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REVIEW ARTICLE

Degraded Peatlands and Their Utilization Opportunities in Kepulauan Meranti Regency, Riau Province, Indonesia

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Abstract Degraded peatlands are caused by various factors, including land fires, water mismanagement, and mining activities. Indicators of degraded peatlands can be identified through the type of land cover observed in the field, which commonly includes shrubs and barren land (open areas of ex-mining land). Therefore, this study aimed to determine the dynamics of the existence of degraded land and its utilization opportunities using spatial, image, and time series analysis methodDepartment Forest Resources Conservation & Ecotourism, Forestry Faculty, Bogor Agricultural University Kampus IPB Darmaga PO.Box 168 Bogor-Indonesias. To conduct the analysis, various data sources were employed, including Landsat imagery, the Regional Spatial Planning (RTRW) map, hotspots data, rainfall data, landforms maps, peatlands data, and soil information. The results of the study showed that between 1999 and 2019, the average area of degraded peatlands amounted to 198,084.54 hectares. Furthermore, the optimal area of degraded peatlands utilized for agriculture amounted to 7,122.45 hectares . Inventory of degraded peatland using the land cover approach can be obtained faster, cheaper, easier than the terrestrial method. Opportunities for using degraded land for agricultural purposes were also identified through the selection of plant species that exhibited adaptability to peatlands and held economic value. These selected plants, including sago, rubber, areca nut, and liberika coffee, were developed within the Meranti Islands Regency.

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1. Introduction

In 2019, based on mapping conducted at a scale of 1:50,000, peatlands in Indonesia covered an expansive area of 13.43 million ha. Consequently, the country has the most extensive tropical peatlands worldwide (Suryani et al., 2020). Out of this vast expanse, approximately 4.4 million ha was classified as degraded peatlands. Among these degraded areas, 3.7 million ha was categorized as shrubland, while 0.7 million ha comprised open land and ex-mining sites (Agus et al., 2014). Degraded or damaged peatlands refer to those visibly characterized by shrubs, exhibiting a decline in hydrological, production, and ecological functions due to the deterioration of the chemical, physical, and biological properties of the peat. The productivity of these peatlands experiences a significant decrease (Masganti et al., 2014).

The area of degraded peatlands in Riau Province reaches around 2.31 million ha or 59.38% of the area. Based on the Soil map from the Center for Agricultural Land Resources (BBSDLP), the area of peatlands in Meranti Regency is 10,346.43 ha (26,6 % of peat area in Riau Province).

Degraded peatlands were caused by various factors including land fires, mismanagement of water, and mining activities (Prasetyo et al., 2022); (Adrianto et al., 2019). This is because 99% of land and forest fires were caused by human activities, often with deliberate intent (Saharjo, 2016). Analysis of hotspots data, with a confidence level exceeding 80%, showed the occurrence of land and forest fires in Kepulauan Meranti Regency between 2001 and 2019. These fires were primarily instigated as a means of clearing land for agricultural and plantation purposes.

The activity of burning land every year, triggered the occurrence of degraded peatlands (Dohong et al., 2017); (Kamlun et al., 2016). In degraded peatlands, there were unfavorable conditions because they required additional treatment in their use for agriculture and plantations. To maximize the agricultural and plantation potential of peatlands, proper treatment was imperative. This entailed implementing measures such as rewetting and fertilization, which were vital for the optimal utilization of peatlands.

There were several approaches to identifying land degradation from various aspects, namely a. type of land cover, b. aspect of chemical nature, and c. biological aspects;

a. The existence of shrubs is important in land degradation studies because shrubs are an indicator of degraded land. This is because the indicators of degraded peatlands based on the type of land cover in the field are characterized by (1) cover crop is shrubs, and (2) land is open ex-mining land (Volkova et al., 2021); (Wahyunto and Daira, 2014).

b. The chemical nature of degraded peatlands shows impoverished nutrient conditions and increased acidity in the mineral soil subsurface. Consequently, the availability of phosphorus (P) and nitrogen (N) levels is noticeably diminished (Birnbaum et al., 2022). This condition poses challenges for plant growth in peatlands. From a physical perspective, degraded peatlands experience a decrease in their water retention capacity, making them more hydrophobic. This occurs due to a reduction in the percentage of pore space within peatlands (Putra et al., 2018); (Liu et al. 2022).

c. From the biological aspect, degraded peatlands contains fewer types of microorganisms in peat which cause the activity to become less intensive (Leifeld et al., (2020). The reduction affects the availability of nutrients and the disruption of degradation process of compounds that are difficult to decompose such as lignin (Wilson et al., 2022).

Given the multitude of impacts affecting degraded peatlands, it is essential to understand their dynamics, including area, distribution, and explore potential utilization opportunities. By gaining knowledge of the changes occurring in these degraded land, efforts can be initiated to address their existing condition and mitigate the ongoing rate of degraded peatlands.

In this study, the identification of degraded peatlands used land cover approach. This approach is used with the following considerations: a. land cover data and satellite images obtained through analysis and downloading from https://eartheexplorer.usgs.gov/, b. availability of land cover in the entire study area and its time series data, c. the distribution of shrubs as an indicator of degraded peatlands can also be indicated in the time series. Therefore, this study aims to determine the dynamics of the existence of degraded land and its utilization opportunities.

2. Methods

The study was carried out in Kepulauan Meranti Regency, located in the Riau Province (Figure 1). This regency was situated in close proximity to the Malacca Strait in the north, bordered by Karimun Regency in the east, Bengkalis Regency in the west, and Siak and Palalawan Regencies in the south (BPS, 2021).

Kepulauan Meranti Regency spanned an area of 3,707.84 km2 or 370,784 ha (BPS 2022) and featured predominantly flat topography. The highest elevation within the regency reached 6.6 meters above mean sea level (msl), located in the West Rangsang sub-district. Furthermore, Kepulauan Meranti Regency was predominantly comprised of peatlands, and the peat area covered approximately 331,862 ha, accounting for 89.50% of regency's total area, as shown in Figure 2.

For this study, Landsat Images from 1999 to 2019 were utilized, along with data on hotspots distribution from 2001 to 2019, Regional Spatial Planning (RTRW) for the period of 2020-2040, rainfall data spanning from 1999 to 2019, landform and soil maps, as well as administrative data. The imagery was employed to extract land cover data using image analysis techniques, focusing on Landsat time series image data from 1999 to 2019. The study activities and their sequence were visually depicted in the provided flow chart, as shown in Figure 3.

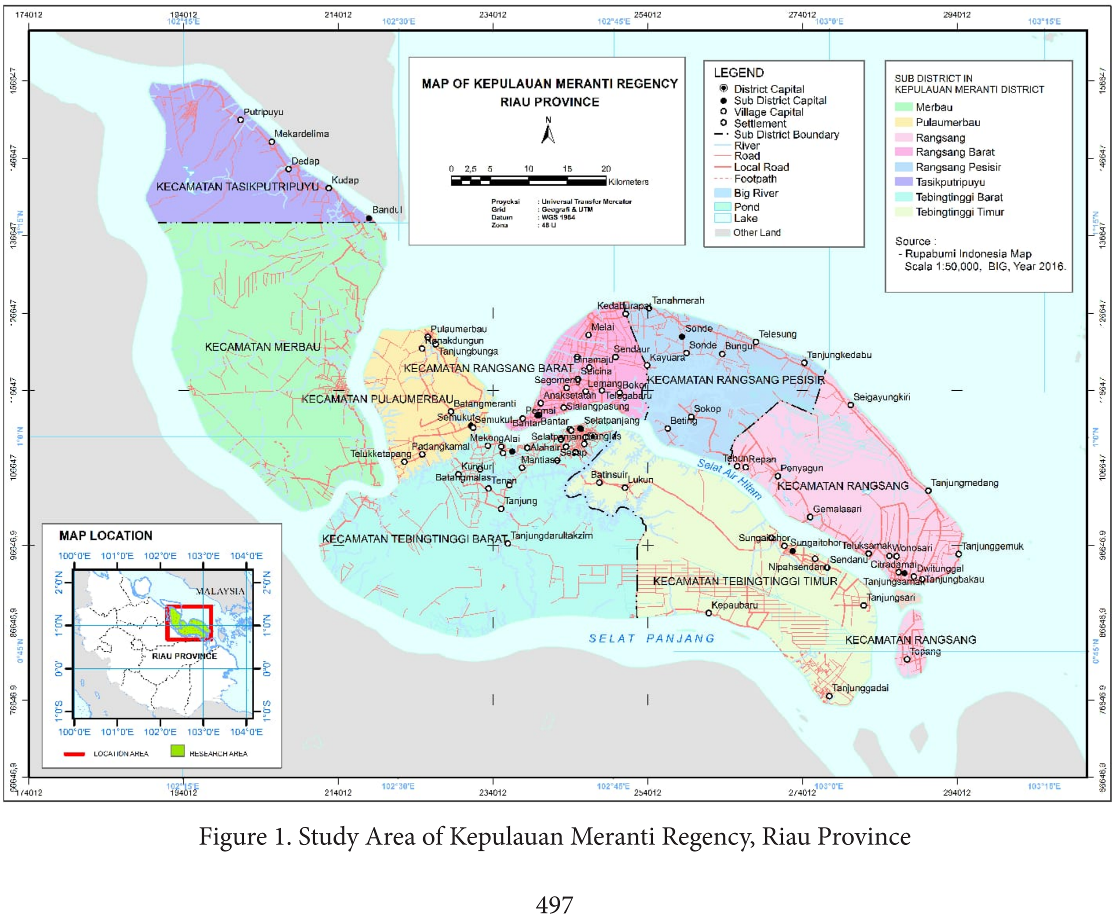


Figure 1. Study Area of Kepulauan Meranti Regency, Riau Province

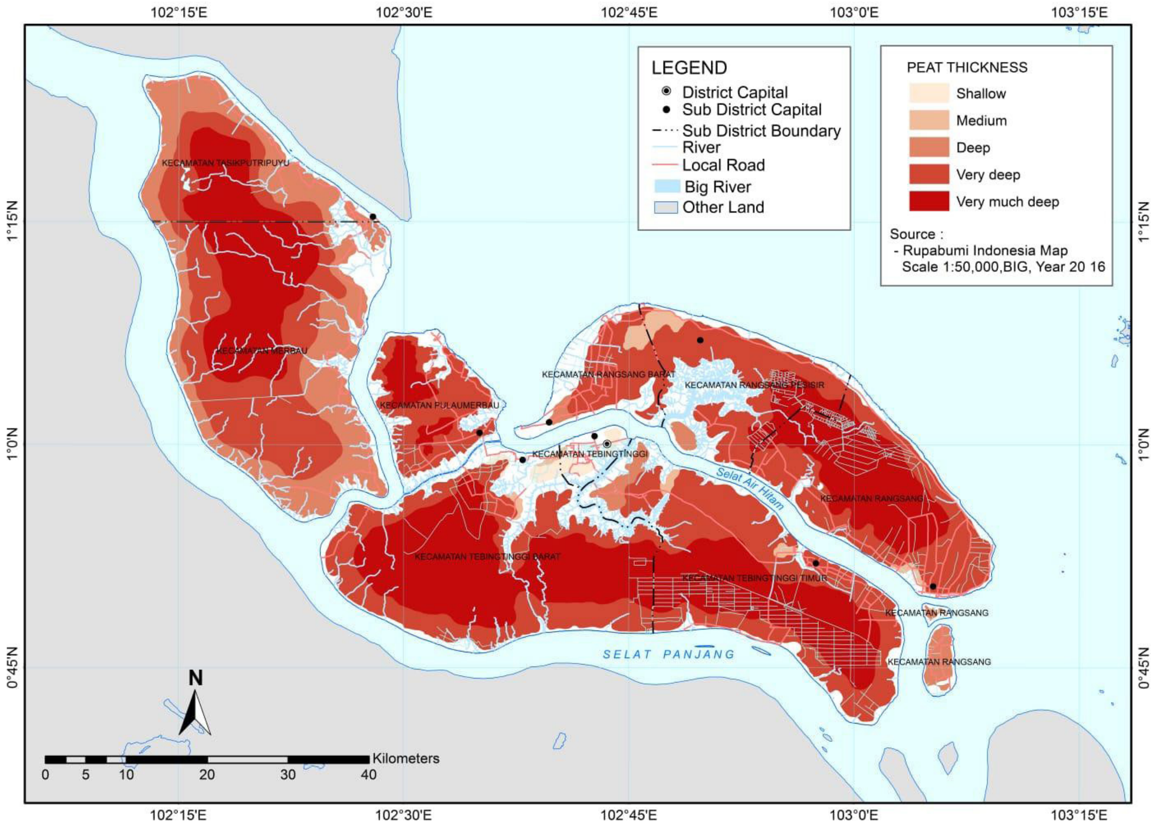


Figure 2. Peatlands Area in Kepulauan Meranti Regency

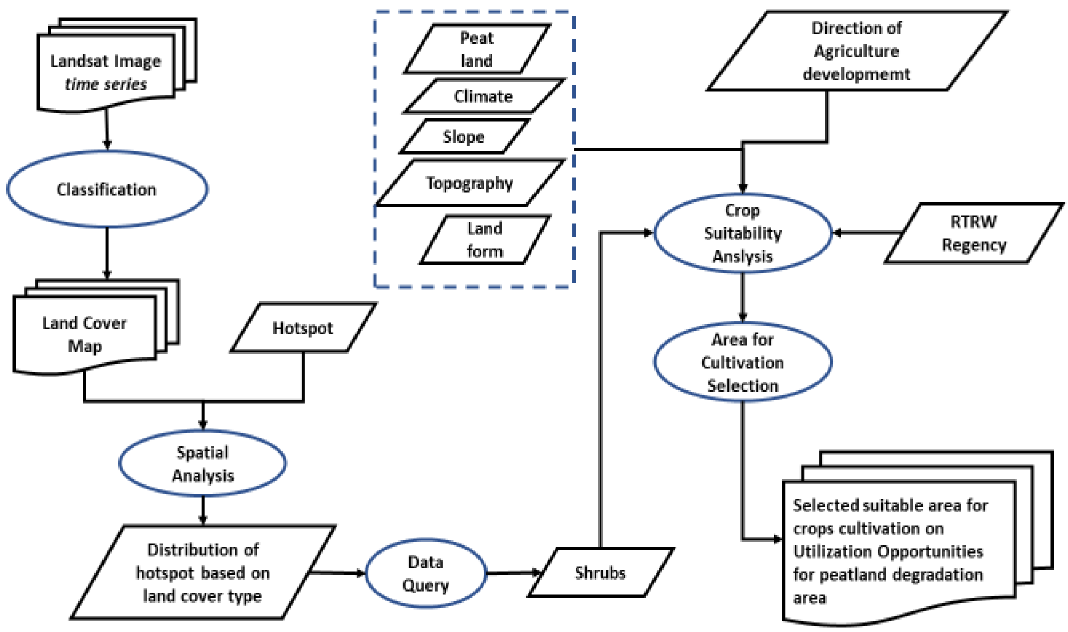


Figure 3. The flow of study activities

By acquiring land cover time series data from 1999 to 2019, it was possible to obtain insights into the dynamics of changes. Spatial analysis was conducted using data queries on land cover data to determine the distribution of shrubs. Furthermore, the dynamics of land cover change data were overlaid with hotspots data, considering a confidence level of over 80%, to extract information on hotspots distribution across different types and periods. This analysis enabled the identification of the number and distribution of hotspots within shrubs land cover category. Subsequently, a crop suitability analysis was conducted to determine which types of commodity crops were adaptive and aligned with the carrying capacity of degraded peatlands. The data employed included peatlands data, landform, and soil maps, as well as topography data. The optimization of degraded peatlands was achieved through spatial analysis, comparing degraded peatlands data (represented by land cover: shrubs) with RTRW maps.

2. Data used

2.1. Land Cover and its Accuracy

Land cover data were obtained through image analysis using Landsat image with a period from 1999 to 2019, as shown in Table 1. Image analysis was carried out in a supervised classification using the Maximum Likelihood Classification (MLC). MLC considered the probability factor (prior probability) of one pixel to be classified into a certain class or category which in this case was land cover type (Jia et al., 2014). This decision-making rule was known as the Bayesian Decision Rule (Sampurno and Thoriq, 2016).

The image analysis used a random sample through the Area of Interest (AOI). The distribution of pixels in the sample area was evenly distributed in 100 sample points in the Meranti Regency Islands, as shown in Figure 4.

Based on the visual interpretation and the expertise of analysts concerning the characteristics of land cover distribution, nine distinct land cover types were identified, along with one cloud category. These included Roads, Mixed Gardens, Secondary Mangrove Forests, Rural areas, Rivers, Urban Settlements, Non-Vegetated Swamps, and Open Land.

The calculated accuracy was based on the overall accuracy area, with the Kappa coefficient. Kappa accuracy was recommended for accuracy tests on land cover classification (Olofsson et al., 2014), and was also known as the kappa index, as shown in Table 2.

Table 1. Landsat imagery used period 1999 to 2019

1999	2000	2001	2002	2003
Landsat 5 09/04/1999	Landsat 7 21/05/2000	Landsat 7 28/08/2001	Landsat 7 14/07/2002	Landsat 7 28/04/2003
2004	2005	2006	2007	2008
Landsat 7 09/07/2004	Landsat 7 07/08/2005	Landsat 7 07/06/2006	Landsat 7 30/09/2007	Landsat 7 21/02/2008
2009	2010	2011	2012	2013
Landsat 7 22/01/2009	Landsat 7 25/01/2010	Landsat 7 23/07/2011	Landsat 7 23/06/2012	Landsat 8 18/06/2013
2014	2015	2016	2017	2018
Landsat 8 21/06/2014	Landsat 8 16/02/2015	Landsat 8 12/07/2016	Landsat 8 09/03/2017	Landsat 8 28/03/2018
2019				
Landsat 8 15/03/2019				

Source: https://earthexplorer.usgs.gov/

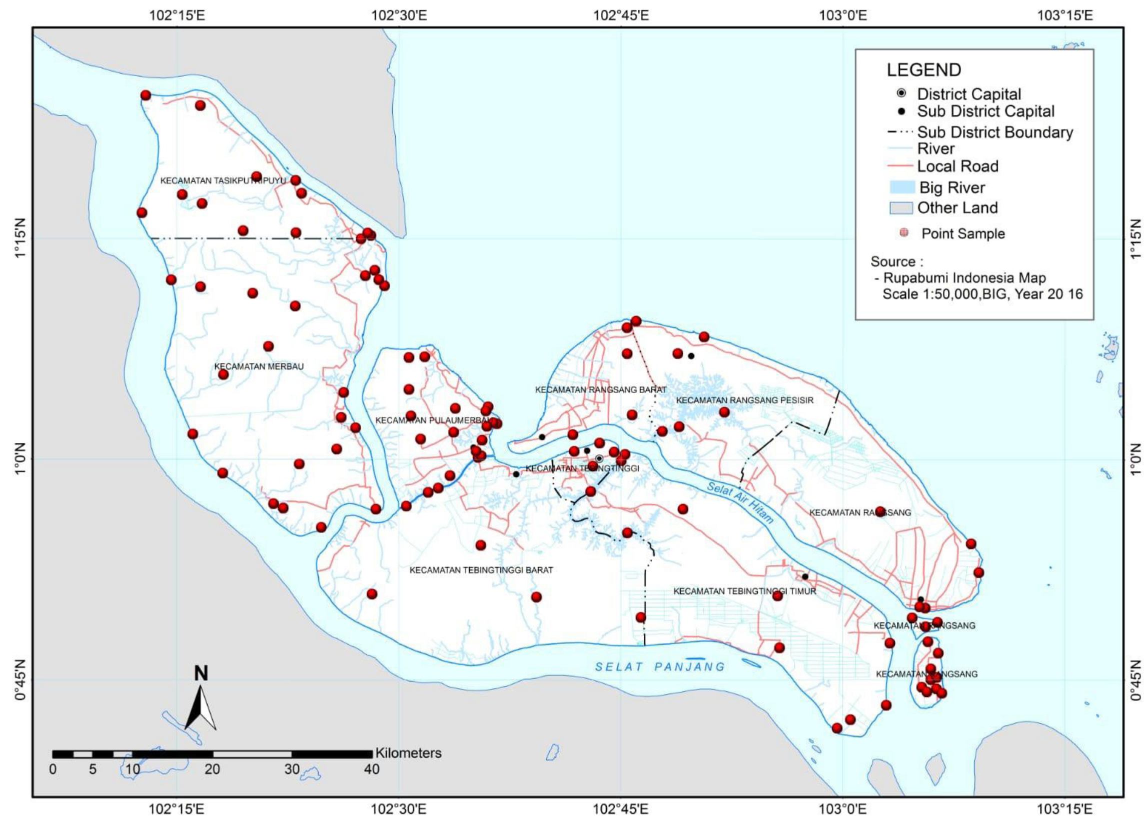


Figure 4. Distribution of land cover point sample year 2019

Table 2. Confussion matrix of land cover type

Reference Data	Class Data on Map				Total	Producer's Accuracy
	a	b	→	j		
a					Xi+	Xii/ Xi+
b						
↓						
j					Xij	
Total Coloum	Xi+				N	
User's Accuracy	Xii/ X+i					

Note: On the map, land cover was classified into the following categories: (a) Cloud, (b) Scrub, (c) Roads, (d) Mixed Gardens, (e) Secondary Mangrove Forests, (f) Rural, (g) Rivers, (h) Urban Settlements, (i) Non-Vegetated Swamps, (j) Open Land.

where:

N = Number of Pixel

Xi = Diagonal value of the contingency matrix

Xii = Diagonal value of the i-th row and i-th column of the contingency matrix

Xi+ = Number of pixels in row - i

X+i = Number of pixels in column -i

Mathematically is presented as follows:

$$\text{User's Accuracy} = \frac{X_{ii}}{X_{+i}} \, x \, 100\% \quad (1)$$

$$\text{Producer's Accuracy} = \frac{X_{ii}}{X_{i+}} \, x \, 100\% \quad (2)$$

$$\text{Overall Accuracy} = \frac{\sum_i^r X_{ii}}{N} \, x \, 100\% \quad (3)$$

$$\text{Kappa Coefficient} = \frac{N \sum_i^r X_{ii} - \sum_i^r X_{i+} X_{+i}}{N^2 - \sum_i^r X_{i+} X_{+i}} \, x \, 100\% \quad (4)$$

2.2. Hotspots

Hotspots is a forest fire indicator that detects a location with a relatively higher temperature compared to its surrounding temperature (forestry ministerial regulation number P.12/Menhut-II/2009). It had a level of confident >50% with a strong indication of fire (Giglio et al., 2020). In this study, hotspots data were used with a level of confidence >80% to provide information on the early detection of forest and land fires (Lailan et al., 2014). This data is used to determine locations that provide a strong indication of the incidence of land and forest fires.

2.3. Rainfall

Rainfall data is used to determine areas suitable for agriculture and plantations from the aspect of climate. Annual rainfall data was obtained from TRMM data in 7 (seven) rainfall gauge stations, as shown in Table 3. TRMM data is precipitation data obtained from the meteorological satellite TRMM (Tropical Rainfall Measuring Mission).

Rainfall data from TRMM obtained from NASA via htpps://gpm.nasa.gov/data- access/downloads/trmm.

2.4. Regional Spatial Plan (RTRW)

Referring to Law No. 26 of 2007 concerning spatial planning, RTRW which in this case is RTRW at the district level. The district spatial plan serves as a guide for several purposes: a. preparation of regional long-term development plans; b. preparation of regional medium-term development plans; c. space utilization and control of space utilization in the district area; d. realizing integration, linkage and balance between sectors.

RTRW data was obtained through the Gistaru website, which was the official website of the Directorate General of Spatial Planning, Ministry of Agrarian and Spatial Planning/ National Land Agency of Indonesia. RTRW of the Meranti Regency was determined based on the regional regulation of Kepulauan Meranti Regency No.8 in the year 2020 regarding Kepulauan Meranti Regency spatial plan for 2020-2040. RTRW was used as a policy direction and strategy for utilization and control of spatial use. In this study, it was used to obtain the optimum area of degraded peatlands for

Table 3. Average of annual rainfall 1998-2019 period at 7 (seven) rainfall stations.

Station	Average of Annual Rainfall (mm/year), 1998-2019 period
Merbau	2.388,21
P_Merbau	2.334,11
Putri_puyu	2.399,12
Rangsang	2.329,01
Rangsang_Barat	2.334,29
Tebing Tinggi Barat	2.306,96
Tebing Tinggi Timur	2.199,41

Source: htpps://gpm.nasa.gov/data-access/downloads/trmm.

agriculture and plantations. Based on the results of the overlay between the sub-district administration data and RTRW, a location designated for agriculture was obtained with an area of 11,154.51 ha, as shown in Table 4.

3.1. Mapping Accuracy

This accuracy test was carried out to determine the accuracy of the supervised classification of land cover. Mapping accuracy was conducted by making a contingency and confusion matrix. The accuracy test was carried out on land cover years 2019 to represent land cover period 1999–2019.

Based on land cover data sampling year 2019 (Table 5) calculations of User's Accuracy, Producer's Accuracy, Overall accuracy, and Kappa coefficient were obtained:

Accuracy Assessment of land cover type year 2019:

The result of the calculation showed that the classification achieved an overall accuracy of 95%, with the user's accuracy and producer's accuracy both at 95%. Additionally, the Kappa coefficient was calculated to be 93.8% using the following formula:

User's Accuracy =

= 95/100 x 100 % = 95 %

Producer's Accuracy =

= 95/100 x 100 % = 95 %

Overall Accuracy =

= 95/100 = 0.95 x 100 = 95%

Kappa Coefficient =

=9500-1925/10000-1925

=7575/8075 x 100 = 93.8080495 = 94%

The results of land cover classification using Landsat image data by MLC were shown in Figure 5.

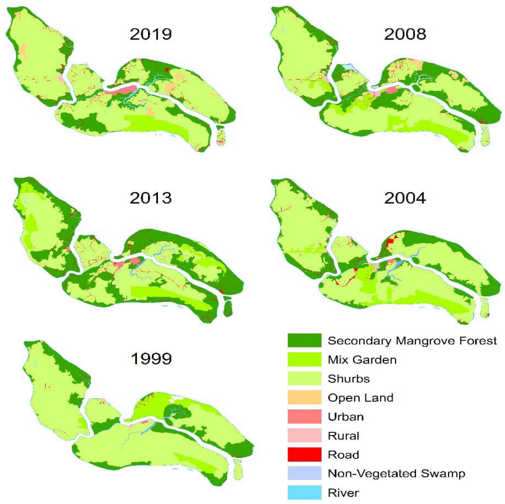


Figure 5. Land cover data for the period of 1999 – 2019

Table 4. Distribution of land use for agriculture based on RTRW 2020-2040 map of Kepulauan Meranti Regency

	Sub District	Area of land used for agriculture (ha)	Large (ha)
1	Tebing Tinggi	Convertible Production Forest Area/ Agricultural Area	13,45
2	Tebing Tinggi Barat	Limited Production Forest Area/Agricultural Area	1.779,91
3	Tebing Tinggi Timur	Limited Production Forest Area/Agricultural Area	680,28
		Convertible Production Forest Area/Agricultural Area	4.771,99
4	Rangsang	Protected Forest Area/Agricultural Area	0,44
		Limited Production Forest Area/Agricultural Area	19,11
5	Rangsang Barat	Limited Production Forest Area/Agricultural Area	285,87
		Convertible Production Forest Area/Agricultural Area	311,84
6	Merbau	Convertible Production Forest Area/Agricultural Area	75,08
7	Pulau Merbau	Protected Forest Area/Agricultural Area	28,79
		Limited Production Forest Area/Agricultural Area	15,23
		Permanent Production Forest Area/Agricultural Area	1,70
		Convertible Production Forest Area/Agricultural Area	595,74
8	Tasik Putripuyu	-	-
9	Rangsang Pesisir.	Convertible Production Forest Area/Agricultural Area	1.575,08
	Total		11.154,51

Source: RTRW Map 2020-2040

Table 5. Confusion Matrix of Land Cover Type Year 2019

Referency Data	Class Data in Map										Total
	a	b	c	d	e	f	g	h	i	j	
a	0										0
b		30			1						31
c			6	1							7
d				2							2
e		1			16						17
f	1					22					23
g							14				14
h								4			4
i									1		1
j	1									0	1
Total	2	31	6	3	17	22	14	4	1	0	100

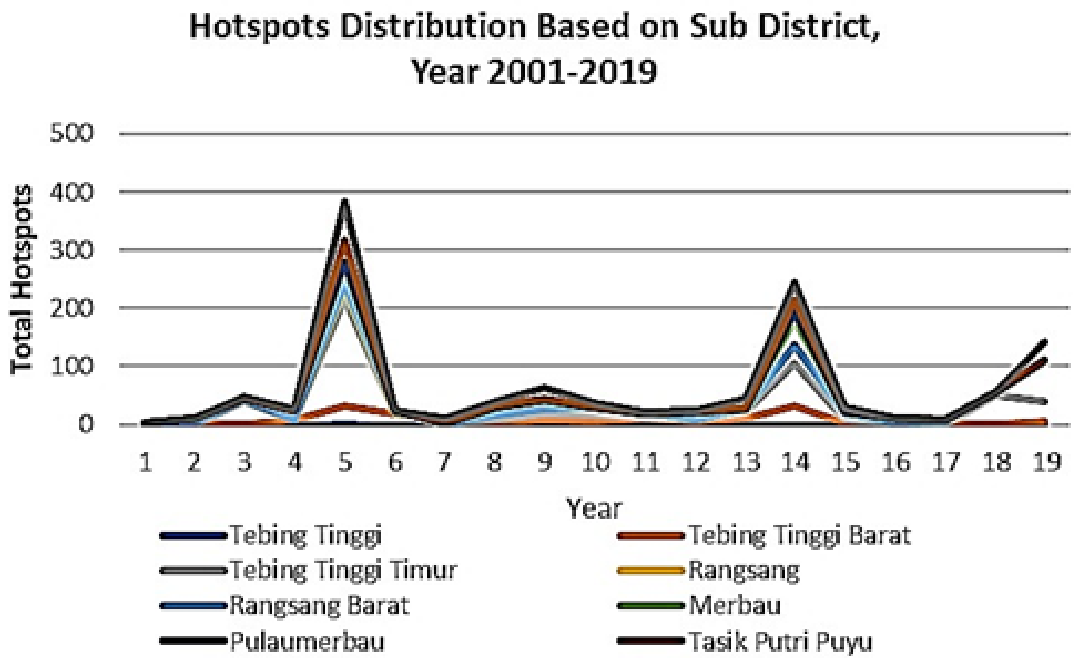


Figure 6. Hotspots Distribution Based on Sub District, Year 2001-2019

3.2. Distribution of Hotspots Based on sub-District and Type of Landcover

By employing spatial analysis, it becomes possible to identify the existence of hotspots and determine the specific time frame associated with two factors, namely 1) sub-district administrative boundaries and 2) land cover data from the years 1999 to 2019. Considering the sub-district administration, the East Tebing Tinggi sub-district exhibited the highest count of hotspots, totaling 432, from the years 2001 to 2019, as depicted in Figure 6.

Based on the type of land cover, the highest number of hotspots during the period 2001 to 2019 was on open land in 2003 with a total of 191 hotspots, and was on shrubs in the year 2012 with a total of 110 hotspots, as shown in Figure 7.

According to the classification of land use under the Indonesian National Standard (SNI), open land refers to areas not suitable for cultivation due to their inherent lack of fertility or the tendency to become infertile after cultivation. These areas also do not support plant growth.

3.3. Accuracy of Land Cover Classification

According to Sutanto (2013), the range of overall accuracy and kappa index deemed suitable for satellite imagery usage is between 80% and 85%. However, in the specific land cover classification conducted for the year 2019, an overall accuracy value of 95% was achieved. For land cover classifications conducted in 2017 and 2015, overall accuracy values of 95% and 94% were obtained. In terms of kappa accuracy, the values obtained were 94% for the year 2019, 94% for 2017, and 93% for 2015. The classification of land cover types using image analysis is categorized as highly accurate with high kappa coefficients.

3.4. The annual rainfall distribution area

From Table 3, the mean annual rainfall in Kepulauan Meranti Regency was >2000 mm/year. Graphically annual rainfall from 1998 to 2019 can be seen in Figure 8.

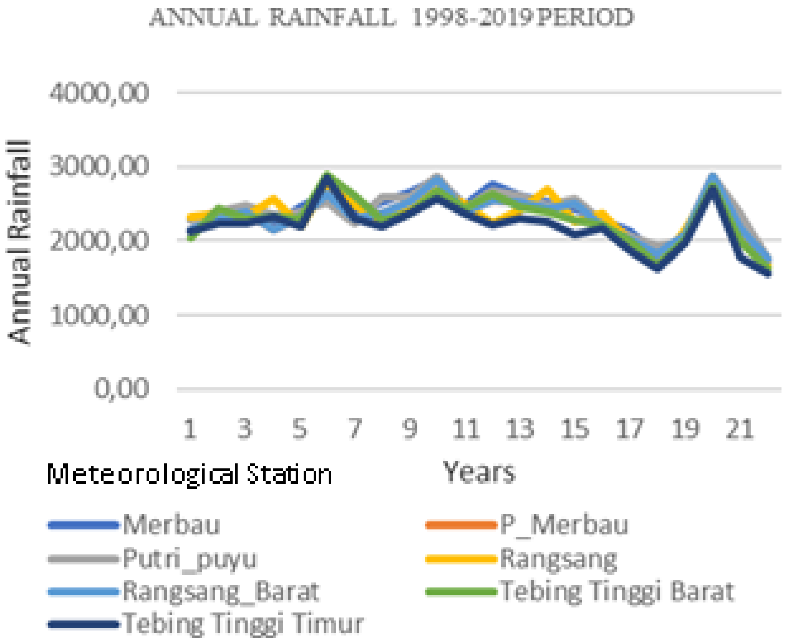


Figure 8. Annual rainfall from 1998 to 2019

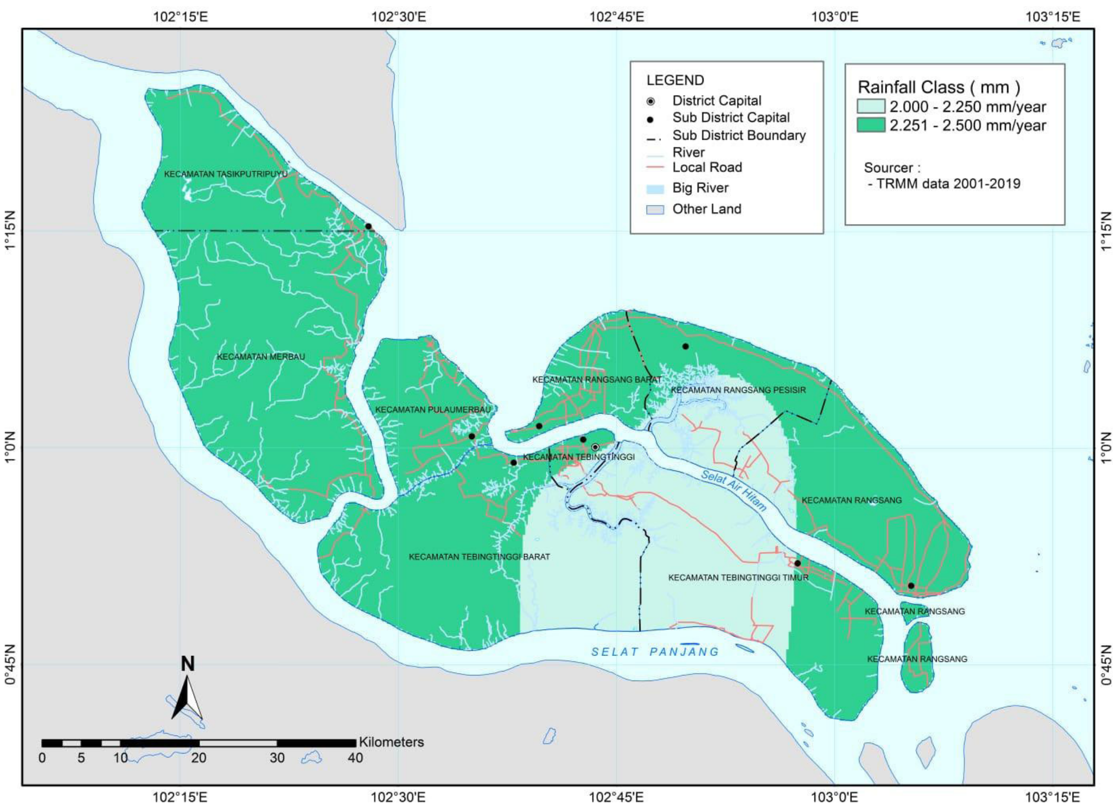


Figure 9. Isohyet Map average of Rainfall (2001–2019)

The minimum and maximum annual rainfall of 1.562.92 mm/year and 2.857,26 mm/year occurred in 2019 and 2003 at the East Tebing Tinggi rainfall gauge station.

The annual rainfall data were used to obtain the distribution area. Spatial distribution was presented in the form of an isohyet map with an interval of 500 mm/year, as shown in Figure 9.

From the isohyet map, spatially the average annual rainfall in Meranti Islands Regency from 1999 to 2019 can be known that ranged from 2000 mm/year to 2500 mm/year.

3.5. The Soil and Landform

Peatlands map was sourced from the Center for Agricultural Land Resources (BBSDLP) and showed that Kepulauan Meranti Regency was dominated by peatlands covering an area of 103.464,3 ha. From peatlands area, it was grouped into 3 (tree) landforms along with the type of soil: Mangrove tidal plain with soil types Alluvial sulfidic and Gleisol Sulfik, Freshwater Peat dome with soil types Organosol Sapric and Organosol Hemic, Tidal peat dome with soil type Organosol sapric and Organosol Hemic, as shown in Figure 10.

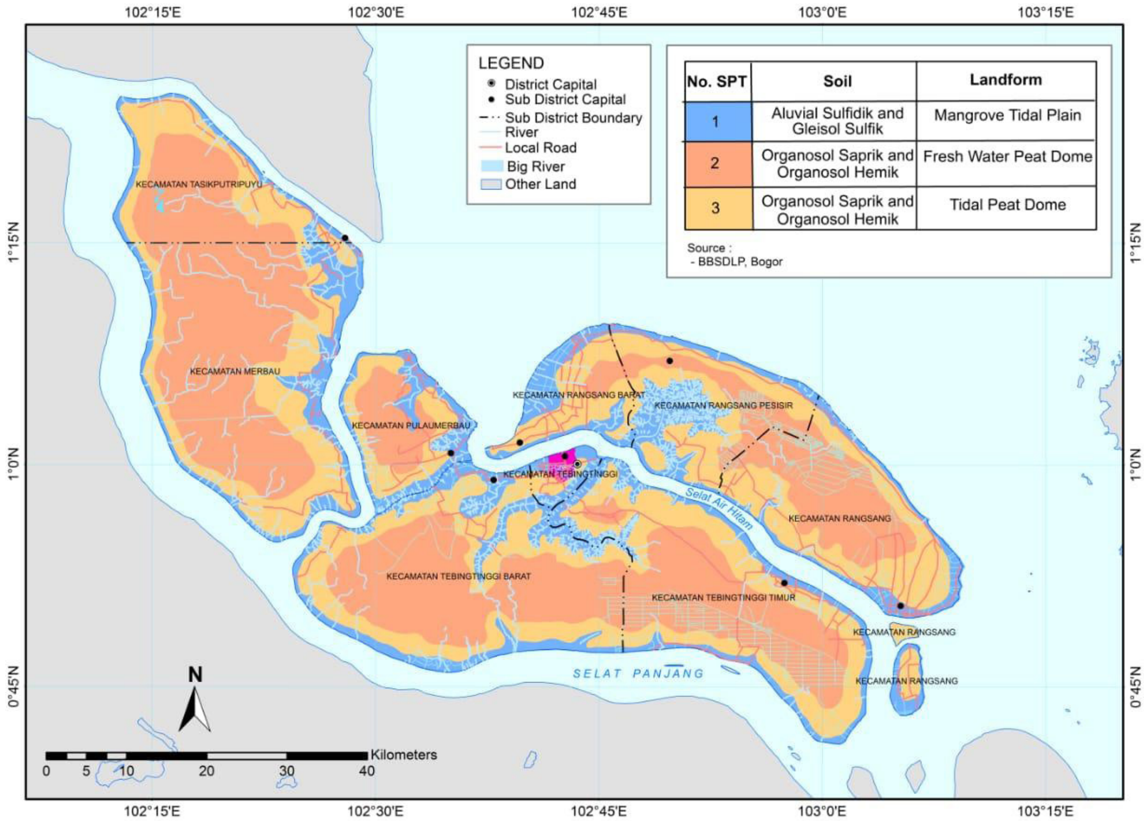


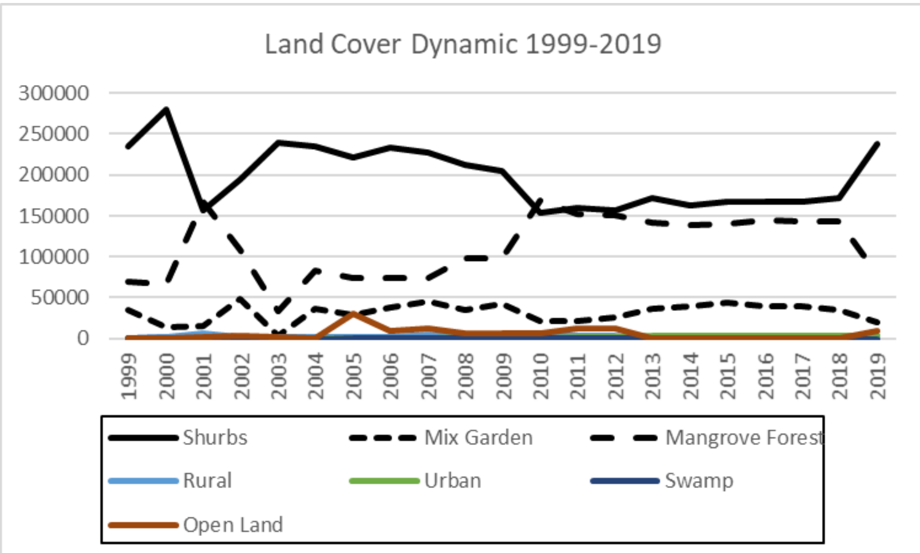
Figure10. Soil Map of Kepulauan Meranti Regency

The distribution of landform showed that Freshwater Peat dome with soil types Organosol Sapric and Hemic dominated the entire area.

3.6. Shrubs dynamics rate

Shrubs represent regions where dry land forests have regenerated, characterized by a prevalence of low-lying vegetation and the absence of discernible remnants from logging activities (BAPLAN Ministry of Forestry, 2001). These shrubland, along with open land, can also be found in periodically waterlogged peatlands. The presence indicates degradation of peatlands and throughout the study period from 1999 to 2019, shrub-covered area was subjected to dynamic changes within the designated area. Furthermore, there was a substantial increase in shrubland coverage in 2000, reaching a total of 280,366.79 hectares, as shown in Figures 11 and 12.

The alteration in shrubland area was primarily instigated by fires and the abandonment of land (Usup et al., 2004). This phenomenon was corroborated by Kubangun et al. (2016), where shrublands were once lush forests but have since transitioned into degraded land, characterized by a shift from dense vegetation cover to a more open landscape.



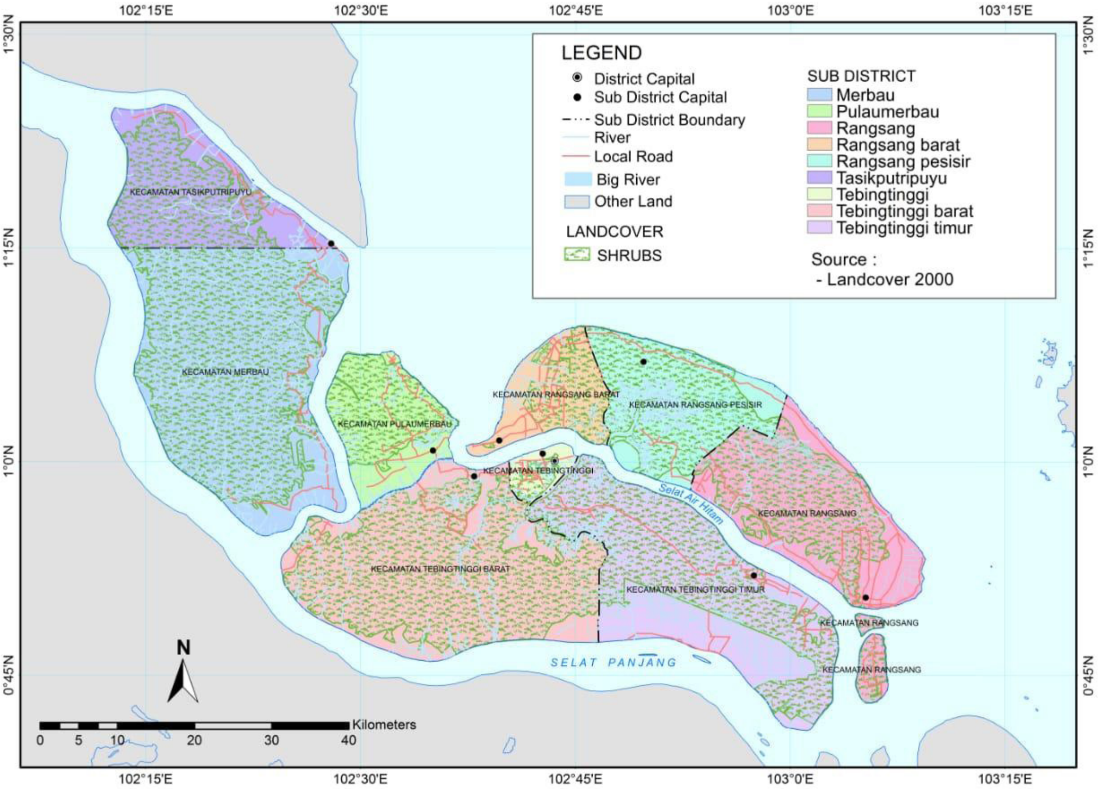


Figure 12. Distribution of shrubs on Kepulauan Meranti Regency

Table 5. Total number of hotspots on landcover 2001-2019 period

Land Cover	Total hotspots
Shrubs	413
Mix Garden	199
Sec Mangrove Forest	249
Rural	0
Urban	0
Swamp	0
Open land	287

Source: Spatial Analysis of Hotspots and Landcover Data

Shrubs represent land cover type particularly susceptible to environmental stress caused by land fires. They serve as effective fuel sources in the event of such fires. Over the period from 2001 to 2019, it was observed that shrubland had the highest number of hotspots, totaling 413 incidents, as shown in Table 5.

3.7. Crops suitability analysis

This analysis was conducted to obtain the appropriate types of agricultural commodities for Kepulauan Meranti Regency, which was dominated by peatlands. From the agricultural commodities, plantation crops are the most widely cultivated group of plants on degraded peatlands, and the types of plantation crops cultivated include oil palm, rubber, coconut, and coffee. (Masganti et al., 2014).

The presence of shrubs, indicating degraded peatlands, is a recurring phenomenon observed almost every year. The extent of degradation varies across the 1999-2019 period, ranging from the smallest area of 154,365.01 ha to the most extensive area of 280,366.79 ha. Despite degradation, peatlands can still be utilized for agricultural and plantation purposes (Miettinen et al., 2016). Utilization of degraded peatlands at the district level is contingent upon land use planning allocation depicted in RTRW map. The outcome of spatial analysis includes: (1) a map showcasing the distribution of shrubs based on spatial plan, as shown in Figure 13, and (2) the identification of an optimal land area of 7,122.45 ha in 2019 for agricultural and plantation cultivation on degraded peatlands.

Utilization of degraded peatlands necessitates careful consideration of the appropriate commodity to be cultivated. The selected commodity should exhibit favorable adaptability to peatlands conditions, possess economic value, and be supported by the availability of capital, requisite skills, and suitable business scale (Subiksa et al., 2011).

According to land suitability, the directions for the development of agricultural commodities in Kepulauan Meranti Regency per District are as follows: sago plants to be developed in Merbau, West Tebing Tinggi, and East Tebing Tinggi Districts, Rubber Plants to be developed in Merbau Island District, areca nut to be developed in Pulau Merbau and West Rangsang sub-districts; Coffee plants to be developed in the West Rangsang sub-district (Sitorus et al., 2012).

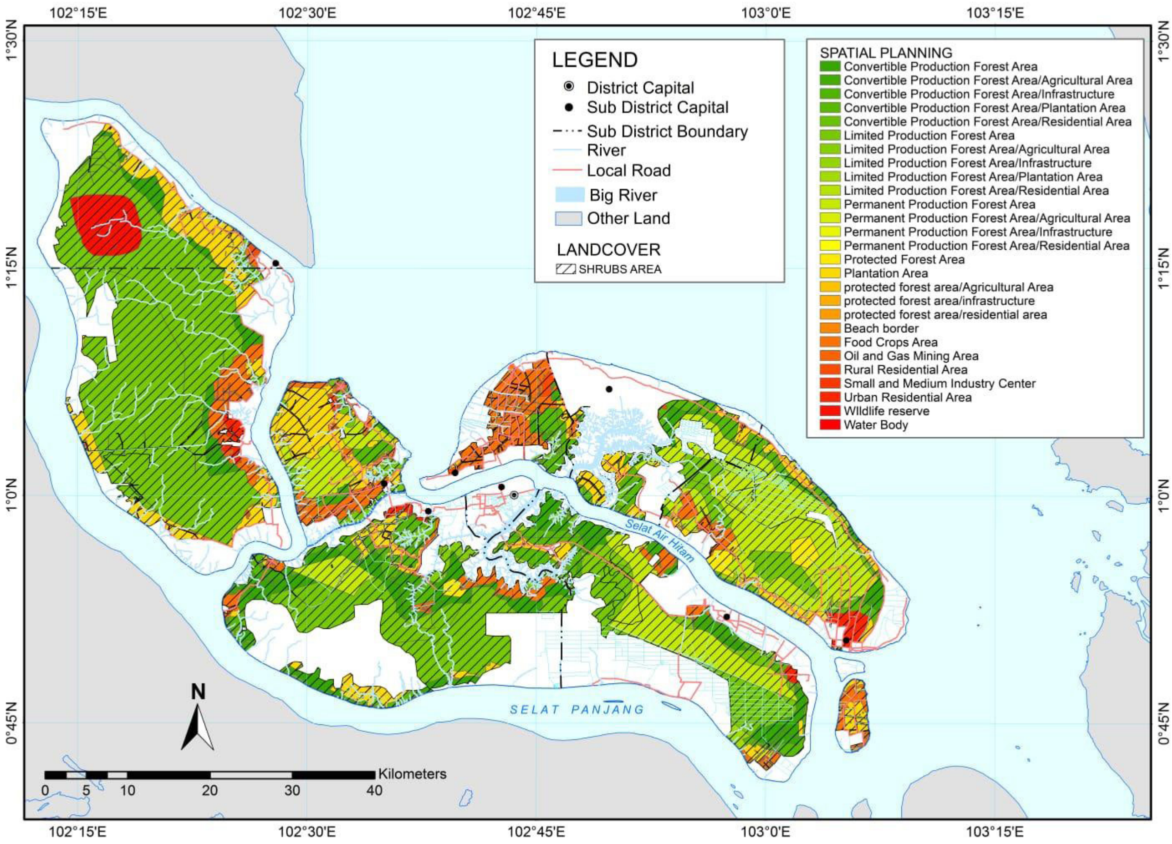


Figure 13. Distribution of shrubs on spatial planning of Kepulauan Meranti Regency

Table 6. Existence of shrubs year 2019 in RTRW of Kepulauan Meranti Regency

Allocation of Land for Agricultural Area in RTRW map	Shrubs Area (Ha)
Convertible Production Forest Area/ Agricultural Area	4.663,29
Limited Production Forest Area/Agricultural Area	2.457,46
Permanent Production Forest Area/ Agricultural Area	1,70
Total	7.122,45

Source: spatial analysis of RTRW and shrubs distribution Year 2019

3.8. Opportunities for utilization of degraded peatlands area

Following its physical conditions (climate, topography, slope, soil), Meranti Islands Regency has an average annual rainfall of >2000 mm/year (Table 2 and Figure 8), height of <300 m mean sea level (msl), flat slope, and composed of peatlands. According to Waluyo and Nurlia, (2017); Lupascu and Wijedasa, (2021), these conditions are suitable for the cultivation of liberica coffee which is adaptive to peatlands. Currently, Liberica coffee has been cultivated with high economic potential (Gusfarina, 2014) as the leading agricultural product (Ardiyani, 2014). This is because the economic value is quite good according to the market price shown in Table 7.

Sago palms are also adaptive to peatlands because the plants grow well in an environment with a pH of 4, resistant to standing water, as well as grow on organic soils (Organosols), with a rainfall range of 2000 to 4000 mm/year (Suripatty et al., 2016). Therefore, Kepulauan Meranti Regency, dominated by peatlands, will be very good when used for food cultivation other than rice. Currently, sago is already an export commodity to Japan, North Korea, Malaysia, and Singapore. The need in Indonesia reaches 300-500 tual/day, and the size is absorbed by 68 units of refineries. This sago business activity generates a turnover of IDR 1.362 trillion per year. (https://mediaperkebunan.id/sagu-penggerak-ekonomi-kabupaten-meranti/).

The cultivation of Liberica coffee and sago is expected to meet the criteria of adaptability to peatlands, economic value, capital availability, required skills, and business scale (Applegate et al., 2022); (Miller, 2022). The cultivation of plants in peatlands is conducted through paludiculture, which refers to a form of cultivation where crops necessitate a drainage level of less than 50 cm (Uda et al., 2020).

Based on degraded peatlands and land use directions per sub-district data, the overlay process between the distribution of shrubs and the administration can determine opportunities for utilization of degraded peatlands per sub-district. The

Table 7. Economic value of liberica coffee

Condition of coffee ore	Price per Kg (Rp)
Wet seeds	2.500–4.000
Dried beans	90.000–120.000
Roast	200.000
Powder	250.000–270.000

Source: (Gusfarina 2014).

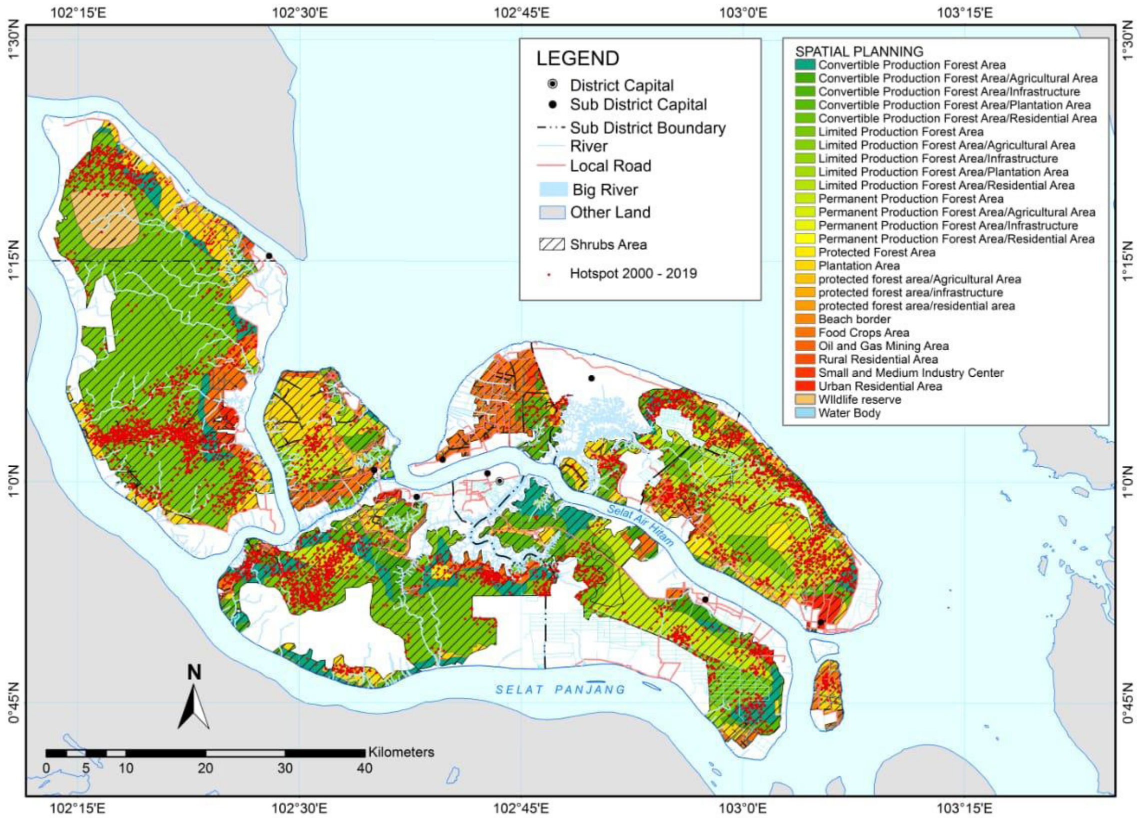


Figure 14. Distribution of shrubs and hotspots on spatial planning of Kepulauan Meranti Regency

priorities can be obtained through the distribution pattern and area of degraded peatlands, starting from the largest (94 ha), in West Rangsang Sub District. Meanwhile, there is an allocation for agricultural activities based on RTRW 2020-2040 map and land units suitable for agricultural cultivation covering an area of 11,154.51 ha and 232,629 ha, respectively (Sitorus et al., 2012).

3.9. Shrubs and land fire mitigation signals

The area covered by shrubs exhibits the highest concentration of hotspots, with a recorded count of 413 between 2000 and 2019. This observation suggests that shrubland areas experience a greater incidence of fires compared to other land cover types. Evidence of fire occurrences can be observed through the presence of hotspots within the period, as shown in Table 4. Spatial distribution is visually represented on spatial planning map of Kepulauan Meranti Regency, highlighting shrubs and hotspots, as shown in Figure 14.

In 2000 shrubs area increases sharply but decreased in the next period. This decrease indicates the restoration of critical peatlands for agriculture and plantation. Referring to the type of land degradation proposed by Prince et al., (2018), the state in the study area belongs to the category "soil can recover when the stressor is removed". This category indicates that when the cause of degradation is eliminated, land returns to its initial.

4. Conclusion

In conclusion, the identification of degraded peatlands using land cover approach can be achieved by analyzing Landsat images. Degraded area used for agriculture is obtained through spatial analysis between the distribution of shrubs and spatial planning maps. Moreover, the information reflected from the distribution of shrubs can be used as a reference to determine the pattern of land fires. Opportunities to use degraded peatlands for agriculture is to select plants that are adaptive to the conditions and have economic value, such as sago, rubber, areca nut, and liberica coffee.

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