PROJECT TITLE: Assessing the impact of deforestation on the temperature changes in the Philippines

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BACKGROUND/INTRODUCTION

Deforestation has been an increasing concern globally as one of the leading causes of climate change. The resulting environmental damage has moreover been attributed to the exacerbation of natural disasters, such as intensifying typhoon cyclones, especially in tropical countries. As such, increasing resilience to climate change had been a top priority by policymakers and world leaders as the implications encompass humanitarian, economic, political, and even cultural aspects in the society (Franta et. al., 2016). In the recent Conference of the Parties (COP) 26 climate summit of the United Nations, more than 100 nations covering over 85% of the world's forest had pledged to end deforestation by 2030—becoming the first major commitment from the conference (Kottasova and Picheta, 2021).

According to Greenpeace Research Laboratories (2013), land-cover changes affect natural cycles and atmospheric circulation, leading to local and regional surface temperatures. Further, changes in land-cover in tropical regions can have potential impacts in weather patterns, among others, at various remote locations in the world (Bettwy, 2005). The rate at which land areas are affected by deforestation have soared drastically over the past two decades, especially in Southeast Asia. In the Philippines, the average temperature has been observed to increase over time. The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) reported that warming has occurred between 1951 to 2006 (Hilario, 2008).

Recently, there has been more research on tropical countries that indicate that deforestation affects increasing temperatures and heat exposure (Wolff et al., 2021). However, there are still limited studies about the Philippines that explore this relationship. There is a need for more studies that investigate the impact of forest ecosystem on climate change (Lasco et al., 2008) as the magnitude particularly on land surface temperature is still limited. In tropical countries, forest cover changes affect evapotranspiration and, consequently, local surface temperatures (Prevedello et al., 2019).

The characterization of vegetation present in an area through satellite imagery can assess the changes in landscape and surrounding ecosystem. From a horizontal surface view, the density of forests, which usually encompass a vast area, can be difficult to determine. Satellite remote sensing make it possible to monitor forest loss area through analyzing the spatial properties of land cover (Othman et al., 2018). Moreover, identifying the correlation between forest loss and temperature increase would help inform decisions in forest management and conservation policies.

OBJECTIVES

The general objective is to assess the correlation between deforestation and temperature changes in the Philippines from 2000 to 2015. The specific objectives are the following:

1) Develop a data model using Python to visualize the trend in tree cover using Global Forest Cover Change (GFCC) over a 15-year time period
2) Determine the sensitivity of variation in forest cover change and temperature in the month of May, typically the warmest month of the year
3) Characterize the extent of forest loss in the Philippines from 2000 to 2015

DATA

The spatial context for this study is the Philippines, an archipelagic country in Southeast Asia located by the western Pacific Ocean. According to the Senate Economic Planning Office (2015), the forest cover in the country has gone down to 23% or around 7 million hectares in 2010 due to commercial and illegal logging to meet agricultural and housing needs attributed to the continuous rise in population. The total land area of the Philippines is 30 million hectares, 47% of which is agricultural land. The Natural Earth Data (n.d.) reports a bounding box of 117.17427453°, 5.58100332277°, 126.537423944°, 18.5052273625° for Western, Southern, Eastern, and Northern limits, respectively.

According to the World Bank Group (2021), the hottest months of the year are typically April and May. Although a general upward trend was observed over the years, fluctuations in temperature have been attributed to the El Niño Southern Oscillation (ENSO). The spatial variation in temperatures are also perceived to be minimal throughout the country, except for certain areas with high elevation. To quantify the impacts of deforestation on increasing temperature, the model investigates past forest cover changes and land surface temperature (LST).

Forest cover was obtained from Land Processes Distributed Active Archive Center (LP DAAC) through NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) Program. The dataset is referred to as Global Forest Cover Change (GFCC) Tree Cover Multi-Year Global which presents the tree cover percentage over the year and recorded every 5 years from 2000 to 2015. GFCC comprises of 30-meter imagery resolution from Landsat 5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and is based on enhanced Global Land Survey (Townshend, 2016). The data used in the model will cover the years 2000, 2005, 2010, and 2015.

For the LST, the dataset will be taken from the Collection-6 (C6) MODIS, in particular, the MOD11B3 Version 6 product. The following product provides the simple average of values from MOD11B1 per pixel size of 5,600 meters over a monthly period at a 1,200 by 1,200-kilometer tile. (Wan et al, 2015). Each granule contains 19 layers, but the model only considers the Daytime Land

Surface Temperature measured in Kelvin and uses a scale factor of 0.02. Moreover, only data for May, which is historically the warmest month of the year, will be used in the model.

Therefore, the datasets will be configured to cover the area of the Philippines for the month of May from year 2000 to 2015 at a 5-year interval.

METHODOLOGY

A hypothesis testing approach was used to assess the correlation between deforestation and the increase in temperature. The approach is summarized into a five-step methodology as outlined below and detailed subsequently:

(i) Compilation of tree cover and land surface temperature datasets for four time periods starting 2000 over a five-year increment

(ii) Standardization of map projection, spatial resolution, and region of all datasets

(iii) Calculation of tree cover change (ΔF) from 2000 to 2015

(iv) Calculation of change in land surface temperature (ΔLST) from 2000 to 2015

(v) Application of statistical analyses to quantify relationships between ΔF and ΔLST

The GFCC and LST of the Philippines for the years 2000, 2005, 2010 and 2015 was acquired from NASA's Earth Data. The model was developed using Python programming. In the preliminary treatment of the datasets, all files were converted into TIF format and then compiled in a VRT. The datasets were then projected into a Plate Carree map and adopted the appropriate coordinates of the defined bounding box, as mentioned in the data section. The new spatial resolution was specified as 0.01 x 0.01 arc degree.

To regard for the missing information, a masked array was applied to standardize the comparison of available data between sets. Performing comparisons between tree cover and temperature started by determining individual annual values and five-year differences. The change in tree cover fraction was used as the assumption in characterizing deforestation (ΔF). Thus, negative differences will pertain to afforestation. Another strategy in assessing relationships is partitioning according to the percent loss of tree cover fraction (e.g., less than 50% and greater than 50% ΔF) and their corresponding changes in temperature, as denoted by the land surface temperature or ΔLST.

To understand the effect and correlation of deforestation to the temperature, the relationship between the two variables was quantified using statistical analyses such as the mean, maximum, minimum, and pearson correlation coefficient values. The variation in results was also assessed qualitatively through time-series visualization, plotted to form the analysis of change.

RESULTS

Deforestation from 2000 to 2015 has caused a 5-year average warming of 0.54°C for the month of May for every 9.12% forest cover loss. In terms of maximum temperature, which ranges from 43.21°C to 46.15°C, the average incremental rise was 0.67°C. The rate at which deforestation occurred over the same time period also increased at an average of 1.27% every 5 years. Figures 1 and 2 below show the Tree Cover Fraction and LST, respectively, from 2000 to 2015:

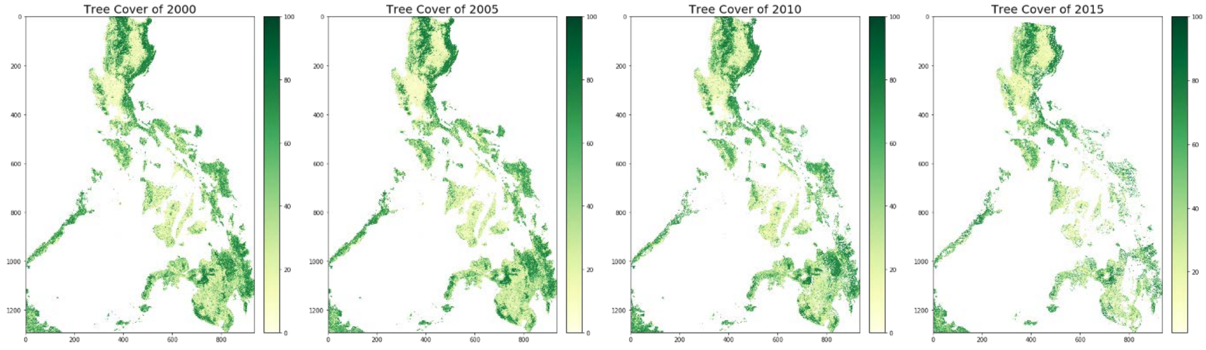

Figure 1: Tree Cover Fraction, %, 2000 to 2015

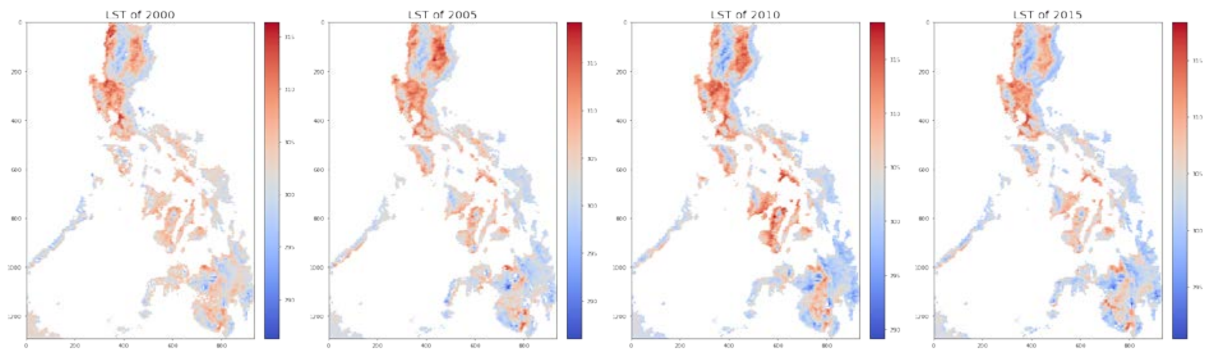

Figure 2: Land Surface Temperature, K, 2000 to 2015

In comparing year to year datasets, the "hotspots" or areas defined with large deforestation rates were classified into: (1) 50 to 80% forest cover loss and (2) more than 80% forest cover loss. The successive analyses compare the temperature changes in those areas between the years 2000 to 2005, 2005 to 2010, 2010 to 2015, and 2000 to 2015.

2000 to 2005

The average ΔF per pixel from 2000 to 2005 is 7.82% with a corresponding mean ΔLST of 1.05°C. In areas with 50 to 80% forest cover change, the average ΔLST accounted for a 1.41°C increase, while areas with more than 80% forest change obtained an average ΔLST of 0.86°C.

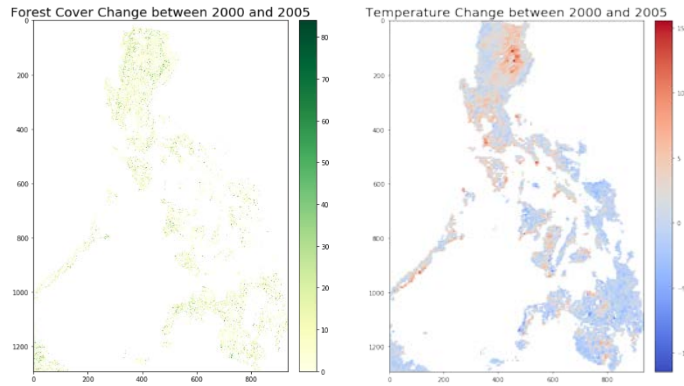

Figure 3: Forest Cover and Temperature Change, 2000 to 2005

2005 to 2010

The average ΔF per pixel from 2005 to 2010 is 9.2% with a corresponding mean ΔLST of 0.76°C. In areas with 50 to 80% forest cover change, the average ΔLST accounted for 0.67°C, while areas with more than 80% forest change obtained an average ΔLST of 0.79°C.

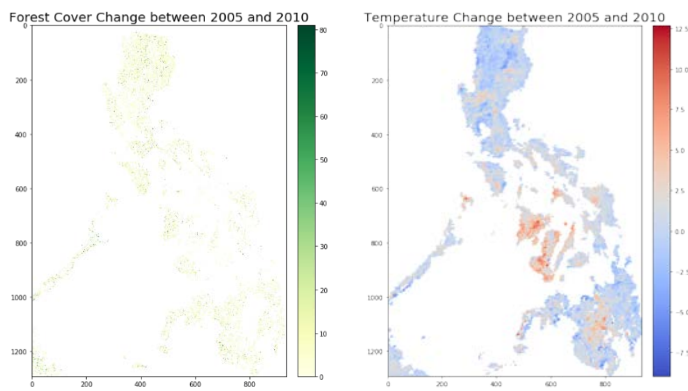

Figure 4: Forest Cover and Temperature Change, 2005 to 2010

2010 to 2015

The average ΔF per pixel from 2010 to 2015 is 10.36% with a corresponding mean ΔLST of -0.19°C. In areas with 50 to 80% forest cover change, the average ΔLST accounted for -0.19°C, while areas with more than 80% forest change obtained an average ΔLST of -0.19°C.

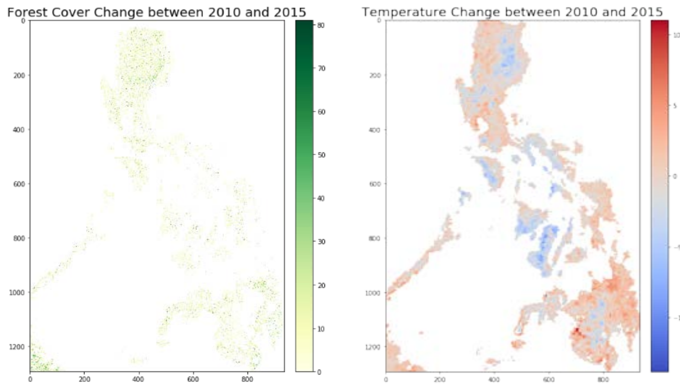

Figure 5: Forest Cover and Temperature Change, 2010 to 2015

2000 to 2015

The average ΔF per pixel from 2000 to 2015 is 11.59% with a corresponding mean ΔLST of 1.63°C. In areas with 50 to 80% forest cover change, the average ΔLST accounted for 1.75°C, while areas with more than 80% forest change obtained an average ΔLST of 1.59°C.

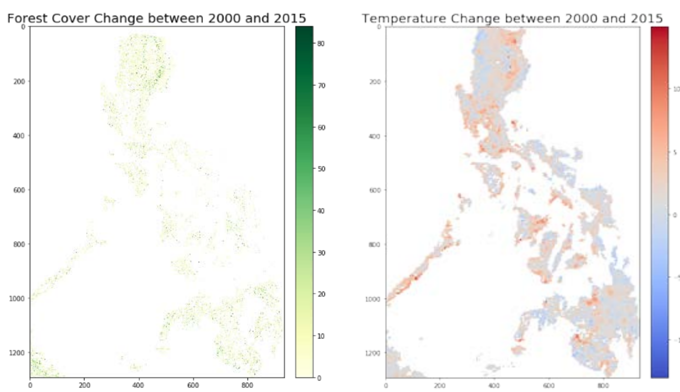

Figure 6: Forest Cover and Temperature Change, 2000 to 2015

The pearson correlation coefficient of the forest cover changes and temperature difference ranged from -0.006 to -0.097, with the lower limit reflective of the data from 2010 to 2015, and the upper limit from 2005 to 2010. Generally, when the correlation coefficient is this low, there is no linear relationship between the two variables, or the dataset is perceived to be weak.

CONCLUSION AND RECOMMENDATION

While the exact relationship between hotspot areas and temperature increases is quite difficult to determine based on the generated model, a general observation on the results would point out that there is an association between the fraction of forest cover loss with increased LST, particularly with at least 50% forest cover losses.

A rise of 1.63°C in average mean temperature between 2000 to 2015 should be treated as alarming. Within the same timeframe, the extent of average forest loss was around 11.59%. This warming trend in the Philippines has also been consistently evident in other temperature characteristics such as minimum and maximum mean temperatures. As the maximum temperature continues to rise at an average of 0.67°C every five years, the potential consequences can be dangerous if no mitigating measures are done. Extreme heat has implications on human health and can limit accessibility of resources such as water and electricity. Based on the results above, it can be concluded that the rate of deforestation affects the temperature increase in the Philippines.

For future research, the model can be improved to ensure normalized data and to account for the information gaps that determine hotspot areas. Conversely, exploring more datasets will improve accuracy and ensure that the values obtained are consistent with one another. Developing and evaluating equation models to determine the link between climate change and forest ecosystems could also be helpful in quantifying the extent of the impact of deforestation and, consequently, aid in the ability to address projected changes. Finally, more studies need to be conducted in the Philippines to fill in limited knowledge regarding the role of the forestry sector and highlight the importance of environmental preservation.

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