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Effect of Pandemic Covid-19 on Tropical Forest Cover in Small Island: Case Mansinam Island Papua using Google Earth Imagery

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Abstract

Covid-19 became a global pandemic in 2020 and has multiple impacts on the economy, social, culture, food systems, and also the environment, especially on tropical forest cover in small island. This study aims to determine the impact of the Covid-19 pandemic on the forest cover of small populated islands. Using remote sensing and geographic information system technology based on high-resolution satellite imagery from google earth imagery, land cover was observed in 2018, 2020, and 2023. This study found that during the 2020 pandemic, tropical forest cover on small populated islands has decreased. Mansinam's forest cover decreased by 4.3%, bare land increased by 80.6%, agricultural land increased by 75.3%, and shrubs increased by 54.9%. Another important finding is that 78.9% of the total deforestation was due to forest conversion to bare land and agricultural land. Land and forest utilization on small islands will increase when accessibility is limited, especially during the pandemic. Future studies will be on the structure and composition of species in locations that experienced deforestation during the pandemic and detailed studies related to changes in the occupations of Mansinam people due to the pandemic that have a relationship with forests.

Keywords: *deforestation, Covid-19, tropical forest, Mansinam, google earth imagery*

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Introduction

Corona virus disease 2019 (Covid-19) first reported in Wuhan Province, China, in December 2019 (World Health Organization, 2020). This disease is caused by the SARS-CoV-2 virus, which can be transmitted among humans (Wu, 2021). More than 118,000 cases in 114 countries with 4,291 deaths. Therefore, on March 11th, 2020, the World Health Organization declared the Covid-19 outbreak as a global pandemic (World Health Organization, 2020). In April 2021, Covid-19 had spread globally to 223 countries with 141 million confirmed cases and 3 million deaths (World Health Organization, 2021).

Apart from being a global health issue, the Covid-19 pandemic also had dozens of impacts on the economy, social, culture, food systems, and also the environment (Yezli & Khan, 2020; Guo & Lee, 2022; Bell et al., 2023). Since experiencing the Covid-19 pandemic, the Indonesian economy decreased from 5.02% in 2019 to 2.97% in 2020 (Direktorat Jenderal Kekayaan Negara, 2023). The Covid-19 pandemic leads to life changes for everyone through the implementation of social restrictions, reduced service capacity, and new ways of life (Weinbrenner et al., 2021). The rapid spread increased the number of infected cases and deaths. Responding to this situation, the government then created a policy to reduce transmission rates with large-scale social restrictions, or "*Pembatasan Sosial Berskala Besar*" (PSBB). PSBB is carried out to reduce the number of transmission cases so that the mortality rate could remain low while still paying attention to the sustainability of development and economic activity (Sarkodie & Owusu, 2021).

PSBB policy during the Covid-19 pandemic in 2020 has affected mental health, the economy, education, and daily routine (Naveed et al., 2024). The pandemic has changed the way people live so that it could directly or indirectly influence the environment. Forests are one part of the environment that was affected during the Covid-19 pandemic. When the PSBB policy was implemented, social activities decreased so that people did work from home (WFH) or performed physical activities away from the crowd, such as visiting the forest. During the pandemic, forests also have an important role as healing forests (Kurniasari et al., 2023) to reduce anxiety and fear due to social distancing (Jayasundara et al., 2024). People find the forest as an alternative space for limited social interactions during the pandemic (Weinbrenner et al., 2021). However, forests as vegetation also have threats such as increasing deforestation and illegal logging during the pandemic.

The PSBB policy has positive and negative effects on forests and the environment. The positive effects of PSBB

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were the decline in gas emissions and particulate matter (Ang et al., 2023), a decrease in land surface temperature (Jallu et al., 2022), decreased waste volume from industry, decreased sources of water pollution, and decreased noise from the transportation and industrial sectors (Bell et al., 2023), etc. Meanwhile, the negative impacts were limited access and availability of food (O'Hara & Toussaint, 2021) and increased medical and home organic waste (Zambrano-Monserrate et al., 2020).

Several studies have been conducted to see the effect of Covid-19 on forests and their ecosystem services, such as a decrease in trading of forest products (Golar et al., 2020; Suwito et al., 2021; Sanudin et al., 2023), forests as a new living room during the pandemic (Weinbrenner et al., 2021), increasing forest destruction (Rafii & Millang, 2021), and impact on forests for ecotourism (Maraseni et al., 2022). There are studies that have also been carried out to determine changes in vegetation using the normalized difference vegetation index during lockdown by Ranjan et al. (2022), Jallu et al. (2022) estimated surface temperature on various types of land cover during the pandemic period. Studies related to the relationship between deforestation and the pandemic have been performed by Brancalion et al. (2020), Singhal et al. (2024), and Rahman et al. (2021), who stated that the pandemic situation makes many aspects not work normally. Movement restrictions, budget deficits, lockdowns, social restrictions, labor shortages, weak law enforcement, and relaxation of government policies make forest management difficult. The chaotic pandemic situation affects human needs such as food, health, and jobs. Pressure on forests to provide agricultural land, firewood, and fiber increases, leading to greater deforestation. Weak supervision on the ground due to lack of labor, movement restrictions, and budgets also increases illegal logging and mining. All of these studies discovered that there was an increase in deforestation during the Covid-19 period. However, these studies are mostly carried out on a global scale and in specific countries, while there is limited research to assess the impact of the pandemic on tropical forests on small populated islands. Forest cover change, or transition, approach by monitoring forest cover before, during, and after the pandemic has ended are used to discover the effects of the Covid pandemic on forests in small islands.

Currently, forest cover monitoring can be performed rapidly using remote sensing technology and geographic information systems (Bhandari et al., 2021). Several free satellite images can be used as a source of up-to-date and past information to determine forest cover dynamics and have been carried out by researchers such as Letsoin et al. (2020), Abebe et al. (2022), Friedl et al. (2022), and Olfato-Parojinog et al. (2023). However, the use of open-source satellite imagery is currently not optimal to support land cover monitoring on small area boundaries such as small islands. For example, Landsat 8 and Landsat 9, which have a resolution of 30 m pixel^{-1}, and Sentinel 2, which has a resolution of 10 m pixel^{-1}, are not optimized to identify more detailed objects/phenomena (Malarvizhi et al., 2016). It needs higher- resolution imagery to perform this analysis, but these satellite products are commercial and therefore high cost. As an alternative, Google Earth (GE) can be used as a virtual globe technology with high-resolution images, convenient to use for data collection, exploration, and visualization of the earth's surface at a low cost (Yu & Gong, 2012). Google Earth Imagery (GEI) is one of the satellite imagery that displays a more detailed form of the earth's surface. GEI is currently widely used for research in the fields of geography, education, visualization of spatial information, and access to high-resolution images (Tooth, 2015).

Based on this description, the research question is whether there is an impact on forest cover on Mansinam Island during the implementation of the local lockdown through observations using high-resolution imagery as illustrated in Figure 1. So, the hypothesis is that the Covid-19

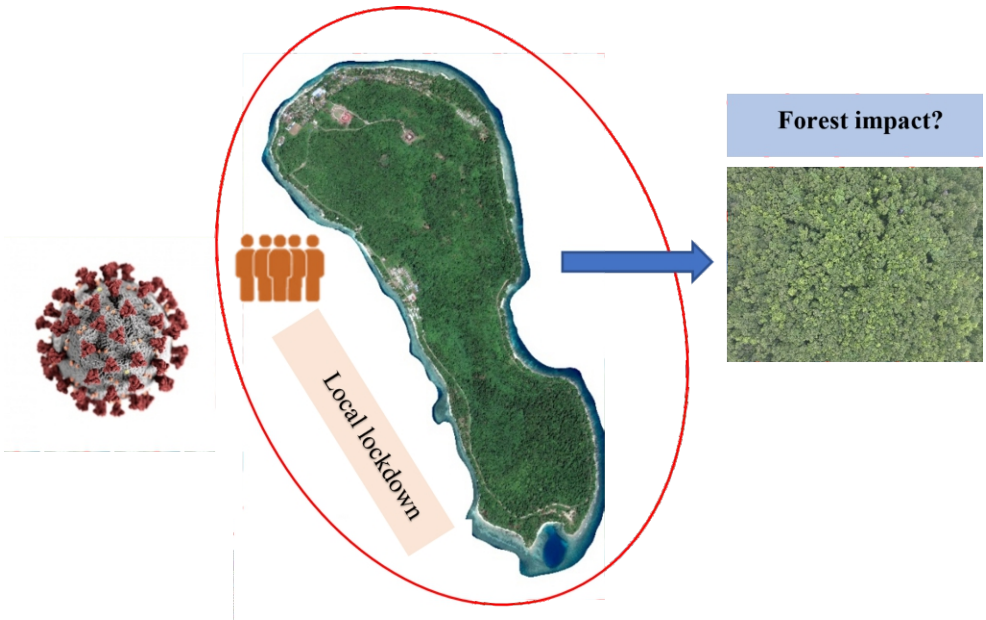

Figure 1 Illustration of the relationship between Covid-19, local lockdown, and forests. Satellite image is from google earth imagery (https://earth.google.com/).

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pandemic has impacted forest cover by increasing deforested land on Mansinam Island due to these accessibility restrictions as a result of movement restrictions, lockdowns, and social distancing. The local lockdown that is carried out will break the chain of needs of the local community in Mansinam, such as food, medicine, and jobs. This situation will put pressure on the forest cover on the island for how to provide the needs required during the pandemic lockdown. For this reason, this study aims to discover the impact of the Covid-19 pandemic on changes in tropical forest cover on Mansinam Island, especially forest deforestation. This study will determine the impact on forest ecosystems on small islands due to Covid-19 countermeasure policies.

Methods

Site study This study was conducted on Mansinam Island, with an area of ± 404 ha, and is located in Manokwari Barat District, Manokwari, West Papua, Indonesia (Figure 2). Mansinam Island is one of the islands located close to Manokwari City and can be reached by boat for around 1.2 km. Mansinam Island is one of the historical sites for Papuans because it is the first place where the gospel was introduced in the land of Papua. The island is also the center of religious tourism in Papua, in which every February 5th there will be religious events and spiritual tours. Mansinam Island is located at coordinates E134°516.6E134°646.2 longitude and S0°5317.1S0°5528.18 latitude, with the dominant ecosystem types being lowland tropical forest and coastal forest (Hematang et al., 2022). Precipitation from CHIRPS (https://www.chc.ucsb.edu/data/chirps) shows Mansinam has an average precipitation of 2,192 mm year^{-1} in 2023, the average wind speed in 2022 reached 2 m second^{-1}, and the average temperature was 28 °C (Badan Pusat Statistik Papua Barat, 2023).

Image acquisition and proccessing Open-access high-resolution imagery from GE is used as the main data source to investigate land cover dynamics. GE is a popular software that displays the globe virtually and can be utilized in all aspects, including education and research (Hu et al., 2013; Tooth, 2015). GE software is available for free on: https://www.google.com/intl/id/earth/about/versions/#earth-pro. Images from GE were downloaded in 4K ultra high definition, which has a pixel count of 4,800 × 2,886 in jpeg format. This image was then geometrically corrected (rectification) through ArcGIS Pro licensed software (Environmental System Research Institute) and saved in *tif* format. The rectification process uses six coordinate points sourced from GE software and spread throughout the image area. Satellite image acquisition was carried out for three different periods: before, during, and after the pandemic (Table 1). The three observation periods were used to see if there were changes in forest cover from before the pandemic to the pandemic and from the pandemic to after the pandemic.

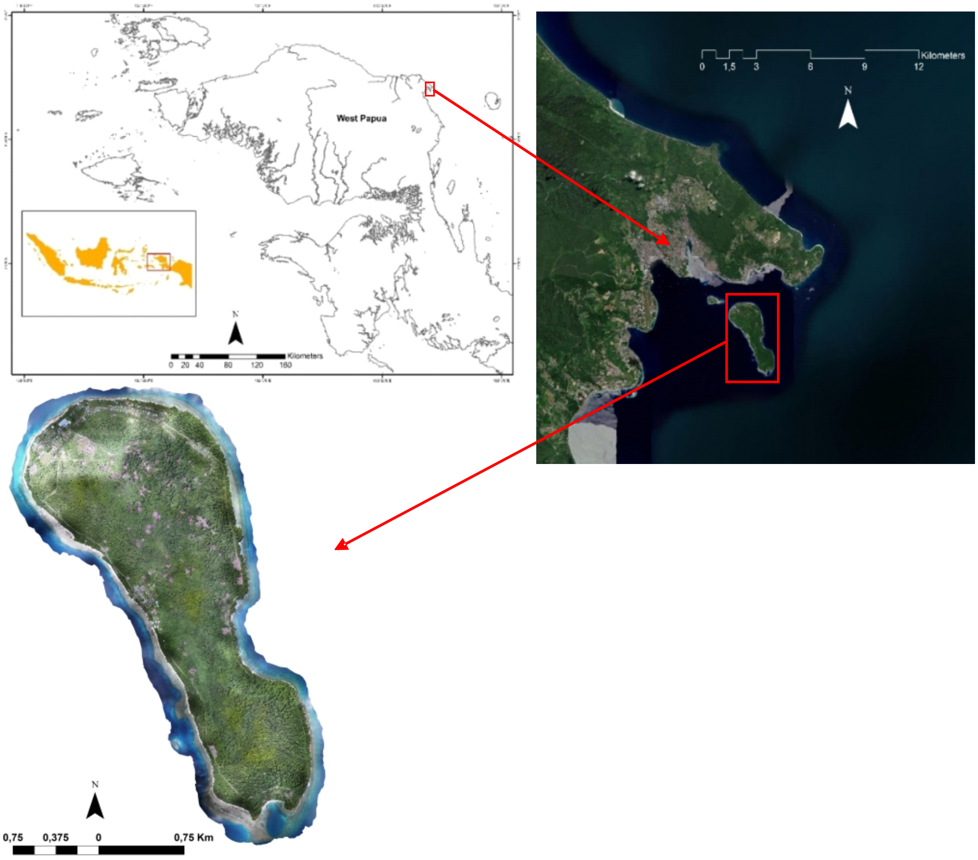

Figure 2 The research location is Mansinam Island, which is located in Manokwari Regency. The second and last image shows satellite imagery (ESRI Basemaps) and Mansinam Island as seen in orthophoto (Hematang et al., 2024).

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Land cover identification Satellite imagery from GE was manually interpreted using the digitization on-screen method to identify land cover visually. Land cover in this study will be used to describe land use activities that will affect the natural land cover. Using GEI for land cover interpretation will be beneficial to clearly see the difference between forested areas and non-forested areas because it has a very high spatial resolution. The focus is more on non-forest cover, particularly the classes of bare land, agricultural land, and built-up land to see the impact of the pandemic on forest deforestation. To identify land cover using satellite imagery, an interpretation key was created as an identification guide (Table 2).

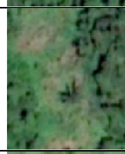
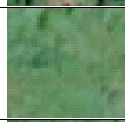
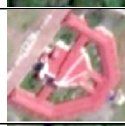
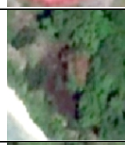
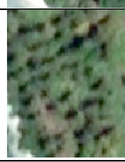
Manual delineation using digitized on-screen technique at a scale of 1: 2,500. The results of identifying changes in forest cover are digitally calculated using ArcGIS Pro version 3.3 software by the Universal Transverse Mercator zone 53 South coordinate projection system with units of hectares. The complete data analysis stages can be seen in Figure 3.

Land cover change and research limitations Land cover change identification is identified by overlaying all land cover datasets that have been identified and delineated. Seven land cover classes were classified into 2 land cover classes: forest and non-forest. The terms deforestation and reforestation are used to identify land cover changes as a result of the Covid-19 pandemic. The Ministry of Environment and Forestry states that deforestation is the change of land cover from natural forest class to non-forest class (Kementerian Lingkungan Hidup dan Kehutanan, 2022), and reforestation is the change in cover from non-forest to forest class. This study does not use accuracy analysis, interview techniques, and field observations for the land cover interpretation because it focuses more on land cover changes that are easier to distinguish between forests and non-forests and does not use ground control points (GCPs) for the satellite image rectification process.

Table 1 Time and platform of image data acquisition

Acquisition time	Remarks	Source
July 29th, 2018	Before the Covid-19 pandemic	Satellite imagery from google earth
June 18th, 2020	During the Covid-19 pandemic	Satellite imagery from google earth
May 30th, 2023	After the Covid-19 pandemic ends	Satellite imagery from google earth

Table 2 Mansinam Island land cover interpretation key

Land cover class	Interpretation	
	Key	Visual 1:2,500
Forest	Rough texture and green objects	
Agricultural land	Smooth texture, brown to green object, looks like low vegetation, and is located on the roadside or between the forest cover	
Shrubs	Slightly smooth texture, green dominant objects, and vegetation appears to be lower in height than forest	
Bare land	Objects are generally white and brown in color and are located near roads	
Built-up land	Diverse object colors, associations with roads, regular and clustered objects	
Water body	Objects are dark to light brown and smooth in texture	
Plantation	Green-colored objects, rough texture, and clustered/ regular objects	

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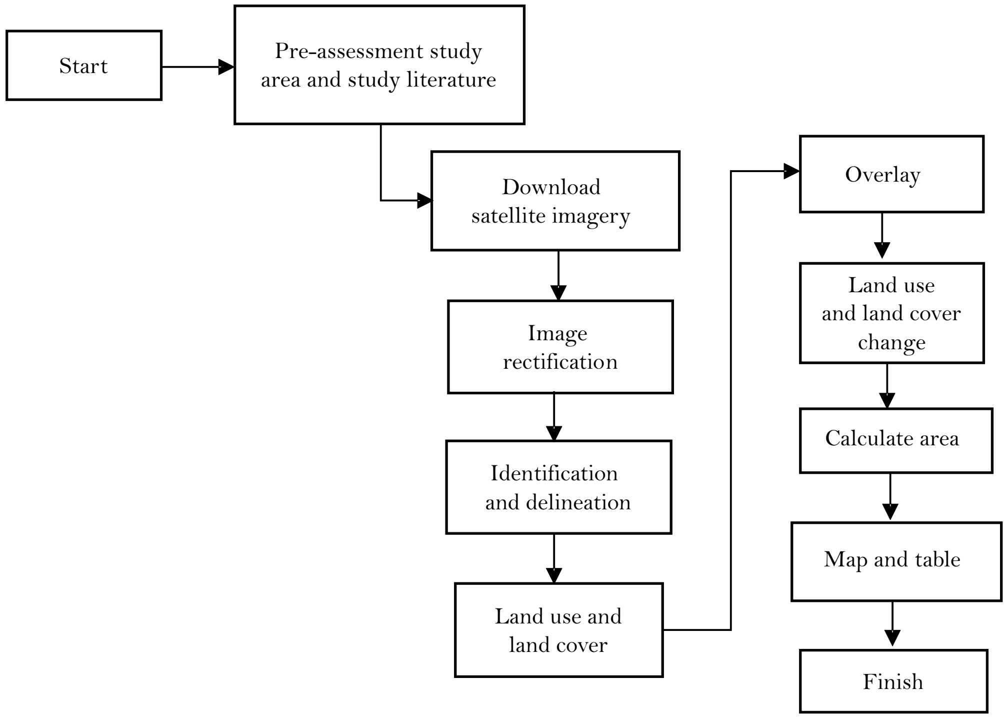

Figure 3 Flow chart for land cover change analysis in this study.

Results and Discussion

Land use and land cover GE satellite images from 2018, 2020, and 2023 that have been rectified have a resolution of 0.8 m pixel^{-1} (Figure 4). The very high resolution of the GEI is useful for distinguishing forest and non-forest land cover. Based on GEI, seven land cover classes with a total of 51 polygons in 2018, 137 polygons in 2020, and 76 polygons in 2023 were successfully identified. The smallest area identified was 0.013 ha.

Mansinam is an inhabited island and has several forest ecosystem types, such as lowland tropical forest and coastal forest (Hematang et al., 2022). Generally, the land cover of Mansinam Island from 20182023 is dominated by forest cover, with the smallest area in that period being ± 341 ha, or 84% of the total island. Forest cover continues to dominate on this island from 2018 to the present, with cover dynamics due to interactions with humans (Figure 5). Some land cover classes did not change during the observation period, such as plantations and water bodies. Both of these land cover classes tend to be stable because there is no intervention from human activities or naturally occurring changes.

Figure 6 shows a significant change in Mansinam's forest cover. Before the Covid pandemic in 2018, Mansinam's forest cover was 357.1 ha, and during the pandemic in 2020, with the PSBB policy, forest cover decreased by 4.3% to 341.6 ha. The change or transition of forest cover in 2020 caused significant changes in several land cover classes, such as bare land cover increasing by 8.7 ha, or 80%, agricultural land going up by 3.6 ha, or 75%, and the shrub class increasing by 3.2 ha, or 55% of the area in 2018. Hematang et al. (2024) also claimed that Mansinam forest cover was identified as 302 ha or 75% using very high-resolution drone imagery in 2020. This figure is by far lower due to differences in the resolution of the imagery used.

GEI has the advantage that there are new satellite image updates with a high spatial resolution of less than 1 m (Malarvizhi et al., 2016), the image size is relatively smaller than other satellite imagery, and the use of the platform is convenient through an attractive interface. However, image updates from GEI are only available in certain areas, such as urban areas that tend to have fast dynamics of regional change, so other areas tend to have out-of-date images. GEI also has inconsistent image quality for all regions (Yu & Gong, 2012), so that high-resolution GEI only covers 2030% of the earth's surface (Stensgaard et al., 2009). GEI also has the disadvantage of a limited total of bands (Li et al., 2020) and only displays satellite images with a combination of the band's "natural color". However, GEI can still be used to identify land cover classes by manual on-screen digitization by interpreters. In addition to using GEI, land cover monitoring can also be used through a combination of satellite imagery and unmanned aerial vehicles (UAV) (Diack et al., 2024), using UAVs with ultra-high resolution orthophotos (Hematang et al., 2024), or cloud-based land cover monitoring using the GEE platform (Ghosh et al., 2022; Jodhani et al., 2024).

Land cover change Land cover of Mansinam Island is dynamic and static. Dynamic land cover includes forests, agricultural land, shrubs, and built-up land, while static land covers are water bodies and plantations. The result displays that land cover changes occurred in 2020 and 2023. There were significant land transitions during the Covid-19 pandemic and after the pandemic. The significant land

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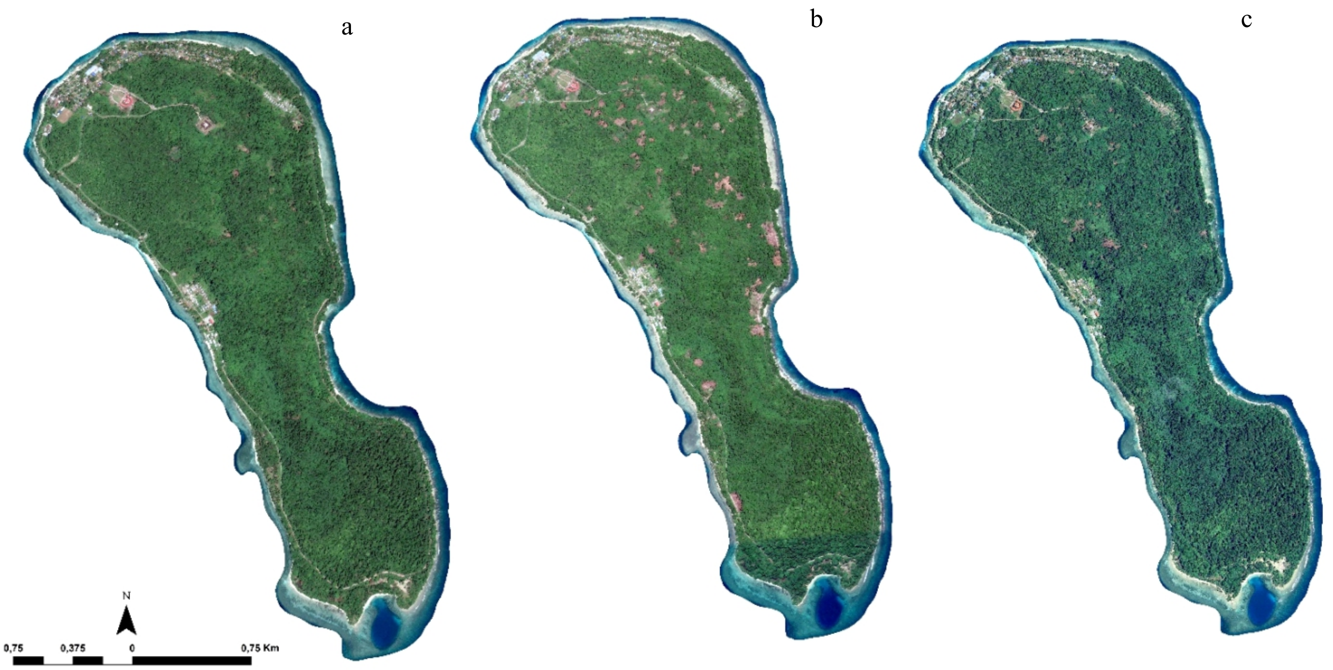

Figure 4 Image of Mansinam Island. Images from Google Earth in (a) 2018, (b) 2020, and (c) 2023 on a spatial resolution of 0.8 m pixel^{-1}.

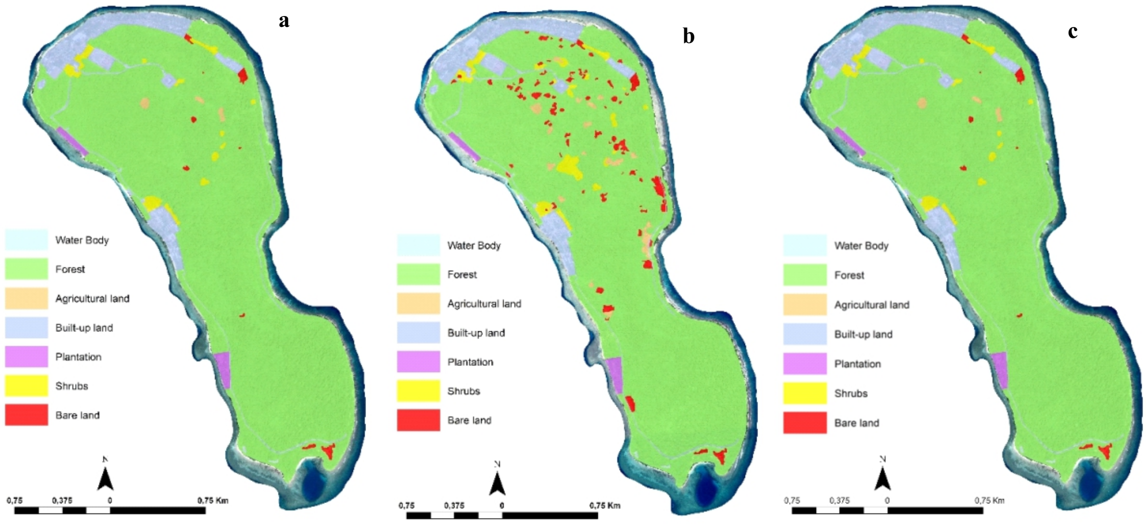

Figure 5 Comparison of Mansinam Island land cover (a) before the Covid-19 pandemic, (b) during the pandemic and (c) after the pandemic.

transitions occurred in three land cover classes, i.e., agricultural land, bare land, and forest. Before the pandemic, the activities of the people of Mansinam Island outside the island were quite diverse. Forum Generasi Muda GKI Papua Barat (2022) in his study stated that there are several community activities such as trading fish (fishermen), working in offices (private and government), shopping for daily needs, going to the hospital, visiting family, and attending school. The anxiety and fear of the Covid-19 virus made the community not only implement PSBB but also local lockdown. When local lockdown was implemented, all activities outside the island were stopped or restricted. Mansinam residents stayed and did more activities on the island as a way of protection from the threat of virus transmission.

Since the Covid-19 virus spread in early 2020, the people

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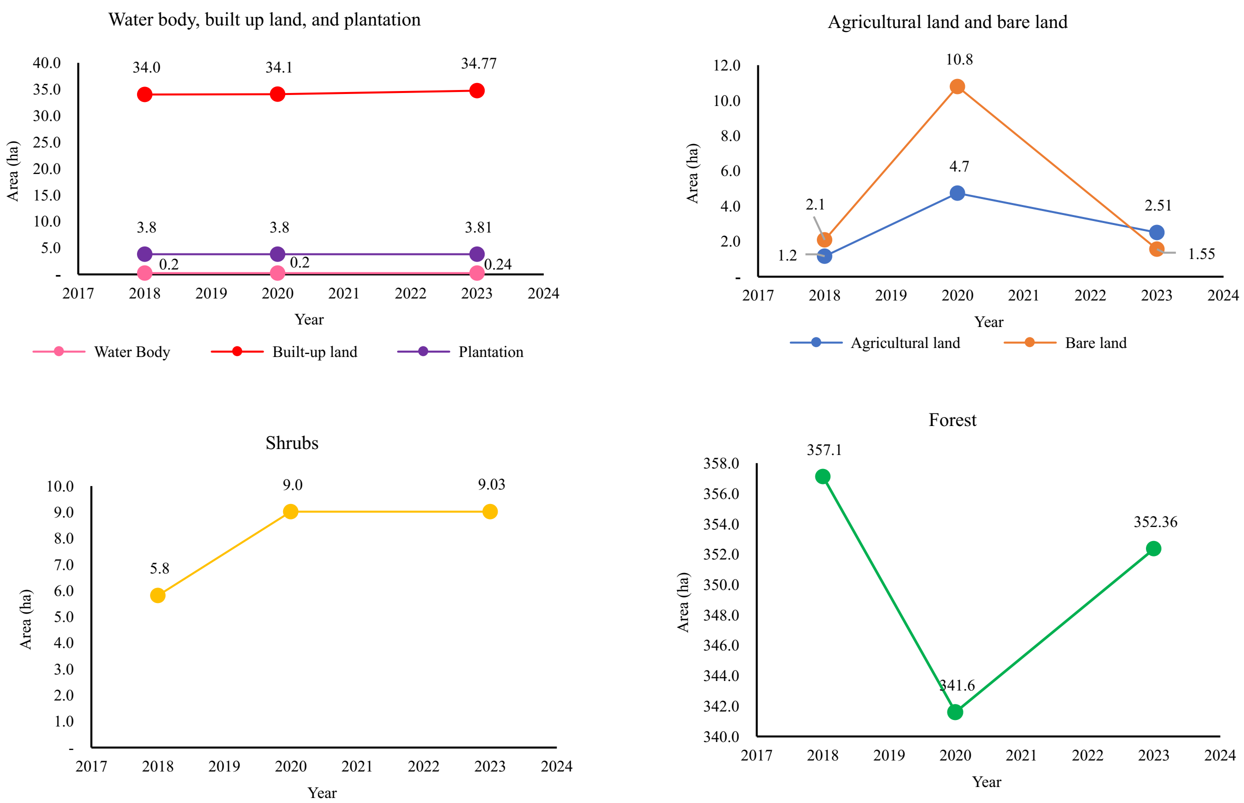

Figure 6 Dynamics of Mansinam cand cover area in 2018, 2020, and 2023.

of the world, including the people on Mansinam Island, have become afraid, stressed, and anxious about the virus (Bäuerle et al., 2020). This is because Mansinam Island is only 1.2 km from Manokwari City and can be arrived at in ± 10 minutes by boat. In response to the pandemic, the people of this island initiated close access in and out of the island (local lockdown). When accessibility is limited, community activities are focused on and around the island. As a consequence, it is expected to have an impact on the ecosystem on the island. Jayasundara et al. (2024) also stated that the interaction between communities and forests will increase as one of the community responses during the Covid-19 pandemic.

The study shows that there was deforestation of 15.6 ha in 2020, namely from forest cover to agricultural land (3.5 ha), forest to bare land (8.8 ha), and forest to shrubs (3.2 ha). 104 polygons experienced deforestation in 2020, with details of 18 areas deforested to agricultural land, 77 polygons deforested to bare land, one polygon for deforestation to built-up land, and eight polygons for deforestation to shrubs. Table 3 displays all the information about polygons on Mansinam Island that experienced land cover change, specifically forest deforestation. This study also found that during the period 2020–2023, there was deforestation in 20 locations/polygons (Table 4). Noticeably, in that period, there was also reforestation in 87 polygons, in which 60 polygons were bare land and 18 polygons were agricultural land in 2020. These polygons then turned back to forest cover in 2023. This indicates that several non-forest land cover classes on Mansinam Island during this time experienced a transition or succession to become forest cover again after the Covid policy was stopped. The distribution of forest cover change can be seen in Figure 7.

Bare land cover increased by 80% in 2020 compared to 2018 or went up by 8.7 ha to 10.4 ha, while in 2023 bare land cover decreased to 1.55 ha (85%). Of the total 10.4 ha of bare land in 2020, 8.8 ha, or 81%, is forest conversion or forest deforestation. This deforestation can be explored on satellite imagery in 2020 (Figure 4) that illustrates the presence of bare land due to land clearing of forest cover. This bare land cover will be used as agricultural land to fulfill daily needs during the implementation of local restrictions on Mansinam Island. Through this study we found agricultural land cover and bare land have a strong relationship in the context of food fulfillment during the local lockdown in Mansinam Island. Before land is utilized as agricultural land, a land-clearing process including the conversion of forest cover, was carried out by the community. After land clearing, some agricultural commodities are planted and turned into agricultural land. We try to calculate, in 2020, agricultural land cover increased by 75.3% to 4.7 ha compared to the previous year. However, in 2023 agricultural land cover decreased to 2.51 ha (47%). Of the total area of 4.7 ha of agricultural land in 2020, 74% or 3.5 ha is a shift in forest cover to agricultural land. With this pattern of cover change, it can be seen that deforestation on Mansinam Island is more due to the expansion of new agricultural land to fulfill the need for food during the pandemic. Hematang et al. (2024) also stated that the decline in primary forest on Mansinam Island was due to conversion into new agricultural land.

As a consequence of the local lockdown, food availability in Mansinam has become a new problem. On average,

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Table 3 Total polygons for land cover transition 2018–2020

2018	2020 Agricultural land	Bare land	Built-up land	Forest	Plantation	Shrubs	Water body	Total
Agricultural land	2					1		3
Bare land	2	6		**2**		1		11
Built-up land			14					14
Forest	**18**	**77**	**1**	28		**8**		132
Plantation					2			2
Shrubs	2	4				11		17
Water body							2	2
Total	24	87	15	30	2	21	2	181

Note: The red color is deforestation and the green color is reforestation

Table 4 Total polygons for land cover transition 2020–2023

2020	2023 Agricultural land	Bare land	Built-up land	Forest	Plantation	Shrubs	Water body	Total
Agricultural land	6			**18**				24
Bare land	3	8	1	**60**		15		87
Built-up land			15					15
Forest	**10**	**6**	**3**	10		**1**		30
Plantation					2			2
Shrubs				**9**		12		21
Water body							2	2
Total	19	14	19	97	2	28	2	181

Note: The red color is deforestation and the green color is reforestation

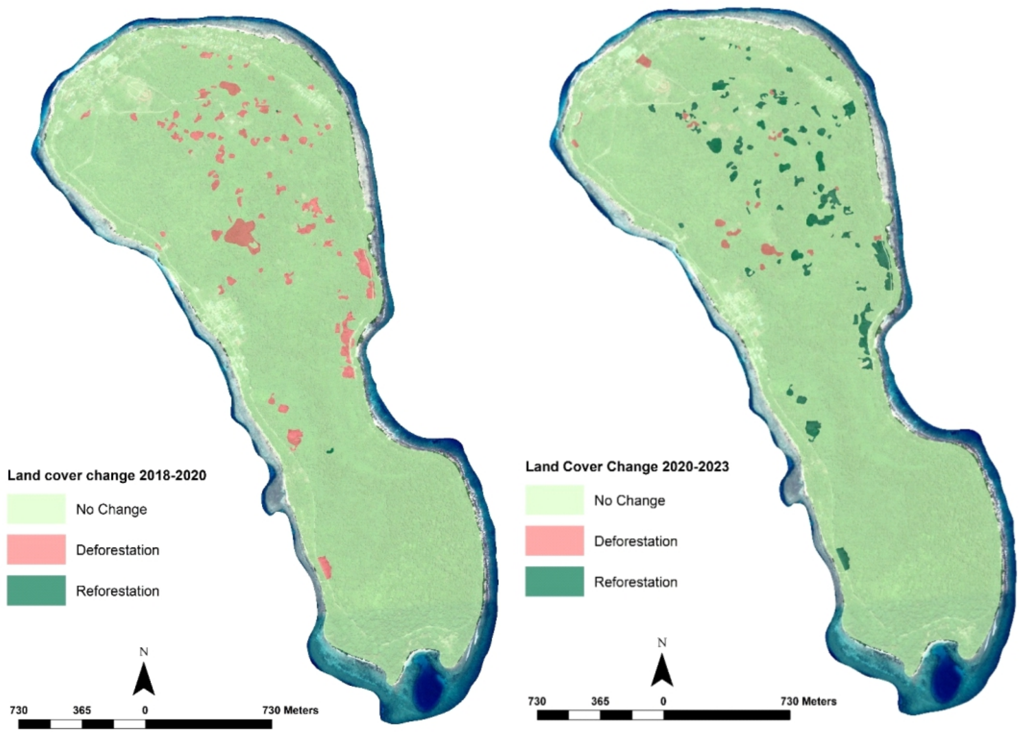

Figure 7 Comparison of land cover changes on Mansinam Island during the Covid-19 pandemic (2018–2020), and after the Covid-19 pandemic (2020–2023).

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Table 5 Land cover transition matrix 2018–2020

2018	2020							Total (ha)
	Agricultural land	Bare land	Built-up land	Forest	Plan-tation	Shrubs	Water body	
Agricultural land	0.8					0.4		1.2
Bare land	0.2	1.7		**0.1**		0.1		2.1
Built-up land			34.0					34.0
Forest	3.5	**8.8**	**0.0**	341.3		**3.2**		357.1
Plantation					3.8			3.8
Shrubs	0.3	0.3				5.3		5.8
Water body							0.2	0.2
Total (ha)	4.7	10.8	34.1	341.3	3.8	9.0	0.2	404.3

Note: The red color is deforestation and the green color is reforestation

Table 6 Land cover transition matrix 2020–2023

2020	2023							Total (ha)
	Agricultural land	Bare land	Built-up land	Forest	Plan-tation	Shrubs	Water body	
Agricultural land	0.9			**3.9**				4.7
Bare land	0.1	1.1	0.1	**7.9**		1.5		10.8
Built-up land			34.1					34.1
Forest	1.5	**0.4**	**0.6**	339.0		**0.1**		341.6
Plantation					3.8			3.8
Shrubs				1.6		7.4		9.0
Water body							0.2	0.2
Total (ha)	2.5	1.6	34.8	352.4	3.8	9.0	0.2	404.3

Note: The red color is deforestation and the green color is reforestation

people's primary energy source is rice consumption. Other than rice, there are several local foods that are also consumed, such as corn (*Zea mays*), bananas (*Musa acuminata*), cassava (*Manihot esculenta*), sweet potatoes (*Ipomoea batatas*), peanuts (*Arachis hypogaea*), and taro root (*Colocasia esculenta*). This type of commodity is so easy to cultivate that it is popular for planting on traditional agricultural land. FOLU Coalition (2019) stated that more than 80% of rice was sourced from outside West Papua. This indicates that food availability (rice) is highly dependent on other regions, and this condition will be even more difficult since the food supply chain has changed significantly during the pandemic (Bilan, et al., 2023). To increase food availability, it is necessary to expand existing agricultural land and convert land into new agricultural land (Bilan et al. 2023; Chebby et al. 2023). This is one of the factors underlying a lot of forest cover that was converted to non-forest cover during the pandemic on Mansinam Island.

During a pandemic, food is one of the basic needs besides medical care. Food availability and accessibility must be prepared as a consequence of the local lockdown. To provide food, many people temporarily changed their profession to become farmers and make new agricultural land by converting various land covers, including forests. It is one of the main keys to getting through the pandemic crisis (Halimatussadiah et al., 2022) because Covid-19 has affected food availability, access, and stability (Laborde et al., 2020). Mansinam's 20182020 land transition data shows an increase in the activity in and around forest cover due to the prolonged lockdown policy. However, land clearing, including forests, was carried out based on customary rules. For the native Papuans, forest tenure is one part of the customary land or *"tanah adat"* (Sopaheluwakan et al., 2023). Generally in Papua, customary forest tenure is claimed by several clans or individuals from a clan. Each clan or individual has been given access or claim rights to land tenure from previous generations and can know the boundaries of customary territories (customary forests) between clans or individuals. Forest resources such as timber and non-timber forest products can only be utilized in accordance with the customary forest of each clan or individual. Anyone who wants to take forest resources outside their customary forest must obtain permission from the customary forest owner. As a consequence, land use, including forests, can only be carried out based on agreed *"tanah adat"*. This factor underlies the spatial distribution of deforestation for agricultural land not in a compact area. After the pandemic ended with the revocation of the PSBB policy by the government, economic and other activities began to return to normal so that community interaction with forests began to decline. Figure 5 and Table 6 shows an increase in forest cover by 10.7 ha in 2023 (3%) from the area of forest cover in 2020. The low frequency of interaction with forests and agricultural land after the pandemic affected these areas that were previously bare land and agricultural land, which then naturally changed into vegetated areas, such as shrubs or secondary forests (Figure 7). Shrubs on satellite imagery can also indicate the presence of agricultural land (De & Maitra, 2021). One of the classifications of agricultural land in Papua is agricultural land mixed with shrubs. Generally, this agricultural land is planted with certain commodities that can survive despite the surrounding shrubs. Table 5 shows that there was a land transition in 20182020 from forest cover to shrubs covering an area of 3.2 ha. Deforestation is suspected to be unproductive agricultural land or agricultural land mixed with bushes.

Forests, gardens, or parks are considered to provide a sense of comfort and calm to society and then become an alternative place to interact. In Papuan context, the forest is considered a place to carry out various activities other than formal work. The hunting activity, looking for firewood, and making small-scale agricultural land has become a routine for Papuans to interact with the forest. Therefore, during the pandemic, Papuans will spend more time in the forest, particularly those who live on small islands such as Mansinam. The high frequency of interaction between the community and the forest during the pandemic will have an impact on the forest. Deforestation is one of the impacts of increased interaction with forests during the pandemic. Brancalion et al. (2020) stated that there was a significant increase in deforestation during the Covid-19 pandemic in almost all tropical countries. Deforestation during the pandemic is due to several factors, such as budget reduction, reallocation policies for forest management (Singhal et al., 2024), and remote monitoring and management of forests (Jayasundara et al., 2024). The effects of Covid are also felt on agroforestry farmers that were during the pandemic, there was a decline in product trading prices, an increase in production costs (Sanudin et al., 2023), and a decrease in ecotourism visits and income (Maraseni et al., 2022).

The limitation of this study is the unavailability of ground-checking data from the identification of land cover. Visually, land cover can still be distinguished well because GEI has a very high resolution. Olfato-Parojinog et al. (2023) and Potere et al. (2009), in their study used GEI as a reference to calculate land cover accuracy from satellite imagery. This study also did not use GCPs to improve geometric accuracy, so that geometrical errors are possible. Hematang et al. (2024) stated that not using GCPs would only impact the positional accuracy but not the accuracy and results of land cover class interpretation, although the use of GCPs could be considered for a similar method in future studies. Further studies are needed on the structure and composition of species in vegetation areas that experienced deforestation during the pandemic. This is essential to determine the rapid recovery of natural vegetation on Mansinam Island. Comprehensive studies related to occupational changes due to the pandemic also need to be carried out to determine the interaction between forests and the occupations of the Mansinam people before and during the pandemic.

Conclusion

This study discovered that during the Covid-19 pandemic, there had been a significant transition or change in forest cover on a small populated island, including Mansinam Island. During the pandemic, tropical forests on Mansinam Island were deforested. However, forest reforestation increased after the pandemic. Deforestation on Mansinam Island during the pandemic was 15.6 ha, and reforestation was 13.4 ha after the pandemic ended in 2023. Another important finding is that 78.9% of the total deforestation was due to forest conversion to bare land and agricultural land. The main factor of deforestation on small islands during the pandemic was the increase in new agricultural land for food availability. This study also claimed that forests on other populated small islands are likely to experience deforestation due to the Covid-19 pandemic. Future studies are needed to determine the structure and composition of species in deforested areas during the pandemic and also related to changes in the occupations of Mansinam people during the Covid pandemic.

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