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RESEARCH ARTICLE

Model for Optimizing Land Use to Support Sustainable Environmental Economic Strengthening in the Upper Kampar River Basin

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Abstract

Simple and complex agroforestry systems can be implemented simultaneously in the cultivation area within the Upper Kampar River Basin. Based on the ArcSWAT simulation results, the surface runoff (Qsurf) was estimated to be 37.20 mm, which is significantly lower than the existing land use runoff in 2014, which was 102.12 mm. This forms the basis for implementing simple agroforestry and complex agroforestry systems in the Upper Kampar River Basin. The plant species that can support these agroforestry systems are selected based on the principles of land conservation and the suitability of local plants in the Upper Kampar Watershed environment. Four types of filler plants are considered: coffee and cocoa for the simple agroforestry system, and gambier and ambon bananas/kepok bananas for the complex agroforestry system. These plant species are the most dominant filler plants in the Upper Kampar Watershed. To optimize the land with these filler plant species, analysis is conducted using Quantitative Methods (QM) for Windows 4 software based on objective functions and constraint functions. The analysis determines that coffee is suitable for the simple agroforestry system, while gambier is suitable for the complex agroforestry system. Before land optimization with the planting of coffee, cocoa, gambier, and ambon bananas/kepok bananas, the net profit is estimated to be IDR. 359,113,963,811.06. After optimizing the land and developing it with the suitable filler plant species, only coffee and gambier are planted, while cocoa and ambon bananas/kepok bananas are planted according to the available area. As a result, the net profit increases to IDR. 951,426,300,000, with an economic value increase of IDR. 592,312,336,188.94 per year.

Keywords: Scenario, land use, runoff reduction, cover crops, land optimization.

1. Introduction

The Upper Kampar Watershed is located in three regencies, namely Kampar Regency covering an area of 73,506.46 hectares (22.25%), Pasaman, and Lima Puluh Kota with an area of 256,816.96 hectares (77.75%). Referring to Nurdin et al.'s study in 2019, based on the Land Use Map of 2014, the Upper Kampar Watershed has a forest area of 142,160.07 hectares (44.431%) and a cultivation area of 177,799.41 hectares (55.569%). In the Pasaman Regency, the Upper Kampar Watershed is located in the South Mapat Tunggul Subdistrict with a population growth rate of 1.56%. In Lima Puluh Kota Regency, it is found in Kapur IX Subdistrict with a population growth rate of 1.02%, Bukit Barisan Subdistrict with a population growth rate of 0.85%, and Pangkalan Koto Baru Subdistrict with a population growth rate of 0.82%. In Kampar Regency, it is found in the XIII Koto Kampar Subdistrict with a population growth rate of 1.48% and Koto Kampar Hulu Subdistrict with a population growth rate of 3.81%. According to (Suasti et al., 2012) the increasing population growth has led to rapid development, resulting in changes in land use patterns. Built-up areas are expanding and encroaching upon natural spaces, causing them to change their functions.

Agroforestry is a land use system that involves various technologies and utilizes annual crops, perennial crops, and/or livestock simultaneously or in rotation over specific periods, resulting in ecological, social, and economic interactions. Agroforestry systems have more advantages compared to other land use systems. One of the advantages of this system is its suitability for steep sloping land. Multistrata agroforestry systems can prevent soil erosion by building organic matter in the soil, improving soil structure, and making the soil more stable (Rendra et al., 2016). The use of ArcSWAT 2012 has simulated three scenarios regarding land use in the year 2014 and has provided the best results in scenario III. Scenario III involves the combined implementation of simple agroforestry patterns and complex agroforestry, simultaneously applied to a cultivation area covering 175,881.45 hectares (54.94%) of the total land area of the Upper Kampar Watershed (330,240.36 hectares). This land use pattern has the potential to reduce surface runoff from the existing Qsurf value of 102.12 mm to Qsurf as low as 37.20 mm (Nurdin et al., 2019).

Quoting from (Jong Jek Siang, 2011), mathematical programming techniques in Operations Research are useful for finding the optimal values of a multi-variable function that satisfies a set of constraints. Some models involving calculus and numerical methods are used to solve these problems. The models that fall under this technique include: Calculus Methods, Nonlinear Programming, Geometric Programming, Quadratic Programming, Linear Programming, Dynamic Programming, Integer Programming, Network Methods: CPM and PERT, Game Theory, Separable Programming, Multi-Objective Programming, etc.

The land use in Scenario III in the cultivation area of the Upper Kampar Watershed has been simulated by (Nurdin et al., 2019) using the ArcSWAT 2012 application. The simulation resulted in lower surface flow, as indicated by the value of Qsurf. However, the suitable and optimal use of filler crops in simple agroforestry and complex agroforestry patterns to provide economic value to the communities around the Upper Kampar Watershed is not known yet.

To determine the optimal land use for filler crops in simple agroforestry and complex agroforestry patterns, the software program "Quantity Method (QM) for Windows" can be used. Quoting from (Harsanto, 2011), QM for Windows is user-friendly software developed to accompany operations management textbooks. It assists in the technical calculation process for quantitative decision-making.

2. Methods

2.1. Research sites

The research location is located within the Upper Kampar Watershed, in the Mapat Tunggul Selatan Subdistrict, Kapur IX Subdistrict, Bukit Barisan and Pangkalan Koto Baru in West Sumatra Province, and the Koto Kampar Hulu and XIII Koto Kampar Subdistricts in Riau Province. The administrative map of the subdistricts within the Upper Kampar Watershed is presented in **Figure 1**.

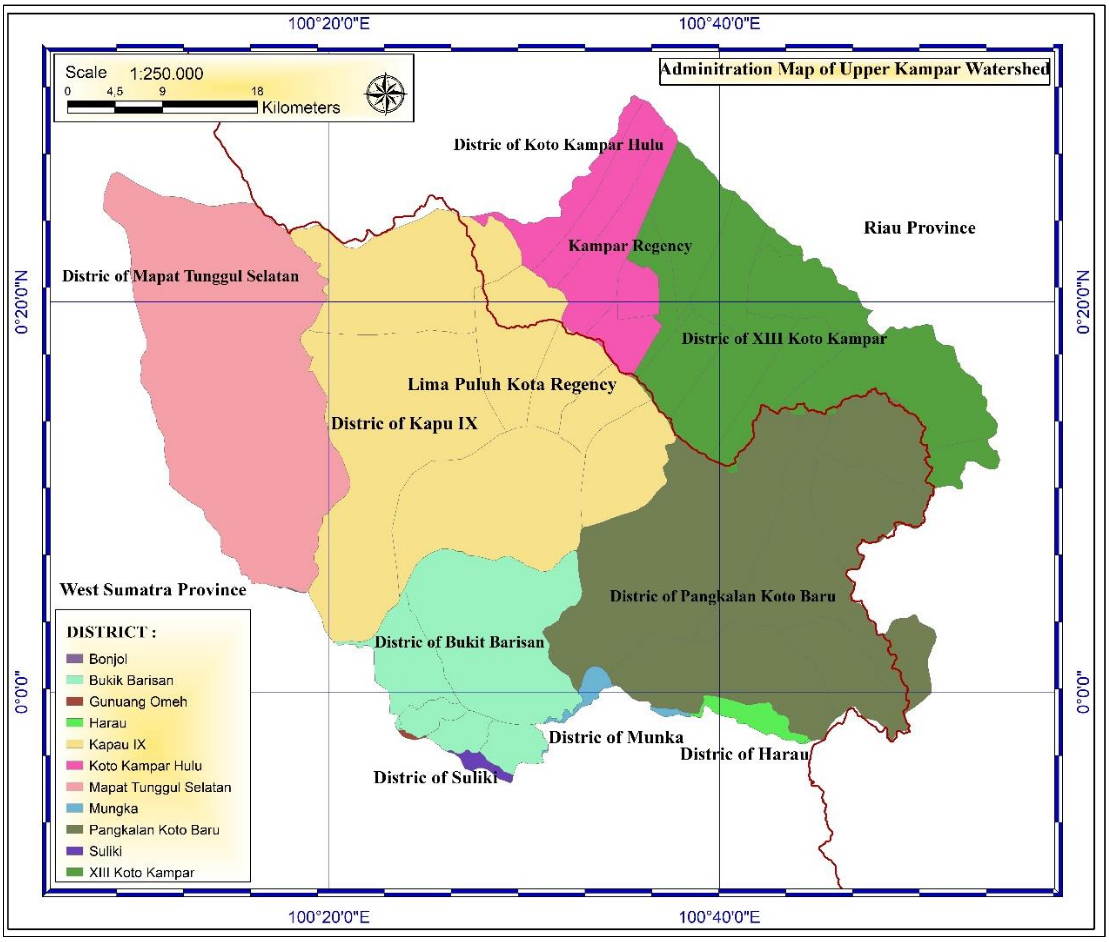

Fig 1. Administrative Map of the Upper Kampar Watershed

2.2. Work Steps for Implementing a Linear Program

a. Determination of Agroforestry Pattern Areas

The implementation of agroforestry patterns in the best scenario for the Upper Kampar Watershed is in scenario III, specifically in the agricultural cultivation area covering an area of 175,881.45 hectares (54.94%) of the total land area within the Upper Kampar Watershed, which is 330,240.36 hectares. According to Nurdin et al. (2019), hydrological analysis using the AcrSWAT application can reduce surface runoff (existing Qsurf) from 102.12 mm to Qsurf = 37.20 mm. This pattern involves the implementation of simple and complex agroforestry simultaneously in the cultivation area within the Upper Kampar Watershed. This Agroforestry pattern serves as the basis for implementing a sustainable land use program in the future in the Upper Kampar Watershed. According to (Lensari et al., 2022) have optimized land use through an agroforestry system by assisting a group of women farmers in planting home gardens, resulting in environmental and economic benefits for the community.

b. Types of Filling Plants in Agroforestry Patterns.

The concept of filler plants in agroforestry patterns is derived from the source of (BPS Kabupaten Lima Puluh Kota, 2017), with an area of 100% in the Upper Kampar Watershed. The three districts used as benchmarks for predicting the extent and productivity of existing filler plant species are Bukik Barisan District, Kapur IX District, and Pangkalan Koto Baru District in Lima Puluh Kota Regency. These districts are used as references for predicting the extent and productivity of existing filler plant species. As for other supporting data, especially in determining selling prices that are not available in the Central Statistics Agency of Lima Puluh Kota Regency, reliable sources such as journals from various publications and other books are used.

c. Use of Linear Programs in Optimization

Linear programming, as referred to in this case, follows several previous authors such as (Niswarni, 2016), (Nasution et al., 2015), (Rotinsulu et al., 2020), and (Rumetna et al., 2021). It aims to find the combination of land areas for different filler crops in simple and complex agroforestry patterns, in order to optimize income based on the production prices of each crop. Both simple and complex agroforestry patterns involve planting more than one type of filler crop, which mathematically forms a set of variables XS1, XSn, XC1, and XCm representing the area of each filler crop as parameters in the agroforestry patterns. Furthermore, the objective function and constraint function can be formulated in mathematical expressions to determine the objective and constraint functions ;

Objective Function

The goal to be achieved is to maximize profit (Z), which is stated in the following equation:

$$\text{Max } Z = PS1XS1+PSnXSn+PC1XC1+PCmXCm \quad (1)$$

Where Z = net profit optimization results

XS1, XSn = The variables represent the area of each type of Filler Crop 1 to n in simple agroforestry.

XC1, XCm = variables in the form of the area of each type of filling plant 1 and to m complex agroforestry

PS1, PSn = arameters in the form of net profit/ha for each type of filler plant 1 and to n for a simple agroforestry pattern

PC1, PCm = parameters in the form of net profit/ha for each type of filler plant 1 and to the m agroforestry complex

Constraint Function

The limitations that exist are the constraints in conducting optimization analysis. This analysis is performed by considering the constraints :

a. First obstacle

A simple agroforestry land area limit can be formulated:

$$XS1 + XSn \leq AS \quad (2)$$

Where,

AS = area of simple agroforestry land suitable for planting

b. Second obstacle

Limits of complex agroforestry land area can be formulated:

$$XC1 + XCm \leq AC \quad (3)$$

Where,

AC = area of complex agroforestry land suitable for Planting

c. The third to sixth constraints limiting the area of each simple agroforestry and complex agroforestry land types can be formulated :

$$Xs1 \geq AS1 \quad (4)$$
$$Xsn \geq ASn \quad (5)$$
$$Xc1 \geq AC1 \quad (6)$$
$$Xcm \geq ACm$$

Where, (7)

AS1, ASn = minimum area limits for each type of filler plan on seder agroforestry

AC1, ACm = minimum area limits for each type of filler plant complex agroforestry patterns.

The value of the net profit/ha for each type of plant including the type of filler considered, the area of simple and complex agroforestry land that is suitable for planting, and the minimum area of each type of filler considered for simple and complex agroforestry is entered into the form of a linear equation. Furthermore, these new equations are input into the Quantitative Methods (QM) for Windows 4 program, and will obtain the optimal area of each type of infill plant on simple and complex agroforestry patterns.

3. Results and Discussion

3.1. Determination of Agroforestry Pattern Areas

The Upper Kamkar Watershed

The implementation of simple and complex agroforestry patterns simultaneously in the cultivation areas within the Upper Kampar Watershed. These cultivation areas include dryland farming, plantations, paddy fields, open land, dryland farming mixed with shrubs, shrubs/brushes, covering a total land area of 175,881.45 hectares (54.94%) out of the total land area of the Upper Kampar Watershed, which is 330,240.36 hectares (Nurdin et al., 2019). According to (Rianse, 2010), in the simple agroforestry pattern, trees are intercropped with various annual crops. High-value economic tree species such as coconut, rubber, cloves, teak, as well as low-value economic tree species such as dadap, lamtoro, kaliandra, are planted, along with annual crops such as rice, corn, soybeans, legumes, cassava, vegetables, and other grasses. In the complex agroforestry pattern, fruit trees such as durian, rambutan, and banana, as well as shrubs like gambier, are cultivated. The implementation of these agroforestry patterns aims to reduce surface runoff (existing Qsurf = 102.12 mm) to Qsurf = 37.20 mm. This can contribute to the reduction of surface water flow, leading to better water management and conservation in the Upper Kampar Watershed.

3.2. Types of Filling Plants in Agroforestry Patterns.

Three sub-districts that have their administrative areas 100% within the Upper Kampar Watershed are Bukit Barisan, Kapur IX, and Pangkalan Koto Baru in Lima Puluh Kota Regency. These sub-districts are used as a benchmark to predict the extent and productivity of existing filler crops within the Upper Kampar Watershed because some of the land already has perennial lowland crops such as coffee, ambon/kepok bananas, cocoa, gambier, bitter beans, rambutan, sapodilla, starfruit, guava, water guava, papaya, soursop, and others. In accordance with land conservation principles, the cultivation of lowland crops in the cultivation areas can serve as erosion prevention, but due to their irregular distribution, planned cultivation patterns need to be implemented, prioritizing local plant species that meet the priorities of the local community. In line with this (P and Meydianawathi, 2014) implemented an agroforestry program by intercropping cassava, peanuts, and corn among the trees, but it can still be optimized by encouraging farmers to cultivate understory plants such as ginger, turmeric, and galangal.

The strategy implemented to ensure the simultaneous implementation of simple and complex agroforestry patterns in the Upper Kampar Watershed is by analyzing the optimal land area for each type of filler crop. The designated land area for simple/complex agroforestry patterns in three districts of Upper Kampar Watershed already consists of 20,004.52 hectares (17.79%), approaching 20% of the total area. Assuming that the effective land area for perennial crops is only 50% of the total agroforestry area and deducting the already planted perennial filler crops by 20%, there is still room to insert 30% of perennial crops. Hence, the total land area available for planting is 52,734.43 hectares out of the 175,781.44 hectares of land allocated for simple and complex agroforestry in DAS Kampar Hulu. This consists of 31,082.50 hectares for simple agroforestry and 21,651.93 hectares for complex agroforestry.

3.3. Use of Linear Programs in Optimizing Land Use

Linear programming, in this case, refers to finding the optimal combination of land areas for filler crops in a simple and complex agroforestry pattern, in order to generate optimal income based on the respective production prices of each crop. Based on data from (BPS Kabupaten Lima Puluh Kota, 2017), the dominant filler crops in three sub-districts, with 100% land area in the Upper Kampar Watershed, that align with the conservation concept for simple agroforestry patterns are coffee and cocoa. In addition, for complex agroforestry, the dominant crops are gambier and Ambon/Kepok bananas.

According to (Ukrita, 201AD), the export of coffee from West Sumatra is still low due to the limited export volume caused by the insufficient quality required for export purposes. Meanwhile (P and Meydianawathi, 2014) state that cocoa beans are relatively expensive, primarily used for export purposes. Indonesia is one of the world's cocoa exporters, with West Sumatra being a major supplier of cocoa in Western Indonesia. The complex agroforestry system involves the cultivation of gambier plants and Ambon/Keppok bananas among existing and new tall plants. According to (Nasution et al., 2015) and (Hendri et al., 2021), Indonesia is the largest producer of gambier in the world, with a significant portion coming from the Limapuluh Kota Regency in West Sumatra. According to (Fairuzi, 2008) states that Ambon/Keppok bananas are not only needed for domestic purposes but also for markets in Pekanbaru and Jakarta, where they are used in various products.

The predicted harvest areas for four types of filler crops in the Upper Kampar Watershed are based on the harvest areas in three districts as shown in Table 1. The respective ratios for each crop type with simple and complex agroforestry areas are 0.40% for coffee, 0.89% for cocoa, 28.43% for gambier, and 0.12% for Ambon bananas. These ratios result in the following harvest areas in the Kampar Hulu Watershed: 419.01 hectares for coffee, 925.67 hectares for cocoa, 20,519.50 hectares for gambier (the largest area), and 83.20 hectares for Ambon bananas. Based on the harvested area of each filler crop in the Upper Kampar Watershed and the productivity in three districts for coffee at 1.30 tons/ha, cocoa at 0.81 tons/ha, gambier at 0.74 tons/ha, and ambon banana at 39.04 tons/ha, these figures are used to estimate the production of the four types of filler crops in the Upper Kampar Watershed. The estimated production is as follows: 545.30 tons of coffee, 747.46 tons of cocoa, 15,093.90 tons of gambier, and 3,248.03 tons of ambon banana. Based on the estimated production, the gross income in the Upper Kampar Watershed for each filler crop is calculated using the following production prices: coffee at IDR 23,500,000/ton, cocoa at IDR 32,083,333/ton, gambier at IDR 27,500,000/ton, and ambon banana at IDR 2,404,186.11/ton. The estimated gross incomes for each crop are as follows: IDR 12,814,569,762.95 for coffee, IDR 29,698,713,417.78 for cocoa, IDR 564,280,646,653.35 for gambier, and IDR 200,027,286.55 for ambon banana.

The cost of production for four types of crops, coffee, cocoa, gambier, and ambon banana, is referenced from several research findings. According to (Listyati et al., 2017), the net profit from coffee sales is IDR 11,417,600, derived from the gross profit of IDR 18,059,500 minus the production cost of IDR 6,641,900, with a net profit to gross profit ratio of 63.22%. For cocoa crops, referring to the findings of (Rusdiana and Martono, 2014), the net profit is IDR 12,225,000, derived from the gross profit of cocoa sales of IDR 21,630,000 minus the production cost of IDR 9,105,000, with a net profit to gross profit ratio of 57.91%. Regarding gambier crops, referring to (A.F and Rosmeilisa, 2001), the net profit is IDR 11,642,500, derived from the gross profit of gambier sales of IDR 19,687,500 minus the production cost of IDR 8,045,000, with a net profit to gross profit ratio of 59.14%. Finally, based on the research conducted by Widowati et al. (2015), the net profit from ambon bananas is IDR 6,278,350, derived from the gross profit of banana sales of IDR 12,750,000 minus the production cost of IDR 6,471,650, with a net profit to gross profit ratio of 49.24%. By applying these net profit to gross profit ratios, the net earnings for coffee are calculated to be IDR 8,101,371,004.14, for cocoa IDR 17,198,524,940.23, for gambier IDR 333,715,574,430.79, and for ambon banana IDR 1,183,821.24. The total net profit (existing) for one year amounts to IDR 359,113,963,811.06.

Optimizing land use with four types of filler crops, namely coffee and cocoa for simple agroforestry patterns, gambier and ambon banana for complex agroforestry patterns, can be conducted and analyzed using the software Quantitative Methods (QM) for Windows 4 based on the objective function and constraint function. The mathematical formulation consists of four variables: two variables, XS1, indicating the area of land for simple agroforestry planted with coffee, XS2, indicating the area of land for simple agroforestry planted with cocoa, two variables, XC1, indicating the area of land for complex agroforestry planted with gambier, and XC2, indicating the area of land for complex agroforestry planted with ambon banana.

Tabel 1. Estimates of the benefits of coffee, cocoa, gambier and ambon/kepok bananas in the Upper Kampar watershed

Description	**Types of filler plants**			
	Coffee	**Cocoa**	**Gambier**	**Ambon banana**
Calculations within 3 districts				
Harvest area (ha)	282,00	623,00	12.139,00	49,22
Production (tonnes)	367,00	503,06	8.929,39	1.921,50
Productivity (tonnes/ha)	1,30	0,81	0,74	39,04
Area of AS (ha)		69.730,79		
Area of AC (ha)				42.696,85
Harvested area ratio/Area fo AS (%)	0,40	0,89		
Harvested area ratio/Area fo AC (%)			28,43	0,12
Estimates within the Upper Kampar River Basin				
Area of AS (ha)		103.608,34		
Area of AC (ha)				72.173,11
Harvest area (ha)	419,01	925,67	20.519,30	83,20
Production (tonnes)	545,30	747,46	15.093,90	3.248,03
Price (IDR/tonnes)	23.500.000,00	32.083.333,50	27.500.000,00	2.404.186,11
Gross income (IDR)	12.814.569.762,95	29.698.713.417,78	564.280.646.653,35	200.027.286,55
Net income/Gross income (%	63,22	57,91	59,14	49,24
Net income (IDR/ha)	19.334.783,33	18.579.458,43	16.263.500,00	1.183.821,24
Net profit (IDR)	8.101.371.004,14	17.198.524.940,23	333.715.574.430,79	98.493.435,90
Total net profit (IDR)				**359.113.963.811,06**

Source : (Listyati et al., 2017), (Rusdiana and Martono, 2014), (Rizal et al., 2015), (A.F and Rosmeilisa, 2001), (BPS Kabupaten Lima Puluh Kota, 2017) and processing and analysis results

So that the net profit value/ha for each type of coffee plant is IDR 19,334,783.33/ha and cocoa is IDR 18,579,458.43/ha, for this type of gambier plant it is IDR 16,263,500/ha and for the type of Ambon banana plant is and IDR 1,183,821.24/ha, so the goal is to maximize net profit (Z) which can be described in the equation:

Maximize Z = 19,334,783.XS1 + 18,579,458.XS2 + 16,263,500.XC1 + 1,183,821.XC2

The first obstacle is the maximum area of simple agroforestry land suitable for planting with coffee filling plants covering an area of 31,082.50 ha. Second obstacle

is the maximum area of complex agroforestry land that is suitable for planting gambier and ambon banana fillers with an area of 21,651.93 ha. The third to sixth obstacle is the minimum limit of simple and complex (existing) agroforestry land, where coffee plants cover an area of 419.01 ha, cocoa cover an area of 925.67 ha, gambir cover an area of 20,519.30 ha and Ambon bananas cover an area of 83.20 ha.

Based on the variables XS1, XS1, XC1 and XC2 which are non-negative variables having values greater than zero, which form the equations as input to the QM for Windows 4 auxiliary program to solve linear programs, with a set of linear programming mathematical formulas:

Maximum Z = 19,334,783.XS1 + 18,579,458.XS2 + 16,263,500.XC1 + 1,183,821.XC2

With delimiter:

$XS1 + XS2 \leq 31.082,50$

$XC1 + XC2 \leq 21.651.9$

$XSi \geq 419,01$

$XS2 \geq 926,67$

$XC1 \geq 20.519,30$

$XC2 \geq 83,20$

The results of optimizing simple agroforestry land with coffee and cocoa filler species and complex agroforestry land with gambir and ambon banana filling plants in the QM for Windows 4 linear program application are in the form of the area of each type of filler plant:

a. XS1 coffee plantation area = 30,155.83 ha

b. XS2 cocoa plantation area = 926.67 ha

c. Gambir XC1 = 21,568.73 ha

d. Ambon banana plantation XC2 = 83.20 ha

e. The net profit value Z = IDR. 951.426.300.00.

The minimum limit of land input for coffee filling plants is as large as coffee plants in the Upper Kampar Watershed, namely, 419.01 ha, where the maximum limit for agroforestry land is 31,082.50 ha, with an optimized land area for coffee plants of 30,155 .83 ha. The remaining simple agroforestry land is only 926.67 ha, which is equal to the minimum area of land for planted cocoa plants as well as the area of output cocoa plants in the QM for Windows 4 model. To obtain optimal land use, the area of coffee land that can be developed area of 29,736.82 ha, cocoa plants are not feasible to develop.

Gambier filler plants with a minimum land area of 20,519.30 ha, with a maximum limit of 21,651.93 ha for complex agroforestry land. Of the 21,568.73 ha of optimized land area for gambier plants, only 83.20 ha of complex agroforestry land remains, the same as the minimal Ambon banana land area. The optimal area of Gambier land that can be developed is 1,049.43 ha, while the Ambon banana land is not feasible for development.

If before optimizing the area planted with coffee was 419.01 ha, cocoa was 925.67 ha, gambir was 20,519.90 ha, and Ambon banana was 83.20 ha, then a net profit of IDR. 359,113,963,811.06. After the land was optimized, it was found that the area for the development of fill land with coffee plant types was 29,736.82 ha, and 1,049.43 ha for gambier plantations, so from the addition of the development area, a net profit of IDR 951,426,300,000.

In other words, after optimizing the land, the amount of increase in economic value for the people around the Upper Kampar Watershed is IDR 592,312,336,188.94 as presented in Table 2. A map of the distribution of agroforestry land for simple and complex patterns is presented in Figure 2.

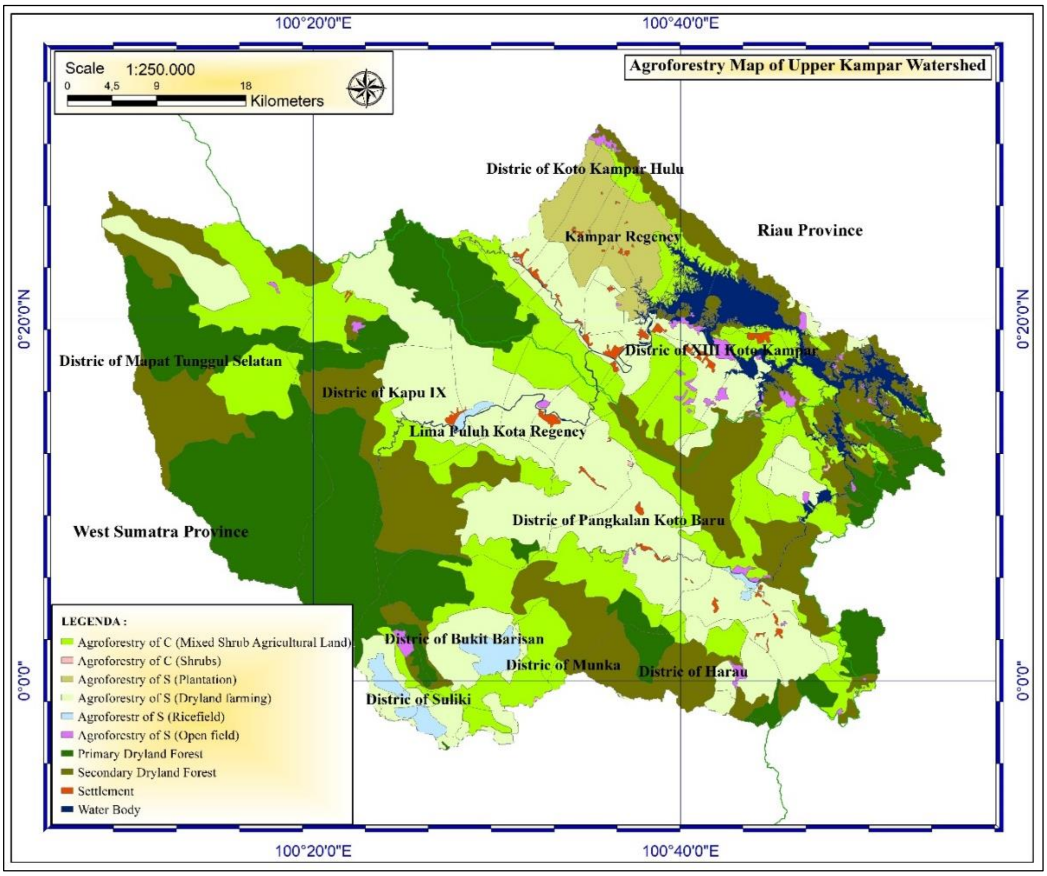

Fig 2. Map of the distribution of agroforestry land in the Upper Kampar Watershed

Table 2. Net profit before and after land optimization

Plant Type	Planting area before optimization (ha)	Net profit before optimization (IDR)	Planted area after optimization (ha)	Net profit After optimization (IDR)	Economic improvement after optimization (IDR)
Coffee	419,01	8.101.371.004,14	30.155,83	544.604.803.108,46	536.503.432.104,32
Cacao	926,67	17.198.524.940,23	926,67	17.198.524.940,23	
Ambon Banana	20.519,30	333.715.574.430,79	21.568,73	389.524.478.515,41	55.808.904.084,62
Gambier	83,20	98.493.435,90	83,20	98.493.435,90	
		359.113.963.811,06		951.426.300.000,00	592.312.336.188,94

Source : Output Results QM for Windows

If the number of farmers is 35,899 people, then the existing net profit before land optimization is IDR. 359,113,963,811.06, or each farmer gets a profit of IDR. 10,003,453.13 for one year or IDR. 833,621.09 / farmer every month. While the net profit after optimization is IDR. 951,426,300,000, so that each farmer gets a net profit of IDR. 26,502,863.59 for one year or IDR. 2,208,571.966/farmer every month. It can be said that there has been an increase in the economic value for each farmer of IDR. 16,499,410.46/year or IDR. 1,374,950.87/month.

4. Conclusion

1. The use of Quantitative Methods (QM) for Windows 4 in optimizing land in the Upper Kampar watershed with coffee filler types for simple agroforestry patterns and Gambier for complex agroforestry patterns can increase the social and economic value of the community.
2. In the condition of the land prior to optimization by planting coffee, cocoa, gambier and Ambon bananas, the net profit was only IDR. 359,113,963,811.06. The results of optimizing the development of infill land that are feasible to develop are only for coffee and gambier plants, while for cocoa and ambon bananas only according to the existing area, so that a net profit of IDR. 951,426,300,000 with an increase of IDR. 592,312,336,188.94 for one year.
3. The simple and complex agroforestry patterns implemented in the Upper Kampar Watershed can increase the economic value of IDR. 16,499,410.46/year/Farmers or IDR. 1,374,950.87/month/Farmers.

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