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Analysis of Land Use Changes in Bener Meriah Regency Using Geographic Information Systems

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ABSTRACT

Bener Meriah Regency is one of the regencies in Aceh Province with high economic growth. This high economic growth naturally impacts various factors, including population growth and land demand. Changes in land use can lead to spatial planning issues if they do not align with the established Regional Spatial Plan (RTRW). These changes in land use need to be reviewed and analyzed to determine the extent of land use changes that have occurred in Bener Meriah Regency since 2009. This study aims to provide information on land use changes occurring in Bener Meriah Regency and to determine how these changes relate to the existing RTRW (Regional Spatial Plan). The method used is descriptive, first processing satellite imagery to obtain land cover data for 2009 and 2023, Then the data was analyzed spatially by overlaying the land cover interpretation data for 2009 and 2023 with the RTRW map of Bener Meriah Regency for the 2012-2032 period. The analysis results of the interpretation of land use in 2009 and 2023 show that there has been a total change in land use reaching 76,703 hectares (40.19%). The changes occurred in the form of an increase in the area of Mixed Dryland Agriculture and Primary Dryland Forest and a decrease in Secondary Dryland Forest and Dryland Agriculture. The level of Conformity with the Bener Meriah Regency Spatial Plan in 2009 was 99.18% in 2023, decreasing to 96.95%.

INTRODUCTION

Land refers to an area on the earth's surface with specific characteristics that include the biosphere, atmosphere, soil, biological layer, hydrology, vegetation, animals, and the results of past and present human activities to a certain extent (FAO, 1976). According to Bintarto (1977), land is defined as a place or area where people gather and live together, where they can utilize the local environment to sustain, continue, and develop their lives.

Land use is any human intervention—either permanent or shifting—on a group of natural and artificial resources, collectively referred to as land, with the aim of fulfilling material, spiritual, or both types of needs (Su Ritohardoyo, 2002). It is therefore clear that all living beings require land to grow and thrive. Various human activities on earth cannot be separated from the different functions of land use.

Rapid population growth leads to increased land demands from society, often resulting in land-use conflicts and mismatches between actual land use and its designated purpose in spatial plans. Since land cannot be increased, what typically occurs is a change in land use, often reducing the proportion of forest areas being converted into agricultural land, or agricultural land being turned into non-agricultural land. Humans modify land use in order to maximize the utility of the land and obtain optimal benefits from it. Land use change involves any human intervention—whether permanent or cyclical—on a set of natural and artificial resources, collectively called land, aimed at meeting their material and spiritual needs or both (Malingreau, 1978).

Various phenomena of land use change have occurred over time. These changes align with increasing population growth, which directly impacts the rising demand for land. Bener Meriah Regency, as one of the regencies in Aceh Province that relies heavily on the agricultural sector, is facing increasing demand for land, particularly for settlements and agriculture. Land use changes in Bener Meriah Regency are largely dominated by the conversion of protected areas into plantation land, especially coffee plantations, and residential areas.

Several previous studies related to this research include an analysis of land use conformity with spatial planning (RTRW) in Cianjur Regency using Geographic Information Systems, which indicated that land use changes cause spatial planning problems (Panjaitan, 2019). Another study, namely an assessment of land use suitability with the Regional Spatial Plan in Bener Meriah Regency, reported a land use discrepancy of 9,475.65 hectares (Zahara, 2016).

Land use change has become a common issue amid current economic growth. Various problems often arise due to the misalignment between land designation and its physical condition. Through this study, the author analyzes and examines the land use changes that have occurred in Bener Meriah Regency from 2009 to 2023. The results of this research are expected to serve as a decision-making tool in reviewing or revising land use and the RTRW of Bener Meriah Regency.

RESEARCH METHOD

Research Location

Bener Meriah Regency has a land area of 197,271.31 hectares. Since 2010, Bener Meriah Regency has been administratively divided into 10 sub-districts (kecamatan), consisting of 27 mukims and 234 villages. The administrative map of Bener Meriah Regency is shown in Figure 1.

Tools and Materials

The materials used in this study include base maps such as the Administrative Map of Bener Meriah Regency, Land Use Maps from 2009 and 2023 (based on satellite image interpretation), and the Protected and Cultivation Area Map from the RTRW of Bener Meriah Regency (Qanun No. 4 of 2013 concerning the Regional Spatial Plan of Bener Meriah Regency for 2012–2032).

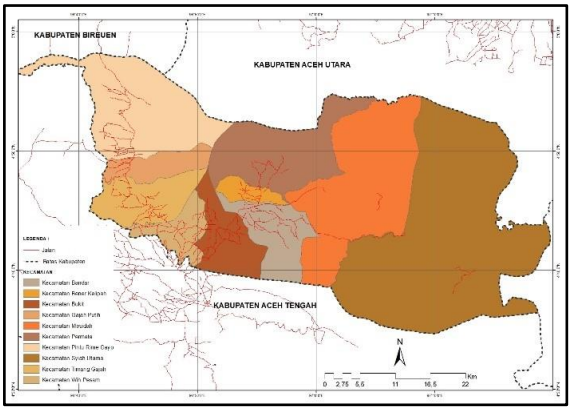


Figure 1. Research Location Map

Tools and Materials

The tools used in this research include hardware such as a computer/laptop, digital camera, Global Positioning System (GPS), scanner, printer, and stationery. Software for spatial analysis includes ArcGIS 10.2.3, and Microsoft Office 2016. The general research procedures are shown in Figure 2.

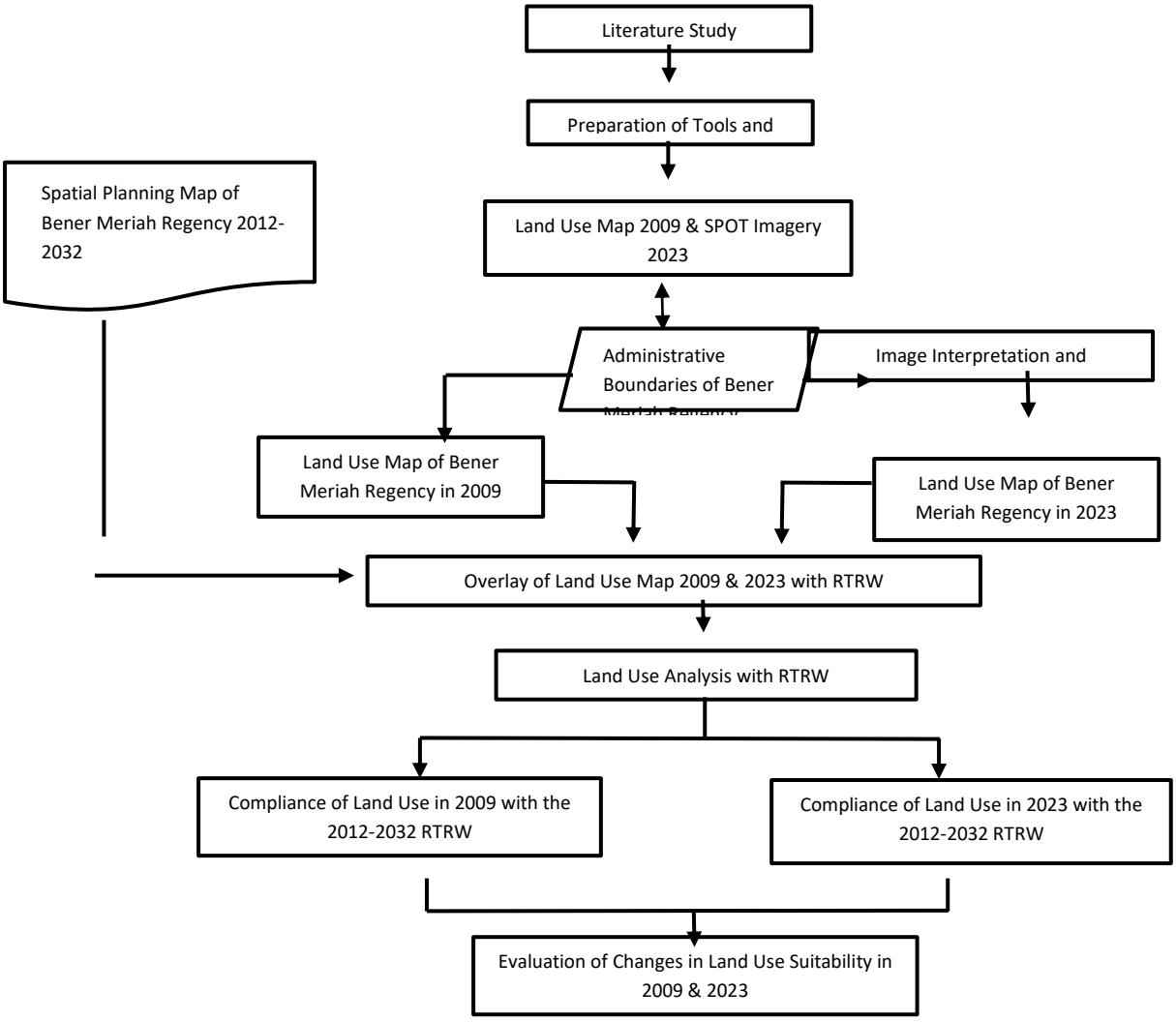


Figure 2. Research Flowchart

Preparation Stage

The research preparation began with a literature review and the collection of necessary documents. This stage also included determining the research method to be used throughout the process, as well as identifying and gathering the data required for the study.

Data Collection

At this stage, both secondary and primary data were collected. Secondary data consisted of spatial and statistical data. The spatial data used included SPOT 7 satellite imagery of Bener Meriah Regency, the Indonesian Topographic Map (RBI), the Regional Spatial Plan (RTRW) map of Bener Meriah Regency, the administrative map of Bener Meriah Regency, and the land use map of Bener Meriah Regency. All data were obtained from various official agencies.

Data Processing

The purpose of the field survey was to visually observe the current land use conditions (existing land use), and to analyze the pattern of land use changes occurring in Bener Meriah Regency to determine whether these changes align with the Regional Spatial Plan of Bener Meriah Regency.

RESULTS AND DISCUSSION

Land Use According to the RTRW

The spatial allocation in Bener Meriah Regency, as outlined in the Regional Spatial Plan (RTRW), is based on two main functions: protected areas and cultivation areas, with a planning horizon of 20 years (2012–2032).

Table 1. Land Use Based on the RTRW of Bener Meriah Regency

No.	Land Use	Area (Ha)	% Area
1	Aquaculture	131	0,07
2	Production Forest	53.997	28,30
3	Rural Settlements	1.519	0,80
4	Permukiman Perkotaan	1.989	1,04
5	Wetland Farming	1.640	0,86
6	Dry Land Agriculture	45.420	23,80
7	Protected forest	63.712	33,39
8	People's Plantations	18.292	9,59
9	Large Plantation	5	0,003
10	Body of Water	326	0,17
11	River-Friendly Protected Area	1.416	0,74
12	horticulture	1.525	0,80
13	HPT	757	0,40
14	Buru Park	42	0,02
15	Livestock Area	53	0,03
	Amount	**190.824**	**100**

Based on the spatial allocation plan, for protected areas, Syiah Utama Sub-district has the largest area at 37,152 hectares, while the sub-district with the smallest protected area is Bener Kelipah, covering 197 hectares. For cultivation areas, Syiah Utama also has the largest area at 42,328 hectares, while the smallest is again Bener Kelipah, with 1,772 hectares. The total area designated for cultivation in Bener Meriah Regency is 125,654 hectares, which accounts for 65.85% of the regency's total area. Meanwhile, the total protected area is 65,170 hectares, or 34.15% of the total area of Bener Meriah Regency.

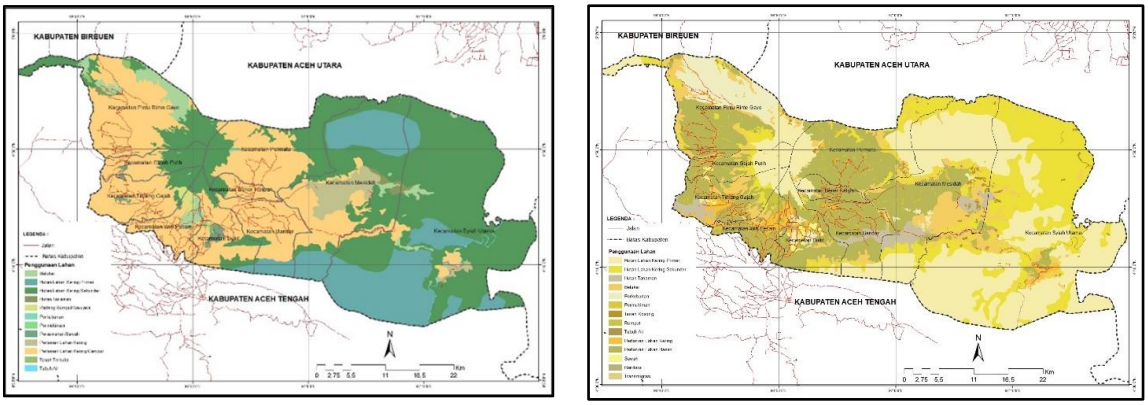
Land Use Analysis for 2009 and 2023

Land Use in 2009 and 2023 From the image interpretation using on-screen digitization of the 2009 satellite imagery, the largest land use type in the study area in 2009 was Secondary Dryland Forest, covering 75,284 hectares or 39.45% of the total area of Bener Meriah Regency. The smallest land use category was Water bodies, covering 41 hectares or 0.02% of the study area.

In 2023, the largest land use type was Primary Dryland Forest, covering 60,987 hectares or 31.96% of the total area of the regency. The smallest was Transmigration Area, covering 33 hectares or 0.02%. The land use maps for 2009 and 2023 are presented in Figures 3a and 3b, respectively.

Table 2. Land Use in 2009 and 2023 – Bener Meriah Regency

No	Land Use Classification	Code	Area in 2009 (Ha)	Area (%) 2009	Area in 2023 (Ha)	Area (%) 2023
1	Secondary Dryland Forest	2002	75,284	39.45	39,805	20.86
2	Primary Dryland Forest	2001	31,917	16.73	60,987	31.96
3	Shrubs (Belukar)	2007	24,411	12.79	16,552	8.67
4	Dryland Agriculture	20091	24,015	12.59	2,745	1.44
5	Plantation Forest	2006	16,473	8.63	4,591	2.41
6	Mixed Dryland Agriculture	20092	16,406	8.60	49,158	25.76
7	Rice Fields	20093	954	0.50	741	0.39
8	Grassland	3000	617	0.32	759	0.40
9	Water	5001	348	0.18	418	0.22
10	Settlement	2012	199	0.10	4,329	2.27
11	Vacant Land	2014	156	0.08	1,494	0.78
12	Plantation	2010	41	0.02	9,086	4.76
13	Airport	20121	-	-	123	0.06
14	Transmigration Area	20122	-	-	33	0.02
	Total		190,821	99.99	190,821	100.00



(a) (b)

Figure 3. Land Use in 2009 (a) and 2023 (b)

Land Use Change Analysis: 2009–2023

The analysis of land use changes from 2009 to 2023 was conducted by comparing the land use in the study area in 2009 with that in 2023. The change analysis was performed using the overlay method to identify both altered and unchanged land use classes. The changes in land use between 2009 and 2023 are presented in Table 4.

The processed data shows that there were significant land use changes over the 14-year period, with both increases and decreases in the area of various land use categories.

Land uses that experienced an increase in area include:

- Mixed Dryland Agriculture increased by 32,752 hectares (17.16%)
- Primary Dryland Forest by 29,070 hectares (15.23%)
- Plantation by 9,045 hectares (4.74%)
- Settlement by 4,130 hectares (2.16%)
- Vacant Land by 1,338 hectares (0.70%)
- Grassland by 142 hectares (0.07%)
- Airport by 123 hectares (0.06%)
- Water Bodies by 70 hectares (0.04%)
- Transmigration Area by 33 hectares (0.02%)

Land uses that experienced a decrease in area include:

- Secondary Dryland Forest decreased by 35,479 hectares (18.59%)
- Dryland Agriculture by 21,270 hectares (11.15%)
- Planted Forest by 11,882 hectares (6.23%)
- Shrubs (Belukar) by 7,859 hectares (4.12%)
- Rice Fields by 213 hectares (0.11%)

Overall, the total land use change in the study area from 2009 to 2023 amounted to 76,703 hectares, or 40.19% of the total area.

Table 4. Land Use Change from 2009 to 2023 – Bener Meriah Regency

No.	Land Use Classification	Area in 2009 (Ha)	Area in 2023 (Ha)	Change (Ha)	Remarks
1	Secondary Dryland Forest	75,284	39,805	-35,479	Decrease in Area
2	Primary Dryland Forest	31,917	60,987	+29,070	Increase in Area
3	Shrubs (Belukar)	24,411	16,552	-7,859	Decrease in Area
4	Dryland Agriculture	24,015	2,745	-21,270	Decrease in Area
5	Mixed Dryland Agriculture	16,406	49,158	+32,752	Increase in Area
6	Rice Fields	954	741	-213	Decrease in Area
7	Planted Forest	16,473	4,591	-11,882	Decrease in Area
8	Grassland	617	759	+142	Increase in Area
9	Vacant Land	156	1,494	+1,338	Increase in Area

No.	Land Use Classification	Area in 2009 (Ha)	Area in 2023 (Ha)	Change (Ha)	Remarks
10	Water Bodies	348	418	+70	Increase in Area
11	Settlement	199	4,329	+4,130	Increase in Area
12	Plantation	41	9,086	+9,045	Increase in Area
13	Airport	0	123	+123	Increase in Area
14	Transmigration Area	0	33	+33	Increase in Area
	Total	190,821	190,821		

The spatial distribution of land use change between 2009 and 2023 is illustrated in Figure 4.

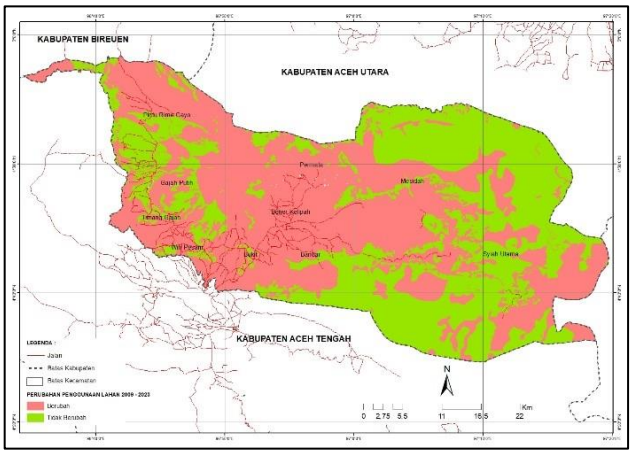


Figure 4. Land Use Change Map 2009 - 2023 Bener Meriah Regency

Analysis of Land Use Suitability in 2009 with the Regional Spatial Plan (RTRW)

The results of the 2009 land use suitability analysis with the Bener Meriah Regency RTRW are presented in Tables 5 and 6. The Bener Meriah RTRW for 2012-2032 was used as the reference for this suitability. Protected Forest was the land use classification in 2009 that most closely aligned with the Bener Meriah RTRW for 2012-2032, covering 62,463.28 ha, or 32.73%. Protected Forest was the land use classification in 2009 that experienced the most land use changes inconsistent with the Bener Meriah RTRW for 2012-2032, accounting for 0.65%. In this study area, protected forest areas experienced extensive encroachment for coffee plantations, resulting in land use violations.

The total land use in 2009 that is in accordance with the Bener Meriah Spatial Plan (RTRW) for 2012-2032 is 189,262 hectares or 99.18%. The suitability of the land use in the 2009 study area with the Bener Meriah Regency RTRW for 2012-2032 will be displayed on a map as shown in Figure 5.

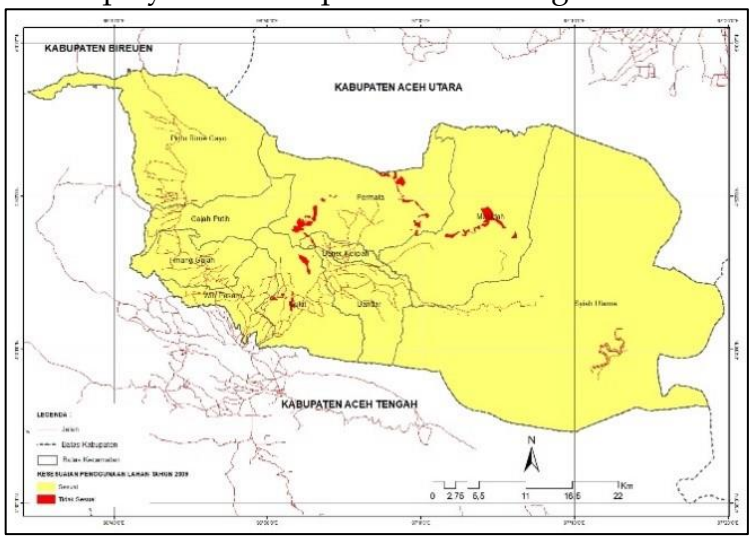


Figure 5. 2009 Land Use Conformity Map with the Regional Spatial Plan

Table 5. 2009 Land Use Conformity with the Regional Spatial Plan (RTRW)

No.	Spatial Allocation Type	Conformity	Area (Ha)
1	Cultivation – Fisheries	Conforming	130.50
2	Cultivation – Horticulture	Conforming	1,524.90
3	Cultivation – Production Forest	Conforming	53,997.67
4	Cultivation – Limited Production Forest	Conforming	757.08
5	Cultivation – Livestock Area	Conforming	52.96
6	Cultivation – Large-scale Plantation	Conforming	4.63
7	Cultivation – Smallholder Plantation	Conforming	18,291.41
8	Cultivation – Rural Settlement	Conforming	1,516.54
9	Cultivation – Urban Settlement	Conforming	1,988.82
10	Cultivation – Wetland Agriculture	Conforming	1,621.69
11	Cultivation – Dryland Agriculture	Conforming	45,353.20
12	Cultivation – Water Bodies	Conforming	322.22
13	Protected – Protected Forest	Conforming	62,463.28
14	Protected – River Border Protected Area	Conforming	1,194.84
15	Protected – Lingga Isaq Hunting Park	Conforming	41.80
	Total		189,262

Table 6. 2009 Land Use Non-Conformity with the RTRW

No.	Spatial Allocation Type	Conformity	Area (Ha)
1	Cultivation – Fisheries	Non-conforming	0.34
2	Cultivation – Wetland Agriculture	Non-conforming	18.46
3	Cultivation – Dryland Agriculture	Non-conforming	66.45
4	Cultivation – Water Bodies	Non-conforming	4.44
5	Protected – Protected Forest	Non-conforming	1,247.53
6	Protected – River Border Protected Area	Non-conforming	221.77
	Total		1,559

Analysis of Land Use Conformity in 2023 with the RTRW

Based on the overlay between the 2023 land use map and the spatial structure outlined in the Regional Spatial Plan (RTRW) of Bener Meriah Regency for the period 2012–2032 (see Tables 7 and 8), it was found that the majority of actual land use is in accordance with the spatial allocation designated by the local government. Out of the total study area of 190,821 hectares, 184,998 hectares or approximately 96.95% were found to be in conformity, while 5,822 hectares or around 3.05% were non-conforming.

The largest area of conformity was identified in the protected forest area, amounting to 60,882.99 hectares, followed by cultivation areas such as production forest with 53,994.91 hectares, dryland agriculture with 43,469.57 hectares, and smallholder plantations with 17,987.20 hectares. This reflects that the spatial structure in Bener Meriah Regency is still heavily influenced by the forestry and agriculture sectors, which continue to demonstrate strong compliance with the spatial plan.

However, several instances of spatial misuse were also identified in certain locations. The main cases of non-conformity occurred in:

- Dryland agriculture areas: 1,950.09 hectares
- Protected forest areas: 2,827.82 hectares
- River border protected areas: 509.16 hectares

These discrepancies indicate that there are land use activities exceeding or violating the functional zoning boundaries—particularly the conversion of protected areas into cultivation or residential uses. This highlights a challenge in maintaining the ecological integrity of zones that are supposed to be preserved.A spatial map illustrating land use conformity in 2023 with the RTRW of Bener Meriah Regency (2012–2032) is shown in Figure 6.

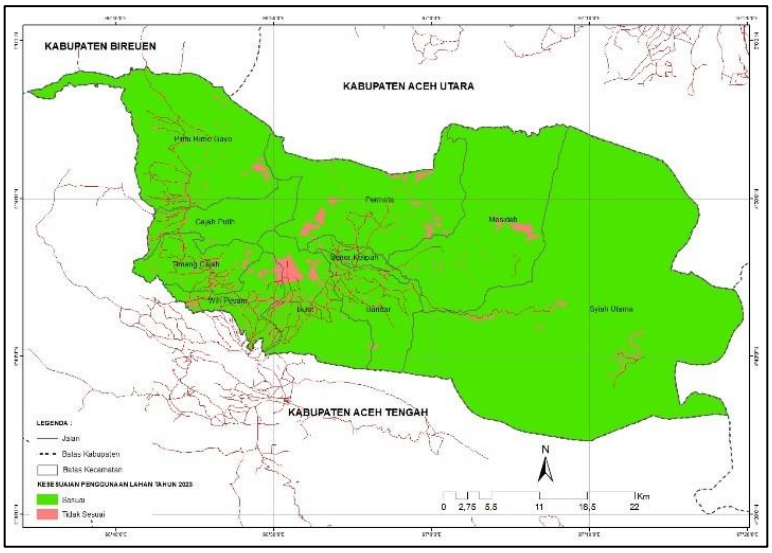


Figure 6. Land Use Compatibility Map in 2023 with the Spatial Plan (RTRW)

Table 7. Land Use Compatibility in 2023 with the Spatial Plan (RTRW)

No	Spatial Pattern	Compatibility	Area (Ha)
1	Cultivation – Fisheries Cultivation	Compatible	107.09
2	Cultivation – Horticulture	Compatible	1,477.57
3	Cultivation – Production Forest	Compatible	53,994.91
4	Cultivation – Limited Production Forest	Compatible	757.08
5	Cultivation – Livestock Area	Compatible	52.96
6	Cultivation – Large Plantation	Compatible	4.63
7	Cultivation – Smallholder Plantation	Compatible	17,987.20
8	Cultivation – Rural Settlement	Compatible	1,516.54
9	Cultivation – Urban Settlement	Compatible	1,988.82
10	Cultivation – Wetland Agriculture	Compatible	1,491.81
11	Cultivation – Dryland Agriculture	Compatible	43,469.57
12	Cultivation – Water Bodies	Compatible	317.94
13	Protection – Protected Forest	Compatible	60,882.99
14	Protection – River Border Protected Area	Compatible	907.45
15	Protection – Lingga Isaq Hunting Park	Compatible	41.80
	Total		184,998

Table 8. Land Use Incompatibility in 2023 with the Spatial Plan (RTRW)

No	Spatial Pattern	Compatibility	Area (Ha)
1	Cultivation – Fisheries Cultivation	Not Compatible	23.76
2	Cultivation – Horticulture	Not Compatible	47.33
3	Cultivation – Production Forest	Not Compatible	2.77
4	Cultivation – Large Plantation	Not Compatible	0.002
5	Cultivation – Smallholder Plantation	Not Compatible	304.22
6	Cultivation – Wetland Agriculture	Not Compatible	148.35
7	Cultivation – Dryland Agriculture	Not Compatible	1,950.09
8	Cultivation – Water Bodies	Not Compatible	8.72
9	Protection – Protected Forest	Not Compatible	2,827.82
10	Protection – River Border Protected Area	Not Compatible	509.16
	Total		5,822

If these conditions are left unaddressed, they could trigger land-use conflicts between communities and spatial management authorities, as well as increase ecological pressure on areas with protective functions—particularly those around river borders, primary forests, and other conservation zones.

Compatibility of Land Use Changes from 2009 to 2023 with the Spatial Plan (RTRW)

An analysis of land use changes between 2009 and 2023 in relation to the Bener Meriah Regency Spatial Plan (RTRW) shows that most spatial utilization remains within the corridors set by spatial planning policies. In 2009, out of a total area of 190,821 hectares, approximately 189,262 hectares (± 99.18%) were used in accordance with the RTRW spatial allocation, while 1,559 hectares (± 0.82%) were categorized as non-compliant. By 2023, the total area of compatible land use slightly declined to 184,998 hectares (± 96.95%), while incompatible land use increased to 5,822 hectares (± 3.05%).

This increase in incompatibility indicates a trend of land-use changes that do not fully align with the RTRW directives. There has been a rise in settlement activities within protected zones, particularly in protected forests and river borders, which should be strictly safeguarded. The area of incompatibility in protected forests rose from 1,247.53 hectares in 2009 to 2,827.82 hectares in 2023. Similarly, incompatibility in river border protected areas grew from 221.77 hectares to 509.16 hectares during the same period.

In addition to protected zones, incompatibility also occurred in cultivation areas such as dryland and wetland agriculture. Non-compliant dryland agriculture expanded from 66.45 hectares in 2009 to 1,950.09 hectares in 2023, while non-compliant wetland agriculture increased from 18.46 hectares to 148.35 hectares. This rise in incompatibility is most likely driven by agricultural expansion, settlements, and other development activities that do not follow the designated spatial patterns, as well as weak enforcement and oversight of zoning regulations.

These changes in land use compatibility have significant implications for environmental integrity, especially in protected areas that play a vital role in maintaining ecosystems and regional water management. Incompatible land use in protected areas not only violates spatial planning regulations but also poses environmental disaster risks such as flooding, landslides, and land degradation. Therefore, local governments need to conduct a comprehensive evaluation of RTRW implementation, strengthen land use monitoring, and raise public awareness about the importance of complying with spatial plans.

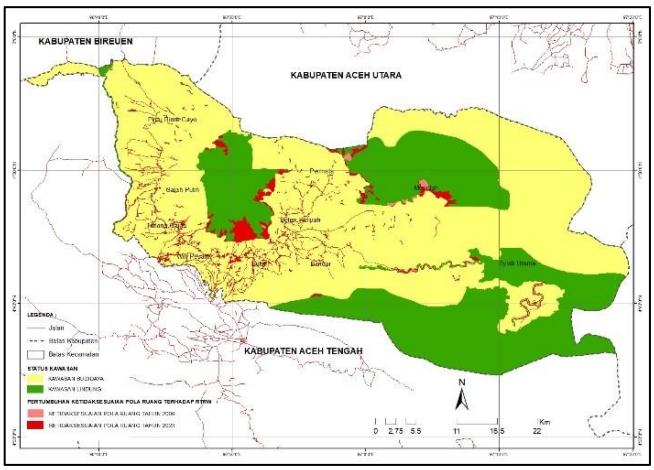


Figure 7. Spatial Pattern Growth Map in 2009 and 2023 with Respect to the Spatial Plan (RTRW)

CONCLUSION

Based on the research conducted, the following conclusions can be drawn: A significant pattern of land use change has occurred in Bener Meriah Regency between 2009 and 2023, with total changes reaching 76,703 hectares (40.19%). The most notable changes include an increase in Mixed Dryland Agriculture and Primary Dryland Forest, along with a decrease in Secondary Dryland Forest and Dryland Agriculture.

The analysis of the Spatial Plan (RTRW) shows that land use compatibility declined from 99.18% in 2009 to 96.95% in 2023, due to increased land use changes driven primarily by growing demand for plantation and residential areas. Incompatibility increased in protected forest areas, river border zones, and several cultivation zones, indicating land use practices that exceeded the designated spatial plan allocations.

DAFTAR PUSTAKA

Aronoff, S. 1989. *Geographic Information System ; A Management Perspective,* Ottawa. WDL, Publication.

Atika, Zihan, Ashfa Achmad, dan Arief Gunawan. 2022. "Perubahan Penggunaan Lahan di Kawasan Perkotaan Redelong dari Tahun 2009-2019. Jurnal Arsitektur dan Perencanaan, Volume (11) Nomor (2) Juli-Desember 2022.

Anon. 2008. "PERATURAN PEMERINTAH REPUBLIK INDONESIA NOMOR 26 TAHUN 2008 TENTANG RENCANA TATA RUANG WILAYAH NASIONAL".

Arsyad. 2006. Konservasi Tanah Dan Air. Kota Bogor: IPB Press.

Catanesse, J, Calow, et, Anthony and Snyder James. 1989. *Pengantar Perencanaan Kota*. Jakarta : Airlangga.

Fauziyah, Muh Iman. 2020. Perubahan Alih Fungsi Lahan. Deeppublish.

Nugroho SP, Putri AR, Widiatmaka. 2022. Perubahan penggunaan lahan dan dampaknya terhadap fungsi ekologis kawasan lindung di DAS Citarum Hulu. *Jurnal Tata Ruang dan Lingkungan*, 13(1):11–21.

Nuraeni, Rani, Santun Risma Pandapotan Sitorus, and Dyah Retno Panuju. 2017. "Analisis Perubahan Penggunaan Lahan dan Arahan Penggunaan Lahan Wilayah Di Kabupaten Bandung." Buletin Tanah dan Lahan 1 (1):79-85.

Peraturan Menteri Pekerjaan Umum Nomor 16/PRT/M/2009 Tentang Pedoman Penyusunan Rencana Tata Ruang Kabupaten.

Prahasta, Eddy. (2009). *Sistem Informasi Geografis Konsep – Konsep Dasar.* Bandung: Informatika Bandung.

Ritohardoyo, Su. 2013. *Penggunaan dan Tata Guna Lahan.* Yogyakarta. Ombak.

Soerjani, 1987. Lingkungan : Sumberdaya Alam, Kependudukan dalam Development Planning. Majalah Demografi Indonesia, 12 (24).

Undang – Undang Republik Indonesia Tahun 2007. Undang-Undang Nomor 26 Tahun 2007. Tentang Tata Ruang.

Qanum Kabupaten Bener Meriah Nomor 4 Tahun 2013 Tentang RRTRW Wilayah Kabupaten Bener Meriah Tahun 2012-2032.