INVESTIGATING THE RELATIONSHIP OF WATER QUALITY ON LAND COVER CHANGE IN BORACAY ISLAND

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ABSTRACT:

Boracay Island, renowned for its pristine beaches, faced challenges arising from haphazard practices on infrastructure and tourism management. A rehabilitation program was initiated which resulted in a significant reconstruction on its land. This study investigates the impact of Land Cover (LC) change caused by the rehabilitation program on water quality parameters (chl-a and TSM) across three key periods: pre-rehabilitation (2017), rehabilitation (2020), and post-rehabilitation (2022). Utilizing Sentinel-2 imagery, quarterly assessments of chl-a and TSM concentrations are conducted to evaluate water quality. The findings revealed significant variations in chl-a and TSM with significance values of 0.043 and 0.014, respectively, within zone 1 of Boracay Island. Post-hoc test revealed differences in chl-a concentrations between 2017 and subsequent years (2020, $p = 0.038$; 2021, $p = 0.036$; and 2022, $p = 0.039$) and between 2019 and subsequent years (2020, $p = 0.043$; 2021, $p = 0.041$; and 2022, $p = 0.044$); as well as in TSM concentrations between 2017 and subsequent years (2020, $p = 0.006$; 2021, $p = 0.008$; and 2022, $p = 0.023$) and between 2019 and subsequent years (2020, $p = 0.014$; 2021, $p = 0.019$; and 2022, $p = 0.049$). However, no significant correlation exists between LC and water quality parameters. It is recommended to refine LC classification through high-resolution satellite imagery, consider extended timeframes, and investigate additional water quality parameters. This study contributes valuable insights into Boracay Island's environmental transformations, guiding sustainable coastal management in similar contexts.

1. INTRODUCTION

Boracay Island located in Malay, Aklan, Philippines, holds several awards and recognitions as one of the world's top beach destinations (Malig, 2012). However, the rapid growth of tourism back in the 1970s prompted haphazard practices on infrastructure and tourism management (Varga, n.d.). Additionally, the surge of tourists, unplanned developments, poor sewage system, and improper waste management caused a degenerating effect on the water quality and ecosystem of the island (Limates et al., 2016; Burgos, 2015). By 2018, a survey on the island's sewerage facilities showed that 85% of residential and commercial properties were pumping wastewater directly into the sea resulting in increased levels of coliform bacteria in its waters (DENR, 2019). This resulted in a rehabilitation program that ran from 2018 to June 2022.

The rehabilitation of Boracay Island made significant reconstruction on its land. DENR reported a total of 300 demolished establishments and structures along the beachfront, while over 1,000 structures were also demolished as part of their road widening program; over 100 sewage management facilities were built within hotels and business establishments (DENR, 2022). This significant land cover (LC) change in the island showed improvements on fecal coliform levels thus probing for a deeper understanding on the relationship between water quality and land cover (LC). The advent of remote sensing made way for numerous studies determining the relationship of water quality and LC using remote sensing technology (Permatesari et al., 2017; Faiilagi, 2015).

Application of statistical tools in determining the relationship between water quality and land cover change has been implemented in various studies such as Li et al. (2012) and Tong and Chen (2002).

This study then aims to (1) identify the LC change of Boracay Island before (2017), during (2020), and after (2022) rehabilitation; (2) utilize Sentinel-2 MSI data, *in situ* data, and MODIS data for Chlorophyll-a (chl-a) and Total Suspended Matter (TSM) assessment; (3) provide a quantitative assessment using correlation analysis to determine the relationship between the water quality and LC change of Boracay Island.

2. MATERIALS AND METHODS

2.1. Study Area and Zones

Boracay Island is an island geographically located 11°57' N to 12°00' latitude, 121°56' to 121°57' E longitude, at the northwest corner of Panay with a land area of almost 1030 hectares, with 400 hectares classified as reserved forest land for protection purposes and the rest being agricultural land owned by the state (Lorenzo & Dedace, 2008). Its coastline length, approximately 24.36 kilometers (PhilAtlas, n.d.), is noted for its four-kilometer stretch beaches and Long or White Beach (Smith et al., 2011). The island's landmass consists of a thin topsoil layer which covers coralline limestone known as karstic soil, which is a porous substance that allows domestic wastes and effluents to easily penetrate and contaminate both the groundwater and the coastal waters (Limates et al., 2016).

Furthermore, Boracay Island can be divided into four zones, as shown in Figure 1, which were derived from the study of Tomoling (2014, unpublished), coinciding with the water quality monitoring stations set by DENR. These zones were distinguished by their unique characteristics, providing valuable insights into the diverse activities observed that impact water quality within each zone. Zonal analysis of the LC and water quality parameters (chl-a and TSM) was done to provide a deeper and accurate analysis of their correlation.

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Each of the zones are characterized by their land activities. Specifically, Zone 1 of the Island is distinguished as a highly urbanized zone and has a prominent role in the tourism sector, primarily due to the presence of the renowned "white beach" stations. This area serves as a focal point for tourist activities that attracts a considerable number of visitors. On the other hand, Zone 2 exhibits a lower level of tourism activity relative to other zones, despite the existence of notable attractions such as Puka Shell beach and a few resorts. Notably, this zone is characterized by its high vegetation area relative to built-up areas within the zone. Contrary to the latter, Zone 3 represents a densely urbanized area on the Island, characterized by the presence of Bulabog beach and high tourism activity. Like Zone 1, this zone serves as a significant hub for tourist activities which attracts a considerable number of visitors. Lastly, Zone 4 encompasses the location of the Cagban Jetty Port, serving as the primary arrival point of tourists who access the island by boat. This area plays a major role in facilitating transportation and as a gateway for tourist arrivals.

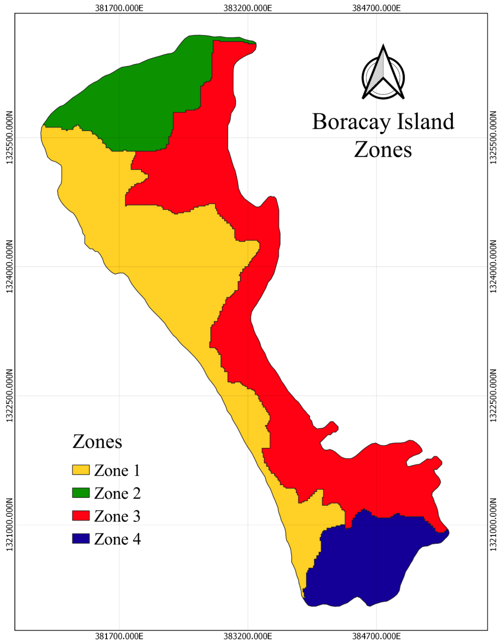

Figure 1. Zonal map of Boracay Island (Tomoling, 2014 [unpublished])

2.2. General Workflow

The general workflow, as shown in Figure 2 shows the general workflow performed in the study which is divided into four (4) main components - Data Gathering, Data Processing and Analysis, Data Validation, and Correlation.

Data gathering involves the Boracay boundary used as the ROI in the study; In-Situ TSM concentration from 2015-2022; extracted MODIS Chl-a values; collection of Sentinel-2 MSI images from inside the Google Earth Engine (GEE) cloud system; and acquisition of Sentinel-2 level 1C satellite images from 2017-2022. Data processing was divided into two (2) - data processing for LC classification and water quality parameters estimation. Data processing for LC classification involves building training data for classification, classifying the images using SVM classifier, accuracy assessment, and post processing using Majority Analysis. For the water quality parameters estimation, the data processing includes extraction of water quality parameter estimates using Case 2 Regional CoastColour (C2RCC) plugin in SNAP. Data analysis involves the analysis of changes with the water quality parameters and change detection of LC classes from the given timeframe. Data validation for the water quality parameters estimation was done through field data comparison from in-situ water quality measurements and MODIS data, whereas, accuracy assessment for LC classification was done through generating confusion matrix. Lastly, correlation analysis was performed to determine the relationship between the LC changes to the water quality.

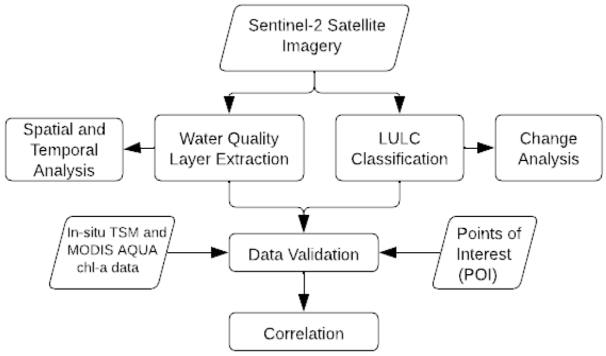

Figure 2. General Methodological Workflow

2.3. Methodology

2.3.1 Data Gathering. As listed in Table 1, the study used the Boracay boundary as the ROI of the study to limit the processes on the desired study area; the vector shapefile was downloaded from the available datasets online through Humanitarian Data Exchange.

A total of 24 Sentinel-2 MSI L1C images were used to extract the TSM and Chl-a data - one image for each quarter of every year from 2017-2022. Furthermore, three (3) Sentinel-2 L2A images directly acquired from GEE were used for the LC classification - one for each year 2017, 2020, and 2022. In all Sentinel-2 images used, cloud coverage was taken into consideration. However, due to the limited availability of satellite images, no specific threshold was followed. Instead, the images were checked individually to ensure that the study area was free of cloud coverage. Additionally, it's worth noting that Sentinel-2 L2A images were already atmospherically corrected products, so no preprocessing was required for these images.

Data	Purpose	Source/s	Resolution
Boracay boundary (vector)	ROI	Humanitarian data exchange	
In-situ TSM data from 2015-2022	Validation of extracted TSM layers	DENR-EMB	
MODIS-derived Chl-a data from 2017-2022 (16 images)	Validation of extracted chl-a layers	MODIS AQUA, GEE	Spatial Resolution: 500 m

Table 1. Summary of Data Used in the Study

Data	Purpose	Source/s	Resolution
Sentinel 2 - MSI L1C from 2017-2022 (24 images)	Extraction of quarterly chl-a and TSM layers in C2RCC	Copernicus Open Access Hub	Spatial Resolution: 4 bands at 10 m, 6 bands at 20 m and 3 bands at 60 m
Sentinel 2 - MSI L2A from 2017,2020, and 2022 (3 images)	LC classification	GEE	Spatial Resolution: 4 bands at 10 m, 6 bands at 20 m and 3 bands at 60 m

Table 1. Summary of Data Used in the Study (Continued)

The in-situ TSM data were acquired from the water quality parameters report from 2015-2022 of the Department of Environment and Natural Resources (DENR) Region 6 - Western Visayas office. Due to the unavailability of in-situ Chl-a data, MODIS AQUA in GEE was used to derive the Chl-a data. Both the in-situ TSM data and the MODIS-derived Chl-a data were used to validate the extracted TSM and Chl-a layers, respectively. However, due to the limited availability of satellite images, only 16 images from MODIS Aqua matched with the dates of the Sentinel-2 images, therefore, only 16 images were used in both Sentinel-2 and MODIS Aqua for comparison.

2.3.2 Land Cover Classification and Analysis. GEE was used for the classification of LC classes for the year 2017, 2020, and 2022. Separate scripts were written for each image for faster processing. The images chosen were all from the second quarter (April and May) of the year to avoid the effect of changing weather conditions. The Boracay boundary shapefile was uploaded into the scripts and the chosen images were clipped to serve as the ROI in the processing. Training data points were collected using random sampling covering the five (5) classes namely water, vegetation, built-up, bare land, and sand as shown in Table 2. These points were divided into 70% training and 30% test data for accuracy assessment. Supervised classification using Support Vector Machine (SVM) classifier was performed on the training data to produce the LC classification. In the study by Basheer et al. (2022), it was revealed that SVM outperformed other classifiers such as Maximum Likelihood (ML), Random Forest/Random Tree (RF/RT), Minimum Distance (MD), and Classification and Regression Tree (CART) when used to develop Land Use Land Cover (LULC) maps. Specifically, the study compared the different classifiers when used in GEE under two different satellite datasets - Landsat and Sentinel-2.

Accuracy assessment was also performed on GEE by calculating the accuracy parameters producer's accuracy, user's accuracy, overall accuracy, and kappa coefficient. For this study, we used a threshold of 85% for the accuracy of the LC maps to be considered acceptable. Post-processing was done to remove the spurious pixels via Majority Analysis in GEE. The area coverage of each land cover type was then calculated for each year.

Classes	2017	2020	2022
Water	120	205	186
Vegetation	120	200	150
Built-up	140	350	418
Bare land	120	140	120
Sand	127	325	300

Table 2. Training POIs for Each Class Per Year

The spatial and temporal analyses of the LC classification were done through post-classification comparison and change detection. Change detection refers to the process of identifying the amount of change in area of the LC classes for the given period. In this study the change detection statistical tool in QGIS was used. three (3) change detection analyses were done to see the magnitude of change for the period 2017 to 2020, 2020 to 2022, and 2017 to 2022.

2.3.3 Water Quality Extraction. Sentinel 2-MSI Level 1C were utilized for extraction of chl-a and TSM for the period 2017-2022 using SNAP Case 2 Regional CoastColour (C2RCC) processor. C2RCC in an algorithm that employs Inherent Optical Properties (IOPs) of water and spectral information from ocean color sensors, utilizing a combination of satellite and in-situ observations to train neural networks, enabling the estimation of water quality parameters such as chl-a and TSM, while incorporating pre-processing, atmospheric correction, and accounting for atmospheric effects to ensure accurate predictions (C2RCC, Documentation; NASA, SNAP data processors - C2RCC algorithm specification). There are 24 images used, one for each quarter of every year from 2017 to 2022, which were individually checked to ensure that the study area was free of cloud coverage. A salinity of 31 PSU and mean quarterly temperature (Table 3) computed from DENR in-situ data were used as input parameters for C2RCC.

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
2017	27.000	30.667	29.566	29.311
2018	30.000	30.000	30.000	30.000
2019	27.500	27.824	28.000	26.588
2020	27.810	30.838	30.408	27.962
2021	27.562	27.952	27.444	27.063
2022	24.965	28.111	29.340	29.542

Table 3. Quarterly Temperature (℃)

In validating the accuracy of the water quality parameters extracted from C2RCC, chl-a data from MODIS Aqua and in-situ TSM records were used. Specifically, validation of chl-a was done using the daily MODIS data collected from 2017 to 2022 via GEE. A 2 km buffer mask was applied to exclude areas beyond shallow waters. Selected dates that corresponded to the acquisition dates of Sentinel-2 images were used. The C2RCC-derived chl-a values were compared and correlated with MODIS data in assessing trends. For TSM, a region of interest (ROI) with a 20 m buffer around DENR monitoring stations were chosen in the C2RCC-derived TSM layers, wherein the mean concentration value of TSM were compared to the in-situ data from the DENR. Trend comparison and correlation were performed by plotting the predicted and observed values for evaluation.

2.3.4 Statistical Analysis. Zonal-level analysis of land cover (LC) using the Boracay zones delineated by Tomoling (2014, unpublished) and water quality parameters was conducted for detailed correlation assessment based on the tourist arrivals and land cover percentage among others. Annual chl-a and TSM variability was quantitatively analyzed using Analysis of Variance (ANOVA) on zone-specific mean values to identify if there was a significant change in the parameters over time. It was then followed by Fisher's Least Significant Difference (LSD) post-hoc tests in determining the specific years which had significant differences. XLSTAT Pearson Correlation (Equation 1) was applied to assess relationships before (2017), during (2020), and after (2022) rehabilitation, at a 0.05 significance level similar to mentioned studies (Li et al., 2012; Tong and Chen, 2002). The input variables used for correlation were chl-a and TSM concentration samples extracted from DENR water quality data from monitoring stations, extracted via Zonal statistics in QGIS, and the area for each land cover class, with confidence level at 95%.

$$t_{n-2} = \frac{r}{1-r^2}\sqrt{n-2} \quad (1)$$

t = Pearson Correlation Coefficient
n = sample size
r = correlation coefficient value

3. RESULTS AND DISCUSSION

3.1. Distribution of Land Cover Classification

All accuracy metrics reached the acceptable accuracy value of 85% across the period studied as shown in Table 4. It is worth mentioning that the accuracy assessment was solely based on the accuracy of the classifier using the 30% of selected POIs as a test set for validation. While this approach provides valuable insights into the land classification accuracy, it is acknowledged that the validation process could have been further improved by incorporating ground truth data or comparing the results with an existing land cover map of the study area. Regrettably, no pre-existing land cover map is available specifically for Boracay Island, thus limiting the available options for extensive validation.

LC Class	**2017**		**2020**		**2022**	
	Prod. Acc. (%)	User's Acc. (%)	Prod. Acc. (%)	User's Acc. (%)	Prod. Acc. (%)	User's Acc. (%)
Water	97.44	92.68	95.38	98.41	98.44	94.03
Vegetation	94.74	97.30	95.51	95.51	97.22	97.22
Built-Up	88.46	88.46	89.66	89.66	86.89	89.08
Bare land	85.00	87.18	95.24	93.02	86.84	94.29
Sand	94.87	94.87	93.14	92.23	92.86	90.10
Overall Accuracy	91.83%		93.24%		91.62%	
Kappa Coefficient	0.8974		0.9132		0.8891	

Table 4. Accuracy Assessment of LC Classification

The LC classification of the year 2017, 2020, and 2022 represents the before-during-after of the rehabilitation program. Area computation showed that the vegetation class consistently had the highest land cover (44-50%) during the three observed years closely followed by built-up (34-39%), while bareland, water, and sand cover a relatively small percentage of the island. Assessment of the LC maps shows changes in the areas of classified LC classes in the Island of Boracay over the five-year period (2017 – 2022). Evident inter-change from one class to the other from before and after the rehabilitation reveals the result of rehabilitation programs done in Boracay Island, specifically in the classes vegetation, built-up, and bare land.

The change analysis as shown in Table 5 highlights significant changes in land cover between 2017 and 2022. Notably, there was a substantial decrease of 59.79% in bare land from 2017 to 2020, followed by a further reduction of 20.41% from 2020 to 2022, resulting in an overall decrease of 68% during the five-year period. Conversely, there was an increase in vegetation of 8.79% from 2017 to 2020, and 4.09% from 2020 to 2022, leading to an increase of 13.25% from 2017 to 2022. The built-up areas experienced an increase of 13.51% from 2017 to 2020, but then saw a decrease of 2.46% from 2020 to 2022, resulting in an overall decrease of 10.72% from 2017 to 2022.

These changes could be the result of the rehabilitation and recovery activities done by the government in the Island. Activities such as ecosystem restoration, adding sewage treatment plants, demolitions of over 1,000 structures as part of their efforts to improve the Boracay circumferential road through road widening and implementation of a 12-meter road easement, and demolition of houses of illegal settlers (DENR, 2022), generally result in the inter-change of built-up area, vegetation or bare land. Furthermore, there is an increase of 6.7% in sand from 2020 to 2022, which can be the result of demolition and clearing of 300 structures at the beachfront in an effort to follow the 25+5-meter beach easement rule of the Island.

LC Class	**2017-2020**	**2020-2022**	**2017-2022**
	Percentage of change (%)	Percentage of change (%)	Percentage of change (%)
Water	-1.727	-0.982	-2.692
Vegetation	8.792	4.093	13.245
Built-Up	13.511	-2.463	10.715
Bareland	-59.794	-20.409	-67.999
Sand	-16.228	6.700	-10.615

Table 5. LC Change in Boracay Island (2017 - 2022)

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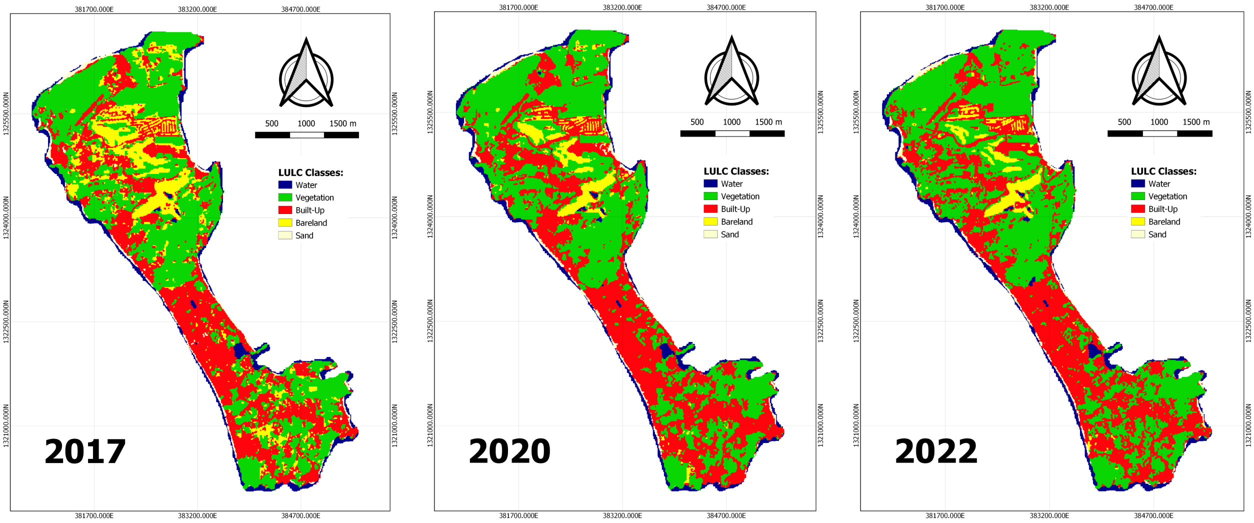


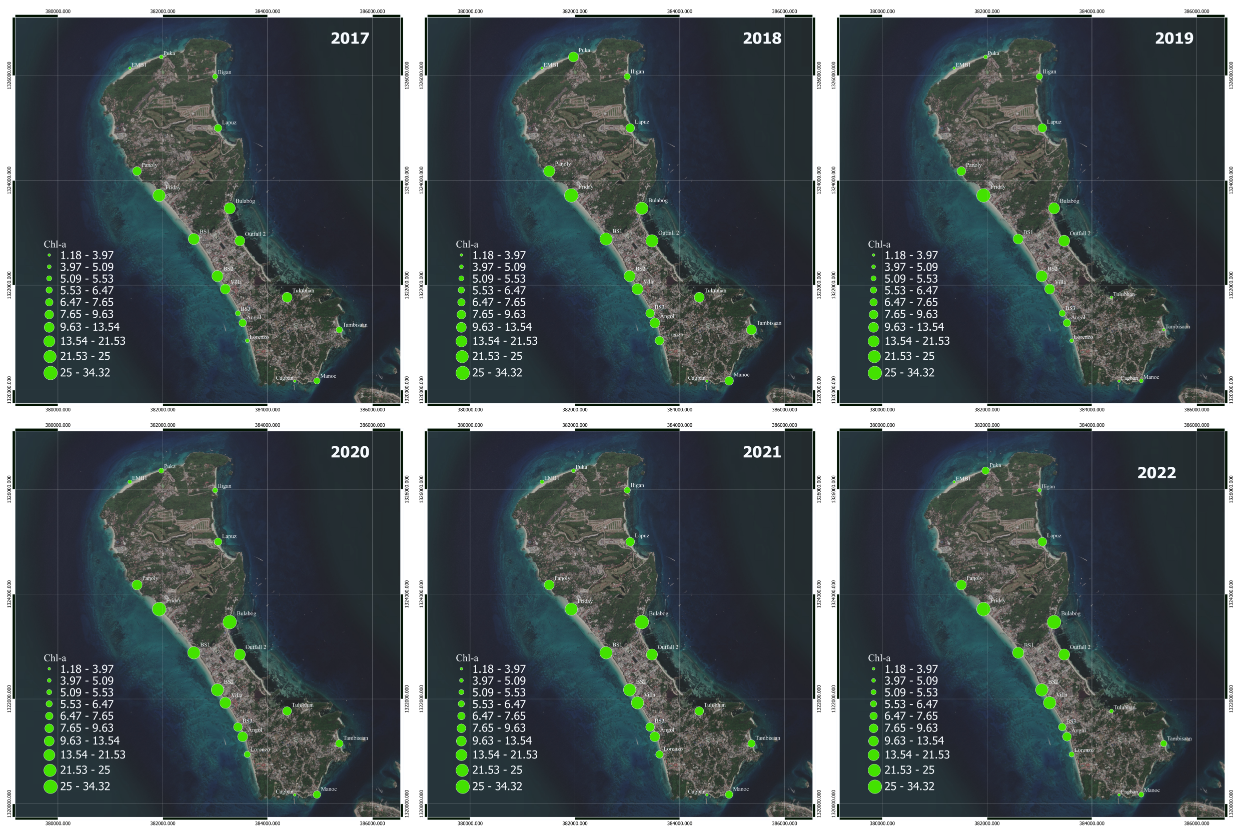
Figure 3. 2017, 2020, and 2022 Land Cover Maps of Boracay Island

3.2. Water Quality Analysis

Figure 4 displays the water quality levels of both TSM and chl-a observations from DENR WQ stations in the island. High chl-a levels were observed in stations located in Zones 1 and 3, specifically at Bulabog Beach, Outfall 2, Club Panoly Beach, Friday's Beach, Boat Station 1, Boat Station 2, and Angol Point, which are close to most of the developed areas in the island. The high level can be attributed to increased nutrient inputs from human activities, in comparison to Zones 2 and 4 with a smaller built-up extent.

TSM levels recorded in Zone 1 and 3 are also higher compared to the other zones, specifically in stations located in Bulabog Beach, Outfall 2, Club Panoly Beach, Friday's Beach, Boat Station 1, Boat Station 2, Boat Station 3, Angol Point, Tulubhan Pier, and Tambisaan Pier, which are in close proximity to developed areas. This suggests that the observed values are affected by human activities such as the discharge of domestic wastewater to sea water. Further, stations along Zones 2 and 4 show a relatively lower TSM concentration because of the limited extent of built-up in the area. Additionally, the close proximity of stations with high chl-a and TSM concentrations aligns with the strong positive correlation observed between these two water quality parameters

a)



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b)

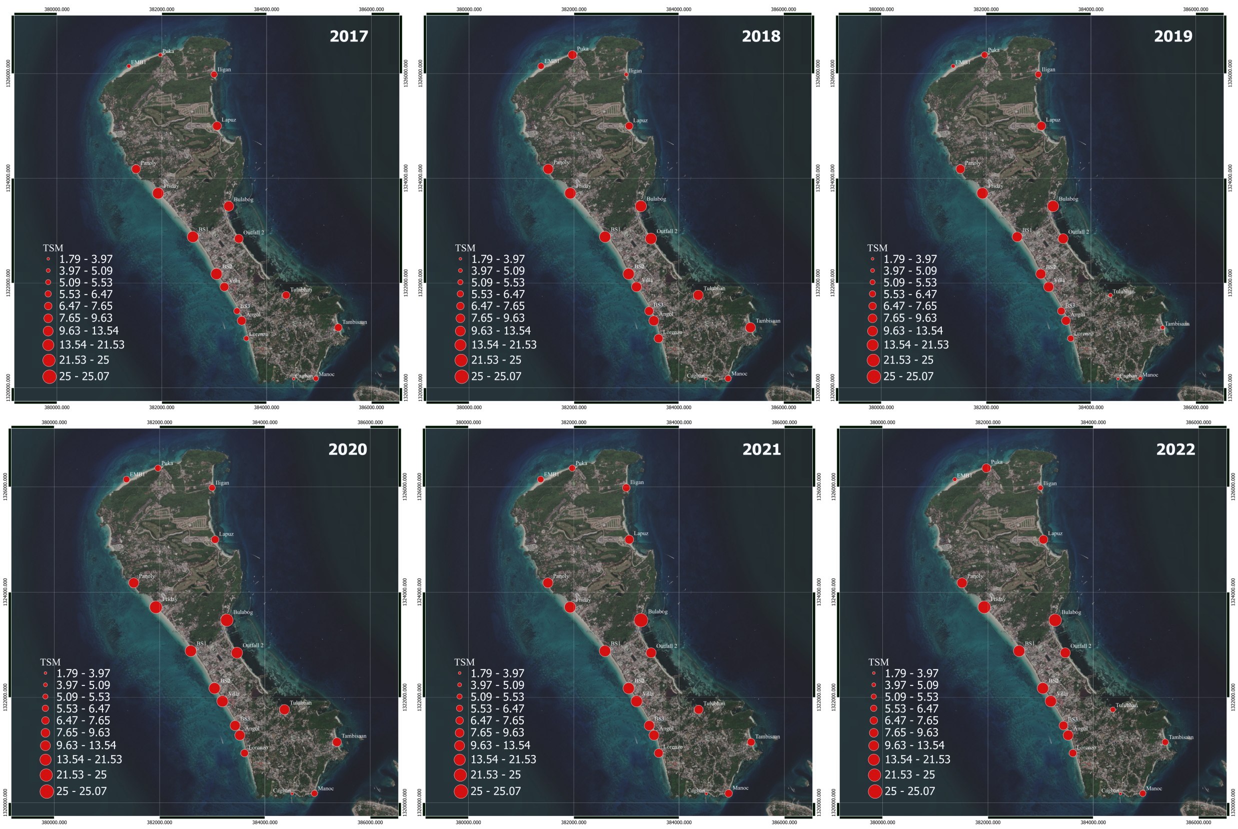

Figure 4. a) Chlorophyll-a and b) Total Suspended Matter (TSM) concentration from DENR Water Quality Stations from 2017 to 2022.

Figure 5 reveals the overall trend of water quality parameters over the years, capturing the influence of seasonal changes and the influx of tourists during peak periods. Notably, the concentrations of TSM and chl-a peaked during Q1 and Q4, while lowest levels were observed in Q2 and Q3. Peaks may be associated with tourist arrivals in Boracay coinciding with holiday season, in which further research may be done, and algal bloom, while low concentrations may be linked to rainy season and low tourist arrivals.

a)

b)

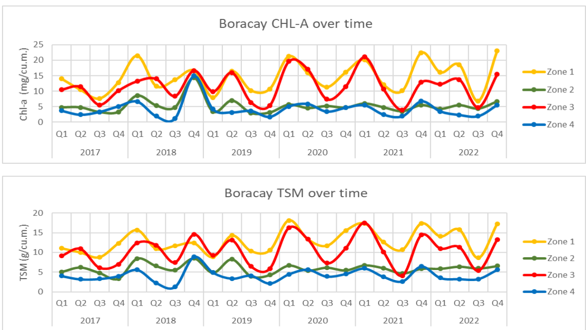

Figure 5. Average Quarterly a) chl-a and b) TSM Concentrations of zones from 01/01/2017 to 12/31/2022

The ANOVA findings in Table 6 indicate significant differences in Zone 1 over a five-year period for both chl-a and TSM concentrations with p-value of 0.043 and 0.014, respectively. Both chl-a and TSM showed an increasing trend in 2017, with significant differences in annual means between 2017 and subsequent years (2020-2022), and between 2019 and the subsequent years, highlighting rising chl-a concentrations. Despite these trends, TSM concentrations remained within DENR-set quality standards for Class SB waters.

Zone	Chl-a		TSM	
	f	*p*-value	f	*p*-value
1	**2.211**	**0.043**	**2.926**	**0.014**
2	2.041	0.092	1.264	0.297
3	0.903	0.481	1.049	0.392
4	0.710	0.620	0.273	0.926

Table 6. ANOVA results for Chl-a and TSM per zone

Results from post-hoc analysis shown in Table 7 showed that significant differences could be observed between the year 2017 and 2020, 2021, and 2022; and between 2019 and 2020, 2021, and 2022 for both water quality parameters indicating an upward trend from the 2017 to 2022, and 2019 to 2022. However, in the case of TSM concentration, despite the increasing trend, the values did not exceed the allowable levels of TSM set by the DENR for water classes SB and SC such as Boracay.

	Chl-a		TSM	
	Mean Diff	Sig.	Mean Diff	Sig.
2017 vs. 2018	-4.611	0.051	-2.103	0.156
2017 vs. 2019	-0.124	0.958	-0.466	0.753
2017 vs. 2020	**-4.900**	**0.038**	**-4.121**	**0.006**
2017 vs. 2021	**-4.950**	**0.036**	**-3.954**	**0.008**
2017 vs. 2022	**-4.879**	**0.039**	**-3.386**	**0.023**
2018 vs. 2019	4.486	0.057	1.637	0.269
2018 vs. 2020	-0.289	0.902	-2.018	0.173
2018 vs. 2021	-0.339	0.885	-1.851	0.211
2018 vs. 2022	-0.268	0.909	-1.283	0.385
2019 vs. 2020	**-4.775**	**0.043**	**-3.655**	**0.014**
2019 vs. 2021	**-4.826**	**0.041**	**-3.488**	**0.019**

Table 7. Post-hoc comparisons for Chl-a and TSM

	Chl-a		TSM	
	Mean Diff	Sig.	Mean Diff	Sig.
2019 vs. 2022	**-4.754**	**0.044**	**-2.920**	**0.049**
2020 vs. 2021	-0.050	0.983	0.167	0.91
2020 vs. 2022	-0.021	0.993	0.735	0.619
2021 vs. 2022	0.071	0.976	0.568	0.701

Table 7. Post-hoc comparisons for Chl-a and TSM (Continued)

3.3. Relationship between Water Quality and Land Cover Classification

The findings revealed that there is no statistically significant relationship between the water quality parameters (chl-a and TSM) and the land cover classes.

	Zone	Classes (r)				
		Urban	Vegetation	Bareland	Water	Sand
CHL-A	1	0.289	0.290	-0.291	0.241	-0.277
	2	0.158	0.240	-0.247	0.140	-0.010
	3	0.187	0.169	-0.185	-0.171	-0.188
	4	0.145	-0.222	-0.033	-0.197	-0.155
TSM	1	0.323	0.334	-0.328	0.244	-0.332
	2	0.173	0.277	-0.281	0.152	-0.002
	3	0.197	0.127	-0.167	-0.129	-0.188
	4	0.183	-0.146	-0.116	-0.200	-0.188

Table 8. Coefficient of correlation (r) of each class with respect to CHL-A and TSM

In the context of the urban class, Zone 1 displayed the highest r-values for both chl-a ($r = 0.289$) and TSM ($r = 0.323$). Similarly, within the vegetation class, Zone 1 exhibited highest r-values of 0.290 for chl-a and 0.334 for TSM. 0.334. However, it is essential to emphasize that the results did not establish a statistically significant relationship between the water quality parameters (chl-a and TSM) and the land cover classes.

Upon closer examination of the correlation matrix, it was observed that urban areas consistently displayed positive relationships with both TSM and chl-a across all zones, albeit the absence of statistical significance. This suggests that an increase in urban areas may potentially contribute to higher concentrations of water quality parameters in the surrounding waters of Boracay.

Conversely, vegetation exhibits positive relationships with chl-a and TSM across all zones, except for Zone 4, where negative correlations were observed (chl-a: $r = -0.222$, TSM: $r = -0.146$) Furthermore, bare land and sandy areas are negatively correlated with all water quality parameters, indicating that an increase in bare land and sand areas is indicative of decreasing chl-a and TSM concentrations.

Given the limited scope for further investigation within the island, the implications drawn from these results heavily relied on the available data and existing research conducted on the study area. The lack of a substantial connection between water quality parameters and land cover change highlights the influence of various natural factors such as rainfall patterns & hydrological processes, which can overlook the impact of land use activities on water quality.

4. CONCLUSION

The study assessed the relationship between the water quality (chl-a and TSM) and land cover change in Boracay Island from pre-rehabilitation to post-rehabilitation (2017 to 2022). LC change analysis showed significant change over the five-year period, specifically, vegetation, built-up, and bare land covers. Vegetation had the most addition to its area while bare land had the most reduction. It is also worth noting that even though built-up increased in its area from 2017 to 2022, it also received a decrease in area from 2020 to 2022. Additionally, sand had a resulting decrease from 2017 to 2022. These changes were attributed to the activities that were done in the Island during the rehabilitation program. Water quality parameters chl-a and TSM derived from C2RCC revealed a significantly increasing trend, specifically in Zone 1, suggesting an influence of seasonal change and tourists' influx to the water quality. The relationship between the LC and water quality parameters showed no statistically significant relationship between the water quality parameters and the LC classes. The researchers suggest correlating water quality with factors other than LC change, such as tourism management and recreational activities that influence water quality. Additionally, consider the use of other WQ parameters that can be observed through remote sensing such as turbidity, salinity, and pH level among others.

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