A Report on Forest Cover Change Detection in an area of Möllergrab Marteloscope

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Abstract

The objective of this study is to perform change detection analysis of forest cover in an area of Möllergrab Marteloscope between the years of 2019 and 2023. Calculation of Canopy Height Models(CHM), calculation of statistical measures and the comparison is needed for Change Detection Analysis. CHM refers to the vegetation canopy height above the ground surface and depends on Digital Surface Model (DSM) and Digital Terrain Model (DTM). The area of interest is a windthrow area situated in Eberswalde city of Germany. Data is collected by "Phantom 4 Real Time Kinematic" Drone with a proper flight planning and Key elements such as type of project, type of terrain, overlap, flight height, rate of image capture, camera specifications and georefrencing. Process of Photogrammetric Reconstruction involve creation of orthomosaic, DSM, calculation of CHM, clipping, providing appropriate symbology and calculating statistics. Change Detection Analysis involve Classification of CHM values into five categories, visualization of Maps of CHM and comparison of their statistical measures. According to the results 2023 shows forest growth and densification as compared to 2019. Negative values for the minimum canopy height in CHM of 2019 and 2023 is due to the presence of noise in DSM or DTM and complex nature of terrain. In the end, due to the sustainable forest management practices, positive changes have occurred in the windthrow study region.

Introduction

The aim of this study is to detect, analyse and report the changes occurred in the forest cover of an area in Möllergrab Marteloscope over the years of 2019 and 2023. The Change Detection Analysis involve calculation of Canopy Height Model(CHM) , calculation of Statistical measures of CHM and the comparison of CHM and its statistical measures between the years of 2019 and 2023.

Canopy or Crown Height Model (CHM) can be defined as a raster representation of the distance or height from the surface of ground to the top of the canopy of trees. CHM is a raster dataset therefore each pixel provides an estimated height or the vertical distance from the ground surface of that canopy at that specific location.

Canopy Height Model depends on two other raster datasets namely, Digital Surface Model and Digital Terrain Model.

Digital Surface Model (DSM) provides the information of the elevation of artificial features above the ground as well as natural features in a particular area.[3]

Digital Terrain Model (DTM) provides the information of elevation of bare earth's surface. Additionally, it includes the vector features of natural terrain for example river and ridges.[3]

CHM is valuable for understanding the changes occurred in the forest by detecting forest loss and forest gain over the different periods of time. It also assesses the variations in vegetation density, observing the forest dynamics such as regeneration, tree mortality and forest fragmentation which in turn assist in making well-informed decisions for sustainable management of forest.

It has been observed that the Möllergrab Marteloscope experienced canopy cover changes over the selected period of time therefore, this report aims to detect, analyse and report the changes occurred from 2019 to 2023.

Materials

Study Region

The Study Region is a windthrow area inside the Möllergrab Marteloscope. Möllergrab with a location of X coordinate (easting) 419284.79051 and Y coordinate (Northing) 5851627.64852 is situated in the Eberswalde City of Germany. It was established in 2017 and State Forest Brandenburg is the owner of the marteloscope.[1]

The size of entire marteloscope is one hectare and is located at an altitude of 50 m.a.s.l which implies 50 metres above the sea level. [1]

In the forest ecosystem of Möllergrab Marteloscope, 857 trees of different Species such as Scots Pine (83.2%), Common Beech (15.2%), Norway Spruce (1.2%) and Sessile Oak (0.3%) are present however, Pine is the most dominant tree species among all.[1]

Möllergrab receives mean annual precipitation of 540 mm and the mean annual temperature is 9.4 degrees Celsius.[1]

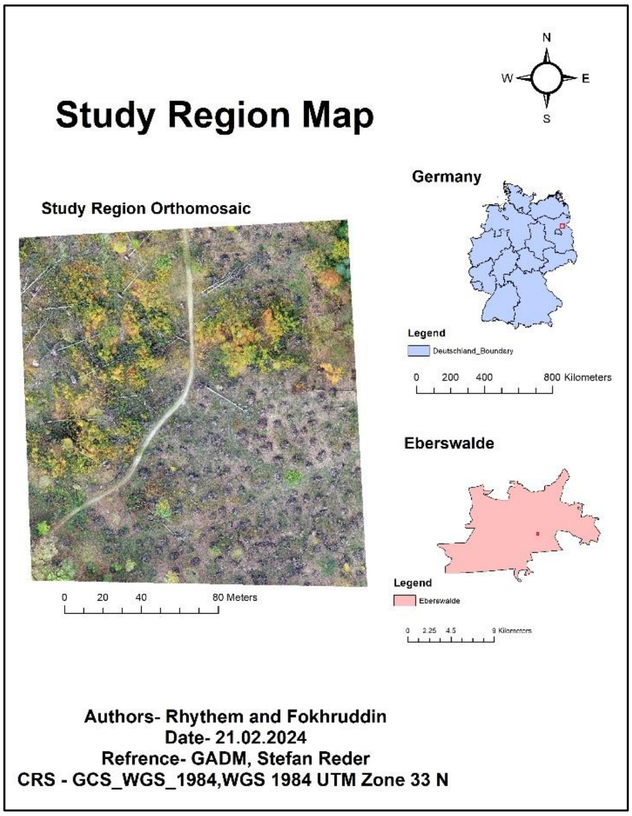


Fig1. Study Region Map

Data Acquisition

Making a proper flight Plan before the flying of drone is a significant step for the process of data collection in the Photogrammetric Projects. Flight Planning is important for assuring the better coverage, finest quality of image and data accuracy.

In this study, Drone "Phantom 4 RTK (Real Time Kinematic)" is used for collecting the data.

The list of factors which need to be considered before a flight planning are as follows:

1. Understanding the kind of Project
   Understanding the nature of project(aerial, terrestrial, mixed) is an important step for the selection of appropriate platform(drone, aircraft or helicopter), camera settings and the required flight height during the project . The type of project for this study is "Aerial.
2. Understanding the topography of Area:
   Depending on the terrain (Forrest and Dense Vegetation, Flat terrain with agriculture fields, building reconstruction, corridor mapping) of the region a suitable flight plan is made [2]. The terrain of this study region is a forest area.
3. Determining Overlap between the Photos
   Depending on the terrain of region of interest, an overlap is decided. For this study, forward and Side overlap of 85% is suitable as it is a forest region.[3]
4. Finding the Flight Height for a particular Ground Sampling Distance(GSD)
   Flight Height(H) is the distance between the platform (drone, airplane, helicopter) and the ground during the process of data collection.
   GSD is related to the spatial resolution and determines how much distance on the ground is covered by a pixel in an aerial imagery[2].
   For Drone "Phantom 4 RTK", Ground Sampling Distance is 2.76cm[3].
5. Calculating the rate of Image Capturing
   Depending on the position of camera either it is perpendicular or parallel to the direction of flight, rate of capturing of Image is calculated. It depends on the velocity of the platform (drone, airplane, helicopter) and the Ground Sampling Distance[2].It assures complete coverage, data accuracy and finest quality image products.

6. Adjusting the Camera Settings
   The settings which include shutter speed, ISO and aperture should be on automatically by the camera. Adjusting appropriate camera settings is important to avoid blur,niose and distortions[2].
7. Georefrencing
   This step is vital to assure accuracy, better coverage and reliable(georefrenced) geospatial data.
   There are two approaches of georefrencing namely direct georefrencing(camera equipeed with GPS) and indirect georefrencing(using Ground Control Points).
   Since GCPs are not clearly visible in Forest Area therefore, direct Georefrencing method was used in this study[3].

Methodology

Photogrammetric Reconstruction:

It is a process of obtaining three dimensional(3D)information from the two dimensional(2D) overlapping photos which are collected during the data acquisition process by the drone equipped with a camera.

It consist of the following steps:

1. Formation of Orthomosaic
During the study course of Module, Orthophotos of Möllergrab Marteloscope are collected by the drone. The collected data(orthophotos) is processed in a software "Pix4Dmapper" to create an orthomosaic raster dataset and a Digital Surface Model. Further, the DSM is made to be georefrenced.
However, for this analysis we refer to the georefrenced data provided by the lecturer Stefan Reder.
2. Calculation of Canopy Height Model(CHM)
   Digital Surface model and Digital terrain Model of year 2019 is provided by the lecturer and they are imported into QGIS software environment for calculating Canopy Height Model. "Raster Calculator" is a tool used to calculate by subtracting Digital terrain Model (DTM) of 2019 from the Digital Surface Model(DSM) of 2019.

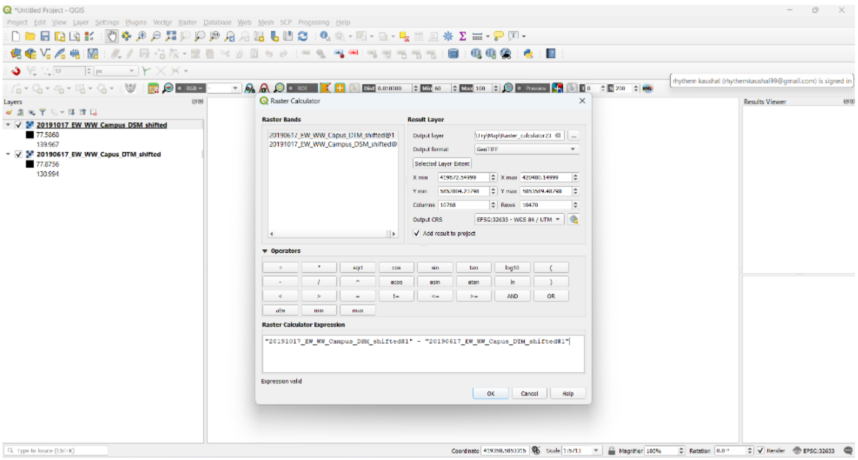


Fig2. CHM Calculation

Similarly, CHM for the year of 2023 is calculated by the subtraction of DTM of year 2021 from the DSM of 2023.

3. Steps required for Change Detection Analysis in the study region
   1. A common area is identified between the CHM of 2023 and 2019 and it is further clipped from them for carrying out change detection analysis.
   2. Therefore, a polygon feature shapefile name as "Studyregion" is made and the Raster Extraction tool "Clip Raster by Mask Layer" is used for clipping the common area between CHMs of 2019 and 2023 from the polygon shapefile of the Study region.

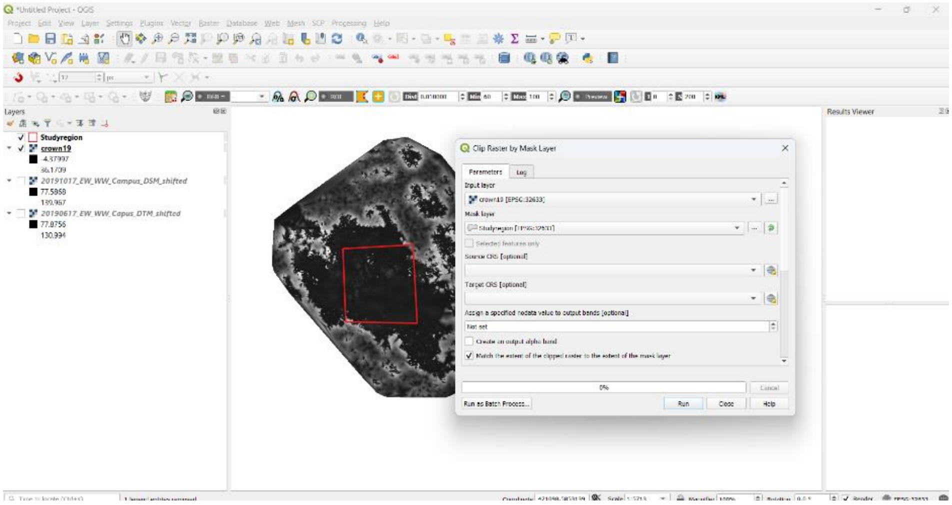


Fig3. Clipping Common Area

3. After the process of clipping, Statistics of clipped canopy height models are calculated using a processing tool "Raster Layer Statistics"

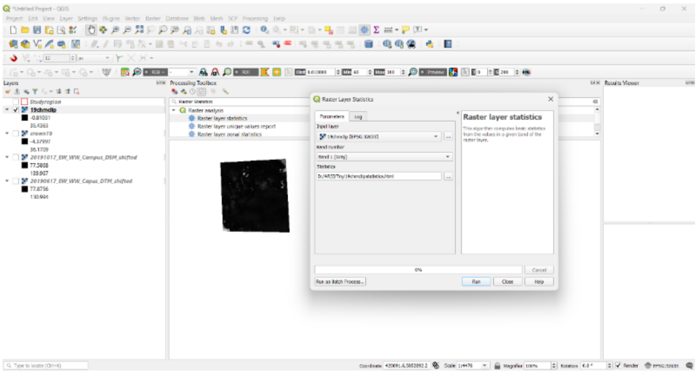


Fig4. Calculating Statistics by "Raster Layer Statistics"

4. Clipped CHMs of 2019 and 2023 is classified into five classes of Equal Intervals and a proper color scheme is provided for better visualization.

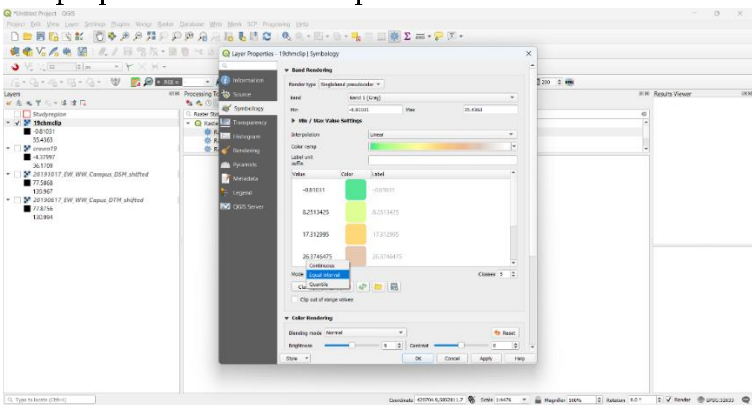


Fig.6. Symbology for CHM

5. Hillshade for CHM 2019 and 2023 are created by the Raster Analysis tool "Hillshade" for enhancing the visualization.

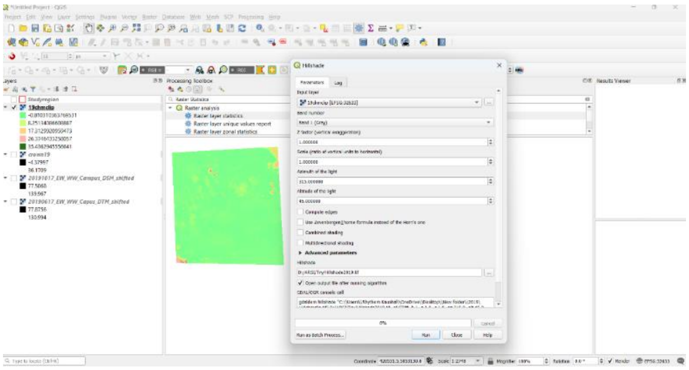


Fig7. Hillshade creation

Fig 8. Hillshade for 2019

Fig9. Hillshade for 2023

Results

The Change Detection Analysis is carried in the following steps:

1. Visualization of Canopy Height Models in the form of Map involve the classification of CHM values into five different categories which are as follows:
    1. Bare Soil corresponds to the CHM value less than 0.1m
    2. Initial Rejuvenation represent the values greater than 0.1m and less than 1.5m.
    3. Established rejuvenation refer the values greater than 1.5m and less than 5m.
    4. Young trees correspond to the values greater than 5 m and less than 15m.
    5. Mature Trees represent the values greater than 15m

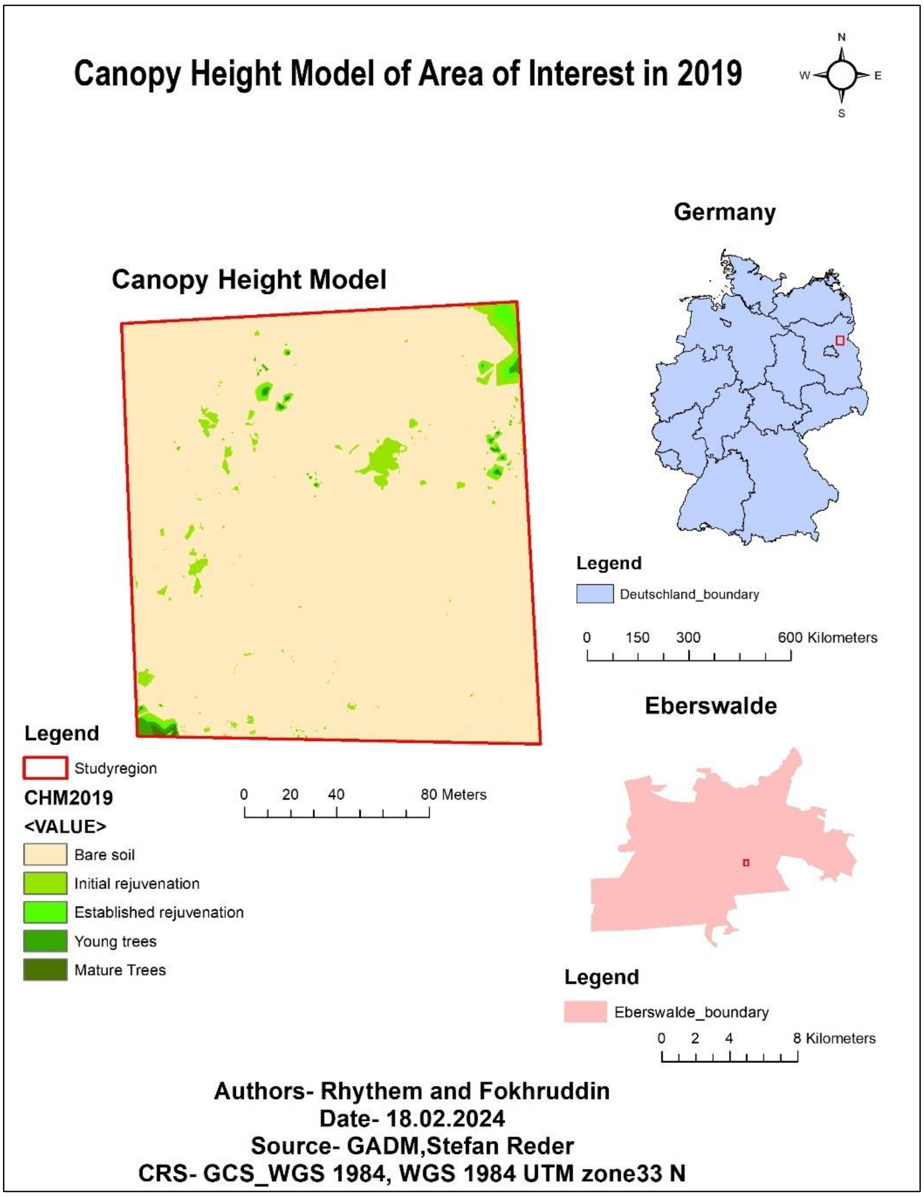


Fig10. Map of CHM of Study Region in 2019

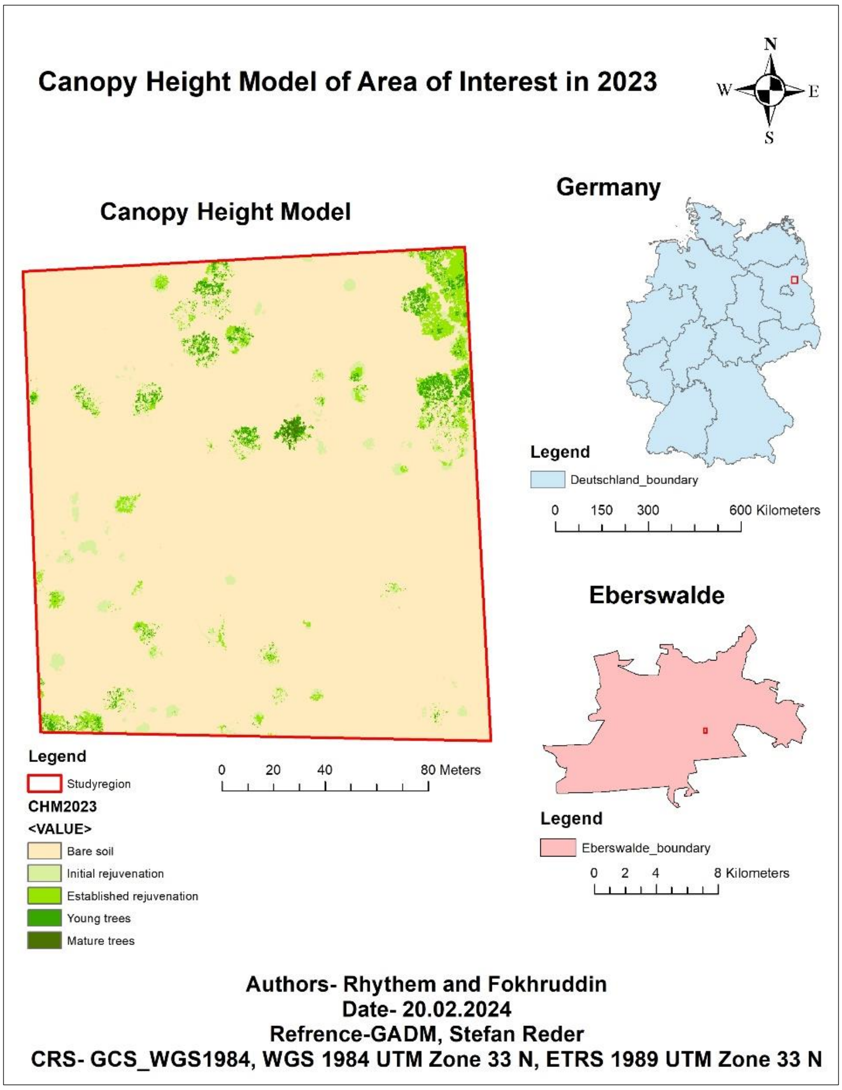
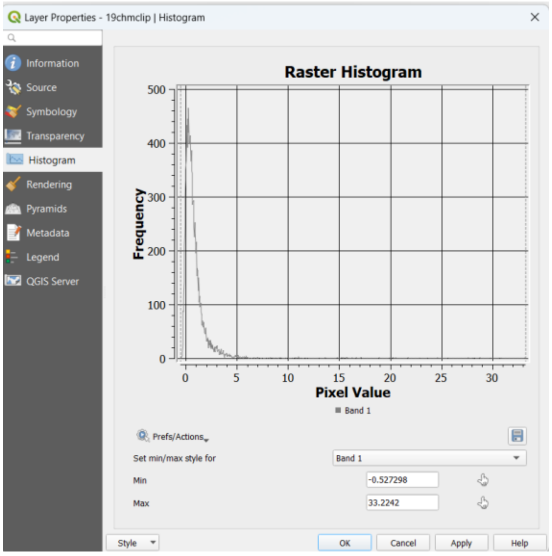


Fig12. Map of CHM of Study Region in 2023

In comparison to the CHM of year2019, 2023 shows increase in the initial rejuvenation leading to the forest growth.In addition to this, young and mature trees have increased in the year of 2023 which leads to greater variability and densification in canopy height of the area of Interest.

2.Histogram Analysis



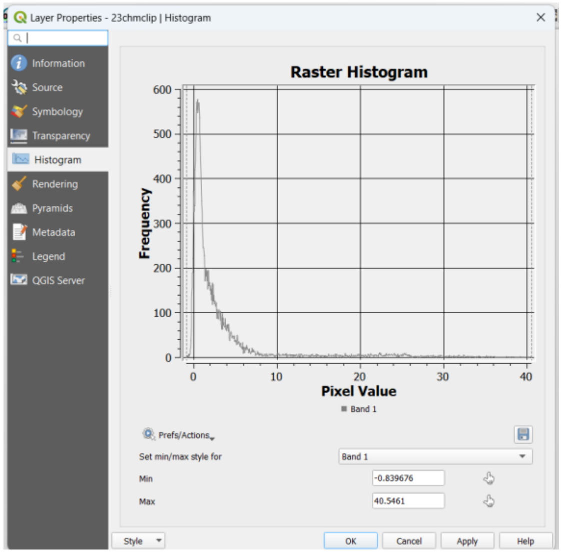


Fig.11 Histogram for 2019 *Fig.12 Histogram for 2023*

Values	CHM2019	CHM2023
Minimum	-0.527298	-0.839676
Maximum	33.2242	40.5461

Minimum value gives the information of shortest canopy height whereas maximum value gives the information of highest canopy height in the region of interest.

Minimum value of canopy height for CHM 2019 is greater than the minimum value for CHM 2023, whereas maximum value of canopy height for CHM 2023 is greater than the maximum value for CHM 2019.

Less value of minimum canopy height in 2019 as compared to 2023 can be attributed to the reason of deforestation. High value of maximum canopy height in 2023 as compared to 2019 can be attributed to the reason of forest regeneration and densification which leads to the growth of taller vegetation.

3. Statistical Analysis from the Raster Layer Statistics

Statistics	CHM2019	CHM2023
Mean value	1.017493322741287	3.09723471020055
Range	40.03065490722656	45.86125183105469
Sum	5800379.415245056	1589051.754241943
Standard Deviation	2.430724237545086	5.596347751211781

1. Here, Mean values refer the average height of forest canopy in the area of Interest. From the table, it is evident that the average height of forest canopy is greater in 2023 than in 2019 which indicates regeneration and growth of the forest canopy over the selected period of time.
2. The Range depicts the variations (difference between highest and lowest CHM values) in height of canopy for the area of interest. In comparison to 2019, 2023 has a broad range for the canopy height which indicates variations have occurred in the forest composition and structure over the selected period of time.
3. Sum represents the entire canopy height (sum of all pixel values in CHM) in the selected area of interest. In contrast to mean values and range, sum represents decline in total canopy height in 2023. Damage caused by wind and deforestation can be the potential causes for this type of change.
4. Standard Deviation measures the deviation of individual canopy height measurement from the measurement of mean value of canopy height. Standard deviation value of the CHM for year 2023 is significantly higher than CHM of 2019 which indicates that variations have occurred in the structure as well as composition of forest region from 2019 to 2023.

Discussion

The Negative values obtained in the minimum values for CHM 2019 and 2023 of the study region is due to the noise present in either DSM or DTM data. Additionally, depending on the terrain complexity such as in steep slopes if the height of vegetation (initial rejuvenation) is less than the ground elevation then negative values can be obtained.

Conclusion

In conclusion, despite being a windthrow area there is a positive change occurred in the study region in the year of 2023 as the mean values, range, standard deviation and the maximum value of canopy height shows increase in value which suggests regeneration of forest canopy, increased variability and composition of forest ecosystem in the study region.

However, the decrease in sum of canopy height as well as in the minimum value of canopy height in 2023 can be due to the deforestation or the disturbances such as damage caused by the wind.

Therefore, it can be concluded that forest area is managed in a sustainable manner.

Refrence

1. http://iplus.efi.int/uploads/DE_InfoSheet_Moellergrab_en.pdf
2. https://support.pix4d.com/hc/en-us/articles/202557359-Getting-Started-Index-PIX4Dmapper
3. Presentations provided during the course module by the lecturer Stefan Reder.