Analysis of land cover change due to deforestation at Holiday Resort Nature Park, North Sumatra Province, Indonesia

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Abstract. Deforestation activities in Indonesia are increasingly becoming a real concern. All of these actions resulted in the loss of 50% of the world's tropical forests, impacting the livelihoods of forest-dependent people. Changes in land cover are common in natural resource use areas. Land change is an important issue for planners and policymakers. One of them is the encroachment of the Holiday Resort Nature Park (HRNP) area of North Sumatra Province, which is a form of forest governance and weak law enforcement. Especially in this area, there are Sumatran elephants (*Elephas maximus sumatranus*), which are classified as critically endangered species. Analysis of land cover change can be used as material for formulating policies. By utilizing the Geographic Information System (GIS), it will be easier to analyze land cover and land use changes. The purpose of this study was to analyze land cover changes due to deforestation at HRNP. Spatial analysis of cover change using imagery and testing the accuracy of deforestation data, land cover satellite imagery, and verification in the field. The results showed that during the past 30 years, there has been deforestation from secondary dryland forest of 2079.3 ha to forest, namely swamp shrubs covering an area of 30.5 ha (1.5%) and non-forest covering an area of 2048.8 ha (98.6%). The highest deforestation rate occurred from 1996 to 2000 as much as 2027.3 ha (97.5%). The form of land cover due to deforestation is plantations 1990.8 ha (95.7%) and land cover forms 57.8 ha (2.8%). The conclusion shows that deforestation was triggered by weak law enforcement from the beginning until now, thus providing a more realistic opportunity for communities to encroach.

Keyword: Deforestation, Holiday Resort Nature Park, Land Cover Change, Satellite Image Classification, Sumatran Elephant

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1 Introduction

History shows that deforestation is closely related to the economic development of a country. According to [1]-[3], in the early stages of economic growth, forests are converted into commodities such as food, wood, and energy. In the next development stage, it is used to extract

high-value commodities such as minerals, biofuels, oil, and natural gas [4]-[5]. According to [6]-[7], all of these actions have resulted in the loss of 50% of the world's tropical forests, affecting the livelihoods of forest-dependent communities, reducing biodiversity, and increasing greenhouse gas emissions.

Commercial agriculture is the most important direct driver of deforestation in tropical and subtropical countries, followed by subsistence agriculture [8]. Both are drivers of the 80% that accounts for most of the effects of deforestation. Loss of control and supervision is also an important factor in deforestation [9]-[11]. According to [12], land cover changes are common in natural resource use areas. Land change is an important issue for planners and policymakers, especially in developing countries, where the problem of law enforcement and management policies between the vertical and horizontal sectors is still weak. One of the impacts of land cover change is the decline in biodiversity and ecosystem balance throughout the world [13].

One of them is the encroachment of the Natural Tourism Park area that occurs in South Labuhanbatu Regency is a weak form. Forest management and law enforcement, because the Holiday Resort Nature Park (HRNP) area is a conservation forest, which means that everyone is prohibited from destroying forest facilities and infrastructure as stipulated by Law Number 41 of 1999 concerning forestry. Especially in this area, there is the Sumatran Elephant (*Elephas maximus sumatranus*) which is classified as a Critically Endangered Species in the Red List of Threatened Species International Union for Conservation of Nature and Natural Resources (IUCN) in 2019 and Government Regulation No. 7 of 1999 concerning the Preservation of Species plants and animals. The problem of illegal forest management hurts all aspects, both economic, health, socio-cultural, and other aspects. According to [14], this area began to be encroached on in 1999. Instead, it was allowed to continue for years without any effort to prevent it, on the other hand, the law was expected to solve neglected problems.

Information regarding changes in land cover due to deforestation in the HRNP area has not been well documented. Analysis of land cover change can be used as research material to formulate policies. According to [15]-[16], by utilizing Geographic Information Systems (GIS), analysis of land cover and land use changes will be easier to do. According to [17], using satellite data is the right way to map land cover and vegetation. The type of land cover, what changes occurred, where they occurred, and how much change occurred between certain time intervals can be analyzed.

According to [18]-[19], this research is very necessary for the principle of forest protection that causes illegal occupation, which is a matter of forestry law. This information is also needed as the basic capital for increasing safety or safeguarding the preservation of natural resources and the environment, utilization, and management of natural resources for purposes of pursuing economic growth, improving the welfare of the people (community) sustainably, maintaining

the benefits of development, maintaining quality or quality. Human life between generations. The purpose of this study was to analyze land cover changes due to deforestation at HRNP Elephant Training Center, North Sumatra Province.

2   Research Method

The research activity will be carried out in the HRNP area, Elephant Training Center, Torganda Village, Torgamba District, South Labuhanbatu Regency, North Sumatra. With an area based on SK. 3913/Menhut-VII/KUH/2014, with an area of 2,100.42 ha. The study was carried out from January to April 2022.
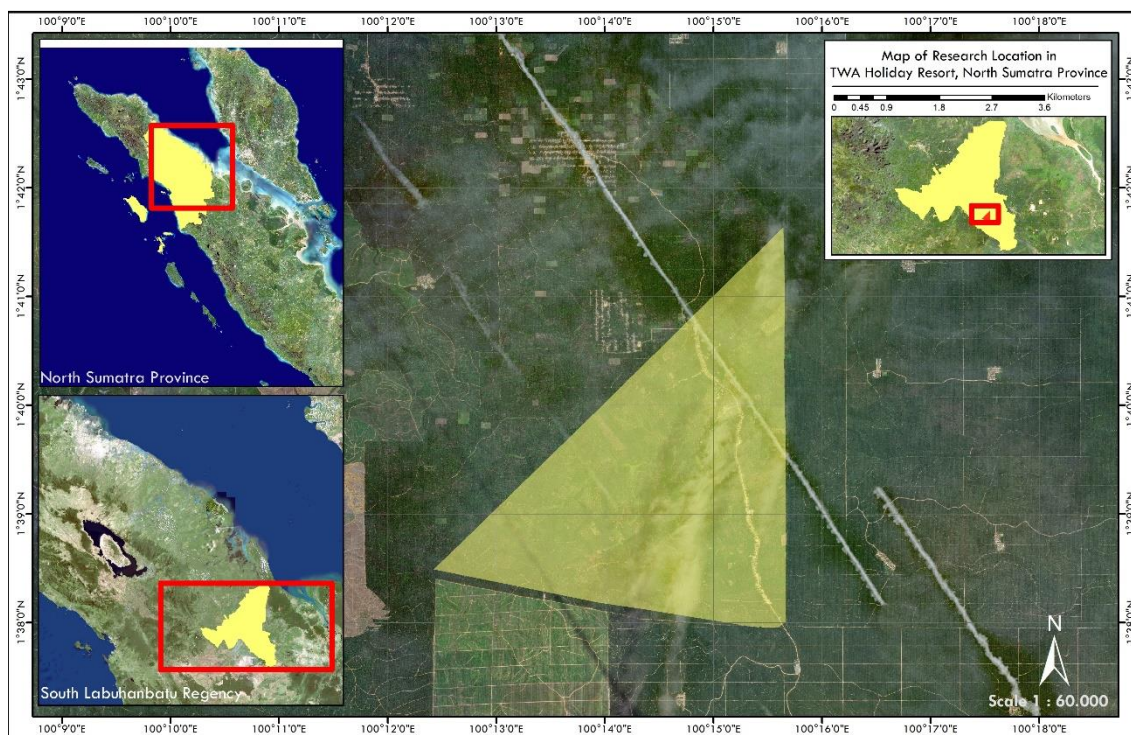

Figure 1 Study Area of Holiday Resort Nature Park (yellow polygon) (1°41'37.5" N-1°38'12.5"N and 100°15'39.8 "E-100°12'35.0"E).

2.1   Data analysis

The data analysis carried out includes spatial and land cover analysis. Field verification and interviews at selected locations based on the density of field verification to determine changes in land cover, including the demographic pattern of the people living in the area. In addition, the demographic pattern of the community in the area is also observed to identify the factors that cause forest fires that lead to land use change. The causal factor analysis was conducted to determine the impact caused by forest fires. Land cover was identified using ArcGIS software version 10.4.

Visual interpretation is a land cover categorization approach that uses color, shape, size, pattern, shadow, texture, and position to infer the distinctive properties of objects in satellite photos. Attribute data analysis was used to make the examination of changes in the type and extent of land cover easier. A comparison of land cover before and after the fire was used to conduct a land cover change study. Land cover change may be measured throughout this period.

Table 1 Landsat data description

No	Time	Satellite Sensor Type
1	1990	Landsat 5 Thematic Mapper (TM)
2	1996	Landsat 5 Thematic Mapper (TM)
3	2000	Landsat 5 Thematic Mapper (TM)
4	2003	Landsat 5 Thematic Mapper (TM)
5	2006	Landsat 5 Thematic Mapper (TM)
6	2009	Landsat 5 Thematic Mapper (TM)
7	2012	Landsat 5 Thematic Mapper (TM)
8	2015	Landsat 8 Operation Land Imager (OLI)
9	2019	Landsat 8 Operation Land Imager (OLI)
10	2020	Landsat 8 Operation Land Imager (OLI)

2.2 Procedures

Detection of land cover and land use changes involves at least two data periods [20]. This study will analyze land cover changes from 1990 to 2020. This research procedure can be divided into the following stages:

A.   Satellite Image Classification

The correction of the satellite imagery used is Landsat 5 imagery for 1990 to 2012 and Landsat 8 imagery for 2020, which has been downloaded from the website www.glovis.usgs.gov. The interpretation method is carried out by identifying land cover classes with delineation techniques based on patterns and characteristics (hue, color, and texture) in the image. Classification is based on actual land cover conditions (data) in the field and is limited according to classification needs, the classification refers to the Regulation [21].

B.   Land cover change analysis

It was carried out using a land cover map obtained from the Forest Area Stabilization Center from 1990 to 2020. The map was processed using ArcGIS 10.4 software with the Overlay method. Calculation of land cover area using the calculate geometry tool, which previously changed the coordinates of the land cover map to UTM (Universal Transfer Mercator), then changed the unit area to hectares. The calculation of the land cover area was then processed further with Ms. Excel, which previously exported the ArcGIS attribute table and then created a pivot table. Changes in land cover are calculated using the equation.

$$Changes\ in\ land\ cover = LUi\ 2020 - LUi\ 1990 \tag{1}$$

Notes : LU :Land cover area (ha)

i : Land cover type

This Land Cover Change Analysis will be side by side with the Demographic Number of communities in the area, which will be presented in the Graph from the year of identification to 2020.

C.   Test Accuracy

The accuracy test is used to identify the type of land use change at HRNP to see the error level made in the sample area classification process. It is done by comparing the results of image classification with data obtained in the field so that the percentage accuracy can be determined. Visits, data collection, monitoring, and recording of important information were carried out. The accuracy test carried out is the current year's data through ground-based observation data with GPS coordinates around the image. This test will affect the level of confidence in the method or classification results [22]. It is also necessary to prove the suitability of the image classification results with the actual conditions in the field [23]-[24]. which is calculated using the formula [25] as follows:

$$Overall\ accuracy = \frac{\sum_{x=1}^{x} xii}{n}\ 100\% \tag{2}$$

Notes : xii : The value of the diagonal row-i and column i of the contingency matrix

x+i : The number of pixels in the column-i

xi+ : The number of pixels in the row-i

n : The number of pixels in the example

Overall accuracy is the number of correctly classified pixels in each class compared to the number of samples used to test accuracy in all classes [26]. The accuracy of an interpretation result can be used for analysis purposes if it has an accuracy level of at least 75% [27].

3   Result and Discussion

It is easier to analyze land cover and land use changes using satellite imagery. Land cover types, what changes occurred, where they occurred, and how much change occurred between certain time intervals can be identified and analyzed.

3.1   Land Cover Change

Land cover class classification in HRNP Elephant Training Center was done using Landsat 5 satellite imagery (1990, 1996, 2000, 2003, 2006, 2009, and 2012) and Landsat 8 (2015, 2019,

and 2020). The HRNP's data on land cover type, area, and percentage of land cover change from 1990 to 2020.

Table 2 The changes in the land cover area

Time	Hp/ 2001	%	Br/ 20071	%	T/ 2014	%	Pk/ 2010	%	Pm/ 2012	%	Pt/ 20091	%	Total
1990	2079.3	100,0	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	2079.3
1996	2079.3	100,0	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	2079.3
2000	0	0,0	52.0	2.5	1959.0	94.2	59.2	2.8	9.0	0.4	0	0,0	2079.3
2003	0	0,0	52.0	2.5	1958.1	94.1	59.2	2.8	9.7	0.4	0	0,0	2079.3
2006	0	0,0	52.0	2.5	1954.6	94.0	59.2	2.8	13.2	0.6	0	0,0	2079.3
2009	0	0,0	52.0	2.5	0.0	0.0	59.2	2.8	19.9	0.9	1947.9	93.6	2079.3
2012	0	0,0	52.0	2.5	0.0	0.0	59.2	2.8	37.6	1.8	1930.2	92.8	2079.3
2015	0	0,0	52.0	2.5	0.0	0.0	1982.6	95.3	44.4	2.1	0	0,0	2079.3
2019	0	0,0	30.5	1.5	0.0	0.0	1990.8	95.7	57.8	2.8	0	0,0	2079.3
2020	0	0,0	30.5	1.5	0.0	0.0	1990.8	95.7	57.8	2.8	0	0,0	2079.3

Information: Hp/2001: Secondary Dryland Forest, Br/20071: Swamp Scrub, T/2014: Undeveloped Land, Pk/2010: Plantation, Pm/2012: Settlement/Land Construction, Pt/20091: Agriculture on Dry Land

The total area of HRNP based on the area of the SHP Conservation Map of the Ministry of Environment and Forestry is 2079.3 Ha, slightly different from the SK. 3913/Menhut-VII/KUH/2014 dated May 14, 2014, with an area of 2100.4 Ha. Based on land cover from 1990 to 2020, there are 6 types of land cover identified with different areas each year. The total land cover from 1990 to 1998 was 2079.3 (100.00%), still with secondary dryland forest. Furthermore, at the beginning of the 1998 reform, there was a significant change in land cover in 2020, namely Swamp Bush, or the core zone of the Elephant Training Center, covering an area of 52 Ha (2.5%), Open Land 1959.0 Ha (94.2%), Plantation 59.2 Ha (2.8%), and Settlement 9.0 Ha (0.4%). The change in the secondary dry land forest to become the largest open land is due to encroachment by the community and into plantations by the company.

Furthermore, until 2009 there was a change in land cover classified from Open Land changes to Dry Land Agriculture. The rest continued to increase in residential areas from 2000, covering an area of 9 Ha (0.4%) to 37.6 Ha (1.8%) in 2012. After the 2014 decree was issued and community conflicts over the area ceased. There was a change in the land cover which can be seen in 2019 with the plantation area become to 1990.8 Ha (95.7%), settlements at 57.8 Ha (2.7%), and swamp bushes at 30.5 Ha (1.4%). The remaining area is the Elephant Training Center and the HRNP office, which are currently maintained, and only have 1.4% left. That is very ironic.
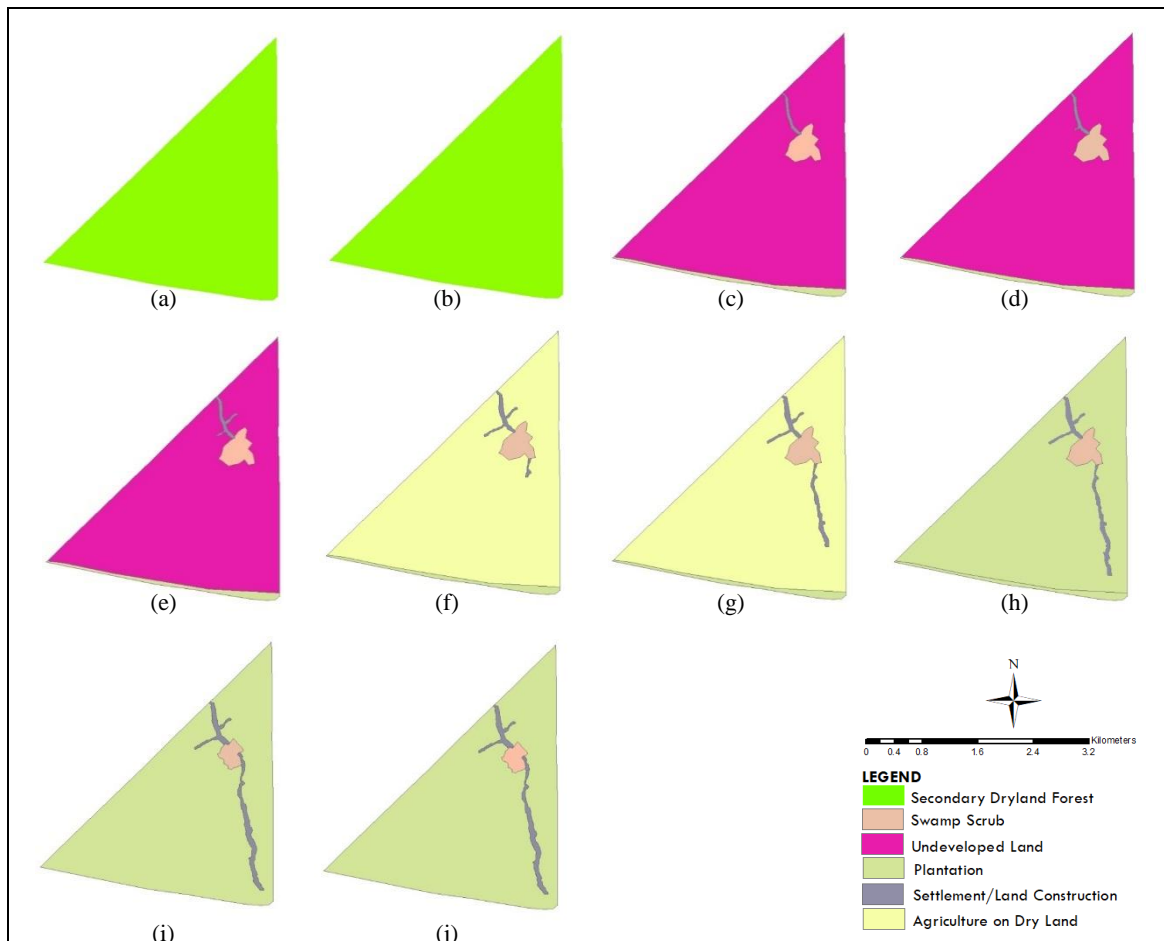
Figure 2 Map of land cover in the HRNP South of Labuhanbatu area, (a) 1990, (b) 1996, (c) 2000, (d) 2003, (e) 2006, (f) 2009, (g) 2012, (h) 2015, (i) 2019, and (j) 2020.

Landsat satellite image classification results showed there was a change in land cover at HRNP between 1990 and 2020. Data on the percentage of land cover change that has increased or decreased in land area at HRNP between 1990 and 2020 can be seen in Figure 3.
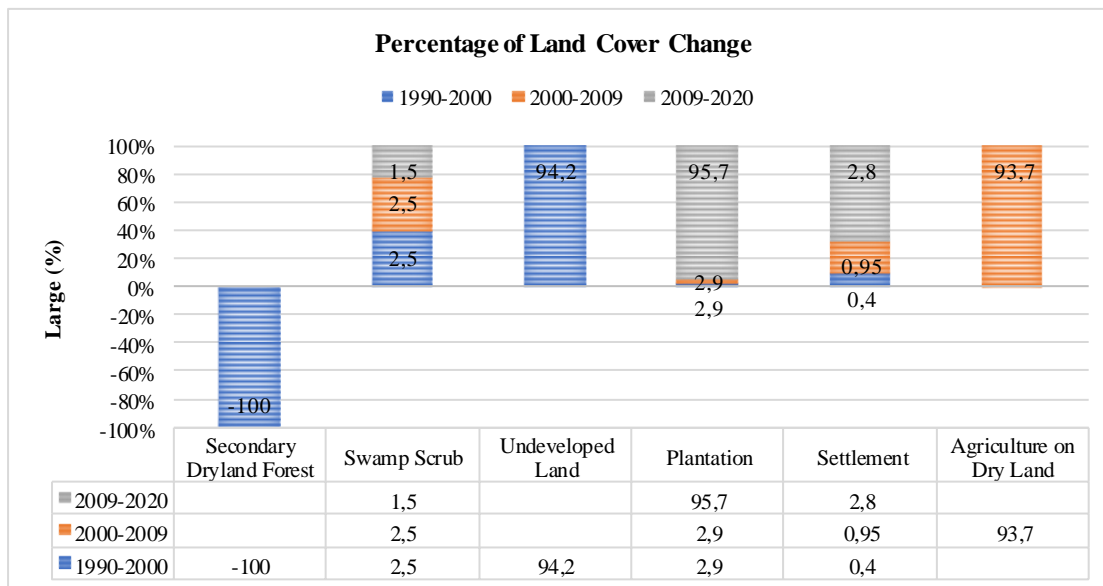
Figure 3 Percentage of Land Cover Change at HRNP 1990-2020

3.2   Accuracy Results

Observations of land cover changes obtained from taking survey points as a validation of the result accuracy in spatial analysis (landslide-prone map). The method used in the validation test of the spatial analysis results is the overall accuracy method for survey point data collection.

Table 3   Land Cover Accuracy Test in HRNP

Types of Land Cover	Survey Point (Number of Areas)						Total
	Hp/2001	Br/20071	T/2014	Pk/2010	Pm/2012	Pt/20091	
Hp/2001	0	0	0	0	0	0	0
Br/20071	0	5	0	1	0	0	6
T/2014	0	0	0	0	0	0	0
Pk/2010	0	0	0	13	3	0	16
Pm/2014	0	0	0	0	14	0	14
Pt/20091	0	0	0	0	0	0	0
Total	0	5	0	14	17	0	36

The calculated results: $((5 + 13 + 14)/36)*100\% = 88.88\%$

In 2019, land cover included primary dry land forest, secondary dry land forest, open land, plantations, and shrubs. Based on the results of the validation test, it is said to be valid the statement [27]. It is said that the accuracy of an interpretation result can be used for analysis purposes if it has an accuracy level of at least 75%.

3.3   Discussion

Deforestation is a farming activity or taking forest products from illegal forest areas that result in forest damage and is carried out by any person or business entity [28]-[29]. It means all forms of community activities without government permission in forest areas are considered nature reserves, conservation forests, production forests, or protected forests will be treated as a

violation of government regulations [30]. Land cover changes affect the climate by changing the composition of carbon dioxide, greenhouse gases, and other substances in the atmosphere [31].

With the existence of the Elephant Training Center (ETC), it is hoped the importance of increasing elephant populations in public awareness can be guaranteed. All hopes are only fantasies and dreams. Tragic and sadistic are the most appropriate words to describe the current condition of HRNP. It is because the area is designated as a conservation area and must be protected, but even become a village equipped with various infrastructure facilities in very good condition, for example, the establishment of the Torganda Village Head Office. In other side, deforestation and land management of the area into oil palm plantations and rubber plantations, which have reached the area of the community, make the suffering of the HRNP even worse. It is because the total area of 2,100.42 ha left by the squatters was only 30 ha. Then the previous location of ETC where 18 elephants were released by liars like the elephants didn't exist. That is why it is certain there is no area left by the browser.
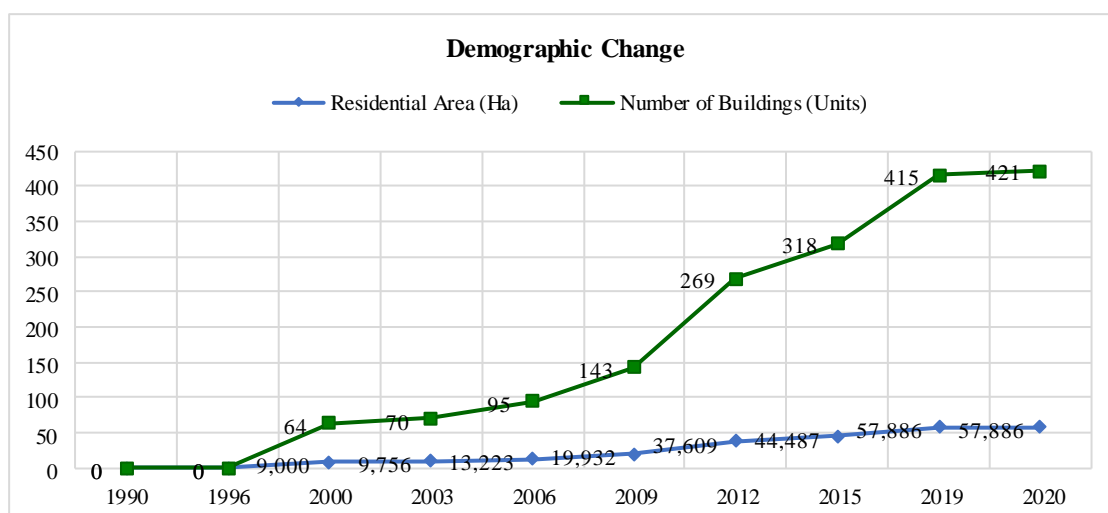

Figure 4 Demographic Growth Chart

In Figure 3, it can be seen that the demographic changes are seen from the area of community settlements in the area, with the number of buildings continuing to increase in the conservation forest. The residential area is currently 57,886 hectares, which exceeds the area of the block for the Sumatran Elephant training center. According to [32], the cause of deforestation in forest areas is the daily livelihood needs of the community and the growing population.

When viewed from the problems that occur in this area, deforestation which began to occur in abundance in 1999 (when the reform era began), has been allowed to continue for years and years without any attempt to stop it. On the other side, laws are expected to resolve the issue. The problem was ignored, such as research on Sumatra Island [33], Kapuas Hulu District [34], Ketapang District, Ketapang District [35], and Palangkaraya, Central Kalimantan [36]. In the

end, this opportunity was exploited by the squatters by looting and building villages in the area, as is happening today.

The implementation of the principle of forest protection in the South Labuhanbatu Regency is still not going well. It is due to the lack of firmness of local government officials in South Labuhanbatu Regency in tackling deforestation in the natural tourist park area. There are still a lot of deforestation activities carried out by the community, such as the establishment of private elementary schools (SD) and junior high schools (SMP), as well as the Village Head Office. The Regional Development Planning Agency (BAPPEDA) of South Labuhanbatu Regency (2017) in [14], why can the establishment of those buildings be due to ignorance? Looking back, it seems impossible that BAPPEDA did not know the establishment of those buildings. It is because the task of BAPPEDA is to be a regional technical institution in the field of research and regional development planning led by a head of the agency responsible for being under and to the Governor/Regent/Mayor through the Regional Secretary.

The real threat will also clearly threaten the existence of the ETC, which only has three branches in the area. Generally, the ETC is a place to train, educate elephants and preserve wild Sumatran elephants. But on the other hand, it is also a place for the conservation and protection of wild elephants. So these animals do not become extinct. ETC can be a place to research elephants for people who want it and want to know more about elephants. In addition, it is also a place to develop and train elephants for attractions that are used to entertain visitors or tourists so that they become attract actions active tourist attractions.

The actual existence of elephants carried out based on ecotourism can be applied to improve the welfare of local communities as well as efforts to increase local participation in conservation. Development-based conservation is an alternative way to avoid environmental damage. As was done at the ETC of Way Kambas National Park [37], Aek Nauli Special Purpose Forest Area (KHDTK) [38], KPHL Kotaagung Utara Lampung [39], and Tangkahan Langkat Area [40]. Sumatran elephants have economic benefits as an ecotourism attraction. The most appropriate tourism management is built to create attractive, safe, and sustainable tour packages.

Development-based conservation is an alternative way to avoid environmental damage. It is because environmental damage will have a significant impact on development and economic growth in an area [41]. Therefore, conservation and economic development are a package that cannot be separated from each other.

The activities of forest encroachers began on a large scale in 1998 in the reform era when the phenomenon of public distrust of the government and law enforcement occurred, so the encroachers considered the HRNP area to be fertile land for them to plant. These causative factors can be described as follows:

1. The occurrence of economic and political crises triggers the emergence of threats and forest disturbances in general, which are carried out by the community/persons en masse, sporadically, brutally, and by their nature, have threatened the sustainability of conservation areas because of using Sleeping Land. And the intellectual actors behind these actions, such as the existence of investors who can capitalize on the encroachment,

2. The economic level of rural communities is insufficient for daily life and does not sustainably optimize the benefits of forests. Their short-term thinking about the benefits of forests, such as illegal logging and deforestation, makes them fall into contemporary thinking. They do not think about the future of a prosperous family. In particular, the surrounding community from the outside village to outside the sub-district comes to increase economic income.

3. At the beginning of deforestation, there were existing apparatus or people from both the government and security forces who weakened the supervision and security. As well as allowing this area to be used and utilized by people who have penetrated it at the beginning,

4. Natural conditions are unrelated to the number of Forest Police (Polisi Kehutanan), and security equipment (infrastructure).

5. There are programs or government instructions that trigger deforestation as a result of poor implementation in the field. As happened with the reason for the government's appeal, any unused land can be turned into productive land.

6. The existence of settlements around the area brings a greater number of surrounding residents, followed by a greater impact on its integrity. This condition is very hard to solve considering the many related agencies, especially the local government, including the village government.

7. Information and transportation facilities are very limited. It is far from the Capital District, Regency, and Province. So the dissemination of information becomes hampered, even though fast and accurate information is the main key to securing conservation areas. Meanwhile, information among squatters is very fast, both in terms of methods and techniques of deforestation. So the pretext when it is ordered is almost the same.

8. There are perception differences in the management of conservation areas among related officials (local government/services, police, military, BBKSDA, and other stakeholders).

9. It is low public awareness about the meaning, role, and benefits of conservation areas for life support systems, science, rich biodiversity, hydrology, and even the lungs of the world. Therefore, the factors that influence anthropogenic activities on deforestation are education and knowledge.

10. The need for large and sustainable funds and also long period programs such as counseling, socialization, law (investigations to court decisions), and community empowerment. Because it is apart from expelling the encroachers, one must also change the perspective/mindset of conservation areas.

The finding shows that deforestation was triggered by weak law enforcement from the beginning until now. It provides the community with more real opportunities for encroachment. It leads to the sale and purchase of forest land in the HRNP area, even though it is only limited to a Village Head Certificate. The same applies to the government's lack of attention and socialization with the community. There need to be strict punishments for perpetrators involved in forest illegality, interventions to increase community capacity within the area by related stakeholders, and forest-surrounding communities to protect forest reserves [42].

4   Conclusions

During the past 30 years, there has been deforestation from secondary dryland forest of 2079.3 ha to forest, namely swamp shrubs covering an area of 30.5 ha (1.5%) and non-forest covering an area of 2048.8 ha (98.6%). The highest deforestation rate occurred from 1996 to 2000 as much as 2027.3 ha (97.5%). The form of land cover due to deforestation is plantations 1990.8 ha (95.7%) and land cover forms 57.8 ha (2.8%). The conclusion shows that deforestation was triggered by weak law enforcement from the beginning until now, thus providing a more realistic opportunity for communities to encroach.

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