Journal

Original Research Article

https://doi.org/10.62142/t6n6m231

Deforestation Trends and Drivers in Central Halmahera Regency

Received: 16 February 2024
Accepted: 15 June 2024
Published: 30 June 2024

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Land use patterns are strongly influenced by human requirements; among the most important problems is deforestation. Particularly with deforestation, central Halmahera Regency has seen significant changes in land usage. We use QGis software and remote sensing data, to seeks and identify the rate of deforestation in Central Halmahera Regency. from Global Forest Change, that satellite pictures data. According to this studies, Weda and Maba were the most impacted areas in Central Halmahera experiencing the worst deforestation between 2014 and 2017. The conversion of forest land into nickel mining sites caused notable destruction in several places. With an average annual loss of 1,435.43 hectares between 2001 and 2013, data showing varying rates of deforestation between 2001 and 2022 shows Rising during 2014 and 2015, the pace of deforestation peaked at 8,852.506 hectares but started to fall in 2016 and 2017.

Keywords: Land use change, Mining, Deforestation, QGIS

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1. Introduction

Deforestation is a significant problem that results in the decrease of wooded regions. This is mostly caused by activities such as transforming forest land into settlements, plantations, and mining (Sabaruddin, Kurniawan, & Nurhikmah, 2023; Bandang et al., 2023). Moreover, in that context, the expansion of the Indonesian economy, which has created investment prospects, has led to a rise in the need for forest land (Sains & Utara, 2016). Based on the 2018 data from the National Statistics Agency, the primary sectors of investment comprise agriculture, forestry, fishery, mining, power, gas, water, construction, trade, and transportation. Out of these, the mining sector receives the most substantial investment. The conversion of forests to mining land is widespread in Indonesia, as the country is abundant in valuable mineral resources. North Maluku province is a highly attractive place for investment in the mining sector (Salim, 2016).

The mining sector is highly favoured in North Maluku province due to its potential for generating employment possibilities (Bernadus & Rorong, 2021). Furthermore, it is expected to contribute to the growth of the economic sector in the province of North Maluku (Sabaruddin, Adriani, & Arif, 2022). Central Halmahera Regency is a key place for boosting the economy through mining investment in North Maluku Province (Sabaruddin & Rasyid, 2023). The land area of Central Halmahera Regency measures 2,276.84 km², while its sea area spans 6,104.65 km². The region is composed of 10 sub-districts, specifically: South Weda District, Weda District, Central Weda District, North Weda District, East Weda District, West Patani District, East Patani District, Patani District, North Patani District, and Gebe Island (Badan Pusat Statistik, 2023). This district is highly advantageous due to its abundance of natural resources, particularly in the mining industry. Central Halmahera is rich in nickel minerals, making it an attractive location for nickel mining firms to investigate and extract nickel resources. PT. Indonesia Weda Bay Industrial Park (IWIP) is one of the major mining enterprises in this district (Alauddin, 2012).

The role of forest areas in Central Halmahera requires modifications (Husen & Baranyanan, 2021). Mining operations should prioritise the extraction and utilisation of minerals found in rocks and soil inside forested areas (Ndraha & Uang, 2018). It is crucial

to assess the magnitude of deforestation in Central Halmahera Regency on an annual basis (Soleman, Alauddin, & Rosyidi, 2020). The objective of this study is to ascertain the deforestation rate in Central Halmahera and identify one of the variables contributing to deforestation in Central Halmahera Regency by analysing changes in land use.

2. Method

This study utilises satellite imagery data obtained directly from the Global Forest Change website by accessing data using the URL: https://earthenginepartners.appspot.com/science-2013-global-forest. The data pertains to worldwide forest change data derived from satellite images using landset 8 OLI in 2013, as documented by Burivalova et al. in 2015. We obtained the data and subsequently superimposed it with the SHP data for Central Halmahera Regency from the website https://tanahair.indonesia.go.id/portal-web. This study exclusively examined satellite imaging data collected from Global Forest Change, specifically analysing the magnitude of alterations in land cover within Central Halmahera between 2001 and 2022. The software we utilise to convert data into a map is QGIS, that is a freely available software tool that can facilitate cartographic tasks. The development of this application was initiated in 2002 by Gary Shermen (Khan, Safat, & Mohiuddin, 2018). Once the region data is acquired, it is utilize using the Microsoft Excel software.

3. Result and Discussion

The area of Central Halmahera Forest state is 181,247.66 Ha. Consisting of protected forests, sanctuary forests, production forests, and limited production forests, permanent production forests, and conversion forests. The area of each forest area can be seen in Table 1.

Table 1. Area of Forest Area in Central Halmahera

No	Forest State	Area Km^2
1	Protected Forest	33.315,21
2	Reserve Forest	16.069,16
3	Limited Production Forest	63.422,48
4	Permanent Production Forest	25.992,81
5	Conservation Forest	42.448,00
Total		181.247,66

Source: Central Halmahera BPS 2019

Based on the Central Halmahera Regency Topographic Map, it is then overlapped with DEM (Digital Elevation Model) data from Global Forest Change. The resulting map can be seen in the image below.

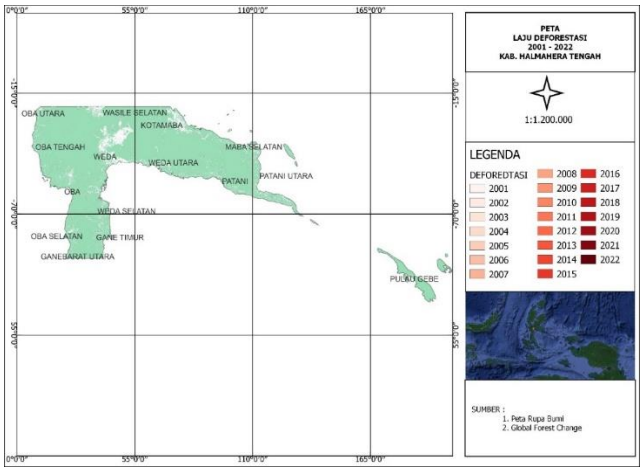


Figure 1. Deforestation Rate Map Resulting from Combining Topographic Maps and DEM Data in Central Halmahera Regency

It can be seen from the data that there have been changes every year starting from 2001 to 2022. The data is deforestation rate data for 22 years. To make it clearer, we have changed the map with a 3-dimensional model. The 3-dimensional map can be seen in the image below.

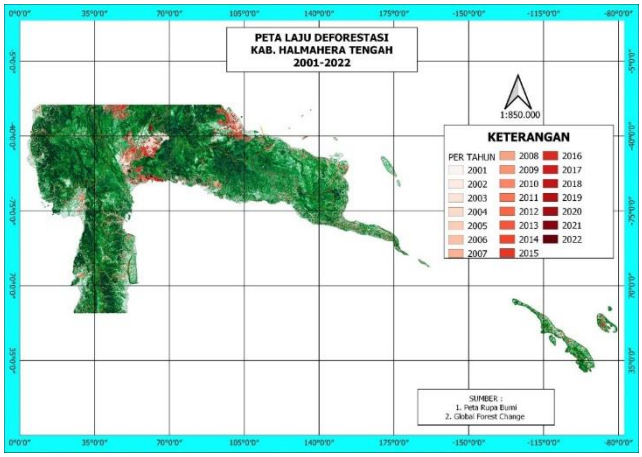


Figure 2. Overlay map of topographic map and DEM data in Central Halmahera Regency.

Figure 4 presents a graphical representation of the rate at which deforestation is occurring in Central Halmahera Regency, focusing on the reduction of forest area between the years 2001 and 2022. The data indicates that deforestation between 2001 and 2013 included variable patterns, resulting in an average reduction of 1,435.43 hectares of land annually. From 2014 to 2015, the graph shows a consistent rise that culminates in an 8,852,505 hectares maximum deforestation estimate. Still, 2016 saw a drop in the pace of deforestation—2,193.53 hectares less. From 2016 to 2017, the rate of deforestation dropped significantly—5,353.30 hectares. The rate of deforestation slowed somewhat between 2017 and 2020 as compared to earlier years. 1,497.14 hectares was the average rate of deforestation over this time. Beginning in 2019, mining operations in Central Halmahera have started to cause a considerable decrease in local deforestation (Paranoan & Albugis, 2022).

Meanwhile, the area of forest that experiences deforestation each year can be seen in the table below.

Table 2. Area of forest in Central Halmahera Regency that experiences deforestation

Year	Area (m2)	Area (Ha)
2001	5.821.387,52	582,139
2002	28.088.675,09	2.808,868
2003	26.905.185,09	2.690,519
2004	15.625.142,05	1.562,514
2005	8.272.134,01	827,213
2006	17.507.198,56	1.750,720
2007	6.867.316,02	686,732
2008	10.636.040,04	1.063,604
2009	27.224.112,59	2.722,411
2010	10.334.788,03	1.033,479
2011	7.787.210,53	778,721
2012	14.105.049,05	1.410,505
2013	7.431.395,03	743,140
2014	17.404.219,56	1.740,422
2015	88.525.052,30	8.852,505
2016	66.589.756,72	6.658,976
2017	13.056.815,04	1.305,682
2018	14.881.234,05	1.488,123
2019	19.005.005,06	1.900,501
2020	13.987.468,55	1.398,747
2021	14.525.418,55	1.452,542
2022	14.372.487,05	1.437,249
Total		**44.895,309**

The findings presented in this study align with previous research that indicates a significant increase in the transformation of forested regions into mining sites from 2014 to 2017 (Azuwara & Tanuwijaya, 2023). In mining sites, pre-construction involves the removal of land. Central Halmahera has seen major destruction from 2014 to 2017. Many mines in Central Halmahera commenced operations in 2018, especially when PT IWIP (Indonesian Weda Bay Industrial Park) in Weda District achieved a significant advancement through a partnership with PT Antam (Aneka Tambang), an Indonesian mining business (Bidul & Widowaty, 2023). We shows the company engages in the exploration and extraction of nickel ore deposits, as well as the production of smelters (Haya & Firman, 2022). This organization needed a spacious location to execute its objectives, leading to modifications in the forest region (Drakel, 2023). In 2018, the Tsingshan Holding Group commenced the establishment of a smelter by involving both domestic and international enterprises.

Based on the data above, it can be seen that there was an increase in the rate of deforestation from 2014 to 2015.

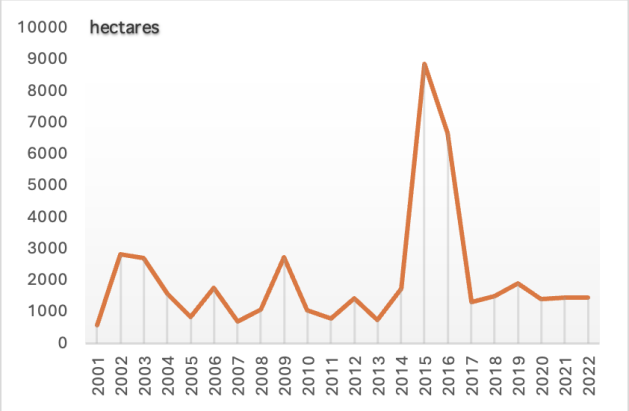


Figure 3. illustrates the rate at which deforestation is occurring in Central Halmahera Regency.

To streamline the project, IWIP acquired land that had previously been utilized by PT Tekindo. As of 2024, PT IWIP operates a total of six smelters, which have been in operation since 2020. Based on data collected from the IWIP.co.id website, PT IWIP currently employs over 36,000 persons.
From the issues mentioned, the author deduces that the deforestation rate in Central Halmahera Regency was caused by mining firms operating in the region. Furthermore, the presence of the mining zone also necessitates an economic cycle that influences the establishment of residential neighborhoods for both the local population and the workers in the area.

4. Conclusion

Overall, the deforestation trends in Central Halmahera highlight the complex interplay between economic growth, population dynamics, and environmental sustainability. The findings underscore the need for comprehensive policies that address the root causes of deforestation while promoting sustainable development and conservation efforts. To add this, the deforestation in Central Halmahera Regency over the past 20 years has experienced significant fluctuations, with the most intense period occurring between 2014 and 2017. The peak of deforestation was reached in 2015, with a staggering 8,852.505 hectares of forest lost. The areas that experienced the most deforestation, as revealed through image data analysis, were Weda and Maba. This extensive deforestation was primarily driven by land use changes from forest areas to nickel mining sites.
Furthermore, in this research we see the population's growth—which includes immigrants as well as locals—helps to explain the rising rates of deforestation resulting from the desire for infrastructure development and homes. Driven by the mining industry, the region's economic growth attracted a sizable workforce, hence increasing the demand on forest areas for both commercial and residential use. Accelerating deforestation in Indonesia has been greatly aided by the investment

environment that favours mining, agriculture, and forestry among other sectors. Particularly in resource-rich provinces like North Maluku, the flood of investments meant for the exploitation of mineral resources has turned large stretches of wooded terrain into mining territory. According to the statistics, major environmental damage has been sacrificed in order to gain economically from mining operations.

5. Author Contributions

The first author's contribution was as compiling and analyzing the article data according to the research results, while the second author's contribution was assisting the first author in analyzing data and research results, the third author's contribution was helping to obtain data in the field, both primary and secondary.

6. Completing Interests

The authors declare that there is no conflict of interest in writing this paper.

7. Acknowledgements

The author thanks all his colleagues who helped with this publication.

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How to cite this article:
B, S., Kurniawan, A. ., & Arif, N. (2024). Deforestation Trends and Drivers in Central Halmahera Regency. *Jurnal Wasian*, *11*(1), 15-19. https://doi.org/10.62142/t6n6m231

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