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Optimization the Combination of Farming Branches in Tidal Land Barito Kuala Regency

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Abstract
Background: *Barito Kuala Regency is a rice production center in South Kalimantan Province. Almost all of the farmers cultivate rice as the main commodity in their farming. For farmers with rice monoculture farming, it is difficult to increase their income or family welfare. One solution for farmers to increase income in order to improve the standard of living and welfare of their families is to cultivate various branches of farming that complement each other in their farming, by utilizing limited resources optimally. This research conducted with the aim of analyzing (1) analyze the amount of farming costs and income obtained ; (2) determine the combination of farming branches that can provide maximum income for farmers; (3) compare the amount of income obtained between the optimal combination of farming branches and the actual combination of farming branches.*
Material and methods: *With a purposive sampling method, two districts (Rantau Bedauh and Mandastana districts) were selected, then two villages were selected from each district (Karang Bunga Village, Karang Indah Village, Sinar Baru Village and Danda Jaya Village). The farmers sampled were 100 people, 25 farmers each. In this study, a descriptive analysis was carried out with the help of a questionnaire, then using a formula to calculate fixed costs, variable costs, total costs, revenues, and income. The calculation results are used in Linear Program Analysis using the TORA application..*
Results: *The actual farming combination is rice cultivation as the main commodity, oranges and vegetables as alternative commodities. There are 16 different vegetable combinations. The combination that gives the biggest income is chili - tomato - eggplant. Based on the optimum calculation results, the combination of vegetables that provide the largest income for cultivation with rice and oranges is chili - soybean – gambas.*
Conclusion*: The combination applied by farmers is still not optimal, this can be seen from the income in optimal conditions which is higher than the actual condition due to limited resources owned by farmers.*
Keyword*: Optimization, linear program analysis, tidal land, combination of farming branches*

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I. Introduction

The demand for food, especially rice, continues to increase in line with the increase in the national population. Until now, the main food consumption of the Indonesian people still relies on rice, which will cause the value of rice consumption to increase in the future. On the production side, increasing land conversion has reduced the area of land, especially for food crops, the use of tidal swamps can be an alternative to this problem.

Based on data from the Food Crops and Horticulture Service of South Kalimantan Province (2018), Barito Kuala Regency is the area with the largest tidal land use in South Kalimantan, namely 100,024 ha, and the largest rice producer in South Kalimantan Province with 389,757 tons per year.

Most farmers tend to cultivate rice, but farmers who only grow rice singly (monoculture) have difficulty increasing their income and family welfare. This is because if farmers experience losses due to crop failure, the farmers do not get compensation for these losses from other branches of agriculture. The solution to this problem is to apply a mixed (multicultural) agricultural pattern.

Because available resources are limited, the ability of farmers to select several complementary branches of agriculture is very important. Precise calculations are needed to determine which combination of branches of agriculture can provide maximum income.

II. Material and Methods

Barito Kuala Regency is the largest rice producer and has the largest tidal area in South Kalimantan Province so it has the potential for tidal areas in the development of agricultural land which is currently decreasing.

The study was conducted in Mandastana District and Rantau Badauh District, Barito Kuala Regency. The time of the study was in August 2019 to July 2020. Sampling in this study was carried out in several stages, the first stage was deliberately determining an area considered representative, namely Barito Kuala Regency. Then determine the area with tidal land type B and type C, Mandastana District and Rantau Badauh District. The villages that were sampled were Karang Bunga Village, Karang Indah Village, Sinar Baru Village and Danda Jaya Village which represented the two districts. The number of samples is 100 people with 25 people in each village. The total sample calculation uses the Slovin formula.

To answer the first objective, the total costs incurred and the income earned are calculated. calculation of total costs by adding up variable costs and fixed costs. Variable costs consist of costs for seeds, fertilizers, medicines and labor costs. while fixed costs consist of land costs and equipment depreciation costs.

Total costs

$$\mathbf{TCj = TVCj + TFCj} \quad (1)$$
$$\mathbf{TVCj = \sum (Xvmj \cdot Pxvmj)} \quad (2)$$
$$\mathbf{TFCj = \sum (Xfnj \cdot Pxfnj)} \quad (3)$$

Where:
TCj = total cost of the -j plant (IDR)
TVCj = total variable cost of the -j plant (IDR)
TFCj = total fixed cost of the -j plant (IDR)
Xvmj = variable input -m, the -j plant
Xfnj = fixed input -n, the -j plant
Pxvmj = unit price of variable input -m, the -j plant (IDR)
Pxfnj = unit price of fixed input, the -j plant (IDR)
j = rice, orange, vegetable farming
m = variable input (seeds, fertilizers, pesticides, and labor)
n = fixed input (land, depreciation of tools and equipment)

Depreciation costs

Inputs in the form of capital goods do not run out in one production process, so it is necessary to calculate the amount of depreciation.

$$\mathbf{D = (Na-Ns)/Up \times L} \quad (4)$$

Where:
D = the amount of depreciation value for fixed capital goods (IDR / year).
Na = the initial value of fixed capital goods which is equal to the purchase price (IDR).
Ns = the final value of fixed capital goods which is estimated to be the same as the price when it is no longer used (IDR).
Up = age of use of fixed capital goods (year).
L = duration of effective use of the item (year).

Total revenue

$$\mathbf{TRj = Yj \cdot Pyj} \quad (5)$$

Where:
TRj = total revenue of the -j plant (IDR).
Yj = the amount of output or the physical yield of the -j plant (kg).
Pyi = unit price of output, the -j plant (IDR / kg).
j = rice, orange, vegetable farming

Total Income

$$\mathbf{\prod total = \sum \prod j} \quad (6)$$
$$\mathbf{\prod j = TRj - TCj} \quad (7)$$

Where:
∏total = total income for one period (IDR / year)
∏j = income of the -j plant for one period (IDR / year)
TRj = total revenue of the -j plant during one period (IDR / year).
TCj = total cost of the -j plant for one period (IDR / year).
j = rice, orange, vegetable farming.

To answer the second and third objectives, to analyze the combination of farming branches that provide maximum income with optimization, according to Soekartawi (1992), in farming activities with limited available resources, farming planning is needed by combining various inputs to maximize profits or minimize costs. can be formulated using the Linear Programming technique approach. This research uses "Linear Program Analysis" with "Simplex Method". Mathematical models that can be used to express linear programming problems are:

PuIDRose function :

$$Maks\, Z = \sum_{i=1}^{n} C_i\, X_i \quad (8)$$

Constraint function :

a. Land

$$\sum_{i=1}^{n} a_i X_i \leq A \quad (9)$$

b. Labor

$$\sum_{i=1}^{n} b_i X_i \leq B \quad (10)$$

c. Other farming capital

$$\sum_{i=1}^{n} d_i X_i \leq D \quad (11)$$

Where:

Z = maximum income (IDR)
Xi = the -i vegetable farming activity
Ci = income from the -i vegetable farming activity (IDR / year)
A = availability of land (borong)
B = availability of family labor and leasing outside the family (HKSP)
D = availability of own capital (IDR)
ai = land requirements in the -i vegetable farming activity (borong)
bi = requirements of family labor and rent of labor outside family (HKSP)
di = requirements of farming capital in the i- vegetable farming activity (IDR)
i = vegetable farming for chilies, kale, tomatoes, long beans, soybeans, cucumbers, tomatoes, spinach and gambas.

Analysis of the optimal solution can be done in several ways :

1. Primal Analysis. This analysis will show the optimal product combination that contributes to the maximum income as well as determine the products that business actors should not cultivate in this case are farmers. This analysis considers the amount of reduced cost value that each product has which will affect the amount of the objective function.
2. Dual analysis. This analysis provides information about the valuation of the resources used in the linear programming model indicated by the value of slack or suIDRlus. The slack / suIDRlus value which is equal to 0 indicates that the resource is limited with a certain dual price value. While a slack / suIDRlus value greater than 0 has a dual price value that is equal to 0, this indicates that the resource is excess.
3. Sensitivity Analysis. Sensitivity analysis is needed to analyze the extent to which optimal results can be applied if there is a change in parameter values which includes variable values and constraints on linear programs, for example changes in production costs or to increase the desired profit. The effect of this change can be seen in the sensitivity interval which consists of a minimum limit and a maximum limit.And for the fourth objective it was answered by drawing conclusions from the results of field interviews conducted with the respondent farmers.

III. Result

Age. Respondents' ages ranged from 25 to 73 years, with the majority age of respondents ranging from 45 to 54 years. There are only 4 farmers who are over 65 years old. years while the other 96.00% are of productive age.

Level of education. The highest education level of the respondents is Bachelor degree and the lowest is elementary school. The most recent education taken by the respondent farmers was elementary school with a percentage of 51.04%.

Farming Experience. Most of the respondent farmers have 11 to 20 years of experience in farming. The experience that farmers have is in the types of lowland rice and orange farming, while vegetable farming is quite new to them.

Land area. Most of the respondent farmers have land with an area ranging from 1 to 35 borong, as many as 60 people out of 100 respondents. Meanwhile, 3 people were recorded with a land area greater than 140 borong, one of whom has land with an area of up to 315 borong.

Actual Farming Cost and Profit Structure

Farming in the research area is carried out using the surjan cultivation system, which is a mixed cropping system characterized by differences in the height of the planting surface on a land with a minimum height difference of 50cm. Each planting area with different heights is planted with rice in the tabukan (low area) and the guludan (high area) is planted with oranges which are then planted with vegetables in between.

Vegetable crops grown by respondent farmers are chilies, kale, tomatoes, long beans, cucumbers, eggplant, soybeans, spinach and gambas. Rice and oranges are assumed to be fixed, so the optimal combination of vegetables will be sought to obtain the greatest income.

The use of labor in the study area consists of male workers and female workers who have different levels of wages so that the calculation of the workforce in this study uses HKSP (Male equivalent working days). The details of the respondent farmer's farming costs per commodity are described in Table 1 below:

Table 1. Farmers respondent's use of farm inputs for one borong

Commodities	Seeds	Fertilizer	Pesticide	Equipment	Labor	Land	Total cost
Rice	2,523	36,345	7,378	8,593	97,848	166,800	319,487
Orange	17,435	6,190	1,626	8,816	18,941	147,840	200,849
Chili	63,432	285,173	85,310	18,314	283,755	176,263	912,247
Kale	200,222	615,568	187,955	18,360	645,006	178,946	1,846,056
Tomato	89,800	822,359	244,659	24,777	384,624	197,778	1,763,997
eggplant	8,230	37,901	13,580	15,307	123,791	193,684	392,494
Long beans	70,000	60,667	40,000	25,154	305,208	185,600	686,629
Soy	192,163	1,515,825	441,786	45,997	313,513	196,000	2,705,283
Cucumber	194,143	1,879,200	356,229	57,952	919,329	171,817	3,578,669
Spinach	356,250	1,256,250	693,750	43,255	1,588,320	190,150	4,127,975
Gambas	360,000	1,116,000	180,000	123,333	2,700,000	180,400	4,659,733

Table 1 describes the total average cost incurred by 100 respondent farmers in 1 year. All of the Farmers' lands are owned by themselves, none of them have the status of lease or pawning or profit sharing, so to calculate the cost of the land, the rent calculation in the study area consists of 2 blocks of rice from every 1 block of land owned. (1 borong = 0.029 Ha, 1 bottle = 10 kg).

Rice is a commodity grown by all respondent farmers and 90% of respondent farmers grow oranges. Meanwhile, the vegetables listed in the table are all vegetables in the study area, in other words not all of the respondent farmers planted these 9 types of vegetables. Based on the production and selling price in effect in 2019, the farm income of the respondent farmers in one year is illustrated in Table 2 below:

Table 2. Farming acceptance of respondent farmers for one borong

Commodities	Production (kg)	Selling price (IDR)	Revenue (IDR)
Rice	72	8,340	599,758
Orange	85	4,693	397,559
Chili	88	50,345	4,440,264
Kale	188	6,964	1,309,322
Tomato	343	3,676	1,260,757
eggplant	116	6,500	756,996
Long beans	257	7,500	1,925,000
Soy	287	10,000	2,867,370
Cucumber	451	4,100	1,848,514
Spinach	327	8,000	2,612,500
Gambas	1,200	8,000	9,600,000

In Table 2, it is known that rice and oranges have the smallest amount of revenue, this is because the calculation of farming takes only 1 year, so that the total revenue during the age of oranges is not calculated as a whole. Meanwhile, rice does not tend to provide a large income, therefore it is better for farmers not to apply monoculture farming or to rely only on rice.

Based on the amount of fees and revenues received by respondent farmers, the average profit earned by 100 respondent farmers is described in Table 3 below:

Table 3. Farming profits of respondent farmers for one borong

Commodities	Revenue	Total cost	Income
Rice	599,758	319,487	280,271
Orange	397,559	200,849	196,710
Chili	4,440,264	912,247	3,528,017
Kale	1,309,322	1,846,056	-536,735
Tomato	1,260,757	1,763,997	-503,239
eggplant	756,996	392,494	364,502
Long beans	1,925,000	686,629	1,238,371
Soy	2,867,370	2,705,283	162,087

Cucumber	1,848,514	3,578,669	-1,730,155
Spinach	2,612,500	4,127,975	-1,515,475
Gambas	9,600,000	4,659,733	4,940,267

In Table 3, it is known that rice and orange commodities, which are the most dominant commodities in the farming of the respondent farmers, have positive incomes. Rice generates an income of IDR. 280.271 for one borong with an average land area of 17 borong, so that the total income reaches IDR. 10.346.642 for one respondent. Oranges have an income value of IDR. 196.710 for one borong, with an average area of land for orange cultivated by farmers of 24 borong, so that the total income earned is IDR. 4.816.319 for one respondent with an average age of the orange being 5 years.

Respondent farmers carry out farming for vegetable commodities with different combinations, there are 16 combinations in the research location. The amount of income obtained by farmers based on their respective combination is described in Table 4 below:

Table 4. The profit of the respondent farmers is based on the cropping pattern

Vegetable Combinations	Income	Average land area
Long beans	3,474,681	3
Chili	15,863,168	6.44
Kale	-621,255	3
Chili + Kale	11,426,426	8.33
Chili + Tomato + Eggplant	29,589,800	18
Long Beans + Kale	1,797,889	10
Eggplant + Chili	18,626,900	14
Kale + Eggplant	-1,331,770	6.3
Gambas + Cucumber + Eggplant	3,914,733	6.5
Chili + Tomato + Soybean	19,392,714	10.21
Kale + Spinach	-1,913,619	6.85
Tomato + Cucumber + Soybean	7,104,310	7.86
Chili + Cucumber + Tomato	8,482,167	8
Chili + Tomato	17,110,528	10
Chili + Kale + Cucumber	19,084,750	14.5
Chili + Tomato + Kale	16,565,958	23

In Table 4 it can be seen that of the 16 combinations of vegetables in the study area, the combination that provides the greatest income is the combination of chilies + tomatoes + eggplant, which is IDR 29.589.800 for one year with land use of 18 borong, the next biggest income is the combination of chilies + tomatoes + soybeans and chilies + kale + cucumber. While there are several other combinations that produce negative incomes, farmers do not know that combination results in losses if it continues to be cultivated.

Analysis of Combination with Optimization

According to Asri and Widayat (1981) the steps taken in the preparation of LP are: 1) Determining activities; 2) Determine resources; 3) Calculating the quantity of input and output of each production activity; 4) Determine capacity limits; and 5) Developing a model. The mathematical model for optimizing the combination of vegetable farming is stated as follows:

Purpose Function:

$Z = 4{,}416{,}543X1 + 1{,}326{,}000X2 + 1{,}150{,}595X3 + 711{,}934X4 + 1{,}783{,}333X5 + 2{,}867{,}370X6 + 1{,}848{,}857X7 + 2{,}612{,}500X8 + 4{,}800{,}000X9$

Constraint Function

- Land $5{,}57X1 + 4{,}00X2 + 3{,}90X3 + 6{,}08X4 + 4{,}50X5 + 2{,}04X6 + 1{,}75X7 + 1{,}60X8 + 1{,}00X9 \leq 30.0$
- Labor $3{,}23X1 + 13{,}10X2 + 6{,}17X3 + 1{,}67X4 + 6{,}18X5 + 10{,}02X6 + 14{,}61X7 + 32{,}49X8 + 34{,}50X9 \leq 121{,}00$
- Capital $452229.00X1 + 1022104.00X2 + 1181594.00X3 + 75018.0X4 + 195820.00X5 + 2195770.00X6 + 2487523.00X7 + 2349505.00X8 + 1779333.00X9 \leq 11738901.00$

Optimization analysis using Linear Programming consists of primal analysis, dual analysis and sensitivity analysis.

Primal Analysis

The results of the primal analysis carried out on the data showed that the optimal combination of vegetable suggested to farmers for cultivation were chilies, soybeans and gambas. The reduced cost value for these types of vegetables is 0, the reduced cost in this case is the reduction in income, if it is still applied, the income will be reduced by the value of the reduced cost for each type of vegetable. Kale has a reduced cost value of 3.455.081.10, meaning that if farmers continue to apply kale farming, it will cause a reduction in income of IDR 3,455,081.10 as illustrated in Table 5.

Table 5. Land area and total income from optimization

Types of vegetables	*Reduced cost*	Area of land	Total income
Chili	0.00	4.55	20088800.06
Kale	3455081.10	0.00	0.00
Tomato	2023890.15	0.00	0.00
eggplant	4268794.74	0.00	0.00
Long beans	2158811.65	0.00	0.00
Soy	0.00	2.40	6891311.90
Cucumber	680470.30	0.00	0.00
Spinach	1981607.89	0.00	0.00
Gambas	0.00	2.45	11762940.95

In Table 5, it can be seen that the largest reduced cost value is found in eggplant with a value of 4.268.794,74 which illustrates that if farmers add 1 more land area for eggplant, it will cause a reduction in income of IDR 4.268.794,74. While the smallest reduced cost value is cucumber with a reduced income of IDR 680.470,30.

The variable value of chilli shows that in optimal conditions with maximum income, farmers are advised to cultivate chilies in an area of 4.55 borong, soybean in an area of 2.40 borong and gambas in an area of 2.45 borong. This combination will be able to generate income of IDR 20.088.800,06 for chilies, IDR 6.891.311,90 for soybeans and IDR 11.762.940,95 for gambas so you can get an overall income of IDR 38.743.052,91.

Dual Analysis

This analysis illustrates the optimal use of resources in farming activities. An assessment of the scarcity or absence of a resource that is a constraint can be seen from the slack value. This slack value explains the excess resources used so that if the slack value is not equal to 0 it means that the currently used resources are excessive and must be reduced to be efficient. Rare resources are indicated by slack with a value of 0. From the calculation results, the three constraints in the form of land, labor and capital have a slack value of 0, which means that these resources are used up in farming activities or are called limiting resources. The use of resources by respondent farmers is illustrated in Table 6.

Table 6. Useconstraint factor optimization results

Constraint factor	Slack	*Dual price*
Land	0.00	809097.54
Labor	0.00	114986.13
Capital	0.00	0.04

The dual price value is the shadow price of a resource. Land constraint is the main obstacle in achieving optimal results because it has the largest dual price value, 809.097,54 which illustrates that the addition of 1 piece of land will increase farm income by IDR 809.097,54. Then the second obstacle is in the form of labor resources where the dual price value is 114.986,13, meaning that if the labor is added by 1 working day, the income will increase to IDR 114.986,13. Meanwhile, the capital constraint is an obstacle that has a dual price of only 0,04, which means that the additional capital will only increase the income of. IDR 0,04 or it can be said that it only affects the addition of income on a very small scale.

Sensitivity Analysis

a. Activity Type Sensitivity Analysis

This analysis shows the sensitivity interval for changes in income for each farm that is suggested to be cultivated and guarantees that it does not affect the optimal solution. This change in income is influenced by changes in prices. The income change sensitivity interval is shown in Table 7.

Table 7. Hosethe sensitivity to changes in income

Types of vegetables	*Allowable decrease*	*Allowable increase*
Chili	-infinity	4614668.79
Soy	2798559.84	*infinity*
Gambas	-infinity	5061165.82

In Table 7, it can be seen that chilli farming has a decrease limit of infinity and an increase limit of 4.614.668,79, meaning that if the farmer's income from chilli farming has decreased to unlimited or has increased to IDR 4.614.668,79, then the total income of the current farmer optimal conditions will not change.

Likewise with gambas which has an infinity decrease limit and has an income increase limit of IDR 5.061.165,82. Meanwhile, soybean has a sensitivity interval with an infinite increase in limit and a decrease in income of IDR. 2 798 559.84 in order to maintain optimal conditions.

b. Right Hand Side (RHS) Sensitivity Analysis

This analysis shows the interval of changes in resource availability, which is indicated by the allowable increase and decrease values, depicted in Table 8.

Table 8. Hosesensitivity to changes in resource availability (constraint factors)

Constraint factor	*Allowable decrease*	*Allowable increase*	*Dual price*
Land	9.61	72.94	810314.35
Labor	57.63	193.53	115049.88
Capital	-infinity	*infinity*	0.04

In Table 8, it can be seen that the availability of land constraints which are currently at 30 borong can be reduced to 9.61 and the limit of increase is up to 72.94, then the range of land resource optimization is 20.39 <land <102.94. This range provides information that land availability is allowed to increase to a maximum of 102.94 borong and down to a minimum of 20.39 borong. So if farmers apply land between these ranges, the dual price of land resources is still IDR 809,097.54.

Labor constraints have ranges between 63.37 <TK <314.53 so that the increase in the availability of labor is a maximum of 314.53 HKSP and a minimum decrease of 63.37 HKSP. The rate of increase or decrease in the availability of labor is influenced by the growing season for other crops such as rice. During the rice planting or harvest season, the availability of labor tends to be concentrated in rice farming, so that the availability of labor for vegetable farming will decrease. On the other hand, if there is no rice planting / harvesting season, the availability of labor for vegetable farming will increase.

Meanwhile, the results of the sensitivity analysis on capital constraints do not have an infinity limit, meaning that if the use of capital continues to be increased to any extent, the value of dual capital resources remains Rp. 0.04, as well as the limit of infinity.

Comparison of Actual and Optimal Conditions

In actual conditions, there are 16 vegetable cropping patterns in the study area, one of the combinations that provides the greatest income is chilli + tomato + eggplant, which is IDR 29.589.800 with an allocation of land use of 18 borong. Meanwhile, based on the calculation results, if the farmer applies a vegetable combination in optimal conditions the farmer will get an income of IDR 16.683.302 using only 9,4 borong of land. In order to compare these 2 conditions, the two fields must have the same area. Therefore, it is assumed that the total land area is 18 borong in actual conditions, the income is calculated only with a land area of 9,4 borong, so the income will be IDR 15.452.451.

Rice and orange farming produces quite a large profit value, this indicates that these two commodities are very appropriate to be applied in the farming combination in the research area, because farmers will benefit from their farming. On the other hand, the application of optimal vegetable combinations in farming is one of the right alternatives to increase farmer incomes. This is because farmers who cultivate rice and oranges with the Surjan system still have land remaining between planting oranges. This area of land can be used to grow vegetables which can provide additional income while the farmers wait for the rice and orange harvests.

IV. Conclusion

Based on research results

1. The average actual farm income of farmers for each commodity is rice amounting to IDR 280.271/ borong, for orange of IDR 196.710 / borong, while the vegetable that provides the greatest income is the combination of chili - tomato - eggplant at IDR 1.643.877 / borong.
2. The optimal combination that can be an alternative for farmers to generate maximum income is chili - soy - gambas. This optimal vegetable combination will generate an income of IDR 1.774.819 / borong.
3. The average total income of farming in actual conditions is IDR 2.120.858 / borong, while optimal combination it will give farmers an average total income of IDR 2.251.800 / borong. This value is bigger when compared to the actual combination that has been done by the farmers.

V. Suggestion

Farmers are expected to be able to follow the optimal combination, because it will provide greater income. The implementation of this combination needs support from all parties, both from extension workers, government elements as policy makers and farmers as direct implementers in the field. Land resources are the most important resources that can be considered by farmers to increase their income

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