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RESEARCH ARTICLE

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Land Suitability and Availability Evaluation for Social Forestry in Pesawaran Regency, Lampung Province

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ABSTRACT

The Indonesian government established Social Forestry (SF) Program in 2015 to overcome inequality in land tenure, overcome agrarian conflicts and improve the welfare of communities around the forests. Pesawaran Regency does not yet have SF location guidelines in the Indicative and Social Forestry Areas Map. In fact, Pesawaran Regency has a forest area potential of 28% and has a Human Development Index (HDI) score below the provincial HDI average. This study aims to (1) analyze land use and cover changes in forest areas in 2015 and 2020, and (2) determine land potential for SF. SPOT image is used to analyze land cover with visual interpretation. Land suitability evaluation uses the Multi Criteria Evaluation (MCE) method based on Geographic Information Systems (GIS). The parameters used in this study were land/use cover, soil type, altitude, slope, rainfall, distance from rivers, distance from settlements, and distance from roads The results show that almost half of the forest area in 2020 is in the form of mixed gardens (49.63%), forests (24%), and coffee/cocoa plantations (22.2%). The potential land use changes are from forests to mixed gardens, coffee/cocoa plantation and mines. The parameters most influencing the land suitability for SF are land cover, slope, and soil type. Based on land suitability and land availability analysis for SF, it was found that 66% of the research area had potential for SF.

Introduction

Forest areas in Indonesia cover more than 120.5 million hectares, or two-thirds of the land area [1]. By the end of 2017, 42.2 million hectares of forest area had been allocated to support economic activities, either managed by corporations (96%) or communities (4%) [2]. The low proportion of forest areas managed by communities shows an imbalance in forest management rights between corporations, private companies, and communities. In fact, there are at least 3,324 (3.97%) villages living within forest areas, and 39,147 (46.76%) villages surrounding forest areas [3]. This indicates that the interactions between local communities and forests are quite high. The inequality of land tenure and the phenomenon of poverty in communities around forested areas are the background for the government's establishment of the Agrarian Reform. Agrarian Reform is a National Priority Program in the National Medium-Term Development Plan (*Rencana Pembangunan Jangka Menengah Nasional*/RPJMN) 2015–2019 with the aim of reducing agrarian inequality for justice, resolving agrarian conflicts, and improving people's welfare.

The form of Agrarian Reform in forest areas is the allocation of forest areas for Land Object of Agrarian Reform (*Tanah Objek Reforma Agraria*/TORA) covering 4.1 million hectares and Social Forestry (SF) covering 12.7 million hectares. In the 2020–2024 RPJMN, Social Forestry is a priority activity in the 6th priority program regarding poverty alleviation to develop areas to reduce welfare and ensure equality. SF is defined as a sustainable forest management system implemented in state forest areas or private/customary forests by local communities or customary law communities as the main actors in improving welfare, environmental

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balance, and social and cultural dynamics [4]. Indonesia has five social forestry schemes: Village Forest (*Hutan Desa*/HD), Community Forest (*Hutan Kemasyarakatan*/HKm), Community Plantation Forest (*Hutan Tanaman Rakyat*/HTR), Customary Forest (*Hutan Adat*/HA), and Forestry Partnership. The Ministry of Environment and Forestry (MoEF) has created an indicator map of social forestry areas (*Peta Indikatif dan Areal Perhutanan Sosial*/PIAPS) to provide direction for forest areas that communities can manage through SF. PIAPS has become one of the bases for the central and local governments in designing SF programs, as the distribution of PIAPS varies across Indonesia.

One of the regencies with the smallest indicative area of SF is Pesawaran Regency. Pesawaran Regency has a potential forest area of ± 28% of its area but only 45 hectares were mapped in PIAPS Revision VIII. The Pesawaran Regency is directly adjacent to the provincial capital, which is the center of regional development. Its strategic location did not lead to the rapid development of the Pesawaran Regency. It can be seen from the 2020 Human Development Index (HDI) for the Pesawaran Regency of 65.79, which is still below the average Lampung Province HDI of 69.69 [5]. Therefore, to protect community access to forest areas and to support regional development in the Pesawaran Regency, it is necessary to prepare a direction for the location of SF. In SF, land cover information is an important factor in providing existing conditions for the community use of forested areas.

With the agrarian reform policy established by the government, it is necessary to study how land cover conditions have changed before and after the policy. To determine the right location for Social Forestry, it is necessary to evaluate the suitability and availability of SF in the Pesawaran Regency. Land evaluation uses socio-economic parameters to assess physical data by correlating various aspects and qualities of physical, biological, and land-use data according to economic goals [6]. Hardjowigeno and Widiatmaka [7] describes land suitability evaluation as the process of assessing the potential of land for a particular use, the results of which are depicted in the form of a map that forms the basis for rational land use planning, so that land can be used optimally and sustainably. This study aims to analyze land use and land cover changes (LUCC) from 2015 to 2020 and to determine the land potential for SF in the Pesawaran Regency.

Materials and Methods

Research Area

The research was conducted in forest areas in the Pesawaran Regency. The forest areas in Pesawaran Regency consist of a conservation function such as the Grand Forest Park (*Taman Hutan Raya*/Tahura), which is managed by the Forest Management Unit Wan Abdul Rahman Grand Forest Park (Tahura Wan Abdul Rahman/WAR); the protection forest (*Hutan Lindung*/HL), which is managed by the Lampung Provincial Forestry Service; the Forest Management Unit of Pesawaran Protection Forest (*Kesatuan Pengelolaan Hutan Lindung*/KPHL Pesawaran); and the production forest (*Hutan Produksi*/HP), which has been granted a forest concession to Inhutani V Ltd. The research locations are shown in Figure 1.

Data Collection Method

Primary data were collected through field data collection, Focus Group Discussions (FGDs), and questionnaires. Secondary data consist of spatial and statistical data obtained from various ministries/institutions, either directly or downloaded from the official website. The types and sources of the data used in this study are listed in Table 1. The tools used in this study were a set of computers equipped with ArcGIS 10.8 and Microsoft Office software, digital cameras, a Global Positioning System (GPS), and stationery.

Data Analysis Method

Land Use/Cover Analysis of Forest Areas in Pesawaran Regency

Land use/cover (LUC) analysis was performed by visual interpretation of the corrected SPOT images of 2015 and 2020. The LUC analysis year was chosen to show changes before and after the agrarian reform. The LUC types were classified based on their physical properties visible in the images. The classification process is conducted by considering several factors such as hue, color, shape, size, texture, pattern, shade, and association [8]. Classification was performed by delineation on a computer screen (on-screen digitation). The type of land cover classes followed the Indonesian National Standard (SNI) 7645-1:2014 concerning the Classification of Land Cover: Part 1: small and medium scale.

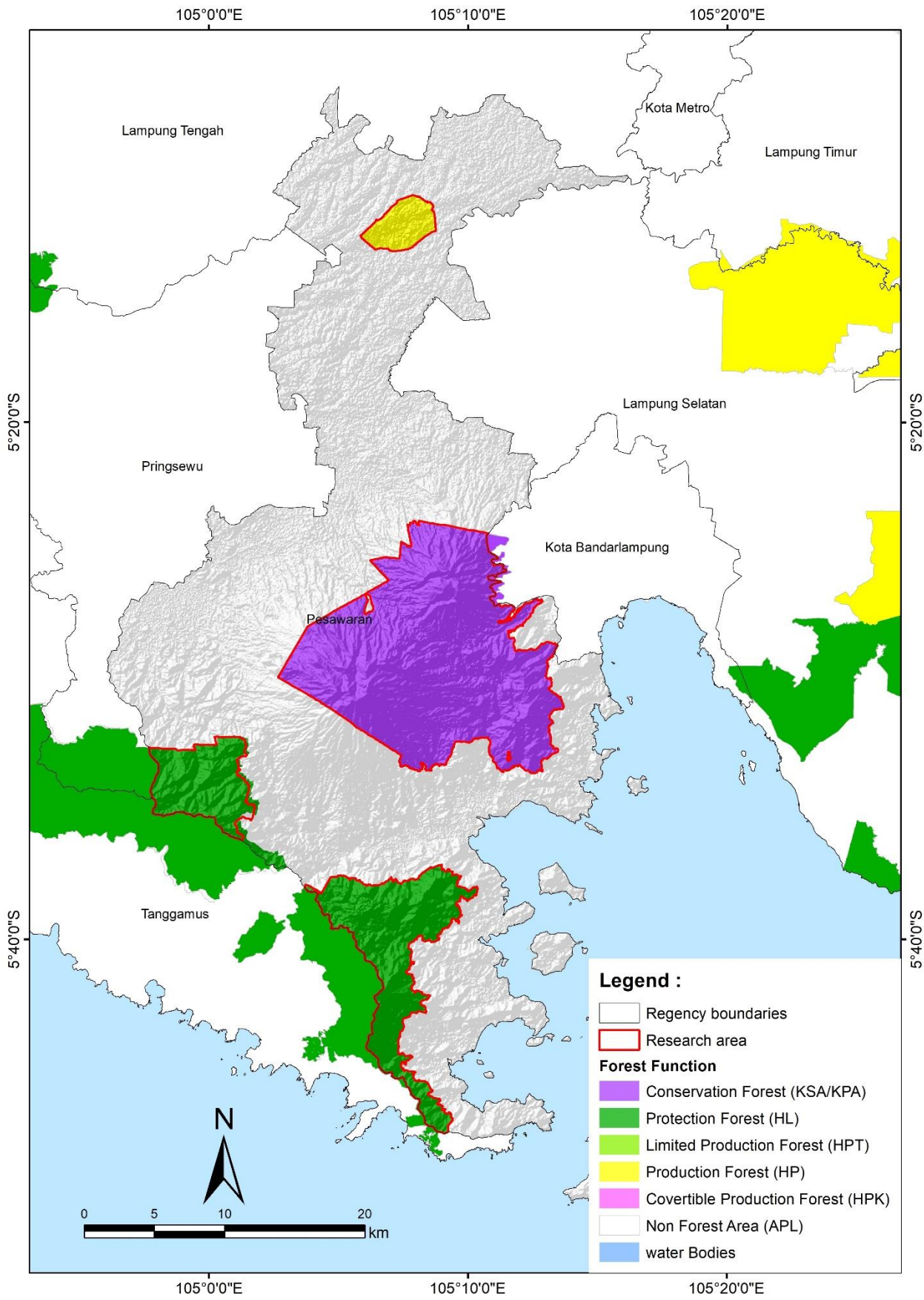


Figure 1. Research area.

Table 1. Data types and sources.

No	Data Type	Year	Area	Data Source
				Primary data
1	Ground checkpoints	March 2022	-	Research Area
2	FGDs	Nov 2022	-	Expert
3	Questionnaires	Nov 2022	-	Expert
				Secondary data
1	Forest Area Map of 1:250,000 scale	2018	Lampung Province	The Ministry of Environment and Forestry (MoEF)
2	SPOT 6/7 Imagery for 2015 and 2020	2015 and 2020	Pesawaran Regency	The National Institute of Aeronautics and Space (*Lembaga Penerbangan dan Antariksa Nasional*/LAPAN)
3	Indonesian Topographical Map of 1:50,000 scale	2022	Pesawaran Regency	The Geospatial Information Agency (*Badan Informasi Geospasial*/BIG)
4	Digital Elevation Model (DEM) Map	2022	Pesawaran Regency	BIG
5	Soil Map Unit 1:50,000 scale	2017	Pesawaran Regency	The Agricultural Land Resources Centre (*Balai Besar Sumber Daya Lahan Pertanian*/BBSDLP)
6	Rainfall Map 1:50,000 scale	2016	Pesawaran Regency	The Pesawaran Regency Regional Development Planning Agency (*Badan Perencanaan Pembangunan Daerah*/ BAPPEDA)
7	Forest Area Utilization/Use Permit Map 1:50,000 scale	2018	Pesawaran Regency	MoEF
8	Forest Area Management Plan Map	2020	Pesawaran Regency	The Lampung Provincial Forestry Service, MoEF
9	Social Forestry permit map 1:50.000 scale	2022	Pesawaran Regency	MoEF

Ground checkpoints are required to calculate the level of confidence, which involves collecting point data from the field. Checkpoints were obtained using the purposive sampling method. This type of sampling uses the researcher's judgement to select the most important sample for the study [9]. This study considered the representativeness of samples from different land cover types and the accessibility of sample locations in forested areas. The minimum number of points required was calculated using the Slovin equation as follows:

$$n = \frac{N}{1+Ne^2} \quad (1)$$

where n is the sample size, N denotes the population size, and e denotes the margin of error. The study used a 10% margin of error, which required a minimum of 100 ground checkpoints.

The confidence level in the classification results was assessed through an accuracy test using a contingency (or confusion) matrix. The confusion matrix is a commonly and widely used method for evaluating accuracy levels which considered the user accuracy, producer's accuracy, overall accuracy, and kappa coefficient. User accuracy reflects the proportion of classification results that correctly correspond to the actual conditions in the area. The Producer's accuracy represents the proportion of each object in the field that is accurately identified or classified. Overall accuracy is calculated by comparing the number of interpreted LUC points that align with the results from ground checks to the total number of ground checkpoints. According to Jensen [10], the overall accuracy should exceed 85%. The Kappa coefficient ranges from 0 to 1. A value of 1 represents perfect agreement in classification results, whereas a value of 0 indicates no agreement at all. McHugh [11] reinterpretation of Cohen. 's Kappa, where 0.8 to 0.9 value shows strong agreement and above 0.9 value shows almost perfect agreement. To calculate the kappa coefficient, the following equation by Basheer et al. [12] was used:

$$Kappa\ coefficient\ (K) = \frac{OA - CA}{1 - CA} \quad (2)$$

Where OA is the accuracy and CA is chance agreement.

$$Change\ agreement\ (CA) = \frac{\sum_i^r \left(\frac{X_{i+}\ X_{+i}}{N}\right)}{N} \quad (3)$$

Where X_{+i} denotes the total number of observations in column i, X_{i+} represents the total number of observations in row-i, N is total number of observations and r is the total number of columns/rows in the confusion matrix.

Land use and land cover changes (LUCC) were analyzed by overlaying the LUC maps for 2015 and 2020 using ArcGIS 10.8. Furthermore, it was processed in tabular form using Microsoft Excel as a transformation matrix, as presented in Table 2.

Table 2. LUCC transformation matrix.

LUC		Year t_1					Sum Year t_0
		A	B	C	D	E	
Year t_0	A						A t_0
	B						B t_0
	C						C t_0
	D						D t_0
	E						E t_0
	Sum Year t_1	A t_1	B t_1	C t_1	D t_1	E t_1	

Note : ▭ : Not changed, ▭ : Changed, A, B, C, etc : LUC code.

Land Suitability and Availability Evaluation for Social Forestry

The analysis of land suitability for SF aimed to identify appropriate areas for SF activities. This evaluation is a crucial part of the land-use planning process, which assesses the value of land for a specific purpose [7]. The stages used to evaluate land suitability using the Multi Criteria Evaluation method based on Geographic Information Systems (MCE-GIS) Method were as follows.

1. Parameter Determination. The parameters for determining land suitability for SF were based on existing literature and expert opinions obtained through FGD. The FGD was conducted by five Social Forestry experts from government agencies, academics, and practitioners.
2. Determining the parameter weight of SF land suitability using the AHP (Analytic Hierarchy Process) method. Parameter weighting was carried out by AHP using a pairwise comparison matrix questionnaire assessed by experts based on a comparison scale of 1 to 9 [13]. According to Abdel-Basset et al. [14], the AHP method consists of several steps.

a. Arrangement of hierarchies so that problems can be understood more clearly. The hierarchy consists of objectives, criteria, subcriteria, and available alternatives. The AHP framework for MCE (Multi Criteria Evaluation) analysis to determine land suitability for SF is shown in Figure 2.

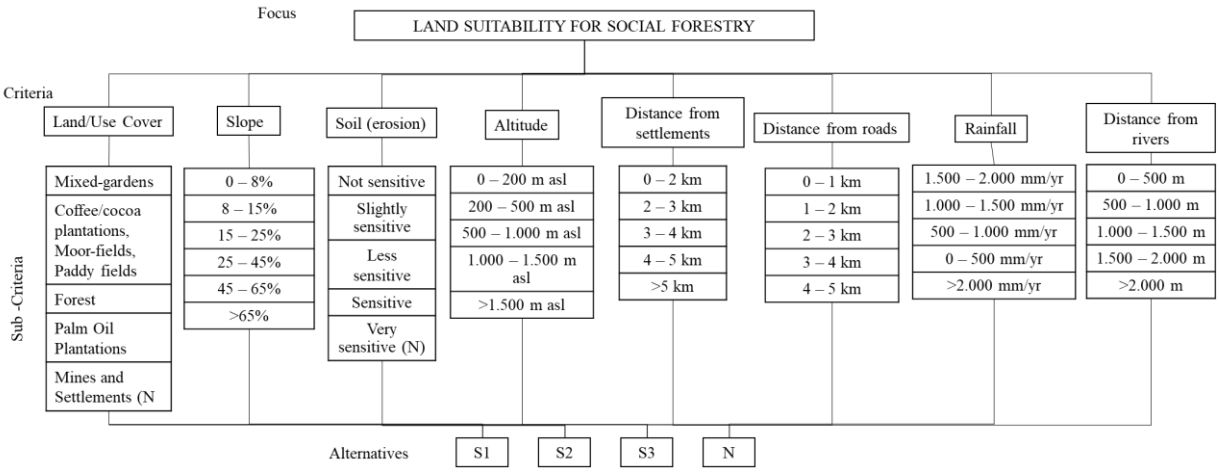


Figure 2. AHP framework for MCE.

b. We built a pairwise comparison matrix to be assessed by the sources based on the comparison scale [13], as presented in Table 3.

Table 3. Fundamental scale of the AHP assessment [13].

Saaty scale	Definitions
1	Equal importance
3	Moderate importanse of one over another
5	Essential or strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values between the two adjacent judgements when compromise is needed

c. Alternative weights and rankings.

In AHP, a Consistent test is required for the results of the resource person's assessment of each pairwise comparison matrix. Consistency values < 10% indicate that the interviewee's judgement results were consistent when filling in the pairwise comparison matrix. According to Marimin and Maghfiroh [15], AHP is used to process data from the assessment of one expert; in its application, the assessment is carried out by several experts so that checking the consistency of the opinions of the sources needs to be checked one by one. Then, consistent opinions are combined using the equation:

$$\overline{X_G} = \sqrt[n]{\prod_{i=1}^{n} X_i} \quad (4)$$

where $\overline{X_G}$ is the geometric mean, n denotes the number of sources, X_i denotes the respondent-i assessment, and $\prod$ denotes the multiplication.

3. Determining the SF land suitability with MCE.

SF land suitability analysis was conducted using the MCE method based on Geographic Information Systems (GIS). The MCE-GIS method allocates suitable land for a particular purpose based on various criteria required in a selected area [16]. Land suitability evaluation methods using MCE belong to the fourth of five stages of development of land suitability evaluation methods in America since the 20th century [17].

The Weighted Linear Combination (WLC) approach in MCE-GIS assumes that each criterion's weight and sub-criteria are different. The weight value was obtained from the results of AHP analysis to obtain the WLC equation. The equation was applied through GIS using the overlay method on thematic maps of land suitability criteria to obtain a suitability score for each land unit through the field calculator process. Boolean constraints can sometimes be applied in overlay analysis using GIS. According to Eastman [16], a constraint is a Boolean criterion that becomes a limitation/constraint and describes areas that are not suitable. Boolean logic is used to make constraint maps with Boolean scales of 0 and 1, where 0 is for unsuitable areas and 1 is for suitable areas. Therefore, the mathematical equation for WLC is modified as follows:

$$S = \left(\sum_{i=1}^{n} W_i \,.\, X_i\right)\left(\prod_{j=1}^{n} C_j\right) \quad (5)$$

where S was Suitability, W_i indicates the weight of the factor-i, X_i indicates the weight of the subfactor-i, n indicates the number of factors, i indicates the type of factor, C_j indicates the constraint of the factor-j, and j indicates the type of constraint.

Land suitability classes were divided into four classes: S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), and N (not suitable). The classification of land suitability classes S1, S2, and S3 uses the determination of the interval boundaries. In contrast, land suitability class N is derived from constraints. To calculate the class interval distance, the following equation was used:

$$I = \frac{S_{max} - S_{min}}{c} \quad (6)$$

where I is size of the class interval distance, S_{max} indicates maximum score, S_{min} indicates minimum score and c indicates number of classes desired.

Land availability for SF was determined by overlaying multiple maps. These include the SF land suitability map, SF permit map, and forest area management plan map (Long-Term Management Plan for Protected Forest Areas [18] and Tahura Wan Abdurahman [19], as well as the Primary Work Plan for production forest areas managed by Inhutani V Ltd [20]). SF cannot be granted in specific areas, including the HL core block; protection block and special block in Tahura WAR; as well as the protected area block and main-tree block in Inhutani V Ltd area.

Results and Discussion

Land Use/Cover in Forest Area in Pesawaran Regency

Based on the interpretation results, LUC of forest areas in Pesawaran Regency is classified into eight classes: forest, mixed gardens, coffee/cocoa plantations, oil palm plantations, moor fields, settlements, paddy fields, and mines. The accuracy of the LUC map 2020 was tested through field checks at 144 points. An overall accuracy value of 93.06% and a kappa coefficient value of 0.9 were obtained. Considering that the overall accuracy value was > 85% [21] and the Kappa coefficient was > 0.8, the LUC map was feasible to use in research for further analysis.

The results of the LUC analysis showed that almost half of the forest area in the Pesawaran Regency in 2020 was in the form of mixed gardens (49.63%), followed by forests (24%) and coffee/cocoa plantations (22.2%) (Figure 3). The total area of each LUC and its changes are presented in Table 4. Forest, coffee/cocoa, and oil palm plantation areas have decreased. Mixed gardens experienced the greatest increase in forest conversion and coffee/cocoa plantations. As shown in Table 4, settlements in the forest area did not increase from 2015 to 2020. However, in the research area, there were still work huts for tenant communities that were used as places to live during the harvest season. Area managers need to improve the control and supervision of work huts so that they do not expand and increase into permanent settlements.

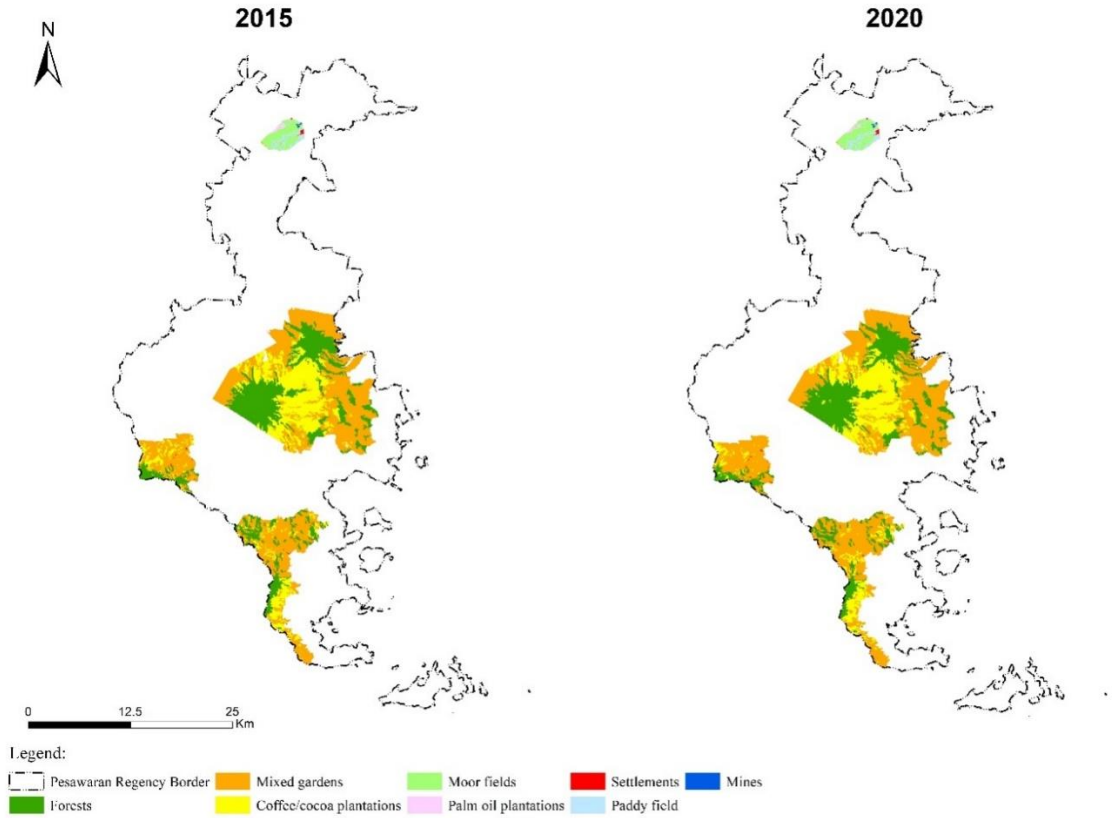


Figure 3. Land use cover in forested areas in 2015 and 2020.

Table 4. Recapitulation of the area and proportion of LUC in forest areas in 2015 and 2020.

LUC		FOR	MIG	CCP	POP	MOF	SET	PAF	MIN	Area (ha)
Area (ha)	2015	8,325	16,081	7,639	117	861	67	317	19	33,427
	2020	8,031	16,588	7,415	99	885	67	318	24	33,427
	LUC 2015–2020	–294	507	–224	–19	24	0	1	5	

Note: FOR= Forest, CCP= Coffee/cocoa plantations, PAF= Paddy fields, MIG= Mixed gardens, MOF= Moor fields, MIN= Mines, POP= Palm oil plantations, SET= Settlements.

The communities applied an agroforestry system to mixed gardens. Agroforestry is an integrated land-use system between forestry and agricultural/plantation crops. In the research area, coffee/cocoa plants were the main plantation crops, whereas the trees planted were Multipurpose Tree Species (MPTS), such as durian, *petai* beans, rubber, areca nut, and nutmeg. Agroforestry pattern productivity can be increased using silvicultural and crop cultivation techniques, such as species site matching, land suitability selection, environmental manipulation, and innovation in maintenance techniques, such as protecting plants from pests, diseases, and weeds [22]. Agroforestry contributes to the food security of small farmers in Indonesia because it has a higher species diversity and indirectly contributes to environmental stability [23].

The pattern of LUCC in the forest areas is presented in Table 5. Forests have been converted to mixed gardens, coffee/cocoa plantations, and mines. Mixed garden conversion was dominated by coffee/cocoa plantations. At the same period, many coffee/cocoa plantations have turned into mixed gardens. In oil palm plantations, the pattern of change to moor fields. The other land cover classes have changed a little over five years. In line with the results of research from [24], it was stated that the factor influencing land change into moor fields was the policy of forest utilization, and the factor influencing land change into community plantations was soil type. Changes in oil palm plantation into moor fields in Pesawaran Regency are allegedly related to Government policies regarding plantation activities without Business Permits in forest areas as regulated in Article 37 point 20 of Law Number 11 of 2020 concerning Job Creation.

Table 5. Forest area land use and cover change pattern 2015–2020.

LUC		2020								Area (ha)
		FOR	MIG	POP	CCP	MOF	SET	PAF	MIN	
2015	FOR	7,974	294		54				3	8,325
	MIG	48	15,499		526	5		2	2	16,081
	POP			99		19				117
	CCP	9	795		6,835					7,639
	MOF		1			860				861
	SET						67			67
	PAF					1		316		317
	MIN					1			18	19
Area (ha)		8,031	16,588	99	7,415	885	67	318	24	33,427

Farmers utilize the shoot-tip grafting technique to revitalize coffee/cocoa plants in mixed gardens converted into coffee/cocoa plantations. Typically, land clearing was done during the rejuvenation process to reduce canopy cover and optimize the growth of coffee/cocoa plants. On the other hand, transitioning from coffee/cocoa plantations to mixed plantations reflects farmers' efforts to implement agroforestry cultivation patterns in their coffee/cocoa plantations. Strengthening the control of forest conversion to mining is crucial due to its significant environmental impact, despite the small area it covers. Illegal mining has been cited as a source of environmental issues such as water pollution, deforestation, poor soil fertility, and limited access to land for agricultural output [25]. Research results by Rendra et al. [26] in Bunut Sebrang Village, Pesawaran Regency, showed that wind movements around illegal gold mines exposed mercury compounds that had accumulated in the bark of MTPS plants.

Land Suitability and Land Availability for Social Forestry

Parameter determination was based on literature and expert FGDs. Herwirawan et al. [27] used rainfall, slope, soil type, distance from local roads, and distance from state boundaries to analyze land suitability for community forest management in North Central Timor Regency. Sirait et al. [28] used soil type, soil depth, drainage, soil pH, soil cation exchange capacity (CEC), and rainfall as the parameters to analyze land suitability for community forests in Sukabumi Regency. Nath et al. [29] used the parameters of climate, soil, altitude, slope, forest cover, distance from roads, distance from settlements, and distance to drainage to analyze land suitability for agroforestry in the Eastern Indian Himalayan region. Chuma et al. [30] used climate parameters, soil type, land cover, altitude, slope, aspect, distance from roads, distance from rivers, and distance from settlements to measure land suitability for implementing agroforestry around the Itombwe Nature Reserve (RNI), Eastern DR Congo: using the AHP approach in geographic information system tools. Biophysical factors such as height, slope, proximity to villages, and roads influence the benefits and challenges forest farmer groups holding HKm approval in Lampung Province face [31]. The results of the expert FGD concluded that the parameters used in this study were LUC, soil type, altitude, slope, rainfall, distance from rivers, distance from settlements, and distance from roads.

According to the AHP analysis, the combined Consistency Ratio (CR) value is 0.018, indicating that the expert's evaluation is consistent. The weights for the land suitability parameters for SF are listed in order: LUC (0.243), slope (0.241), soil type (0.116), altitude (0.107), distance from settlements (0.107), distance from roads (0.068), rainfall (0.061), and distance from rivers (0.057). The weight value indicates the size of the influence of these parameters on land suitability for SF. Figure 4 shows the AHP framework for MCE-GIS analysis used to determine land suitability for SF.

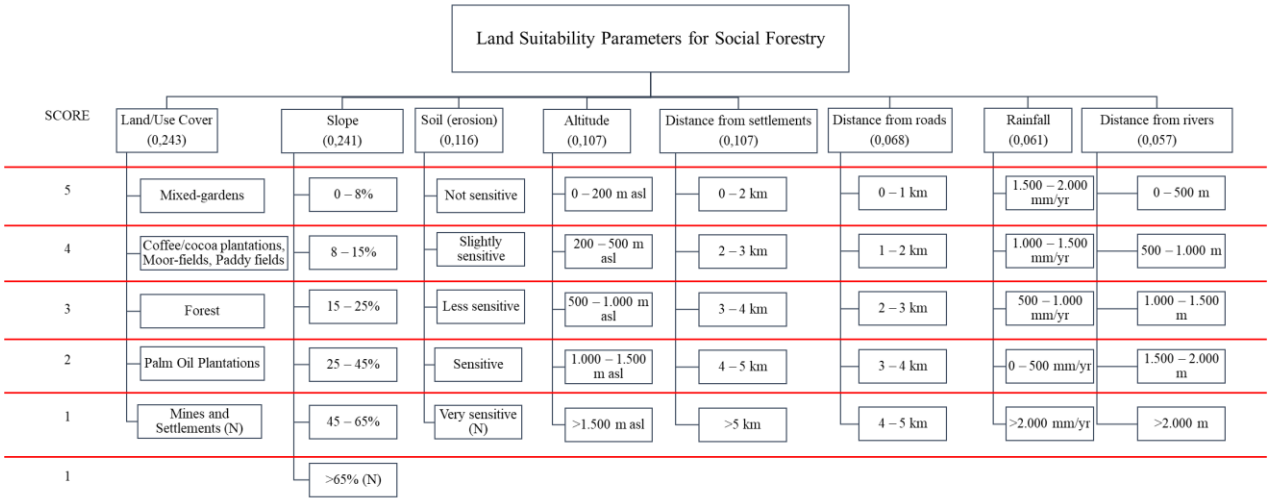
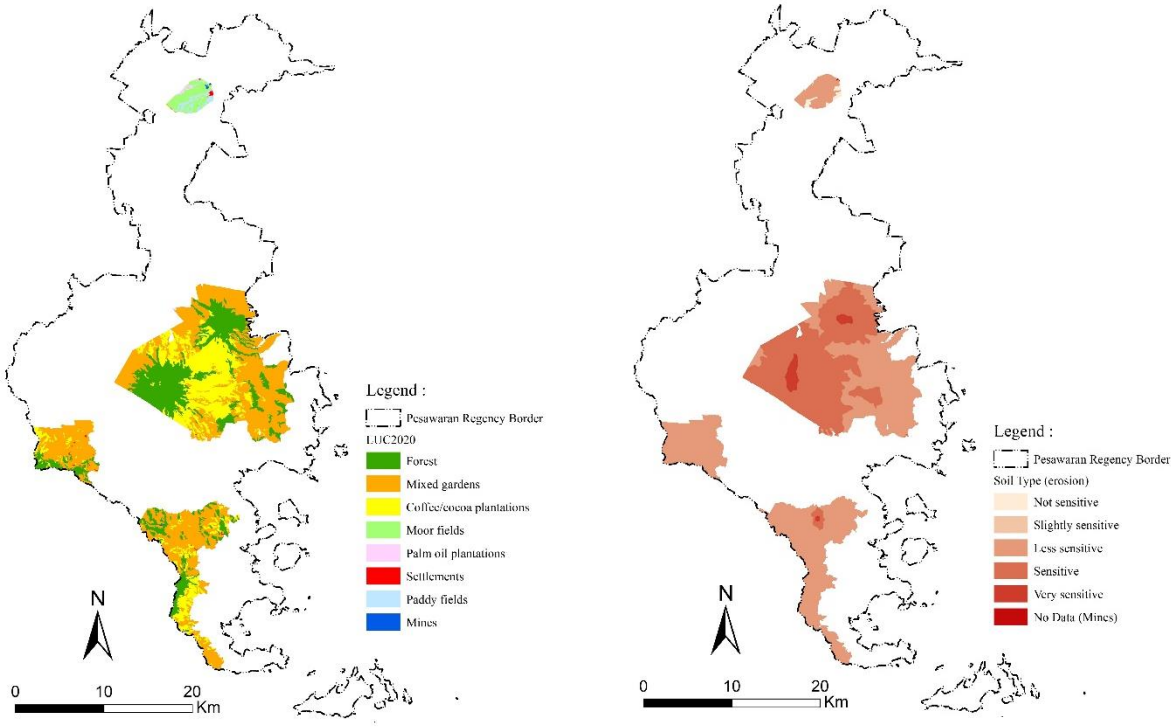
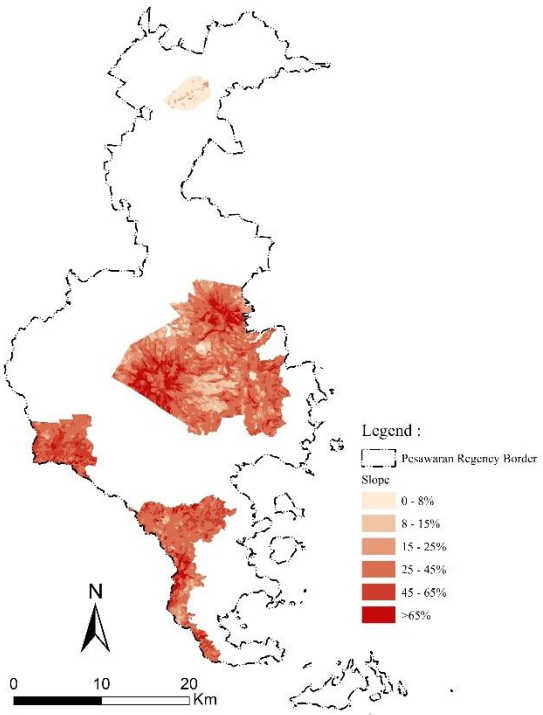


Figure 4. AHP framework for MCE to determine land suitability for SF.

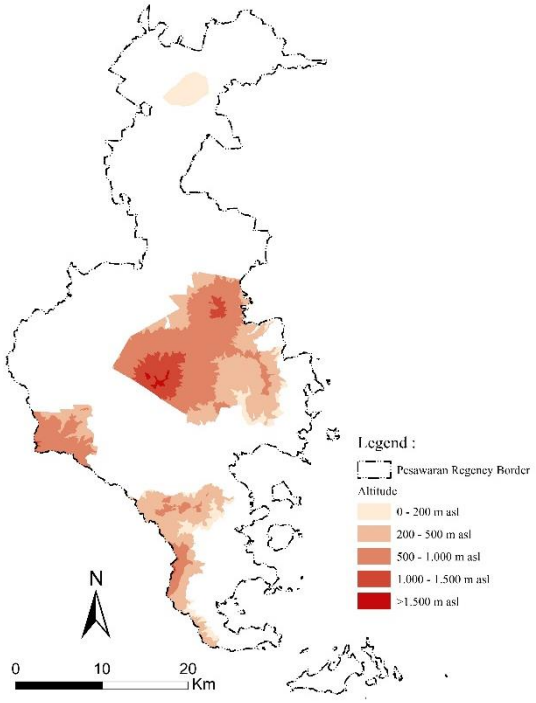
Most of the forest areas in Pesawaran Regency have been managed by the community, as seen from the LUC (see figure 3), which is dominated by mixed gardens, coffee/cocoa plantations, oil palm plantations, paddy fields, and moor fields. Settlements and mining are limiting factors (constraints) because social forestry practices cannot be carried out in built-up and mining areas. Altitude and slope maps were obtained from DEM map analysis. Slope class > 65% is a limiting factor (constraint) because the slope is very steep and it is risky to utilize the land through PS. The soil type map was obtained from BBSDLP and grouped based on the level of sensitivity to erosion according to the Decree of the Minister of Agriculture No. 837/Kpts/Um/11/1980 concerning Criteria and Procedures for Designating Protected Forests. A soil class that is very sensitive to erosion becomes a limiting factor (constraint). The Topographical Map of Indonesia, which contains information on road networks, river networks, and settlements, forms the basis for creating distance maps of roads, rivers, and settlements. A rainfall map was obtained from Development Planning Agency at Sub-National Level of the Pesawaran Regency. A parameter map of the Social Forestry land suitability analysis is shown in Figure 5.



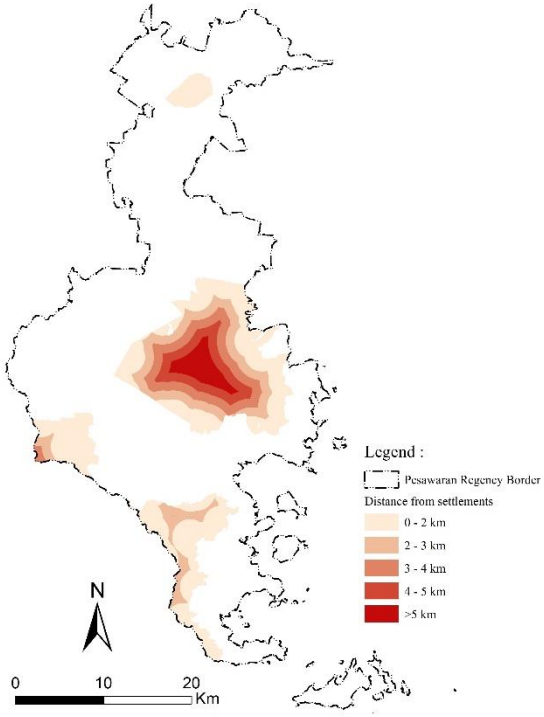
(a) **(b)**


Legend :
Pesawaran Regency Border
Slope
0 - 8%
8 - 15%
15 - 25%
25 - 45%
45 - 65%
>65%
N
0
10
20
Km

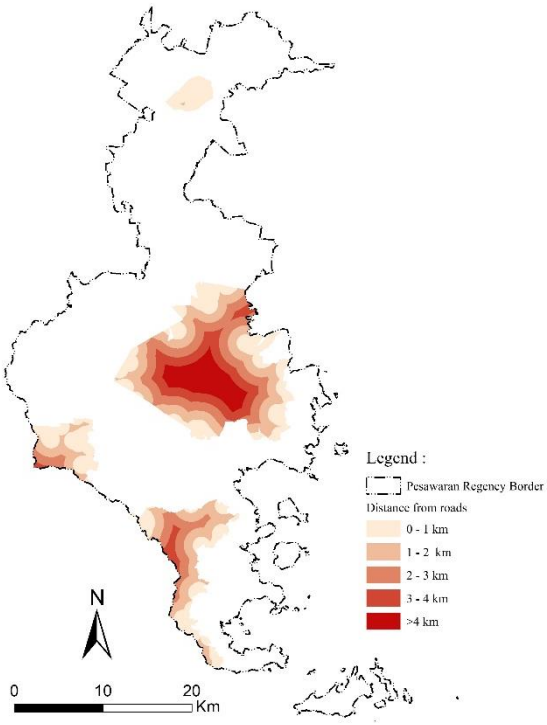
(c)


Legend :
Pesawaran Regency Border
Altitude
0 - 200 m asl
200 - 500 m asl
500 - 1.000 m asl
1.000 - 1.500 m asl
>1.500 m asl
N
0
10
20
Km

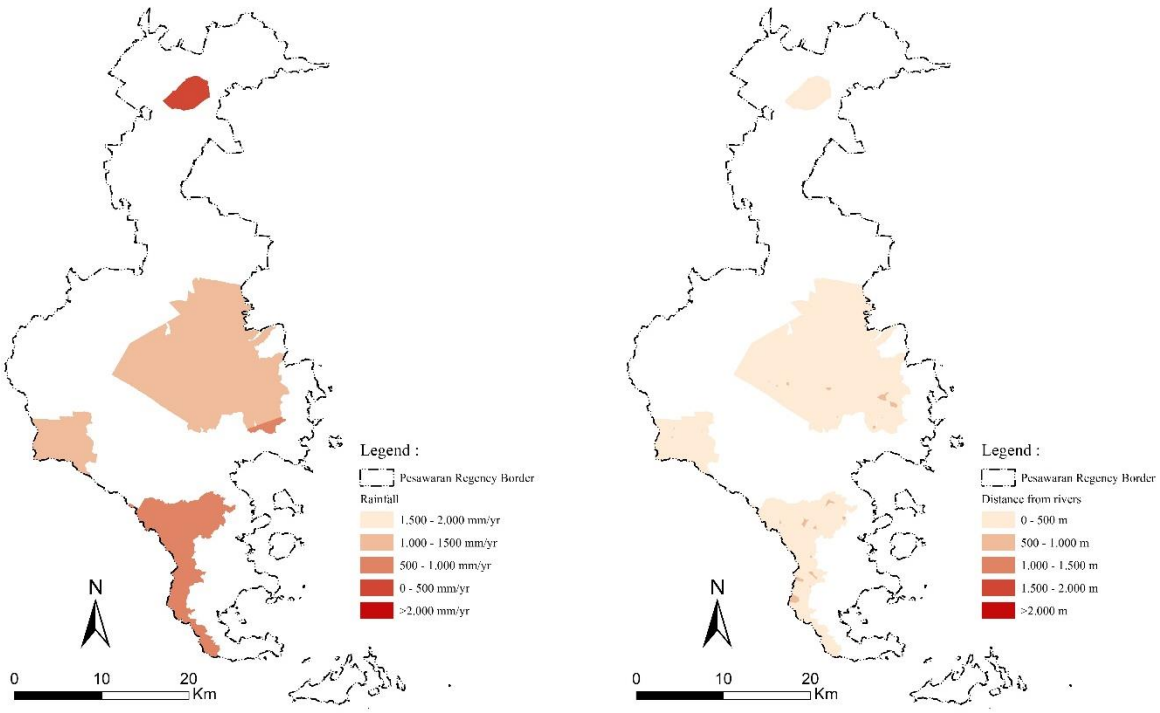
(d)


Legend :
Pesawaran Regency Border
Distance from settlements
0 - 2 km
2 - 3 km
3 - 4 km
4 - 5 km
>5 km
N
0
10
20
Km

(e)


Legend :
Pesawaran Regency Border
Distance from roads
0 - 1 km
1 - 2 km
2 - 3 km
3 - 4 km
>4 km
N
0
10
20
Km

(f)



(g) **(h)**

Figure 5. The parameter map of Social Forestry land suitability analysis; (a) LUC map 2020, (b) Soil type, (c) Slope, (d) Altitude, (e) Distance from settlements, (f) Distance from roads, (g) Rainfall, (h) Distance from rivers.

According to the MCE-GIS method, 92% of the research area in Pesawaran Regency is suitable for SF, while the remaining 8% (2,781 hectares) is unsuitable (N), as shown in Figure 6. The land suitability class was moderately suitable (S2), covering 18,543 ha (55%). The highly suitable class (S1) was second, covering 11,860 ha (36%), while the marginally suitable class (S3) covered only 243 ha (1%). Table 6 presents the land suitability for SF if we consider forest function and management area.

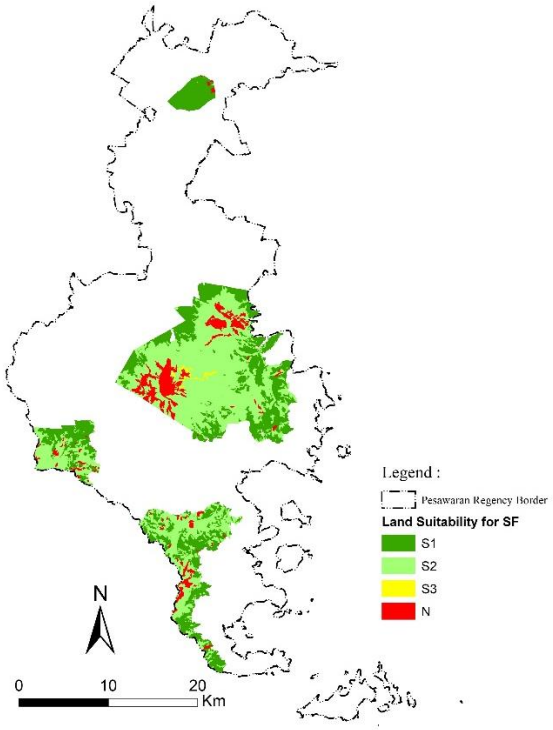


Figure 6. Land suitability for Social Forestry in Pesawaran Regency.

Table 6. Land suitability class for Social Forestry based on forest functions.

Forest Function	S1	S2	S3	N	Constraints
Production Forest	1,300	5	-	46	LUC is settlements (25 ha) and mines (21 ha)
Protection Forest	4,470	5,536	-	668	Soil type is very sensitive to erosion (28 ha) Slope is > 65% (597 ha) LUC is settlements (37 ha) and mines (6 ha)
Grand Forest Park	6,091	13,002	243	2,067	Soil type is very sensitive to erosion (595 ha) Slope is > 65% (1,467 ha) LUC is settlements (5 ha)
Total in hectares	11,860	18,543	243	2,781	

The S1 land suitability class dominates the production forest area owing to its flat slope (0 to 8%), moor and paddy field land cover, and the Cambisol district soil type, which is less sensitive to erosion. This forest area is situated in the lowlands (less than 200 m above sea level) and is easily accessible to roads (less than 1 km away). Rainfall is relatively low (less than 500 mm/year), so rice field irrigation depends on the nearby river. Permanent settlements can be found within the production forest area bordering Non-Forest Areas. The physical characteristics of land make it suitable for community-based forest management through Social Forestry. Since 1999, the production forest area in Pesawaran Regency has been given Forest Concession to Inhutani V Ltd, with *Sengon* (*Paraserianthes falcataria*) as the primary plant species. However, there was tenure conflict in this area. Inhutani V Ltd cannot optimally exploit the forest because the land is controlled by the community in the form of moorlands (seasonal agricultural land and rainfed rice fields). A social forestry scheme as a forestry partnership, could be a solution. Companies and communities can make cooperative agreements that are recognized and provided legal protection by the minister. Thus, the community is legally protected from land use. The challenge is to encourage those who have cultivated land in production forest areas to become agroforestry farmers to ensure the sustainability of the forest function, as it provides timber forest products.

The protected forest area was mostly dominated by highly suitable (S1) and moderately suitable (S2) land for SF. This is due to the presence of mixed gardens and the Cambisol district soil type, which is less sensitive to erosion despite a steep slope of 25 to 45%. The protected forest area is situated 200 to 1,000 m above sea level and receives annual rainfall of 500 to 1,000 mm. Access to the area is challenging because it has a hilly topography and steep slopes, although the road is less than a kilometer away. In the Tahura WAR, moderately suitable land (S2) is prevalent because of its extensive mixed garden land cover. However, this area is characterized by a steep slope (25 to 45%) and erosion-sensitive soil (Andosol). The distance from the road is mostly within the 1 to 2 km range, although there are footpaths with quite difficult terrain owing to varying slopes dominated by a steep slope class (25 to 45%). The rainfall in this area is higher (ranging from 1,000 to 1,500 mm/year) than that in other forest areas. Therefore, woody vegetation is needed as the soil type is prone to erosion. Settlements are also located at the edge of the Tahura area.

Based on the management plan map of each forest function, social forestry can only be allowed in Utilization Blocks in HL with a choice of SF schemes, including HD, HKm, and HA; in Life Plantation Blocks of the Concession Forest of Inhutani V Ltd with a Forestry Partnership scheme; and in Rehabilitation Blocks, Collection Blocks, Utilization Blocks, and Traditional Blocks of the Tahura WAR with a Forestry Partnership scheme in Conservation Areas or the Conservation Partnership. Before Law Number 11 of 2020 concerning Job Creation was issued, forestry partnerships could be carried out in HL based on a cooperation agreement between the Head of KPH and the community. Based on the latest policy, forestry partnerships have not been implemented by the KPH and communities. By 2022, 61 SF agreements were issued in Pesawaran Regency, consisting of two Forestry Partnerships in HP: eight HKm and 17 forestry partnerships (between the heads of KPH Pesawaran and communities) in HL, and 17 Conservation Partnerships and 17 Cooperation Agreements for Conservation Partnerships between forest farmer groups and Tahura Managers. By overlaying the map of land suitability for SF with the map of forest management plans and SF agreement areas, a map of land suitability and availability for SF in Pesawaran Regency was created. This map, as presented in Table 7 and Figure 7, shows that 22,223 ha, or 66% of the research area, has potential for SF.

Based on the results of this research, the Pesawaran Regency has an SF potential of 22,223 ha. This value greatly exceeds the PIAPS Revision VIII, which describes an indicative potential of 45 ha. Through Social Forestry, communities are given legal access to forest areas under applicable regulations with the hope that the community can obtain economic benefits from the existence of the forest through their participation in

maintaining forest functions. One of the implementations of Social Forestry with the HTR scheme in Lampung Province, with an average cultivated area of 1.5 hectares per household, is known to contribute an average income of IDR 8,036,507/household/month, or 67.72% of total household income [32]. The results of this research can be used as a consideration for the revision of PIAPS. PIAPS revision materials are not only from the Central Government but can also be submitted through the Regional Government. To improve the welfare of communities around forests in their area, the Regional Government of Pesawaran Regency can play an active role in the SF program.

The SF Program enables rural communities around forests to gain employment and income [33], influencing community behavior for the better, as shown by reduced encroachment, forest destruction [34], and illegal logging [35]. One of the Social Forestry schemes of the Sungai Buluh Nagari Forest in Padang Pariaman Regency is known to contribute to the regional economy [36]. Most studies have analyzed social forestry from a social and economic perspective rather than an environmental perspective, implying that economic opportunity is the primary benefit of social forestry implementation. In contrast, social and ecological issues are key impediments to its implementation [37]. SF has evolved from its original objectives of community empowerment and devolution of local community rights to win-win solutions of empowerment and rights inheritance for sustainable forest management, climate change mitigation, and entrepreneurship strengthening [38].

Table 7. Land suitable and available for social forestry in Pesawaran Regency.

Forest function	Plan management	SF agreements (Yes/No)	S1	S2	S3	Sum (ha)	Available/ unavailable
Protection Forest	Core block	-	272	1,275	-	1,547	Unavailable
	Utilization block	Yes	1,223	1,198	-	2,421	Unavailable
		No	**2,975**	**3,063**	-	**6,038**	**Available**
Production Forest	Protected area	-	267	-	-	267	Unavailable
	Primary plant area	-	163	-	-	163	Unavailable
	Plant life area	Yes	32	-	-	32	Unavailable
		No	**838**	**5**	-	**843**	**Available**
Grand Forest Park	Protection block	-	12	2,360	234	2,606	Unavailable
	Rehabilitation block	No	**2**	**524**	-	**526**	**Available**
	Collection block	Yes	3	21	-	24	Unavailable
		No	**602**	**1,458**	-	**2,060**	**Available**
	Utilization block	Yes		4	-	4	Unavailable
		No	**391**	**538**	-	**930**	**Available**
	Traditional block	Yes	353	1,007	0	1,359	Unavailable
		No	**4,728**	**7,090**	**9**	**11,827**	**Available**
Total suitable land (ha)			11,860	18,543	243	30,646	
Total suitable and available land (ha)			**9,536**	**12,677**	**9**	**22,223**	

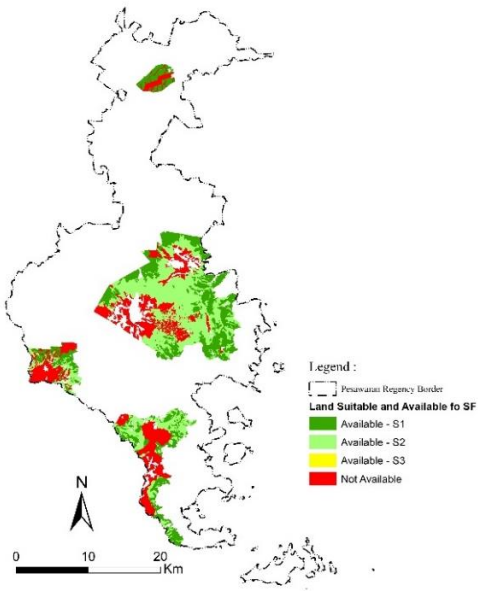


Figure 7. Land suitable and available for Social Forestry in Pesawaran Regency.

Conclusions

The LUC in forest areas in Pesawaran Regency in 2020 was dominated by mixed gardens (49.63%), followed by forests (24%), and coffee/cocoa plantations (22.2%). From 2015 to 2020, forest was reduced to mixed gardens, coffee/cocoa plantations, and mines. The mixed garden experienced an increase in area from the forest and coffee/cocoa plantations. The most influential parameters on land suitability for Social Forestry in Pesawaran Regency are LUC, slope, and soil type. Of the 33,427 ha of forest area in Pesawaran Regency, 30,646 ha is suitable for SF, and the dominant land suitability level is moderately suitable (S2). From this area, the potential area (suitable and available) for community management through the SF scheme was 22,223 ha.

Author Contributions

DAK: Conceptualization, Methodology, Software, Investigation, Writing - Review & Editing; **WD**: Review & Editing, Supervision; **DS**: Review & Editing, Supervision

Conflicts of interest

There are no conflicts to declare.

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