

Forest and Land Cover in the Tambrau Lifescape, West Papua

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1. INTRODUCTION

1.1. BACKGROUND

The Tambrau Lifescape¹ in West Papua Province contains significant preserved forest cover with high biodiversity. Since 2011, the Tambrau Regency government established a policy to protect the environment by establishing the regency as a Conservation District (Bappeda Tambrau 2014). Most of the forest areas in Tambrau Regency have also been allocated as protected areas in the Provincial Spatial Plan. The regency has a widespread forest cover ratio, totalling 93.8% of its total area. Protected areas also cover almost 75% of the total land area of the Regency, consisting of protected forests (36.27%) and the North and South Tambrau Nature Reserve (63.73%)². The policy commitments to govern Tambrau under conservation principles is evident in the overall vision and mission of the Tambrau Regency government. Indeed, one of the core elements of Tambrau's mission is to focus on environmental sustainability through the establishment of a conservation regency.

Apart from the widespread conservation area commitment, Tambrau is also uniquely committed to supporting the diverse socio-cultural character of the regency. Tambrau forests have a close relationship with the culture and livelihoods of the people³. Strong customary relationships are manifested through the strong claims for the rights of land and forests, which are recognized as a key pillar of development in Tambrau. The local government also supports efforts to recognize Indigenous Peoples, specifically through a regional regulation issued by the regency parliament.⁴

Development challenges in Tambrau Regency are also closely linked to issues of environment and conservation. Accurate baseline data and information are essential to make policy in accordance with stated commitments, particularly related to forest protection and conservation, as well as the recognition and empowerment of Indigenous Peoples territories. Therefore, as part of public participation to support local governments, Forest Watch Indonesia (FWI) and Samdhana Institute conducted baseline information on forest and land cover in the Tambrau regency.

Changes in land use and land cover are fundamental factors in the analysis of the environment in vast forested landscapes like Tambrau. Such analysis provides the basis for developing a broader understanding about ecological dimensions and any changes taking place in the lifescapes. To support such ends, this study sought to provide time series data and information on forest cover conditions and overall land use conditions in the Tambrau Lifescape. The provision of data and information towards these ends can be assessed through the interpretation of Landsat 5, Landsat 7 ETM + or Landsat 8 OLI satellite imagery, and high resolution Satellite imagery / CSRT SPOT 6/7 using geographic information system / GIS and remote sensing technology.

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1. In this research we apply the term Lifescape to broaden engagement on landscapes and the environment in ways that are attentive to the communities that live there.
 2. FWI. 2020. Infrastruktur di Papua untuk siapa?
 3. Sepus M. Fatem dan Gabriel Asem. 2015. Kabupaten konservasi sebagai political action pemerintah daerah dalam mendukung konservasi sumberdaya alam hayati: Studi kasus Kabupaten Tambrau, Papua Barat
 4. Peraturan Daerah No.6/37/2018 tentang Pengakuan dan Perlindungan Masyarakat Hukum Adat di Kabupaten Tambrau

There are key differences between the overall concept of land use and land cover. Land use relates to human activities or activities on a plot of land, whereas land cover is more of a physical manifestation of an object over an area of land without considering the human activities taking place at those locations (Lillesland and Kiefer, 1990). In general, the information that can geometrically be extracted from a satellite image are objects in the form of lines and polygons in an area. Two methods can be applied to obtain information from imagery data, namely visual analysis (analog) and digital analysis (numeric).

1.2. PURPOSE

This study aims to:

1. Develop a baseline time series map of forest cover conditions in the Tamberau Lifescape from Landsat satellite imagery derived from 1990, 2000, 2010 and 2019 using GIS and Remote Sensing technology.
2. Gain knowledge on the conditions and rate of change in forest cover conditions in Tamberau from 1994, 2000, 2010 and 2019.
3. Gain knowledge on the current conditions of land uses in the Tamberau Lifescape

2. METHOD

2.1. SCOPE

The scope of this study is as follows:

1. Acquisition and processing of Landsat satellite imagery and high resolution satellite imagery / CSRT SPOT 6/7 in the Tamberau Lifescape;
2. Interpretation of forest cover and land use in the Tamberau Lifescape from Landsat satellite imagery and high resolution satellite imagery SPOT 6/7;
3. Spatial analysis of land cover maps and land use maps in the Tamberau Lifescape;
4. Compilation of a report that presents the results through maps and land cover data.

2.2. DATA, SOFTWARE AND EQUIPMENT

The spatial data analyzed, included:

1. Satellite imagery in the form of Landsat images MMS-5 path / row 106/060, 106/061, 107/060, 107/061 and 121/059 recorded in 1994 with a spatial resolution (pixel) of 30 x 30 m
2. Satellite imagery in the form of Landsat 7-ETM path / row 106/060, 106/061, 107/060, 107/061 and 121/059 imagery recorded in 2000 and 2010 with a spatial resolution (pixel) of 30 x 30 m
3. Satellite imagery in the form of Landsat 8-OLI imagery path / row 106/060, 106/061, 107/060, 107/061 and 121/059 recorded in 2019 with a spatial resolution (pixel) of 30 x 30 m
4. High resolution satellite image SPOT 6/7 2019 recording year with coverage in the Tamberau Lifescape

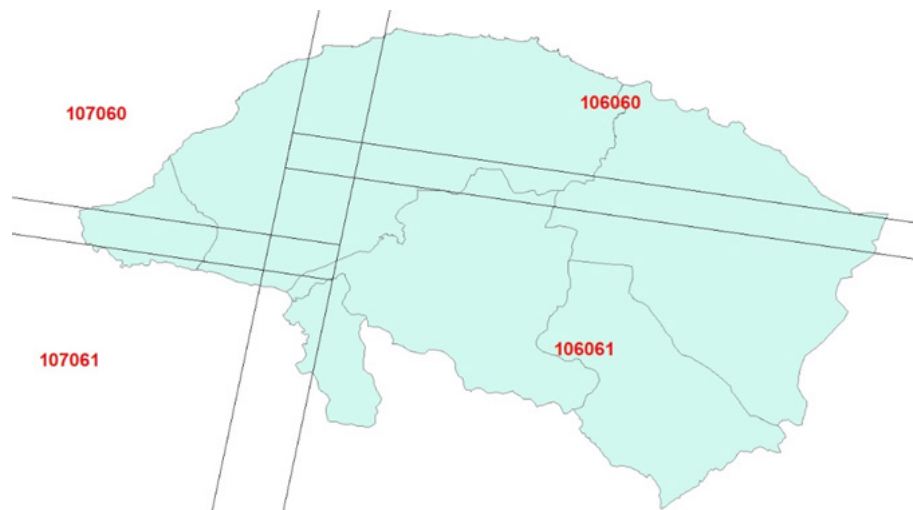


Figure 1. Landsat image coverage of the Tamberau Lifescape

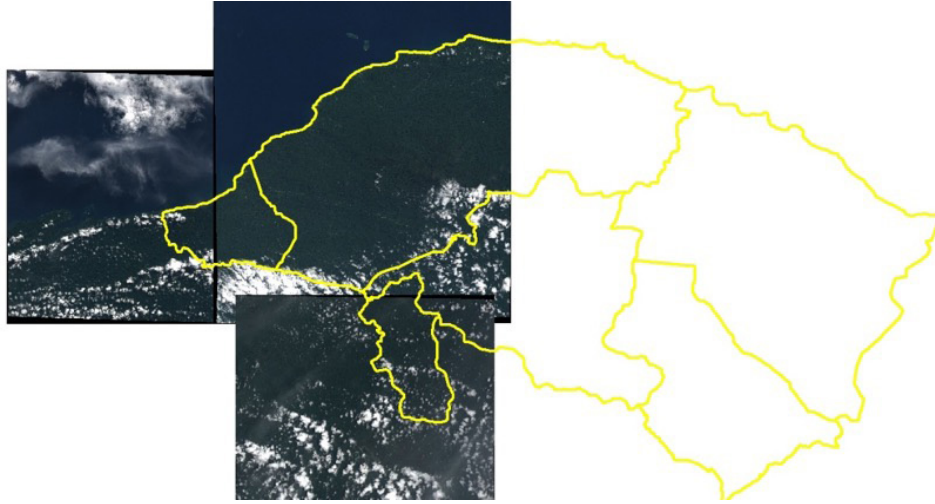


Figure 2. Image coverage of SPOT 6/7 of the Tamberau Lifescape

2.3. DATA PROCESSING: SATELLITE IMAGE INTERPRETATION

The satellite image interpretation process was carried out based on the following stages:

1. Import Data

Import data is conducted by converting the satellite image data format from the recording format (GeoTIFF) to a format that matches the format of the software used for image processing.

2. Radiometric Correction

Radiometric correction is carried out because of a radiometric error caused by an error in the response of the detector, as well as due to atmospheric influence. According to Curran (1985, in Nursanti 1989) radiometric correction is performed to improve visual quality and correct pixel values that do not match the actual value of the object's spectral reflection or emission. Radiometric correction includes radiometric calibration and atmospheric correction to reduce cloud cover in the observation area. Atmospheric correction can be carried out by using satellite image data processing software such as PCI Geomatics 2014.

3. Geometric Correction

Geometric corrections are performed because of geometric errors caused by: 1) A systematic error, or an error predicted to occur, due to specifications relating to the position, motion, and orbit of the satellite; 2) Random errors or previously unexpected errors.

The Landsat image used in the activity was geometrically corrected by the USGS, because the image used is a Level 1T image. This is an image that applies systematic geometric correction. Use of tie points, or onboard position information for resampling the image, was conducted so that it could be cartographically projected onto the WGS84, G873, or other available versions. The processing result data with the L1T level was also terrain-corrected for displacement relief.

4. Satellite image sharpening / image enhancement

Satellite image sharpening was carried out to produce good quality satellite image viewing and to improve image capabilities by increasing the differences between objects so as to facilitate visual interpretation. Satellite image sharpening was done by adjusting the combination / composite relative to the histogram band that was used. Several types of image enhancement included the manipulation of contrast, spatial feature manipulation, and multi-image manipulation.

On Screen Digitation

On Screen Digitation, or digitizing on a computer screen, was one of the image interpretation techniques applied. This was conducted by looking at the visual appearance of the satellite image on the computer screen, then extracting it onto a map with a certain theme. Adjusting the combination (composite) of colors in the image, thus made it easier to interpret the results.

5. Classification

The classification for forest cover interpretation included 2 classes, namely: Forest Cover and Non-Forest Cover. For land use classification, interpretation used the classification based on SNI-7645-1-2014 at a mapping scale of 1: 50,000 / 1: 25,000.

2.4. SITE SELECTION

The Tambrau Regency in West Papua Province was designated as a national conservation area in Ministerial Decree No. 53 / KEPMEN-KP / 2017 concerning Coastal Conservation Areas and Small Islands. This stipulation is the government's effort to protect natural resources and also serves to regulate the involvement of the central government in environmental conservation programs, as well as providing the basis for additional financing support. Tambrau has widespread forest coverage and is inhabited by several groups of Indigenous Peoples. There are five Indigenous Peoples communities who have rights to land in Tambrau, including: Abun, Miyah, Mpur, Ireres, and Moi Kelim. Given these key contextual factors, we attempted to create a forest cover baseline for the five locations that correspond to Indigenous Peoples' territories and also conducted a land use study in three of these territories, including Abun, Miyah, and Moi Kelim.

3. GENERAL CONDITIONS OF TAMBRAUW

The Tamberau region is located at the top of what is commonly known as the Bird's Head of West Papua. The regency covers coastal areas and mountainous regions. Before becoming a separate regency, Tamberau's administrative status was divided. Part of the west side of Tamberau was joined to the Sorong regency administration and the eastern side followed the administration of Manokwari regency. Only in 2008 did Tamberau become its own regency. Therefore, the administrative position is located between Sorong in the west and Manokwari to the east, as well as the Maybrat regency to the south. Even though the administrative area is governed by a new regency government, the area has long been known as a distinct region called Tamberau (or Tamrau or Tamarau).

The Tamberau area is inhabited by five different major tribes (suku), namely the Moi Kelim, Abun, Miyah, Mpur, and Ileres. The Moi Kelim occupy the far northwest areas of the regency, covering the coastal area nearby Sorong. The Abun is spread out widely in the northern coastal area and into the highlands of the Tamberau region. The Miyah inhabits the south-central part of Tamberau, which is mostly plateau lands, geographically located in the middle of the Bird's Head. The Mpur occupies the area around the southeastern portions, which covers a wider geographic region and even spreads to the Bintuni Bay area. Meanwhile, the Ileres inhabits the easternmost side towards Manokwari and on to Bintuni Bay.

The diversity of the characteristics of these Indigenous Peoples also translates into a unique and diverse region. Villages from each of these groups are spread out and inhabit areas from coastal areas to the highlands. Even within groups that may originate from the same language groups, there is also a great deal of diversity between communities, as they take on very different ways of life from one lifescape to the next (from coasts to forests). The five major Indigenous Peoples presented in the analysis for the Tamberau Lifescape mirrors the overall differences in language used between these groups. The names of the five Indigenous Peoples correspond to the different names of the language used in each region. Importantly, this can lead to differences in the names that one group or another uses to refer to the same features of the lifescapes.

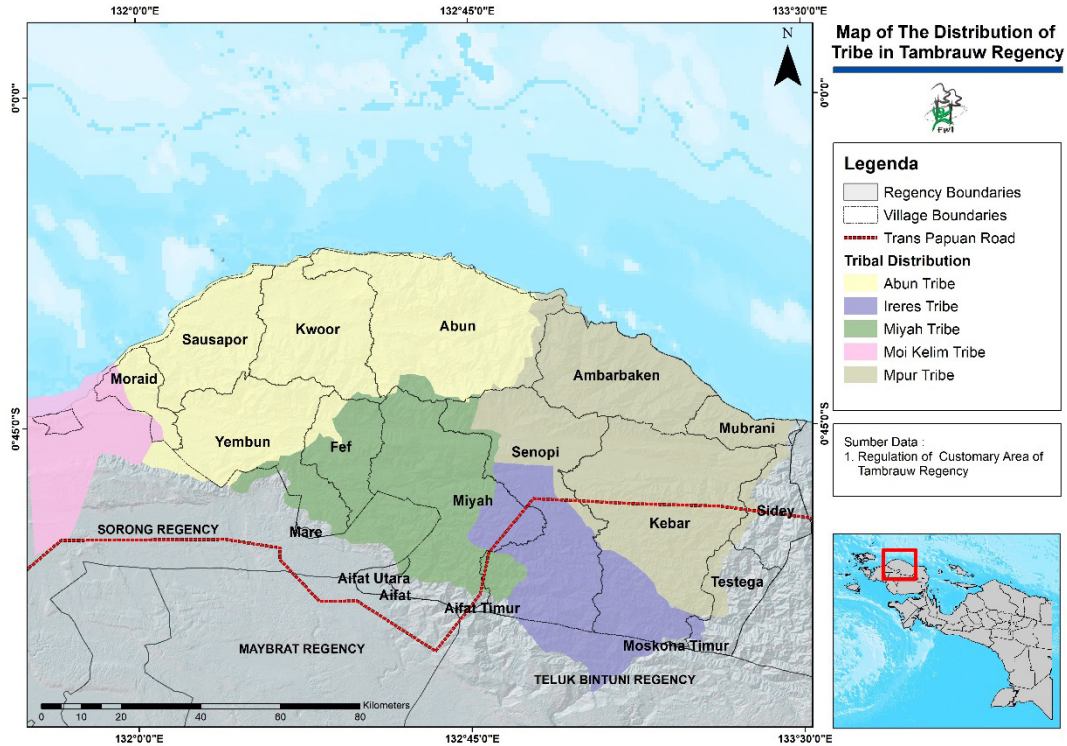


Figure 3. Map of the distribution of Indigenous Peoples in Tamberau

3.1. FOREST COVER IN INDIGENOUS PEOPLES TERRITORIES IN TAMBRAUW

Based on the interpretation of Landsat satellite imagery, forest cover areas in the Tamberau Lifescape are presented as land cover matrices between 1994, 2000, 2010 and 2019 as follows:

Table 1. Forest cover change in Tamberauw

No	Year	Natural forest (Ha)	Percentage of natural forest to land area	Annual average deforestation	
				Ha	%
1	1994	1,116,422	95%		
2	2000	1,105,294	94%	1,855	0.2%
3	2010	1,082,522	92%	2,277	0.2%
4	2019	1,042,687	89%	4,426	0.4%

Area by Indigenous Peoples group in the Tambrau Lifescape is presented as follows:

Table 2. Forest cover and deforestation in Indigenous territories in the Tambrau Lifescape

Customary Area	Land size (Ha)	Forest in 1994 (Ha)		Forest in 2000 (Ha)		Deforestation per year		Forest in 2010 (Ha)		Deforestation per year		Forest in 2019 (Ha)		Deforestation per year	
		Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Abun	393,458	377,996	96%	374,741	95%	542.5	0,14%	369,941	94%	480.0	0,13%	362,696	92%	805.0	0,22%
Ireres	151,939	142,251	94%	142,067	94%	30.7	0,02%	138,232	91%	383.5	0,28%	133,586	88%	516.2	0,39%
Miyah	207,846	203,344	98%	202,874	98%	78.3	0,04%	200,805	97%	206.9	0,10%	197,425	95%	375.6	0,19%
Moi Kelim	46,887	45,981	98%	44,493	95%	248.0	0,54%	42,305	90%	218.8	0,52%	40,066	85%	248.8	0,62%
Mpur	326,359	303,529	93%	299,573	92%	659.3	0,22%	291,250	89%	832.3	0,29%	270,566	83%	2,298.2	0,85%
Total	1,126,489	1,073,101	95%	1,063,748	94%	1,558.8	0,15%	1,042,533	93%	2,121.5	0,20%	1,004,339	89%	4,243.8	0,42%

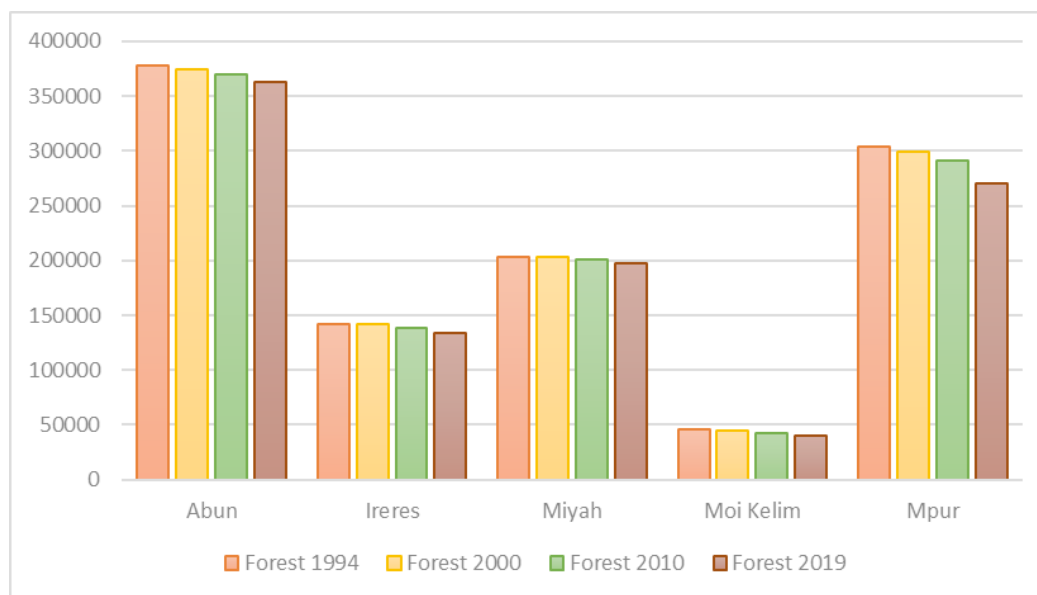


Figure 4. Forest cover change in the Tambrau Lifescape

Figure 4 on forest cover change in Indigenous territories of the Tambrau Lifescape indicate a general reduction of forest areas. Given widespread forest cover, such changes likely indicate deforestation. Overall, customary forest areas were reduced in the Tambrau Lifescape from an area of 1,073,101 hectares, or about 95 percent of the land of in 1994 to 1,004,339 hectares, or 89 percent, in 2019.

In 1994, the Abun Indigenous territories amounted to about 96 percent of its land area as forests, totaling 377,996 hectares. Abun territories decreased in overall natural forest area cover by 4 percent, or an area of 15,300 hectares in the 1994-2019 period. Approximately 94 percent of Mpur's territory was natural forest, amounting to a total of 142,251 hectares in 1994. This territory experienced the largest reduction in forest area, amounting to a conversion of 32,000 hectares, or about 10 percent loss from the 1994 to 2019 period. Forest areas declined to a total of 270,566 hectares, which accounts for 83 percent of its total land area.

In 1994, 98 percent of the Miyah territory was natural forest, totaling 203,344 hectares. In 2019, the natural forest was reduced to 197,425 hectares, or amounting to about 95 percent of forests for the entire area. The Ireres territory had natural forests of 151,939 hectares, or a total of 94 percent of its land area in 1994. In 2019, forested areas were reduced to 133,586 hectares, or 88 percent of the land area. There has also been a decrease in the area of natural forests in the Moi Kelim customary area. In 1994, natural forest cover amounted to 46,887 hectares, or around 98 percent of the land area. In 2019, the total decreased to 40,066 hectares, or around 85 percent. This area has experienced the largest percentage of forest loss.

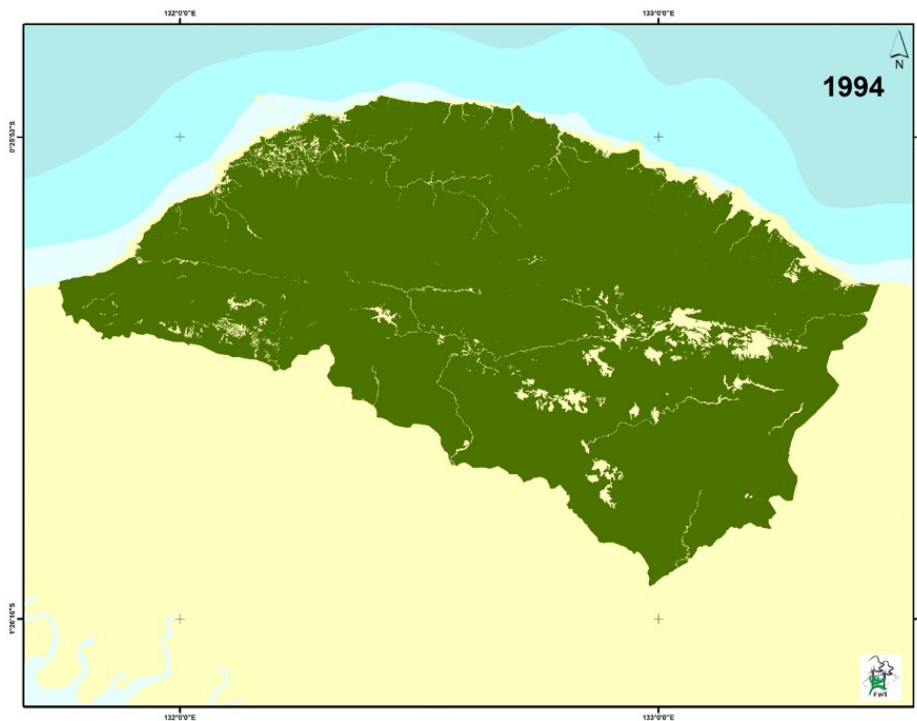


Figure 5. Map of Forest Cover in the Tamberau Lifescape, 1994

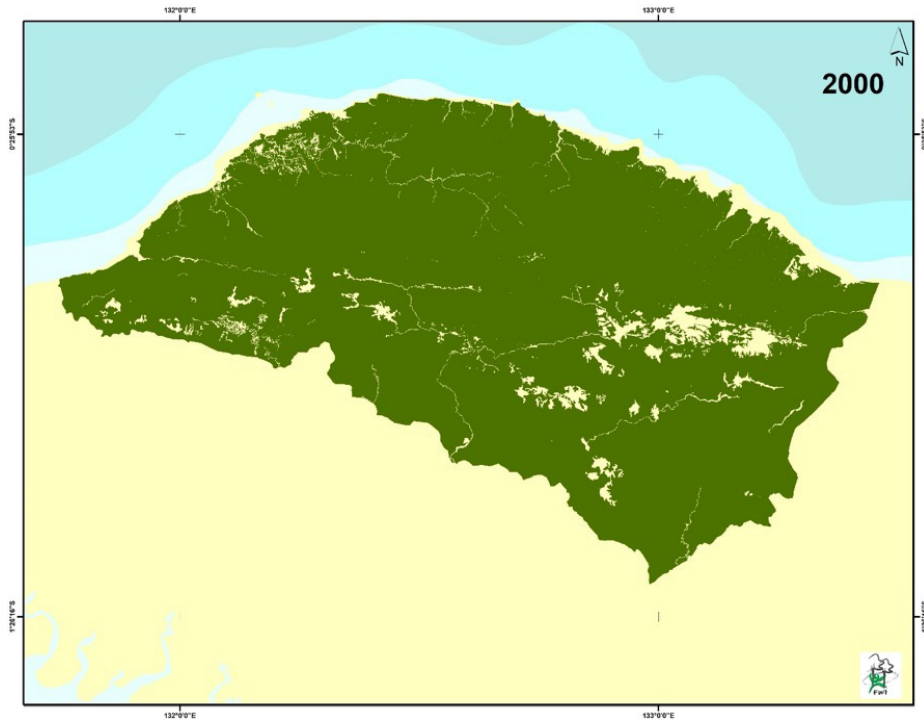


Figure 6. Map of Forest Cover in the Tamberau Lifescape, 2000

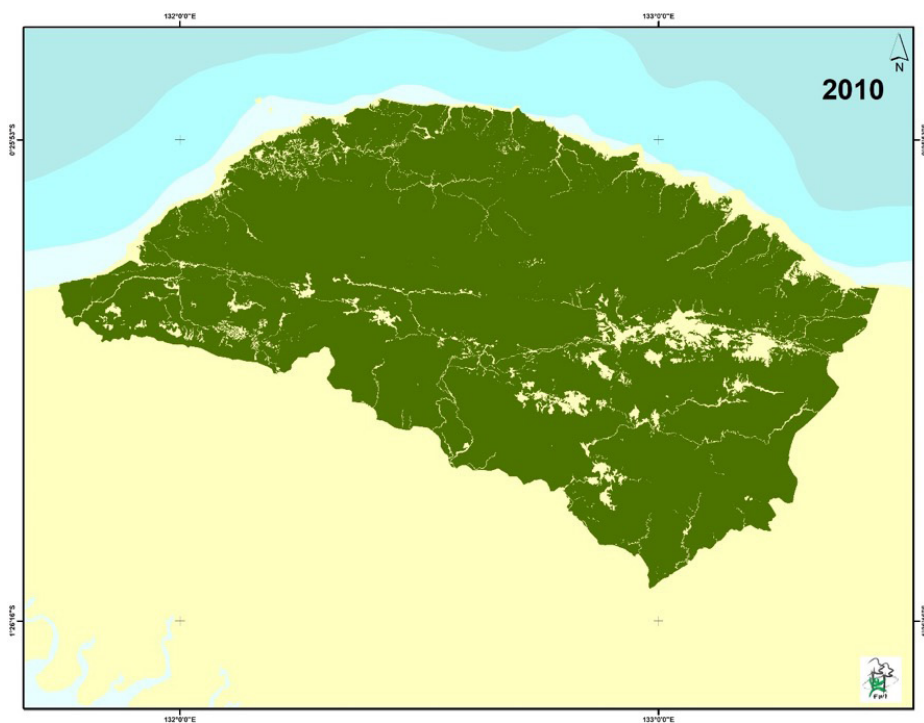


Figure 7. Map of Forest Cover in the Tamberau Lifescape, 2010

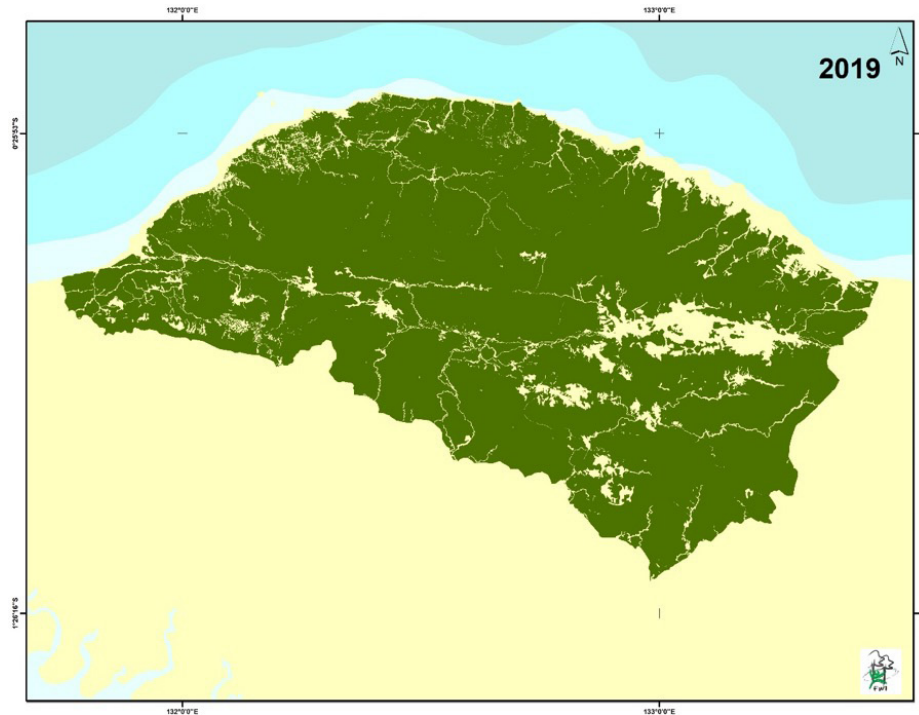


Figure 8. Map of Forest Cover in the TAMBRAUW LIFESCAPE in 2019

3.2 DEFORESTATION OF THE TAMBRAUW LIFESCAPE

Based on the results of digitizing Landsat images in the Indigenous territories of the TAMBRAUW Lifescape, the map shows that there are many changes in river flow, whereby the flow became clearer during the digitization process. In addition, areas that were already non-forested in 1994 served as the locus for expanded land cover change in subsequent periods. The results also show that areas near the coast experienced a continuous decrease in forests during every period.

Table 2 shows forest cover and deforestation dimensions of Indigenous territories in the TAMBRAUW Lifescape. The data shows that in general, the period of 1994-2000 saw the largest amount of deforestation in the Moi Kelim territory, averaging 248 hectares of forest loss per year, or about 0.54 percent per year. The Mpur territory averaged deforestation of 659.3 hectares per year, accounting for about 0.22 percent annual losses. Thereafter, the Abun territory experienced average deforestation of 542.5 hectares, or about 0.14 percent of its land per year. For the Miyah territory, deforestation occurred at a rate of around 78.3 hectares per year, or at a marginal 0.04 percent. Finally, the territory with the least deforestation is the Ileres region, with an annual percentage of 30.7 hectares forest loss per year, or 0.02 percent.

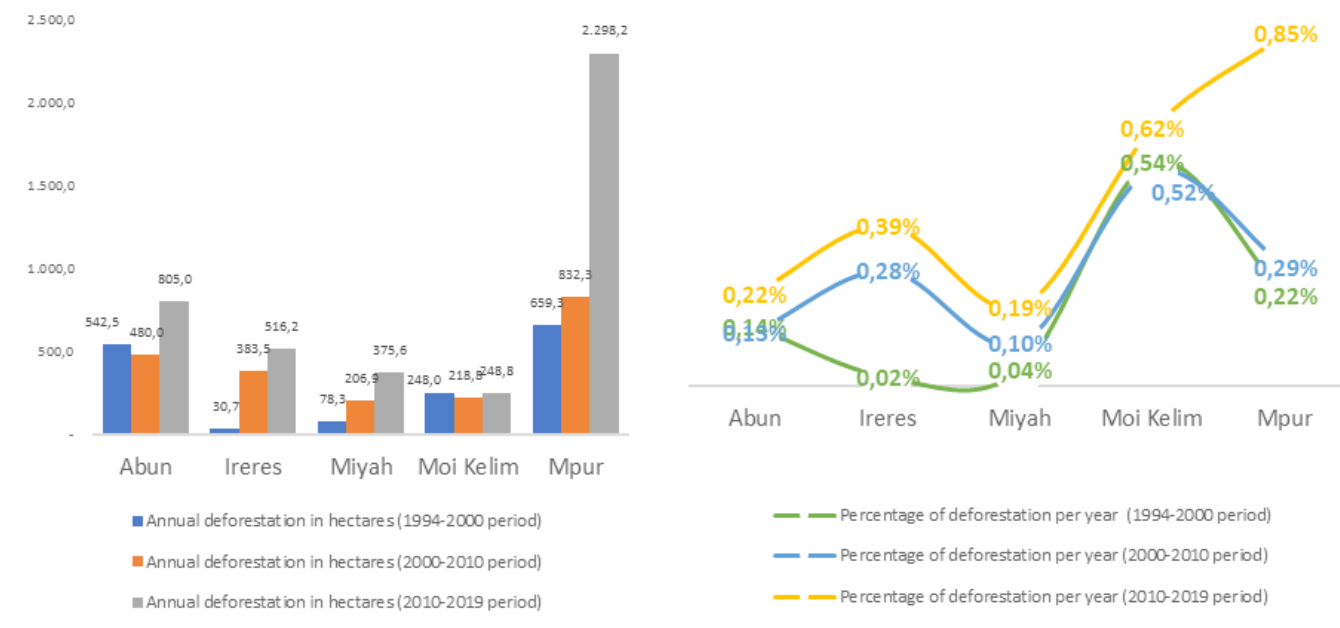


Figure 9. Deforestation within Indigenous Territories

During the 2010-2019 period, average deforestation began to increase in Indigenous territories. Deforestation in the Mpur territory increased in terms of annual average change when compared to the 1994-2000 period, with a rate of 0.85 percent, corresponding to an area of 2,298.2 hectares. The second highest rate of deforestation occurred in the Moi Kelim territory at 248.8 hectares, or 0.62 percent. Third is the Ireres territory, with an average annual deforestation of around 516.2 hectares, or 0.39 percent. The Abun territory in this period experienced deforestation of 805 hectares per year, or 0.22 percent.

In 2019, the total forest area across the Tambrau Lifescape amounted to 1,004,339 hectares. This decrease in forest area from year to year requires special attention from the government, especially with the stated policy interests to conserve forests. The region is designated as a food security and conservation district in its development plan, and this must be supported by the readiness of technology and government instruments to support the creation of sustainable development and forest management.

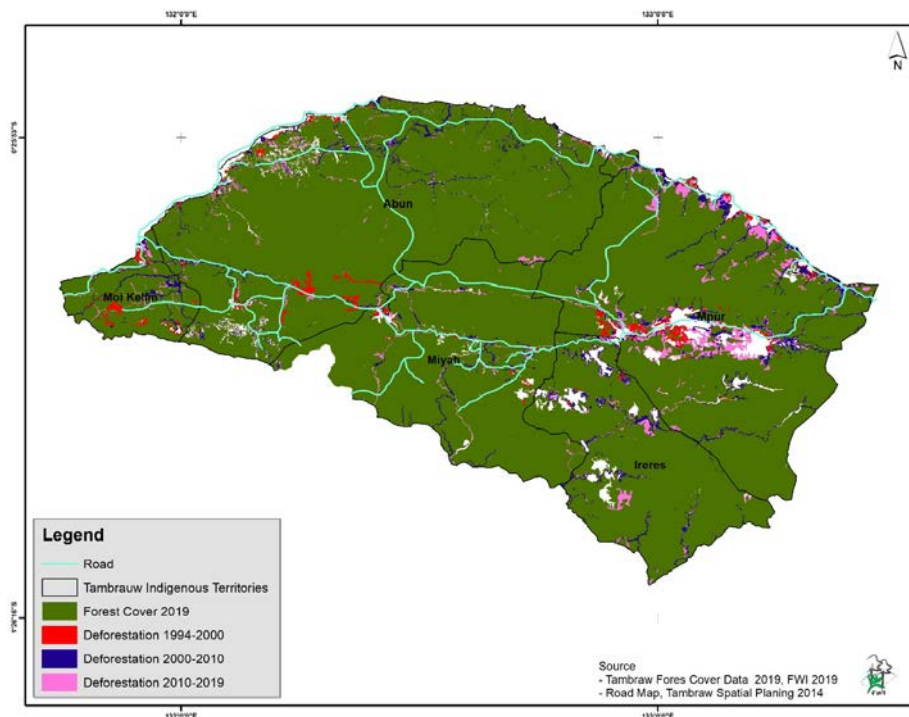


Figure 10. Deforestation map in Indigenous territories

3.3 OVERLAPPING INDIGENOUS TERRITORIES WITH CONCESSIONS

Across the 5 customary areas in Tamberau Regency, key challenges continue to emerge from overlapping administrative and cultural boundaries, specifically from the siting of production forests, plantations, and mining concessions within Indigenous territories. Furthermore, additional complications take place due to overlapping concession areas between logging (HPH), oil palm plantations, and mining concessions, which have also created issues in customary areas. These challenges indicate poor forest management, which can lead to social conflicts and deforestation. Conflicts can occur among communities, between companies, and between communities and companies. Meanwhile, deforestation can also take place by exploitation in areas that were not planned for such land uses. Most of the Indigenous territories have disputed overlaps with HPH covering 14% of their territories, or a total of 160,035 hectares. In addition, 13% (150,881 hectares) of land have overlapping issues between mining concessions and customary areas.

The area with the largest overlap is in the Abun territory, covering 124,755 hectares, or 32% of the total area. This occurs due to an overlap between HPH and Indigenous territories, as well as an additional 4,245 hectares overlap between mining and their Indigenous territory. The Mpur territory has an area of 2,405 hectares overlapping with HPH, 28,860 hectares overlapping with mining/plantations concessions, 11,132 hectares overlapping with plantations, and 54,904 hectares overlapping with mining concessions. Meanwhile, 66% of the Moi Kelim territory overlaps with a HPH concession.

Table 3. Overlapping concessions and Indigenous territories

Indigenous Territories	Overlap of indigenous territories with concessions					Area with no overlap	Area (Ha)
	Logging-Mining	Logging	Plantation-Mining	Plantation	Mining		
Abun		124,755			4,245	264,458	393,458
Ireres			2,858		58,804	90,276	151,939
Miyah	7	1,889			32,926	173,023	207,846
Moi Kelim		30,986				15,901	46,887
Mpur		2,405	28,860	11,132	54,907	229,056	326,359
Total	7	160,035	31,719	11,132	150,881	772,715	1,126,488

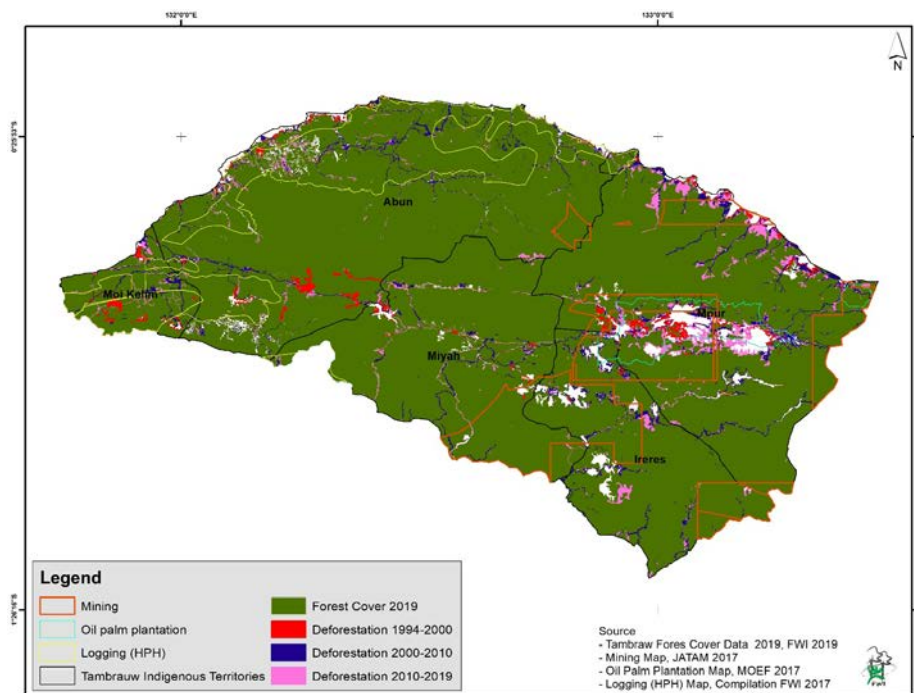


Figure 11. Overlapping concessions with Indigenous territories

The deforestation that occurred in Indigenous territories overlapping with concessions accounted for around 42 percent of total deforestation in the 1994-2019 period, amounting to a total area of 28,902 hectares. When compared with the total land area, deforestation that occurred during the 1994-2019 period in HPH concession areas amounted to 9,837 hectares, or about 6 percent of concession areas that overlap with Indigenous territories. In oil palm plantations, deforestation took place at an order of 2,555 hectares, amounting to about 23 percent of concession areas overlapping with Indigenous territory. Deforestation in mining concessions covered a total of 9,745 hectares, about 6 percent of mining concessions overlapping with Indigenous territories.

The highest amount of deforestation occurred in oil palm plantations, accounting for 25 percent of the oil palm concession area. The second highest amount of deforestation occurred in overlapping concessions between HPH, oil palm plantations, and mining in Indigenous territories, which amounted to 6,765 hectares, or 21 percent of concession area overlaps. Meanwhile, deforestation occurring in Indigenous territories without any permits covered 39,861 hectares, or about 5 percent of customary areas.

Table 4. Deforestation during 1994-2019 within concession areas in the Tamberau Lifescape

Concessions in Tamberau Lifescape	Concession size (ha)	Deforestation 1994-2019	
		Ha	%
Logging (HPH)	160,035	9,837	6%
Oil palm plantation	11,132	2,555	23%
Mining	150,881	9,745	6%
Overlap logging-mining-plantation	31,726	6,765	21%
Indigenous territories with no concessions	772,715	39,861	5%
Total deforestation	1,126,488	68,763	6%

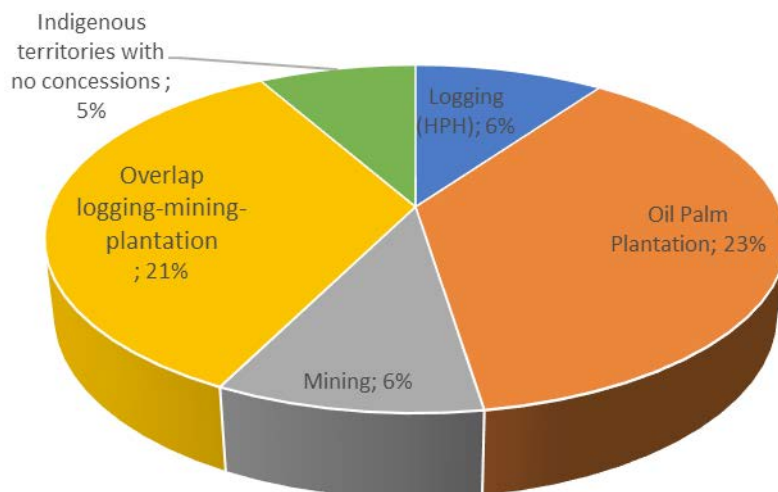


Figure 12. Deforestation from 1994-2019 within concessions across the Tamberau Lifescape

3.4 CUSTOMARY TERRITORIES IN THE TAMBRAUW REGENCY SPATIAL PLAN

According to the existing spatial plan, the total area of Tambrau Regency includes 312,127 hectares (or 26.7%) designated as protected forests, 364,797 hectares (or 31.2%) designated as nature reserves, and 190,153 hectares (16.2%) designated as forest reserves. In total this translates to 74% of the Tambrau Regency designated as an area that must be maintained as forests, whereas areas designated for production forests and other uses (such as plantations or agriculture), should raise concern because current trends point to the increasing likelihood of other uses extending beyond the designated spatial pattern of the regency. It is highly probable that protected areas in the spatial plan will experience a change in designation to production, agriculture, or plantation areas.

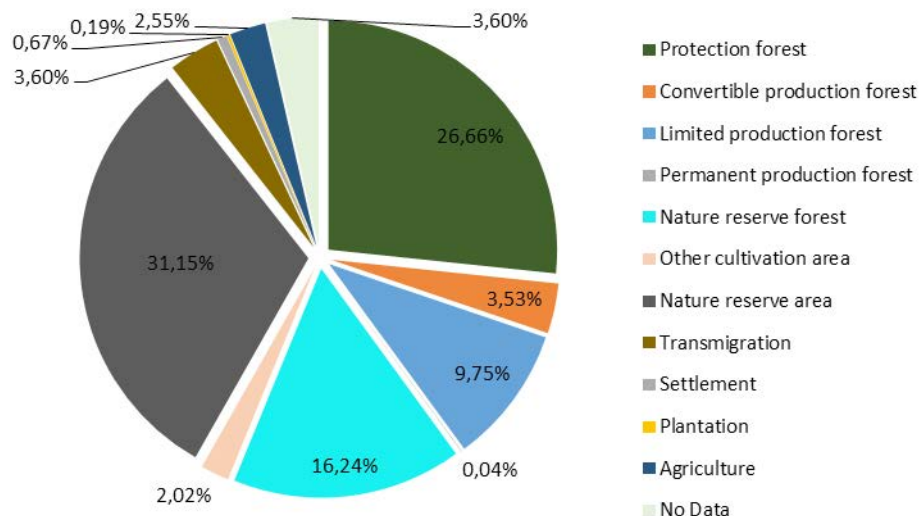


Figure 13. Land Use Area Designation in the Tambrau Regency Spatial Plan

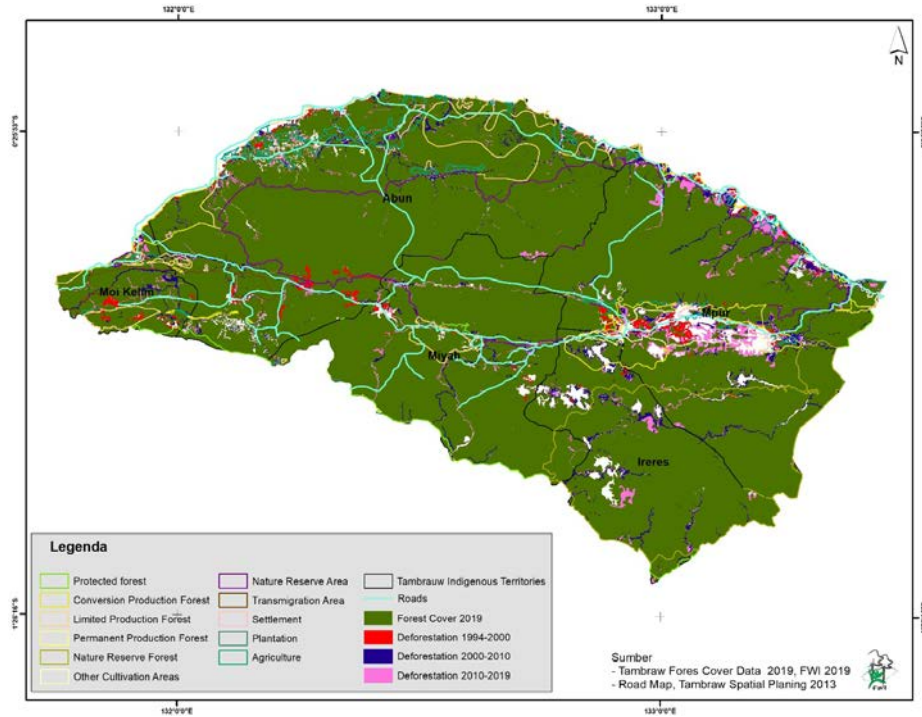


Figure 14. Map of Tamberau Regency Spatial Plan in Customary Areas

Table 5. Indigenous territories in spatial plans

Customary area	Protection forest	Convertible production forest	Limited production forest	Permanent production forest	Nature reserve forest	Other cultivation area	Nature reserve area	Transmigration	Settlement	Plantation	Agriculture	No data	Total (Ha)
Abun	95,887	10,871	97,407			436	151,395	17,274	3,950		14,824	1,413	393,458
Ireres	26,238	6,761			115,231	1,651	1,211		269		12	567	151,939
Miyah	126,458		8,122	113	7,415		64,349		112	368	337	572	207,846
Moi Kelim	9,284	1,639	7,198			10	522	24,924	618		1,253	1,438	46,887
Mpur	52,044	22,069	1,456		67,507	21,527	147,319		2,910		11,177	348	326,359
Grand Total	309,911	41,341	114,184	113	190,153	23,624	364,797	42,198	7,859	368	27,603	4,338	1,126,488

Table 6. Percentage of Indigenous territories in spatial plans

Customary area	Protection forest	Convertible production forest	Limited production forest	Permanent production forest	Nature reserve forest	Other cultivation area	Nature reserve area	Transmigration	Settlement	Plantation	Agriculture	No data	Total
Abun	24.4%	2.8%	24.8%	0.0%	0.0%	0.1%	38.5%	4.4%	1.0%	0.0%	3.8%	0.4%	100.0%
Ireres	17.3%	4.4%	0.0%	0.0%	75.8%	1.1%	0.8%	0.0%	0.2%	0.0%	0.0%	0.4%	100.0%
Miyah	60.8%	0.0%	3.9%	0.1%	3.6%	0.0%	31.0%	0.0%	0.1%	0.2%	0.2%	0.3%	100.0%
Moi Kelim	19.8%	3.5%	15.4%	0.0%	0.0%	0.0%	1.1%	53.2%	1.3%	0.0%	2.7%	3.1%	100.0%
Mpur	15.9%	6.8%	0.4%	0.0%	20.7%	6.6%	45.1%	0.0%	0.9%	0.0%	3.4%	0.1%	100.0%
Grand Total	27.5%	3.7%	10.1%	0.0%	16.9%	2.1%	32.4%	3.7%	0.7%	0.0%	2.5%	0.4%	100.0%

3.5 DEFORESTATION OF INDIGENOUS TERRITORIES IN THE TAMBRAUW REGENCY SPATIAL PLANS

The figure below highlights the percentage of deforestation occurring in Indigenous territories according to overall spatial patterns. In the period 1994-2000, it is evident that deforestation occurred mostly in conservation areas, namely in protected forests at 0.21 percent and natural reserves at 0.13 percent. In cultivation areas, the amount of deforestation was 0.16 percent, with 0.10 percent taking place in limited production forests. If the data is compared to the period 2000-2010, deforestation still occurs in conservation areas with an increasing rate of change. Deforestation in protected forests increased from 0.21 percent to 0.55 percent, and deforestation also increased in nature reserve areas by 0.13 percent. In the 2010-2019 period, Tambrau was also designated as a conservation district to strengthen protections on forests. Although conservation area designation took place, there was still an increase in deforestation. Figure C shows that deforestation in protected forests occurred at a rate of 0.78 percent, nature reserve forest at a rate of 0.74 percent loss, and nature reserve areas at 0.35 percent reduction. All of these areas experienced an increase in deforestation when compared to the 2000-2010 period.

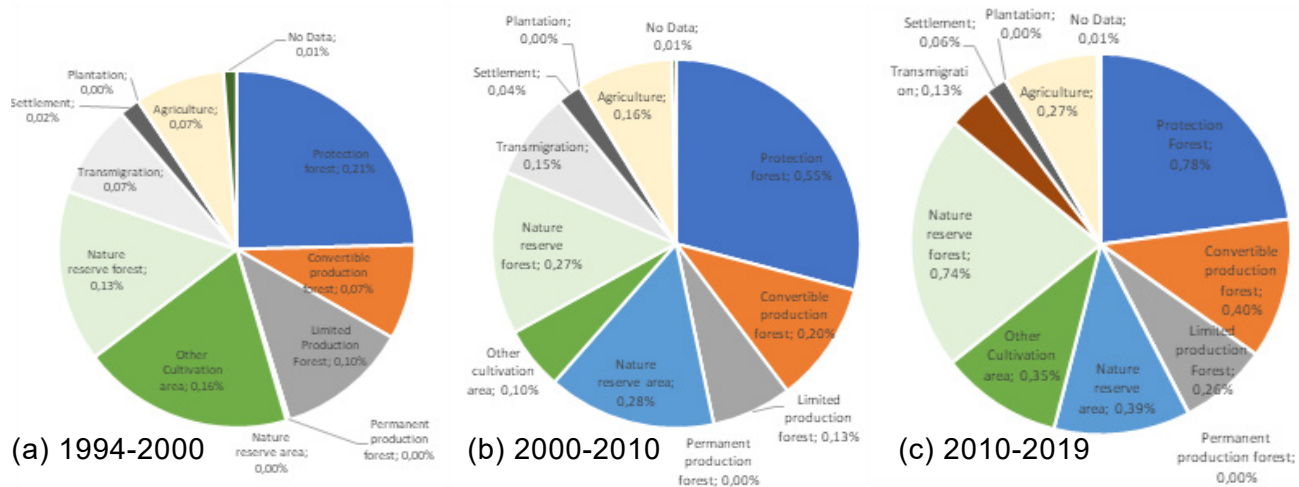


Figure 15. Percentage of deforestation in Indigenous territories relative to the spatial plan for (a) 1994-2000, (b) 2000-2010, and (c) 2010-2019

3.6 NON-FOREST LAND COVER

Land cover analysis does not reflect all changes in Indigenous territories. The land cover analyzed in this section examines non-forest land cover, which was conducted as a complementary assessment on the overall land use forms after deforestation. In this way, we were better able to understand the underlying drivers of deforestation.

Land Cover in Abun

Of the total 393,458 hectares of the Abun territory, land cover analyzed included a total area of 12,923 hectares. The area analyzed represents most of the land cover types in the Abun territory. The land cover in the Abun area is dominated by rainforest, totaling 11,385 hectares, or 88.10%, of the area of analysis. The Abun land cover also consists of 345 hectares of gardens, 34 hectares of an area designated as the airport, and 25 hectares of residential structures / areas that have increased along with population growth and government development programs. It is possible that the remaining Abun forest areas will be reduced by community activities, which can be seen from the presence of burnt areas that include a relatively significant portion in the analysis area, totaling 61 hectares. This was most likely caused by land clearing. Burning as a method for land clearing aims to open up land for new cultivation, or clear land to change forest growth patterns that can make way for gardens and shrub areas from burned area succession.

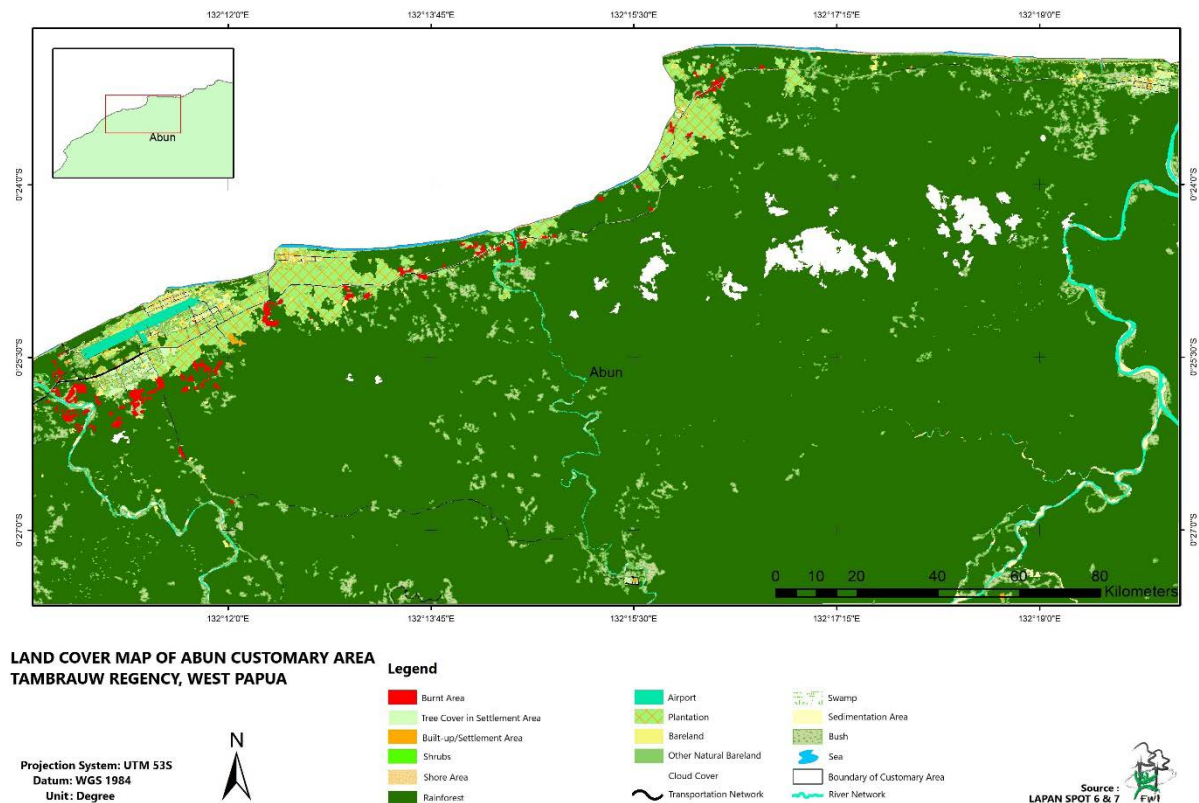


Figure 16. Map of land cover in part of the Abun Indigenous territory

Table 7. Abun Land Cover

Abun	Hectare	Persentase
Burn Area	61	0,50%
Tree Cover in Settlement Area	50	0,40%
Build Up/Settlement Area	25	0,20%
Shore Area	21	0,20%
Transportation Network	45	0,40%
Airport	34	0,30%
Plantation	345	2,70%
Bare land	104	0,80%
Other Natural Bare land	20	0,20%
Sea	22	0,20%
Cloud Cover	198	1,50%
Swamp	0	0,00%
Sedimentation Area	64	0,50%
Bush	450	3,50%
River	98	0,80%
Total	12.923	100,00%

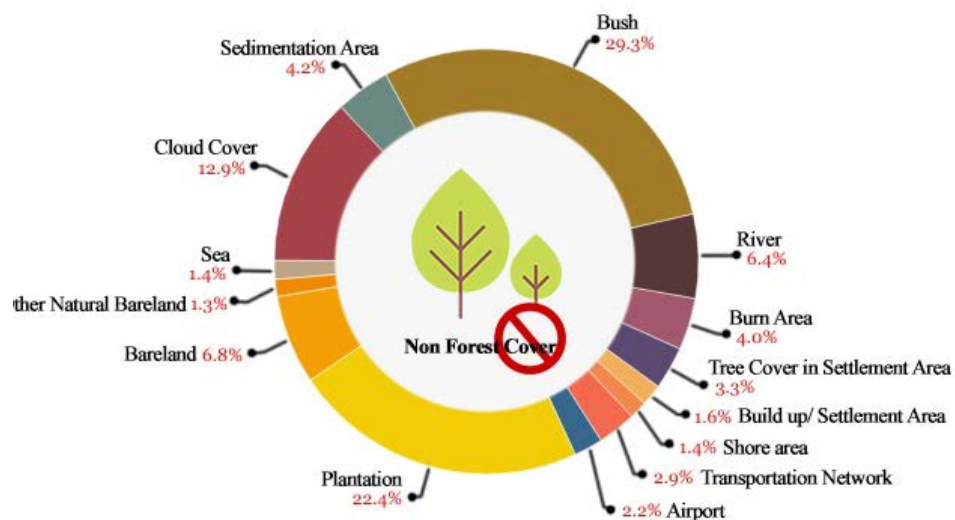


Figure 17. Percentage of non-forest land cover in the Abun territory

Land Cover in Miyah

In the Miyah territory, land cover is dominated by 92% rainforest, which amounts to a total area of 4,994 hectares (table 8). Meanwhile, non-forest areas are dominated by shrubs, which account for around 43% of the total area (figure 18). This land cover pattern is the result of land clearing, which initially occurred for the construction of transportation routes and settlement areas. Thereafter, these areas are left unused and in time are overgrown with shrubs, establishing a distinct land cover category. The bush area land cover dominates the overall transformation patterns that take place in and around residential areas. Apart from the shrub classification, the dominant non-forest land cover are trees in residential areas, which amount to a total area of about 16%. These wooded areas consist of former forests that are left behind by the community, and are located in a residential area.

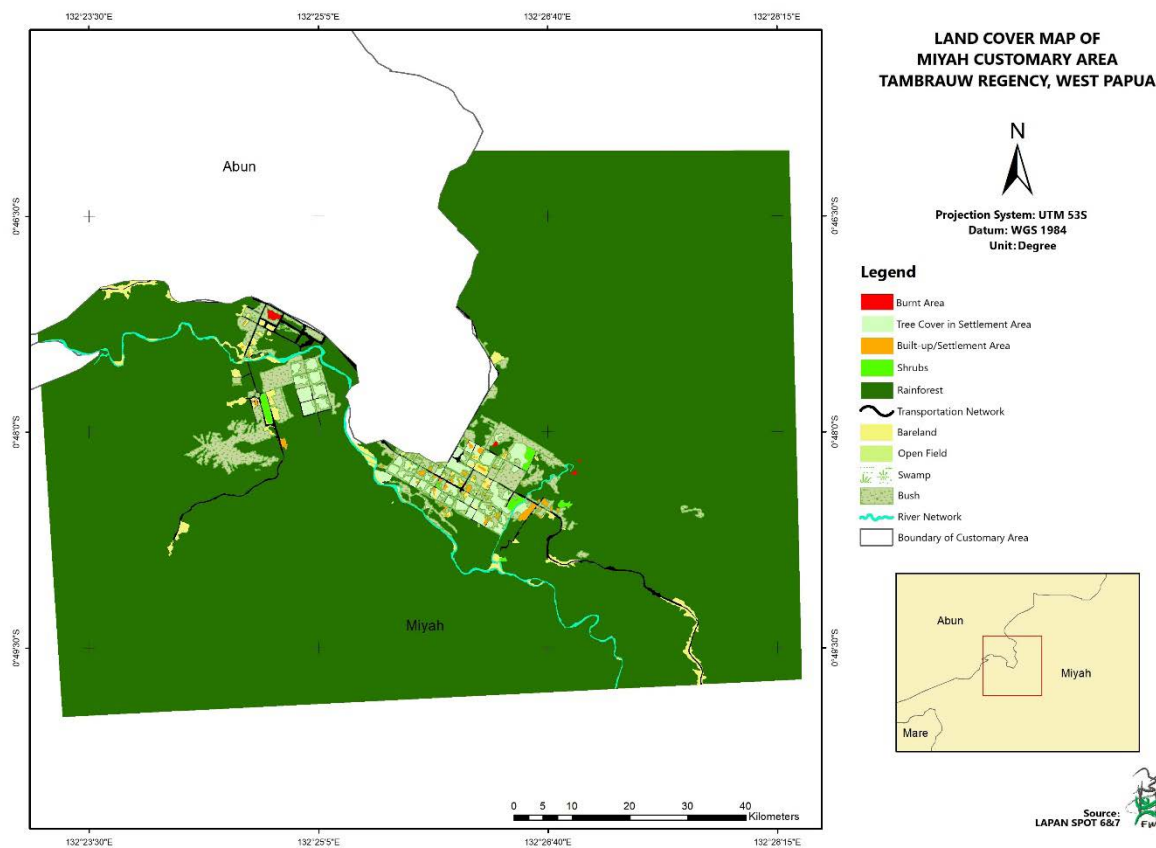


Figure 18. Map of Land Cover in part of the Miyah Indigenous Territories

Table 8. Total land cover classifications in the Miyah Indigenous Territory

Miyah	Hectare	Percentage
Burned Area	2	0,05%
Tree Cover in Settlement Area	65	1,22%
Build up/Settlement Area	15	0,27%
Shrubs	10	0,20%
Rain Forest	4.944	92,57%
Transportation network	52	0,98%
Bare land	53	0,99%
Swamp	0	0,01%
Bush	169	3,17%
River	30	0,55%
Total	5.341	100,00%

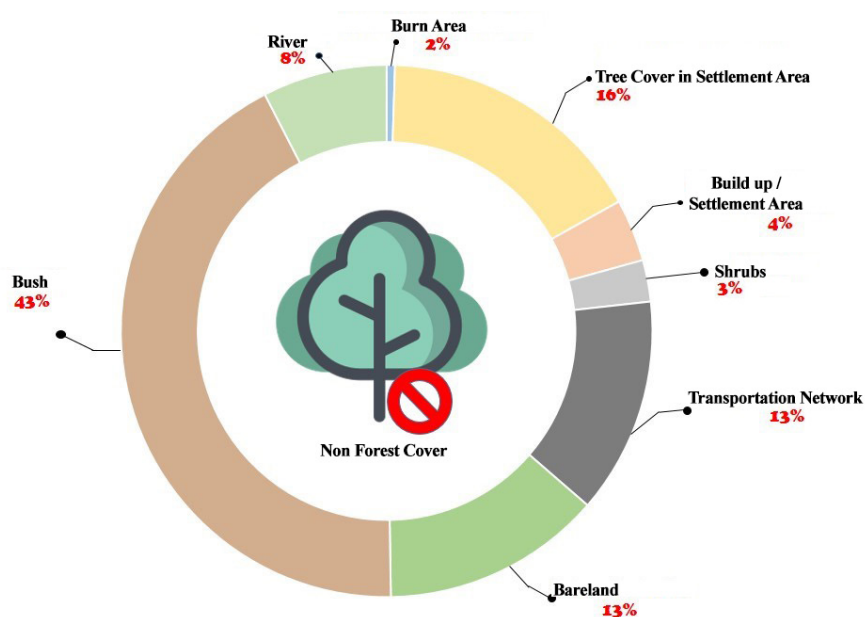


Figure 19. Percentage of non-forest land cover in the Miyah territory

Land Cover in Moi Kelim

Based on the remote avoidance analysis, Mio Kelim is an area that is dominated by rainforest land cover (97%) for a total of 8,720 hectares (table 9). Meanwhile, non-forest areas are dominated by shrubs and bushes with a percentage of 22% and 37%. More bushes were found in association with settlement areas and following transportation routes. This shows that shrubs arise due to the opening of land from clearing, which has subsequently not been used for productive purposes for a long time. Meanwhile, shrubs that appear in formerly dry forest areas grow back with low vegetation (Savitri 2017), which indicates land clearing either for plantations or other activities.

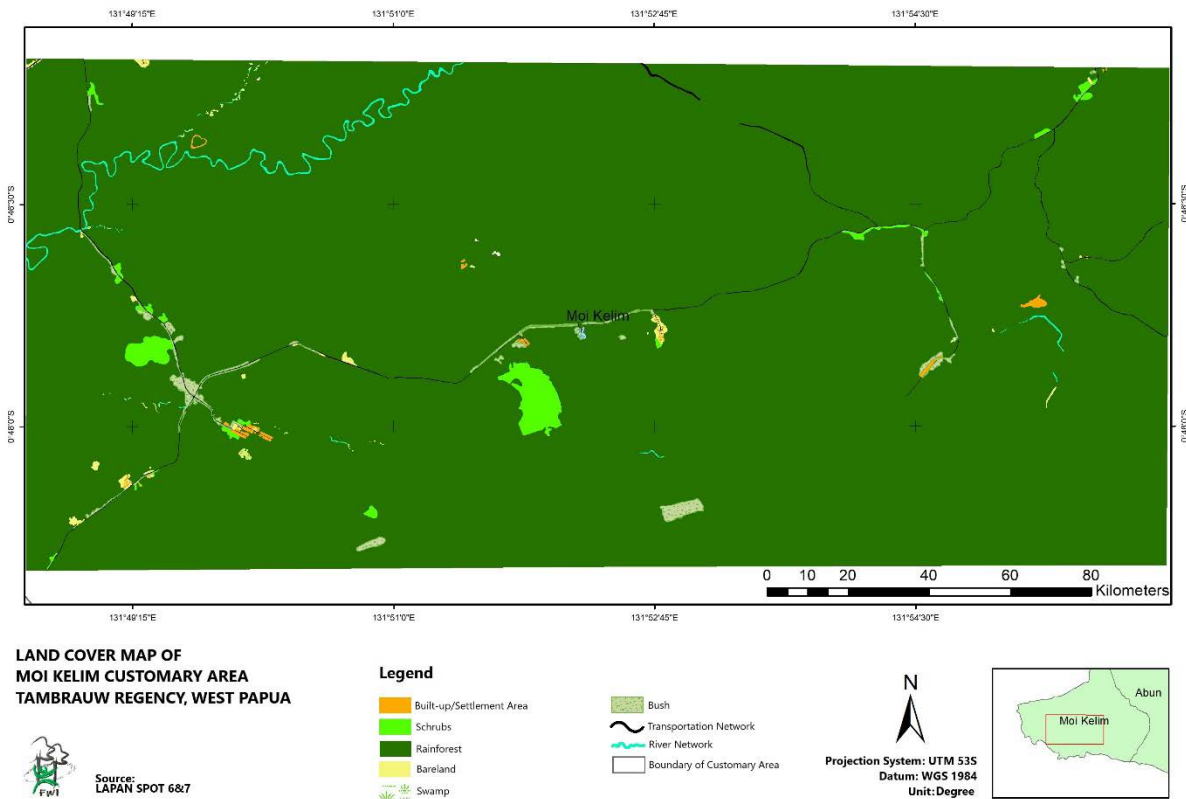


Table 9. Moi Kelim total area land cover classifications

Moi Kelim	Hectare	percentage
Build Up/Settlement Area	12	0,13%
Shrubs	76	0,85%
Water Body	1	0,01%
Rain Forest	8.720	97,71%
Transportation Network	27	0,30%
Bareland	17	0,19%
Swamp	1	0,01%
Bush	45	0,50%
River	26	0,29%
Total	8.925	100,00%

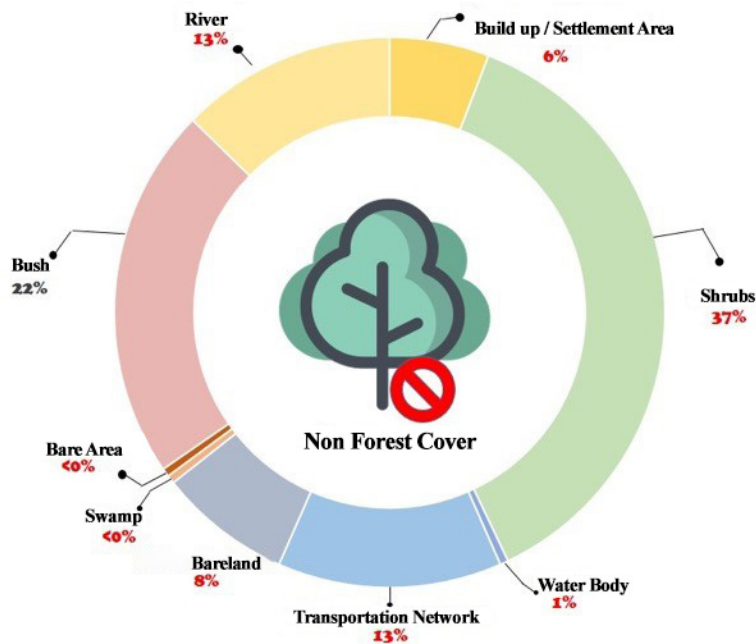


Figure 21. Moi Kelim non-forest land cover

4. CONCLUSION

Natural forest cover in the Tamberauw Regency over the three periods 1994-2000, 2000-2010, and 2010-2019, continued to experience increasing rates of deforestation. This study identifies several key aspects of these trends, as follows:

1. The Tamberauw Lifescape had 95 percent of natural forest cover in 1994, and by 2019, the total forest cover area was reduced to 89 percent.⁵
2. Deforestation in Indigenous territories increased from the 1994-2000 period, which experienced 0.15 percent declines annually, and became more pronounced during the 2000-2010 period to 0.2 percent annually, finally becoming more extensive during the 2010-2019 period, at an annual average rate of 0.42 percent.
3. The overall deforestation rate in areas of overlapping Indigenous territory and concession areas from 1994-2019 totaled 8 percent of the concession areas. Deforestation that occurred in Indigenous territories without concession permits amounted to a total of 6 percent.
4. Deforestation continues to occur in conservation and cultivation areas, and overall, the total numbers of deforestation continue to increase. Even though the Tamberauw regency government has designated the regency as a conservation district, it still continues to experience high levels of deforestation.
5. The most dominant uses of non-forest land in Indigenous territories are shrubs, transportation networks, open land, gardens, and bushes.

Recommendations

By examining the initial baseline results uncovered in this study, it is evident that Tamberauw is a regency that is contributing to overall deforestation. Even though natural forest areas remain widespread, the trends unfolding in Tamberauw require attention to address the potential for large scale future deforestation. In this case, it would be necessary to conduct:

1. More in-depth analysis of the causes of deforestation in Tamberauw, both in terms of the direct and indirect causes;
2. Forest monitoring that is undertaken by various stakeholders – involving government authorities and local communities – to better determine the temporal and spatial dimensions of deforestation in Tamberauw;
3. Follow up studies to ground truth, validate, and explain the overall nuances of these findings that can better explain overall land cover change dynamics and their implications for Indigenous territories;
4. Further studies on socio-economic potential and ecological change in Tamberauw that are in accordance with the priorities of Indigenous People.

⁵ The year 2017, was a particularly significant year, in which extensive deforestation rates occurred across West Papua

The pressure on forest conservation and resources cannot be separated from policies at the central and local levels, which influence the drivers accelerating deforestation (PKHI, 2011). Therefore, the principles of good governance must be put forward as a common ground for better forest management in the future. This will ensure that Indigenous Peoples can have greater certainty on managing forest resources, as well as establishing better policies that protects Indigenous and local communities, through the support and cooperation between central and local governments.

In the context of local government plans and policies, an adaptive governance approach is needed, which must approach development programming based on efforts to conserve socio-cultural values. It must also consider the broader priorities of economic development in ways that continue to conserve ecological and development aspects in an integrated manner. Doing so is also in line with Tamberau's branding as a conservation district.

Forest resource management must also be carried out fairly, democratically, efficiently, and professionally in order to ensure the success of its functions and benefits for the welfare of the people in Tamberau. This could be achieved through:

1. Strengthening policies and regulations that protect initiatives for the preservation and sustainability of lifescapes in Tamberau;
2. Strengthening and prioritizing the implementation of policies regarding conservation districts in Tamberau;
3. Mapping the strategic locations for conservation program targets by involving Indigenous Peoples;
4. Implementing a partnership initiative that minimizes the negative impacts on nature and sociocultural issues of the local community.
5. Economic development initiatives for the purpose of aligning the values of saving forests and supporting lifescapes of local communities with the goal of generating economic gains.

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