

Determining Forest Cover Change In National Greening Program Sites In A High Conservation Priority Area By Utilizing Remote Sensing Techniques

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Article Info	Abstract
Submitted: Jun. 27, 2023 Approved: Jan. 24, 2024 Published: Apr. 5, 2024 Keywords: QGIS NGP remote sensing forest cover reforestation	Deforestation in the Philippines resulted in a reduction in forest cover to just 10% of its original size in recent decades. To address deforestation, the Philippine government introduced the National Greening Program (NGP) and the Enhanced National Greening Program (ENGP). However, earlier studies have found that previous evaluations of these initiatives failed to sufficiently assess their impact on forest cover in the respective implementation areas. Thus, this study utilized Remote Sensing techniques to evaluate the effects of these programs in Brgy. Minoyan, Murcia, Negros Occidental (123.1199°E, 10.4983938°N), which is the largest NGP/ENGP planting site in Western Visayas, a region categorized as "highest conservation priority". The implementation of ENGP increased forest cover by 223.9 hectares and a decrease in grasslands and barren land by 192.2 ha and 31.8 ha, respectively. These findings indicate an increase in forest areas highlighting the program's effectiveness.

Introduction. - Deforestation has been a pressing issue present in the Philippines [1]. Its prevalence is evidenced by the fact that the country's forest cover has significantly decreased in past decades, as the forest cover in the country now only represents 10% of its original size [2]. This decrease in forest cover due to deforestation may cause a multitude of negative impacts on the environment such as biodiversity loss, exacerbation of climate change, depletion of water and food resources, and an increase in poverty [3].

In line with these issues, the government launched the National Greening Program (NGP) in 2011 under Executive Order 26 series of 2011. This program involved planting seedlings across the country from the year 2011 up to 2016. The underlying state policy of this initiative is to achieve sustainable development in the forestry sector by addressing poverty reduction, food security, biodiversity conservation, and climate change adaptation and mitigation. This was later followed by the Enhanced National Greening Program (ENGP) which aimed to expand upon the initiatives of the NGP throughout the years from the year 2016 up to 2028. These programs aim to bring back the vegetative cover of the country and to achieve impacts more than reforestation in line with the aforementioned underlying state policy. Moreover, the NGP and ENGP initiatives also align with Goal 15 of the United Nations Sustainable Development Goals, which aims to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land

degradation and halt biodiversity loss as it focuses on reforestation and sustainable forest management [4]. As the NGP and the ENGP aimed to bring reforestation to the Philippines, it is increasingly important to assess whether the activities have reached their desired impacts. In fact, Perez et al. [2] stressed the importance of the comprehensive monitoring of the forest cover changes associated with the program to improve assessment of the successes of these activities. Included in the sites for the implementation of the NGP was a bamboo plantation area in Brgy. Minoyan, Murcia, Negros Occidental, established in the year 2020 at the Bago River Watershed Reserve. The aforementioned NGP site is noteworthy as it is the largest in Western Visayas, wherein forest fragments are considered global centers of endemism and biodiversity [1]. This makes these forest fragments fall into the highest priority for conservation, according to the International Union for Conservation of Nature.

Considering the importance of monitoring the forest cover change associated with the greening programs, the researchers sought to determine the change in the forest cover throughout the implementation of these greening programs with the use of Remote Sensing (RS). This study is especially important as there have not been good ground confirmations of the reported successes in the areas of activities of the NGP and the ENGP [2]. The researchers utilized RS in determining the forest cover change, which is a technology and science used to observe, measure, and map objects on Earth's surface from a distance [5]. Although



Greening Program sites traditionally use Key Informant Interviews and Focus Group Discussions to determine the forest cover in a given area, the researchers utilized RS as it was recognized that remote sensing could be beneficial in measuring vegetation growth in those sites [6].

Given the benefits of RS and the importance of monitoring the ENGP, this study aims to:

- (i) Calculate the area of different land cover classes in the study site in 2020 and 2023 through the use of the Normalized Difference Vegetation Index and QGIS Tisler 3.24 and;
- (ii) Determine the percent change of the cover of different land cover classes in the study site throughout the implementation of the ENGP by using the percent change formula.

Methods. - The study is descriptive and it aims to evaluate and compare the change in forest cover in Brgy. Minoyan, Murcia, Negros Occidental, and measure the change brought upon by the ENGP on the forest cover in the area.

Study area. Negros Occidental (10.2477° N, 122.9888° E) is classified as a first-class province, and prioritizes the advancement of sustainable agricultural practices, while also emphasizing the safeguarding of its primary watersheds. The province encompasses 792,607 hectares of land. Out of this, 68% or 540,385.62 hectares are categorized as Alienable and Disposable Land, and the remaining 32% or 252,221.38 hectares are classified as Forestland [7]. Negros Island, as a whole, is one of the regions that encounter severe flooding, super typhoons, drought, biodiversity loss, and other natural disasters. These problems are further aggravated by the absence of integrated planning, coupled with insufficient capacity and dedication of local government units to include biodiversity conservation in local development and land use planning at the municipal, city, and provincial levels [8]. Furthermore, these problems also demonstrated the importance of strict implementation and monitoring of environmental activities conducted within the region. Upon consultation with the DENR, it was discovered that there are several NGP planting sites in Western Visayas, the largest among these is situated at Brgy. Minoyan, Murcia, Negros Occidental, a site established in the year 2020 in which bamboo species are the planted commodities. The planting site in the mentioned location is the chosen study site, as its massive area makes it ideal for RS as it allows for more training points. The study area included the implementation sites of the ENGP in Brgy. Minoyan, Murcia, Negros Occidental (123.1199°E, 10.4983938°N; 123.1895739°E, 10.5588658°N). The site used for the study was composed of a 547-ha reforestation site and a 100-ha reforestation site at the Bago River Watershed Reserve (Figure 1 & 2).

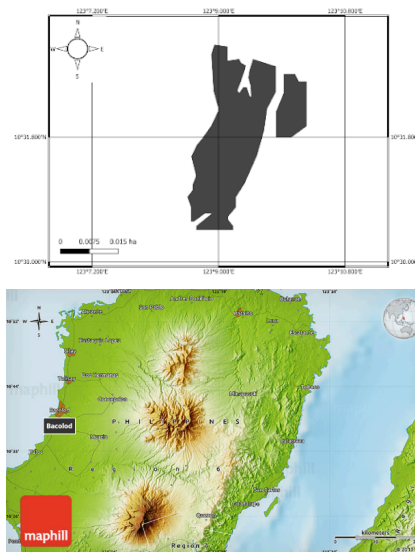


Figure 1. (top) Study area at Negros Occidental and (bottom) corresponding satellite image (MapPhl, 2011).

Satellite image collection. Using the Google Earth Engine, satellite imagery of the study site was obtained from Landsat 8. This also included the preprocessing of the images through a script in Google Earth Engine. This included cloud masking, temporal filtering, and mosaicking. The cloud coverage was set to 20% as was used by Dida et al. [9], and only the image with the lowest cloud cover satisfying the minimum threshold was considered.

Generation of Normalized Difference Vegetation Index. Using QGIS and the Semi-Automatic Classification(SCP) plugin. An NDVI image of the site was made through the use of the Band Calc function of the SCP plugin. For the raster calculation of the bands, the formula used for Landsat 8 is:

$$(NDVI)_{LandSat8} = \frac{Band\ 5 - Band\ 4}{Band\ 5 + Band\ 4}$$

Land Cover Classification. Through the Supervised Classification technique, the area was classified into different land cover classes. This included the setting of the Regions-of-Interest (RoIs) and processing the training points through the Spectral Angle Mapping (SAM) Algorithm.

Supervised classification included the setting of Regions-of-Interests (RoIs) through the use of the SCP plugin in QGIS [10]. The RoIs were classified into three predetermined classes, namely: Barren Land, Grasslands, and Forest as was adapted from Negassa et al. [11] and Adhikary et al. [12] as these were the observed classes in the study site.

Through the use of the SCP plugin in QGIS, each pixel of the study site was automatically classified through the SAM Algorithm in which each pixel was evaluated to the class it is most likely to be a member of [13].



Sieving. Through QGIS, the classified image was then processed through the Sieve tool. The sieve tool removed groups of 2 pixels or less from the image, this was done after visually assessing the impact of the number selection on the image [14] in order to reduce noise and achieve a better visual representation of the classification map [15].

Classification Report. A classification report of the classified image was generated through the SCP plugin in QGIS [16]. This report calculated the class statistics specifically: the area (in percentage) of each class in the study site classification map.

Data Analysis. An adapted version of the percent rate formula was used to analyze the raw data and determine the percentage of change for the program. The different percentage changes of each land classification's cover from 2020, the year that the study site was established, to its current state in 2023 was computed.

Safety Procedure. Potential safety hazards present in the study were the overuse of computers and improper posture while using computers. These hazards could have potentially given eyestrain and headaches, and musculoskeletal issues respectively. In order to combat this, proper safety procedures were exercised, such as following the 20-20-20 rule (a 20-second break every 20 minutes, to view an object 20 feet away) [17] and taking frequent short breaks from using computers. Furthermore, all data collected for this research was sourced from reliable and publicly accessible outlets. The data acquisition process was entirely conducted online, ensuring no harm to individuals or animals, and no parties were adversely affected during the course of this study.

Results and Discussion. - The study aimed to determine the change in forest cover through the implementation of the Enhanced National Greening Program (ENGP) in Negros Occidental, using remote sensing techniques. To determine this change, the area cover of different land cover classes in the study site in 2020 and 2023 was calculated through the use of the Normalized Difference Vegetation Index and QGIS software, and the percent change of the cover of different land cover classes in the study site throughout the implementation of the ENGP was determined using the percent change formula. These objectives were attained through Landsat satellite image collection using the Google Earth Engine; the generation of NDVI Images, land cover classification, generation of classification report using the SCP plugin in QGIS; sieving in QGIS; and the use of the percent change formula.

The land cover of each year was found using Landsat images using the Google Earth Engine, from where images of each year were then processed through the generation of NDVI Images, land cover classification, and sieving. The data was finally found using the generation of a classification report for each respective year. In the year 2020, barren lands comprised 113.0 hectares or 17.5% of

the entire plant site, while grasslands comprised 433.0 hectares or 66.9% of the entire plant site, and forests comprised 101.0 hectares or 15.6% of the entire plant site. Meanwhile, in 2023, barren land comprised 81.2 hectares or 12.6% of the entire plant site, while grasslands comprised 240.9 hectares or 37.2% of the entire plant site, and forests comprised 324.9 hectares or 50.2% of the entire plant site. This shows that in 2020, grasslands occupied the largest area in the plant site, followed by the barren land, while forests accounted for the smallest portion. By 2023, there was a shift, with forest cover increasing to occupy the largest portion, followed by grasslands, and then barren land accounted for the smallest portion.

Table 1. The area of the different land cover classes in 2020 and 2023 in hectares (ha).

	2020	2023
Forest	101.0	324.9
Grassland	433.0	240.9
Barren Land	113.0	81.2

Table 2. The area of the different land cover classes in 2020 and 2023 in percent (%).

	2020	2023
Forest	15.6	50.2
Grassland	66.9	37.2
Barren Land	17.5	12.6

The percent change in different land classes throughout the implementation of the ENGP in the study site was determined using the percent change formula. The formula was applied to the different classes, comparing their values between the start of the ENGP in the site in 2020 and its most recent state in 2023.

During the implementation of the Enhanced National Greening Program (ENGP) in the study site, it was found that there were negative percent changes in barren land and grassland of -28.1% and 44.4%, respectively, while the forest class showed a positive percent change of 221.8% (Table 3).

Table 3. Summary of percent change (%) from the establishment of the site in 2020 to the current state of the site in 2023.

	Forest	Grass-land	Barren Land
2020 to 2023	221.8	-44.4	-28.1



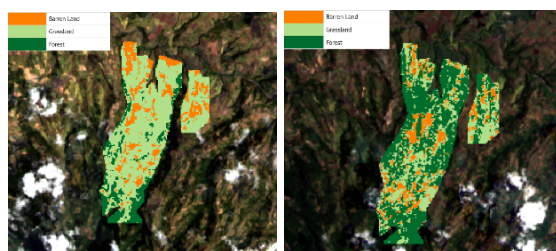


Figure 2. (left) Classified Study Site in 2020 and (right) Classified Study Site in 2023.

Through these results, it was observed, through the years of implementation of the ENGP in the study site that there was an increase in the percentage of the area that was covered by forest, demonstrating the positive effect the program had on the forestation site. The results of the study show that NDVI can be utilized in order to find the different land cover classes in the study site. This finding is in line with the study of Baloloy (2014), who found that NDVI has been a reliable indicator for spatiotemporal analysis of vegetation change. Given these results, it was found that through RS methods information about the land cover classification of the study site in the years 2020 and 2023 were obtained. This resultant information however was limited as only satellite images from Landsat were used which may lead to less accuracy.

The results of this study show that during the implementation of the greening programs, there was an increase in the growth of forests in the study site. The results of this study show that during the implementation of the ENGP in the study site forest cover increased while grasslands and barren land decreased. These changes show that the program has had a positive effect on forest cover in the study site. However, these results are contrasting with those of Perez et al. [2], wherein it was found that greening programs had no particular effect on forest cover in the greater Luzon area. These results may be contrasting due to underlying factors creating differences in the respective study sites, factors such as the availability of resources in the study site, specifically the availability of light, space, soil nutrients, and water; and physical conditions of the study site, specifically: elevation, topography, and climate conditions [19]. Moreover, the results of this study are limited as the researchers did not conduct the reclassification method in the SCP plugin and an accuracy assessment was not conducted.

Through the use of RS techniques, the change in forest cover in hectares throughout the implementation of the ENGP in Negros Occidental was determined. Moreover, NDVI was used to determine the change in forest distribution at the study site, supplementing the lack of studies on the implementation of the ENGP. In this study site, RS was successfully used to determine forest cover change in the area, showing that in future forestation measures, RS can be utilized to supplement data gathered from ground truthing.

Limitations. The resultant data from the research was solely utilized to determine the change brought about by the ENGP in the specific study site, rather than all unique and potential sites in the nation. In this study, the site utilized had only been established in the year 2020.

As a result, the research did not include the years that corresponded to the implementation of NGP (2010-2016) and part of the ENGP (2016-2019), as the study site was yet to be a part of both programs. Moreover, an accuracy assessment was not conducted due to the lack of necessary data. Finally, the study only focuses on the time span during which the ENGP was implemented in the study site and does not take into account any other anthropogenic or natural events in the area as its focus was the ENGP and its effects on the study site, and the study area used for the study was restricted to the given shapefile obtained from the Department of Environment and Natural Resources (DENR) Region VI, and only the bounds within this shapefile were considered the study site.

Conclusion. - From the year 2020 to 2023, the predominant class in the area changed from grassland in 2020 to forest cover in 2023. Moreover, in this span, barren land and grassland both decreased, while the forest cover in the study site increased. This shows that during the years of the implementation of ENGP, there was an expansion of forest cover in the area and that this was a result of the ENGP.

Recommendations. - For future research, the use of other satellite images may lead to increased accuracy compared to using only Landsat satellites. It is also recommended that future studies use datasets supplemented by images from other free satellites, such as Sentinel and MODIS. Furthermore, an accuracy assessment can be conducted to supplement their findings. Finally, utilizing the reclassification method in the SCP plugin is proposed to account for the redistribution of classes, thereby further supporting and substantiating the results of future studies.

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References

- [1] Hamann A. 2002. The North Negros Forest Reserve A Biodiversity Hotspot at Risk. *Silliman Journal*. 43. [accessed 2023 Jun 8]. https://www.ualberta.ca/~ahamann/publications/pdfs/Hamann_2002.pdf.
- [2] Perez GJ, Comiso JC, Aragones LV, Merida HC, Ong PS. 2020. Reforestation and Deforestation in Northern Luzon, Philippines: Critical Issues as Observed from Space. *Forests*. 11(10):1071. doi:<https://doi.org/10.3390/f11101071>



- [3] Nunez C. 2022. Deforestation and Its Effect on the Planet. National Geographic. <https://www.nationalgeographic.com/environment/article/deforestation>.
- [4] United Nations. 2022. Goal 15 | Department of Economic and Social Affairs. United Nations. <https://sdgs.un.org/goals/goal15>.
- [5] Arellano, CM., Maralit, AA., Paringit, EC., Sarmiento, CJ., Faelga, RA., Tandoc, FA., ... & Pamittan, FJ. 2019. Multi-temporal Analysis of Dense and Sparse Forests' Radar Backscatter using Sentinel-1A Collection in Google Earth Engine. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences.
- [6] Carandang A, Bugayong L, Dolom P, Garcia L, Villanueva M, Espiritu N. 2013. Analysis of key drivers of deforestation and forest degradation in the Philippines. Manila, Philippines: Deutsche Gesellschaft fur Internationale Zusammenarbeit.
- [7] Department of Environment and Natural Resources. 2019. Regional Profile. Denrgovph. <https://r6.denr.gov.ph/index.php/about-us/regional-profile>.
- [8] Biodiversity Management Bureau. 2018. Negros Island Biodiversity Strategy and Action Plan. www.philbio.org.ph/wp-content/uploads/2021/11/Negros-Island-Biodiversity-Strategy-and-Action-Plan-2018-2028_low-res.pdf
- [9] Dida JJV, Araza AB, Eduarte GT, Umali AGA, Malabrigo PL, Razal RA. 2021. Towards nationwide mapping of bamboo resources in the Philippines: testing the pixel-based and fractional cover approaches. *Int J Remote Sens.* 42(9):3380–3404. doi:<https://doi.org/10.1080/01431161.2020.1871099>.
- [10] Hossain MdS, Khan MdAH, Oluwajuwon TV, Biswas J, Rubaiot Abdullah SM, Tanvir MdSSI, Munira S, Chowdhury MdNA. 2023. Spatiotemporal change detection of land use land cover (LULC) in Fashiakhali wildlife sanctuary (FKWS) impact area, Bangladesh, employing multispectral images and GIS. *Model Earth Syst Envi.* doi:<https://doi.org/10.1007/s40808-022-01653-7>.
- [11] Negassa MD, Mallie DT, Gemedo DO. 2020. Forest cover change detection using Geographic Information Systems and remote sensing techniques: a spatio-temporal study on Komto Protected forest priority area, East Wollega Zone, Ethiopia. *Envi Syst Res.* 9(1). doi:<https://doi.org/10.1186/s40068-020-0163-z>.
- [12] Adhikary PP, Barman D, Madhu M, Dash CJ, Jakhar P, Hombegowda HC, Naik BS, Sahoo DC, Beer K. 2019. Land use and land cover dynamics with special emphasis on shifting cultivation in Eastern Ghats Highlands of India using remote sensing data and GIS. *Environmental Monitoring and Assessment.* 191(5):315. doi:<https://doi.org/10.1007/s10661-019-7447-7>
- [13] Rashmi S, Addamani S, Venkat, Ravikiran S. 2014. Spectral Angle Mapper Algorithm for Remote Sensing Image Classification. *IJISSET -International Journal of Innovative Science, Engineering & Technology.* 1. http://www.ijiset.com/v1s4/IJISSET_V1_I4_27.pdf.
- [14] Amos C, Petropoulos GP, Ferentinos KP. 2018. Determining the use of Sentinel-2A MSI for wildfire burning & severity detection. *International Journal of Remote Sensing.* 40(3):905–930. doi:<https://doi.org/10.1080/01431161.2018.1519284>.
- [15] Hespings, M. 2020. Remote Sensing-Based Land Cover Classification and Change Detection Using Sentinel-2 Data and Random Forest : A Case Study of Rusinga Island, Kenya. *Liu.diva-Portal.org*, <http://liu.diva-portal.org/smash/record.jsf?pid=diva2:1443933>
- [16] Congedo L. 2022. Semi-Automatic Classification Plugin Documentation. [accessed 2023 Mar 21]. <https://media.readthedocs.org/pdf/semiautomaticclassificationmanual/latest/semiautomaticclassificationmanual.pdf>.
- [17] Sheppard AL., & Wolffsohn JS. 2018. Digital eye strain: prevalence, measurement and amelioration. *BMJ open ophthalmology*, 3(1), e000146. doi:<https://doi.org/10.1136/bmjophth-2018-000146>
- [18] Baloloy A. 2014. Detecting Vegetation Change in the Philippines during the Period 1997 to 2002 using AVHRR GIMMS - NDVI Time Series Data. <http://dx.doi.org/10.13140/RG.2.2.25905.33126>
- [19] Li T, Liang J, Chen X, Wang H, Zhang S, Pu Y, Xu X, Li H, Xu J, Wu X, et al. 2021. The interacting roles and relative importance of climate, topography, soil properties and mineralogical composition on soil potassium variations at a national scale in China. *CATENA.* 196:104875. doi:<https://doi.org/10.1016/j.catena.2020.104875>.

