021.05.030.

Jodlbauer, H. and Strasser, S. (2019) 'Capacity-driven production planning', *Computers in Industry*, Vol. 113, p.103126, Elsevier BV, DOI: 10.1016/j.compind.2019.103126.

Li, H., Zhao, Y. and Zheng, F. (2020) 'The framework of an agricultural land-use decision support system based on ecological environmental constraints', *Science of the Total Environment*, Vol. 717, No. 1, pp.1–10.

Limpianchob, C. (2017) 'Integrated of harvesting and production planning in aromatic coconut supply chain using mixed-integer linear programming', Int. J. Oper. Res., Vol. 30, No. 3, pp.29–30.

Marble, D.F., Calkins, H.W. and Peuquet, D.J. (1984) *Basic Readings in Geographic Information Systems*, Marble, D.F. (Ed.), SPAD Systems, Williamsville, NY.

Nadaraja, D., Lu, C. and Islam, M.M. (2021) 'The sustainability assessment of plantation agriculture – a systematic review of sustainability indicators', *Sustainable Production and Consumption*, Vol. 26, pp.892–910, DOI: 10.1016/j.spc.2020.12.042.

Nair, K.P.P. (2010) 'The coconut palm (*Cocos nucifera* L.)', in *The Agronomy and Economy of Important Tree Crops of the Developing World*, 1st ed., pp.67–109, Elsevier Inc., Burlington, DOI: 10.1016/b978-0-12-384677-8.00003-5.

Nolte, K. and Ostermeier, M. (2017) 'Labour market effects of large-scale agricultural investment: conceptual considerations and estimated employment effects', *World Development*, Vol. 98, pp.430–446, DOI: 10.1016/j.worlddev.2017.05.012.

Özkan, B., Dengiz, O. and Turan, İ.D. (2020) 'Site suitability analysis for potential agricultural land with spatial fuzzy multi-criteria decision analysis in regional scale under semi-arid terrestrial ecosystem', *Scientific Reports*, Vol. 10, No. 1, pp.1–18, DOI: 10.1038/s41598-020-79105-4.

Page, G.W. and Patton, C.V. (1991) 'Location quotient', in *Quick Answers to Quantitative Problems*, Academic Press, Inc., San Diego, pp.173–177, DOI: 10.1016/b978-0-12-543570-3.50018-3.

Pahmeyer, C., Kuhn, T. and Britz, W. (2021) '"Fruchtfolge": a crop rotation decision support system for optimizing cropping choice with big data and spatial explicit modeling', *Computer and Electronics in Agriculture*, Vol. 181, No. 1, pp.1–11.

Pranadi, A.D. et al. (2019) 'Sensitivity analysis of financial parameters in varying PV penetrations in the optimum location of a feeder', *Energy Procedia*, Vol. 156, pp.95–99, Elsevier BV, DOI: 10.1016/j.egypro.2018.11.101.

Qian, X. (2021) 'Production planning and equity investment decisions in agriculture with closed membership cooperatives', *European Journal of Operational Research*, Vol. 294, No. 2, pp.684–699, DOI: 10.1016/j.ejor.2021.02.007.

Reniers, G., Talarico, L. and Paltrinieri, N. (2016) 'Cost-benefit analysis of safety measures', in *Dynamic Risk Analysis in the Chemical and Petroleum Industry*, Elsevier Inc., USA, DOI: 10.1016/B978-0-12-803765-2.00016-0.

Ritung, S. et al. (2011) *Evaluasi Lahan untuk Komoditas Pertanian*, Edisi Revisi, Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian, Badan Penelitian dan Pengembangan Pertanian.

Rossiter, D.G. (1996) 'A theoretical framework for land evaluation', *Geoderma*, Vol. 72, Nos. 3–4, pp.165–190, DOI: 10.1016/0016-7061(96)00031-6.

Rossiter, D.G. (2009) 'Land evaluation: towards a revised framework; land and water discussion paper 6', *Geoderma*, Vol. 148, Nos. 3–4, pp.428–429, Elsevier BV, DOI: 10.1016/j.geoderma.2008.11.001.

Santander, O. et al. (2020) 'On the interaction and integration of production planning and (advanced) process control', *Computers and Chemical Engineering*, Vol. 133, p.106627, Elsevier Ltd., DOI: 10.1016/j.compchemeng.2019.106627.

Sarabi, E.P. and Darestani, S.A. (2021) 'Developing a decision support system for logistics service provider selection employing fuzzy MULTIMOORA & BWM in mining equipment', *Applied Soft Computing Journal*, Vol. 98, No. 1, pp.1–14.

Sheng, Y. and Zhang, S. (2009) 'Analysis of problems and trends of decision support systems development', paper presented at the *2009 International Conference on E-Business and Information System Security*, 23–24 May, Wuhan, China.

Shkodra, J., Gjonbalaj, M. and Beqiri, V. (2011) 'The role of financial analysis in agricultural farms in Kosovo – ProQuest', *International Journal of Arts & Sciences*, Vol. 4, No. 26, pp.157–162 [online] https://search.proquest.com/docview/1318037208/B2AF8BBF46ED402DPQ/1?accountid=173015.

Sofiyuddin, M. et al. (2021) 'Sustainable land preparation for farmer-managed lowland agriculture in Indonesia', *Forest Policy and Economics*, September, Vol. 130, DOI: 10.1016/j.forpol.2021.102534.

Srivastava, Y., Semwal, A.D. and Sharma, G.K. (2018) 'Virgin coconut oil as functional oil', in *Therapeutic, Probiotic, and Unconventional Foods*, pp.291–301, Elsevier Inc., Kidlington, DOI: 10.1016/B978-0-12-814625-5.00015-7.

Taechatanasat, P. and Armstrong, L. (2014) 'Decision support system data for farmer decision making', *Proceedings of Asian Federation for Information Technology in Agriculture*, pp.472–486 [online] http://ro.ecu.edu.au/ecuworkspost2013/855.

Teerasoponpong, S. and Sopadang, A. (2021) 'A simulation-optimization approach for adaptive manufacturing capacity planning in small and medium-sized enterprises', *Expert Systems with Applications*, February 2020, Vol. 168, DOI: 10.1016/j.eswa.2020.114451.

Teixeira, A.H.d.C. et al. (2019) 'Water productivity assessments for dwarf coconut by using Landsat 8 images and agrometeorological data', *ISPRS Journal of Photogrammetry and Remote Sensing*, July, Vol. 155, pp.150–158, DOI: 10.1016/j.isprsjprs.2019.07.006.

Terribile, F. et al. (2015) 'A web-based spatial decision supporting system for land', *Solid Earth*, Vol. 6, pp.903–928, DOI: 10.5194/se-6-903-2015.

Trusova, N.V. et al. (2021) 'Determinants of the innovative and investment development of agriculture', *International Journal of Agricultural Extension*, Vol. 9, No. 4, pp.81–100, DOI: 10.33687/ijae.009.00.3724.

Vazquez, D.A.Z. et al. (2021) 'Optimal production planning and machinery scheduling for semi-arid farms', *Computers and Electronics in Agriculture*, July, Vol. 187, DOI: 10.1016/j.compag.2021.106288.

Wahyunto, W. et al. (2016) *Pedoman Penilaian Kesesuaian Lahan Untuk Komoditas Pertanian Strategis Tingkat Semi Detail Skala 1:50.000.*

Wang, L. et al. (2021) 'A decision support system for tobacco cultivation measures based on BPNN and GA', *Computers and Electronics in Agriculture*, December 2020, Vol. 181, p.105928, Elsevier BV, DOI: 10.1016/j.compag.2020.105928.

Yazdani, M. et al. (2017) 'PT US CR', *Expert Systems with Applications*, Elsevier Ltd., DOI: 10.1016/j.eswa.2017.07.014.

Yin, G. et al. (2020) 'How do the industrial land use intensity and dominant industries guide the urban land use? Evidences from 19 industrial land categories in ten cities of China', *Sustainable Cities and Society*, September 2018, Vol. 53, DOI: 10.1016/j.scs.2019.101978.

Zhai, Z. et al. (2020) 'Decision support systems for Agriculture 4.0: survey and challenges', *Computers and Electronics in Agriculture*, January, Vol. 170, pp.105–256, Elsevier, DOI: 10.1016/j.compag.2020.105256.