

Determining the Impact of the COVID-19 Lockdown on Mangroves of a Class C Coastline in Iloilo City, Philippines through Remote Sensing

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Article Info	Abstract
Submitted: Jun. 27, 2023 Approved: Oct. 22, 2023 Published: Dec. 31, 2023 Keywords: QGIS mangroves pandemic remote sensing COVID-19 lockdown	The growth of mangroves is negatively impacted by human activity; however, lockdowns were imposed across the Philippines during the COVID-19 outbreak, resulting in a decrease in human activity. This study determined the lockdown's impact in terms of the decrease in human activity on the mangroves in the Batiano River, Iloilo City, Philippines. The mangrove area was mapped yearly from 2017 to 2021 using the Quantum Geographic Information System (QGIS). Percent changes in the area every year were computed and showed results of 0.57%, -0.09%, 2.22%, and 1.08% in 2018 to 2021 respectively, compared to the immediate previous years. The marked increase from 2019 to 2020 can be attributed to mangrove cutting prohibition and preservation by the Department of Environment and Natural Resources (DENR). The percent change from 2020 to 2021 is higher compared to the years with no interventions and lockdowns, but cannot be attributed to the lockdown alone.

Introduction. - Mangroves are types of trees that grow near bodies of water, such as rivers, seas, and other coastal areas. These types of trees are in decline due to anthropogenic factors which include conversion of the area to fish and shrimp ponds and urban development, which occupy the area of mangrove forests; logging (both legal and illegal), which reduces mangrove forests; and pollution [1,2]. The area that mangroves occupy in the Philippines has diminished from 500000 ha in 1918 to 120000 ha in 1994 because of natural and anthropogenic factors [3]. There have been multiple efforts to restore the mangrove forest cover in the country, done by the government and non-government organizations (NGOs), but until now, the mangrove forest cover has continued to be in danger [4]. However, in March 2020, lockdowns were implemented all over the country, which restricted going out unless necessary [5]. Land, water, and air pollution, which are some factors in the decline of mangroves, have decreased during the lockdown period, as shown in the studies by Aunan et al. and Diraviya et al. [6,7]. As it has been established that mangroves are also greatly affected by human activities and pollution, mangrove forests can be another metric by which the effect of the lockdown can be measured. In this study, the possible impact of the lockdown on the mangroves in the Batiano River, Iloilo City was determined by mapping using the Quantum Geographic Information System (QGIS) software [8]. The Batiano River is home to several marine species, with 16 of the 35 species of mangroves found in the Philippines, and is also significant for the fishing industry of the city, making the site significant for this study [9,10]. This study determined the impact of the lockdown on *Avicennia marina* mangroves in the Batiano River, Iloilo City in 2017, 2018, 2019, 2020, and 2021 by calculating the

area of mangroves each year and comparing the percent changes for every two years to analyze the trend in mangrove growth pre and post-lockdown.

With this, the study specifically aimed to:

- (i) determine the area of mangrove cover (10° 41' 31"N to 10° 41' 18"N and 122° 33' 00"E to 122° 33' 13"E) in the Batiano River, Iloilo City during 2017, 2018, 2019, 2020, and 2021 using QGIS;
- (ii) solve for the percent change in the area of mangrove cover yearly; and
- (iii) compare the percent changes of the aforementioned years.

Methods. - The methodology consisted of four major steps: gathering and georeferencing the satellite images of the chosen study site every year from 2017 to 2021 using Google Earth Pro and Smart GIS; mapping the mangroves by tracing them using polygons; calculating the mangrove area via the drawn polygons; and analyzing the data by comparing the percent changes during each year.

Study site. Iloilo City is a highly urbanized city in Western Visayas. The city is significant in providing function to the region for trade and commerce, education, research, and tourism. Furthermore, all of the barangays and districts comprising the city have also been classified as urban [10].

This study's chosen sampling site is located in the Batiano River, Iloilo City, Philippines (from 10° 41' 31"N to 10° 41' 18"N and from 122° 33' 00"E to 122° 33' 13"E). The Iloilo-Batiano River System falls under the



classification of Class C, which can be fishery water, recreational water for boating and fishing, or agriculture, irrigation, and livestock watering. This makes the river significant to the aquaculture, boating, and agriculture industries of Iloilo City [11]. The mangrove forest is also directly adjacent to a coastal community. Moreover, the rivers are home to 16 out of the 35 species of mangroves found in the Philippines, including one rare species [10]. The local government of Iloilo City declared through Executive Order 055 - Series of 2020 that the city would be put under enhanced community quarantine (ECQ) during 2020, making the chosen site suitable for assessment of the effects of the lockdown. The site's satellite image for the year 2021 is shown in Figure 1.

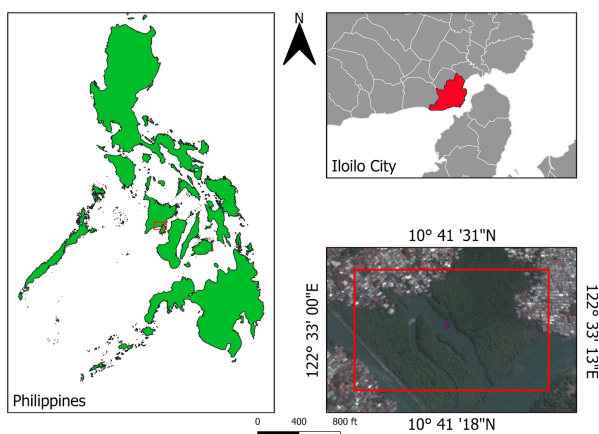


Figure 1. Study Site in the Batiano River, Iloilo City, Philippines.

The site was visited by researchers to determine the human activities, and mangrove tree planting and fishing were observed. The captain of the community was interviewed, and it was confirmed that the aforementioned activities were paused during the lockdown. The mangrove species used for tree planting in the area was confirmed to be *Avicennia marina*. Due to the area of mangroves being adjacent to a community, there was also a significant amount of trash found in the mangrove area and in the river. Shown in Figure 2 are the images taken during the inspection of the Batiano River and its mangroves.

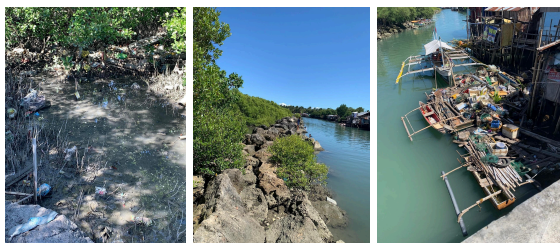


Figure 2. Mangrove area in the Batiano River.

Collection and Georeferencing of Satellite Images. One satellite image was collected each from April 27, 2017; February 9, 2018; March 2, 2019; April 18, 2020; and April 30, 2021. The images were obtained from Google Earth Pro version 7.3.2, an application that contains features such as being able to obtain a

satellite view of an area at different dates by changing the time. The satellite images needed for each date were then georeferenced in Smart GIS version 23.02.

Mapping of Mangrove Area. Before the mapping process, a site inspection was done to ensure that the plants being mapped are mangroves. The georeferenced satellite images' mangrove area was manually mapped in QGIS version 3.28.1 by tracing the area using a polygon and turned into a shapefile layer. If the mangrove areas were scattered, multiple polygons were created for each mangrove patch.

Calculation of Mangrove Area. After the tracing was completed, the attribute table of the shapefile layer was opened, and a new field was added, which served as the column for each polygon's area. The field calculator was then opened, and the command '\$area' was inputted, which automatically calculated the area size of each polygon. The given area sizes were then added to obtain the total area of the mangroves during the given year.

Data Analysis. The percent change in mangrove area cover was calculated. Next, the percent changes were then compared and the trend in the change of mangrove forest cover was observed. It was then analyzed whether or not the change in the mangrove area was affected by the lockdown. This is further explained in the discussion section.

Computing for the Percent Change in Mangrove Forest Cover. The percent change is the percentage of increase or decrease of mangroves in an area for the given year compared to the previous year. The percent changes were calculated using the formula:

$$\Delta\% = \frac{\text{Final Area} - \text{Initial Area}}{\text{Initial Area}} \times 100\%$$

The final area is the area of mangrove cover in a given year and the initial area is the area of the mangrove cover in the preceding year. A positive percentage indicated an increase in area while a negative percentage indicated a decrease.

Analyzing the Trend of Percent Changes. The percent changes that were calculated were used to assess the possible effects of the lockdown by analyzing the trend. The percent changes in the area both before and during the lockdown were compared.

Safety Procedure. This study mainly involved the use of digital data; therefore, the possible hazard that was foreseen was the radiation from the computers. This was mitigated by limiting the time spent facing computers, and while unnecessary, anti-radiation glasses were also reserved to be worn for protection in case problems arose when facing the computer during the data gathering procedure in the computer software. Furthermore, during the site inspections, there was a companion of legal age present in order to secure the site inspection process.



Results and Discussion. - The mangrove forest of the Batiano River, Iloilo City (from $10^{\circ} 41' 31''\text{N}$ to $10^{\circ} 41' 18''\text{N}$ and from $122^{\circ} 33' 00''\text{E}$ to $122^{\circ} 33' 13''\text{E}$) was mapped from 2017 to 2021. Shown in Figure 3 are the mapped areas of the mangrove forest, where the change in the area throughout the years can be visualized with the initial year 2017 and the final year 2021.

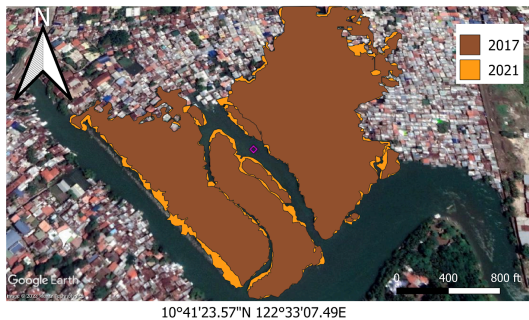


Figure 3. Change in mangrove forest cover, 2017 to 2021.

The areas calculated from the mangrove forest cover of the Batiano River, Iloilo City, Philippines, were 89283.79 m^2 (April 27, 2017), 89787.33 m^2 (February 9, 2018), 89707.32 m^2 (March 2, 2019), 91695.85 m^2 (April 18, 2020), and 92684.52 m^2 (April 30, 2021). Using the data gathered from the mangrove forest's area, the percent changes for every year were calculated. Percent changes in area were 0.57% from 2017 to 2018, -0.09% from 2018 to 2019, 2.22% from 2019 to 2020, and 1.08% from 2020 to 2021. A change of less than one percent was seen from 2017 to 2019, while an increase of more than one percent was seen from 2019 to 2021, with the highest increase from 2019 to 2020. Shown in Figure 4 is the trend of change in mangrove areas during the years 2017 to 2021.

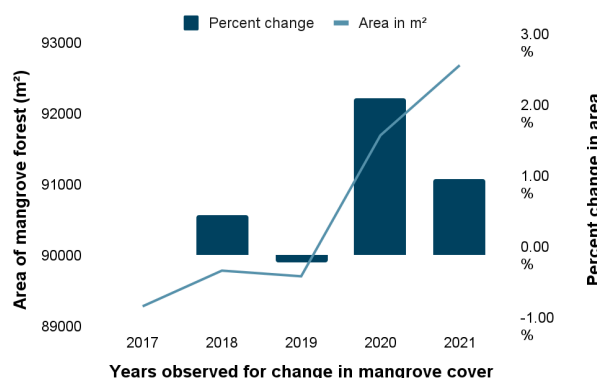


Figure 4. Area (in m^2) and percent change of mangrove cover in the Batiano River, Iloilo City, Philippines, 2017 to 2021.

Mangrove area growth from 2017 to 2019 was gradual, despite other human activities present in the area potentially impacting the mangrove forest, due to the area's mangrove tree planting initiative that started in 2016. The gradual increase in the area can be attributed to the time mangroves take to grow, which is usually ten to twenty years until they fully mature [12]. Moreover, the *Avicennia marina* species

of mangrove grows in sandy, muddy, and coralline rock substrates [13]. The area's substrate is muddy, as observed from visiting the site, which is suitable for the species of *Avicennia marina*. This could have contributed to the area consistently increasing throughout the years except from 2018 to 2019. Common human activities that impact mangroves are those that require utilization of the forests' area, such as the expansion of aquaculture, tourism, and coastal development [2]. Moreover, mangroves are also used as resources, such as wood for construction and fuel [4]. However, this is not the case for the mangroves in the Batiano River, as the human activities found on the site do not involve the destruction of mangroves, like fishing and mangrove tree planting. Lastly, the decrease in area from 2018 to 2019 could likely be a personal error due to the methods being done manually.

An increase of 1988.53 m^2 or 2.22% occurred from 2019 to 2020. Additional information about the activities on the mangroves in the Batiano River, Iloilo City was gathered for possible explanations of the marked increase in area. There were mangrove tree planting activities that started in 2016 by the community's local government, and the prohibition of the cutting of mangroves in 2019 based on Republic Act No. 7161. There was also an intervention by the Department of Environment and Natural Resources (DENR) to preserve the mangroves in the area, which occurred from 2019 to 2020. When human activities are persistent, action toward the restoration of mangroves is needed to combat the impact of human activities.

There was a 1.08% or 988.67 m^2 increase in the area of mangroves from 2020 to 2021, which was during the lockdown. This can also be attributed to the intervention of the DENR and the adopted ordinance. However, the mangrove tree planting paused during the lockdown. This left the mangroves to just grow naturally, causing a slower increase in the mangrove forest's area. Nevertheless, there were no other human activities ongoing due to the lockdown. This might have contributed to faster growth than in 2017 to 2019. Additionally, studies have shown that improvements in environmental conditions were caused by the restriction of human activity due to the lockdown, shown in indicators of air quality and water quality [8,15]. However, the same cannot be concluded for mangroves, as there are other factors, such as mangrove tree planting, that may impact the mangrove forest differently, and changes in mangroves take longer to be noticeable [13].

The lockdown only had a partially positive impact on mangroves, as before the lockdown was imposed, other factors already had a positive impact. Improvements in environmental conditions during the COVID-19 lockdown did not take effect as quickly in mangroves as it did in pollution, due to reforestation efforts being present, which already helped the mangrove forest's conditions before the lockdown. With that, any increase or decrease in the area of mangrove cover in the Batiano River cannot be solely attributed to the lockdown.



Limitations. The limitations of this study mainly focus on its methodology. First, the availability of satellite images was limited, which specifically led to one of the images being low quality, making it prone to personal errors. Second, the mangrove forest cover was only monitored for the total area occupied, which could be different when it comes to its vegetation and colonization rate. Third, although the area was visited to ensure that the plants seen in the satellite images are indeed mangroves, it cannot be assumed for the whole area. Some parts of the forest are too far to be visited, which makes it difficult to determine whether there are other plants growing adjacent to the mangroves. Lastly, the years used for comparing the trend of growth before and during the lockdown only generalized the years in which the lockdown occurred, not the actual time frame of the lockdown.

Conclusion. - Generally, there was an increase in the mangrove area from 2017 to 2021, with a marked increase from 2019 to 2020. Although during the lockdown, there was an increase in area, it is not as high as the increase in the preceding year. Thus, the increase cannot be solely attributed to the lockdown, but prior human interventions such as mangrove tree planting, regulations to protect the mangroves, and government interventions were able to contribute to the increase in the area of mangrove forest cover.

Recommendations. - Satellite images from Google Earth Pro were used for mapping, but other satellite websites could be used for image collection so that the satellite images to be used are ensured to be available and high quality to avoid errors in future studies. Due to the limited available images, not all months had satellite images in Google Earth Pro version 7.3.2. Determining the conditions of a mangrove forest could be done by using other assessments, such as colonization rate, which indicates how quickly mangroves occupy a new area, and vegetation index, which determines the density and vegetation of plants in an area based on their color. Selecting an area without rehabilitations for mangroves can determine the impact of the lockdown better. Focusing on changes that occurred monthly instead of annually could be done in future studies to have a clear comparison of the change that occurred before and during the lockdown. Other parameters such as land pollution and grassland vegetation could also be compared. Lastly, no satellite images for the year 2022 were available on Google Earth Pro, which made this study unable to describe the status of mangrove forests after the lockdown; therefore, it is recommended that studies in the future investigate the trend of mangrove area change post lockdown.

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