ASSESSMENT OF THE RELATIONSHIP BETWEEN CARBON STOCK AND TREE SPECIES: A CASE STUDY MT KENYA FOREST

Joy Christine Nduta Kimani*[1], Dr Eunice Nduati†[2]

[1,2]Jomo Kenyatta University of Agriculture and Technology, Kenya

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Summary

Reducing carbon emissions from deforestation in developing countries is of central importance in efforts to combat climate change. Among the challenges is quantifying nations' carbon emissions from deforestation, which requires information on forest clearing and carbon storage. Reductions in diversity and species composition change the flow of energy thus affecting the essential services that the ecosystem provides to humans. A greater understanding of the relationship between tree species diversity and carbon pools is, therefore, necessary to enlighten policy considerations. The main objective of this study is to analyze the relationship between carbon stock and tree species in Mt Kenya Forest, Kenya.

KEYWORDS: Above Ground Biomass, Above Ground Carbon, tree species, Random Forest, Shannon Index

1. Introduction

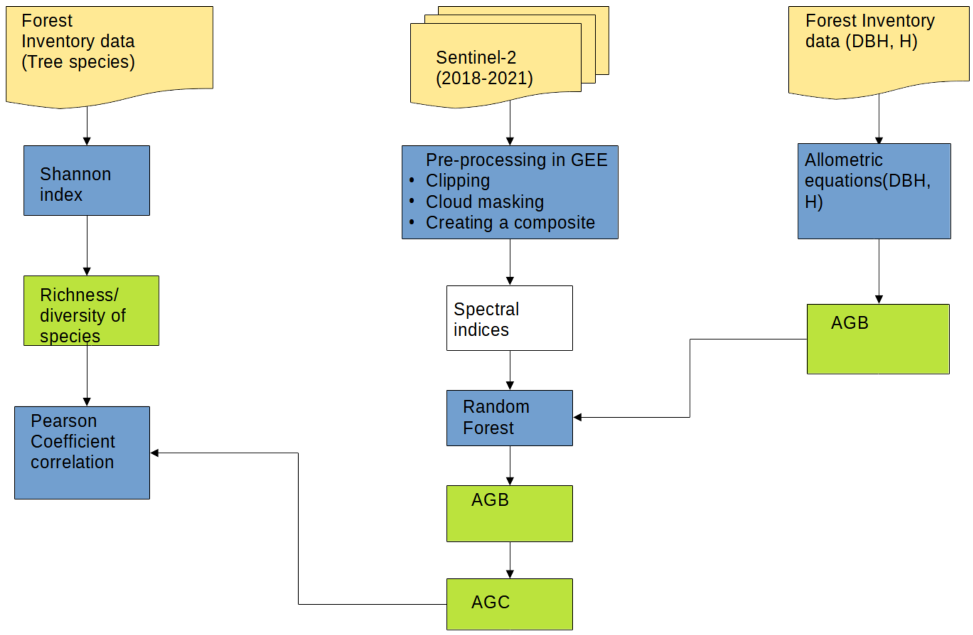
The relationship between the diversity and tree biomass in a forest highly contributes to its ecosystem services provisions. The total tree biomass contributes to the total carbon of the forest and is highly dependent on the species identity, site conditions, stand density, tree diversity among others. By comparing diverse degrees of tree mixtures in natural forests, we can gain insight into the ecosystem service's provision level and dynamics(Bravo et al., 2021). Carbon stock assessment is one of the important steps to start with sustainable land use planning concerning low carbon emission. The compensation occurs if the REDD+ activities are monitored, measured, and verified, and the actual emissions are below the Forest Reference Emission Level (FREL)(Alexander et al., 2011). Deforestation and forest degradation, particularly in tropical regions, are significant contributors to two of the biggest pressing global environmental challenges, namely biodiversity loss and global climate change (Talbot, 2010). Although considerable resources and efforts have been invested by the Kenyan Government in improving the management of the protected areas of the Mt Kenya ecosystem in the past years, there are tremendous threats and pressures on the ecosystem.

A greater understanding of the relationship between biodiversity and carbon pools is therefore necessary on an area and regional scale to enlighten policy considerations (Midgley et al., 2010)(Midgley et al., 2010); (Thompson et al., 2012). The spatial information derived from the estimation and mapping of tree species is crucial for effective and strategic forest management and biodiversity conservation. It also helps us understand other ecological processes e.g., species extinction or increase, net productivity, growth rates per species (Li et al., 2020).

* joychristin2@gmail.com

† enduati@jkuat.ac.ke

2. Methodology



The forest inventory data was provided by Kenya Forest Service (KFS) and Kenya Forest Research Institute (KEFRI). The Sentinel-2 images were pre-processed in Google Earth Engine and then various spectral indices were computed in QGIS. Both the Shannon index and R algorithm were computed in R. To analyze the relationship between the Tree species diversity and AGC, the Pearson Coefficient correlation was used. It was also implemented in R. The Random Forest algorithm calculated the AGB per pixel in the images. AGB was converted to AGC by applying the conversion factor of 0.47, which represents 47% of the dry biomass assumed to be carbon for all parts of the tree as the default value recommended by the (IPCC, 2007).

$$AGC=0.47*AGB \quad (1)$$

3. Results

3.1 Tree Species Map

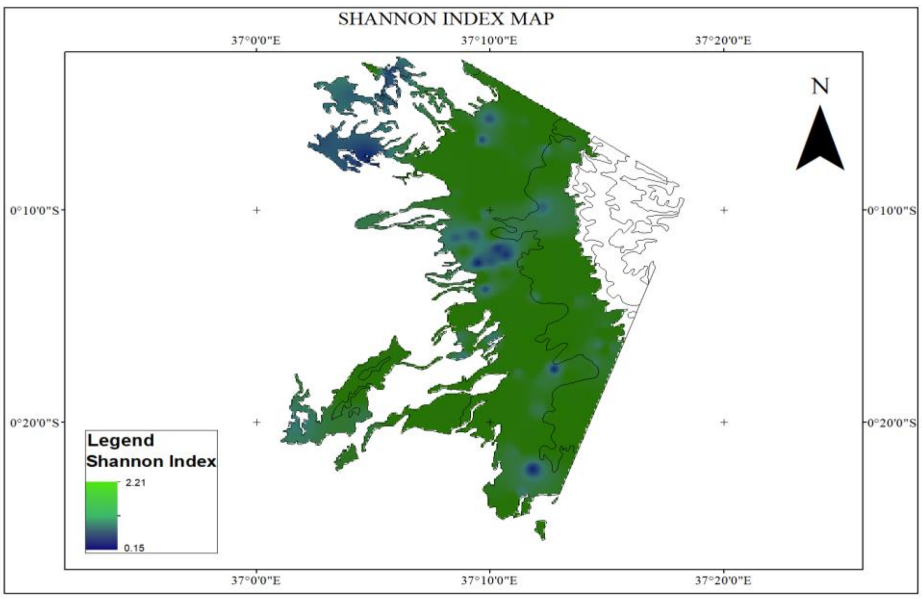


Figure 1: Tree Species diversity map

3.2 AGC maps

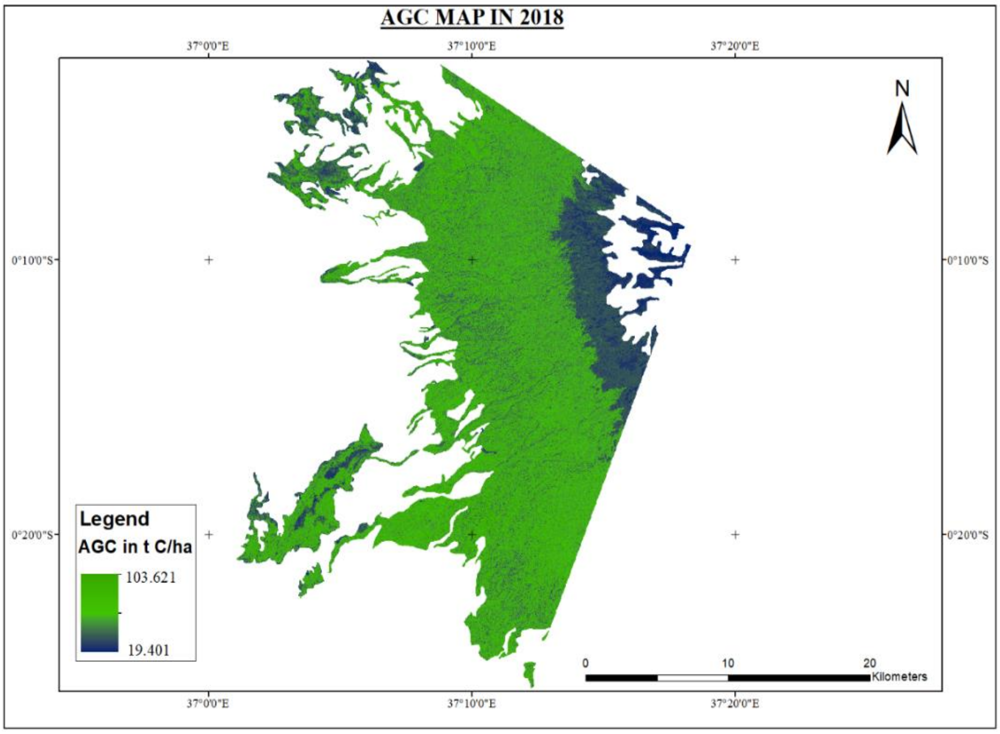


Figure 2 AGC Map in 2018

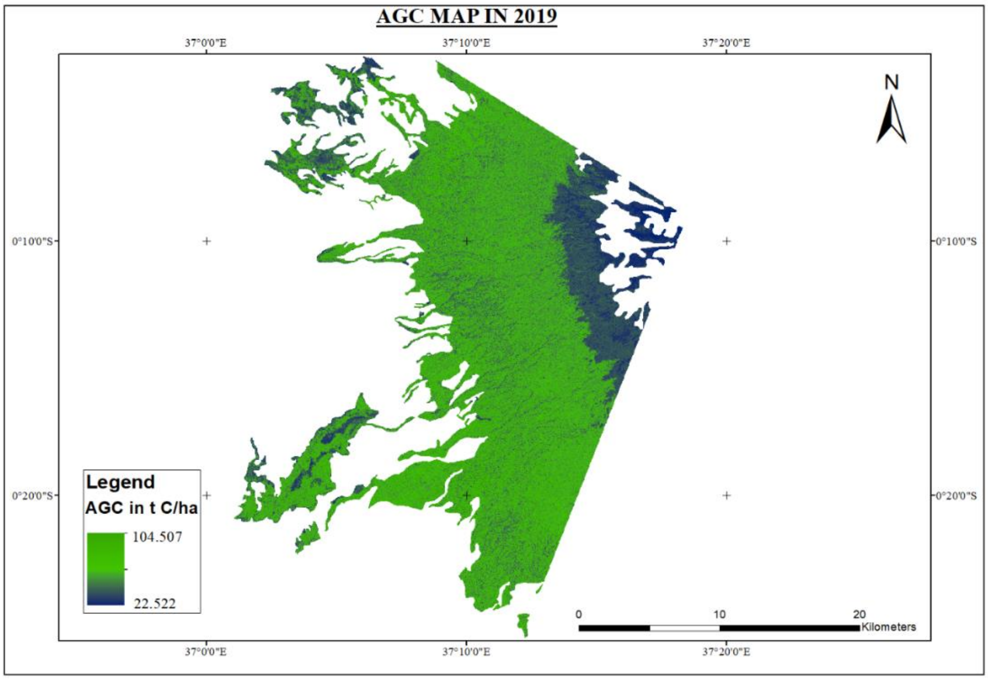


Figure 3 AGC map in 2019

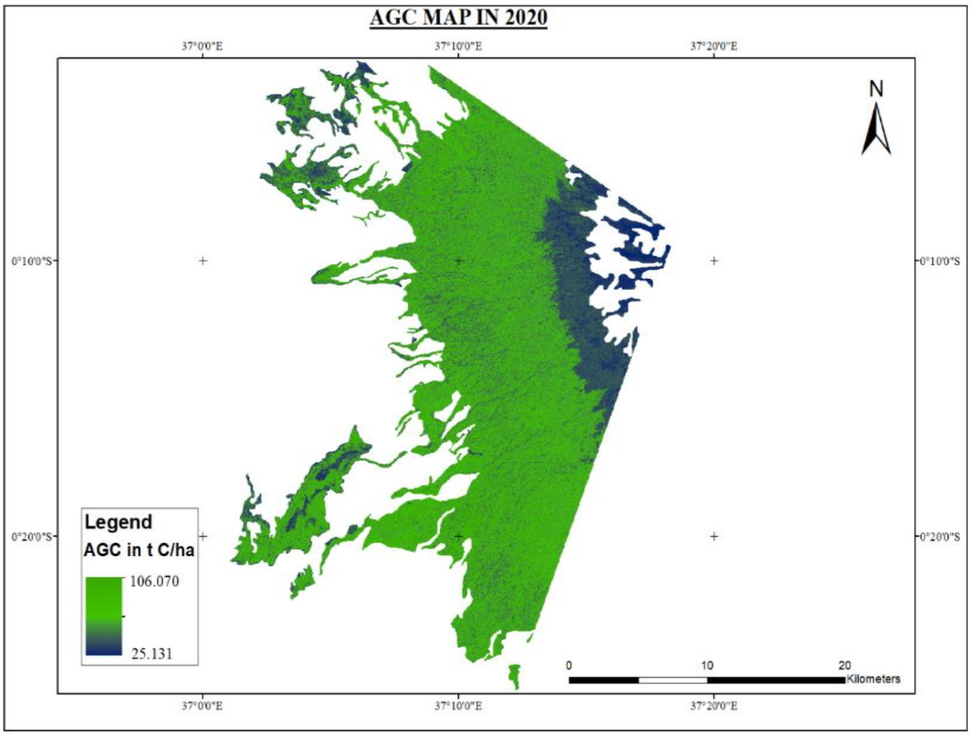


Figure 4 AGC map in 2020

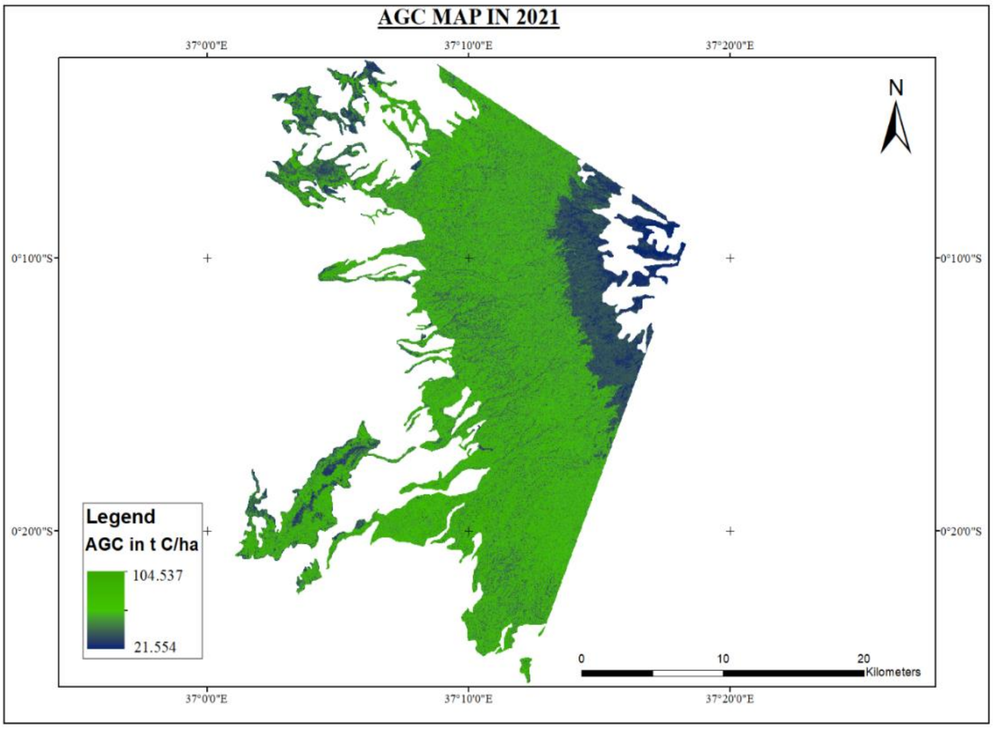


Figure 5 AGC map in 2021

3.3 AGC vs Species diversity

The relationship between the AGC and Species data was plotted using Pearson correlation. The assumption made is that the Shannon index i.e., species diversity was constant throughout the four years. The AGC was the only parameter that was changing throughout the four years. There was a positive and strong and significant relationship between aboveground carbon stock and species diversity in Mt Kenya.

As diversity increased, so did AGC. The lower the P-value, the higher the significance of the correlation between the variables i.e., AGC and Species diversity. The R^2 values for the scatter plots were;

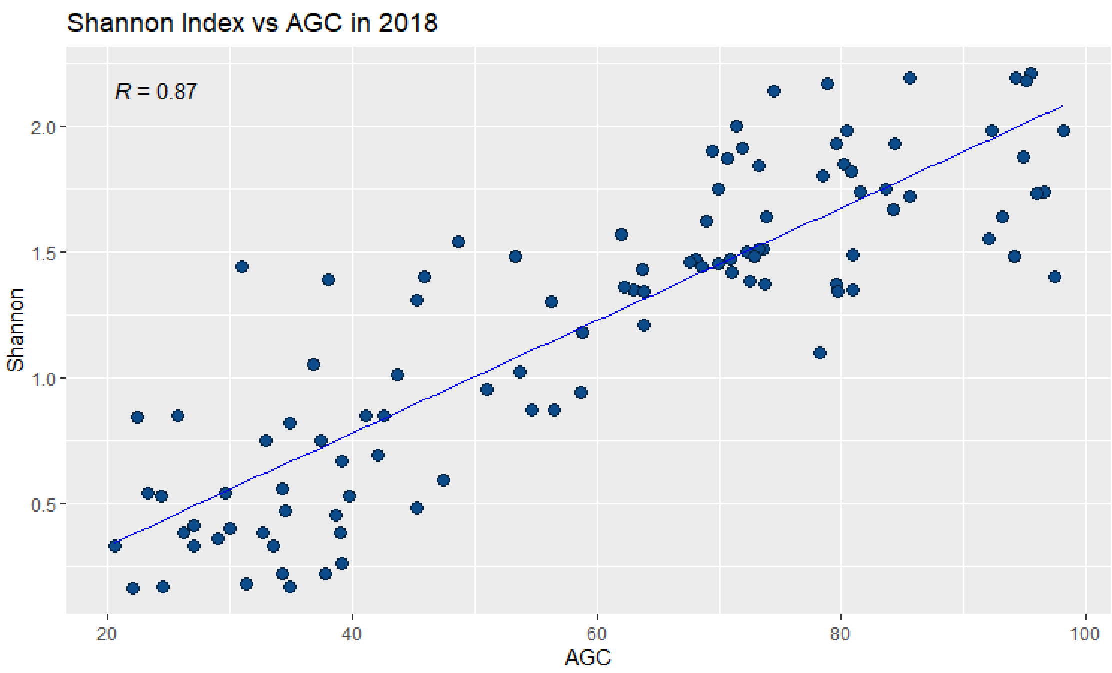


Figure 6 Shannon Index Vs AGC in 2018

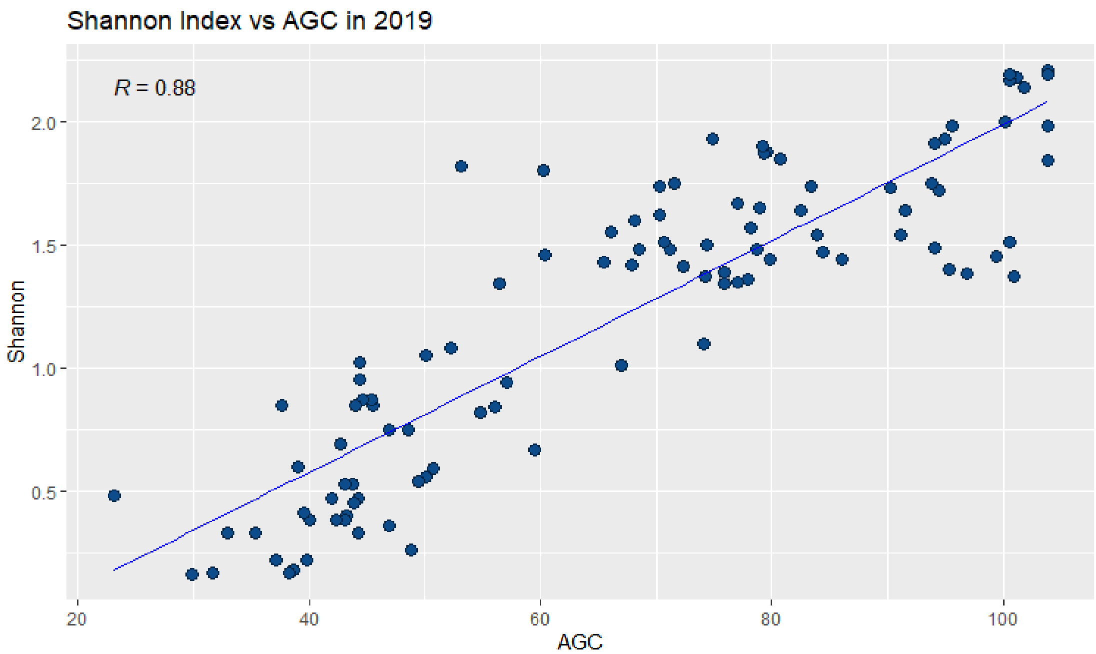


Figure 7 Shannon Index Vs AGC in 2019

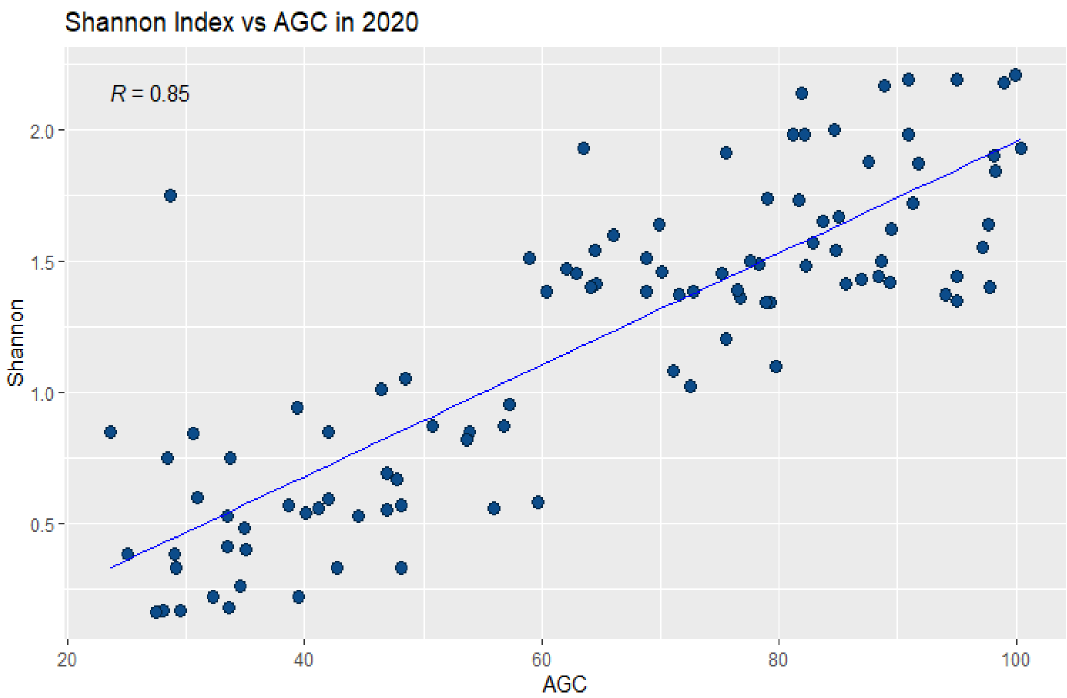


Figure 8 Shannon Index Vs AGC in 2020

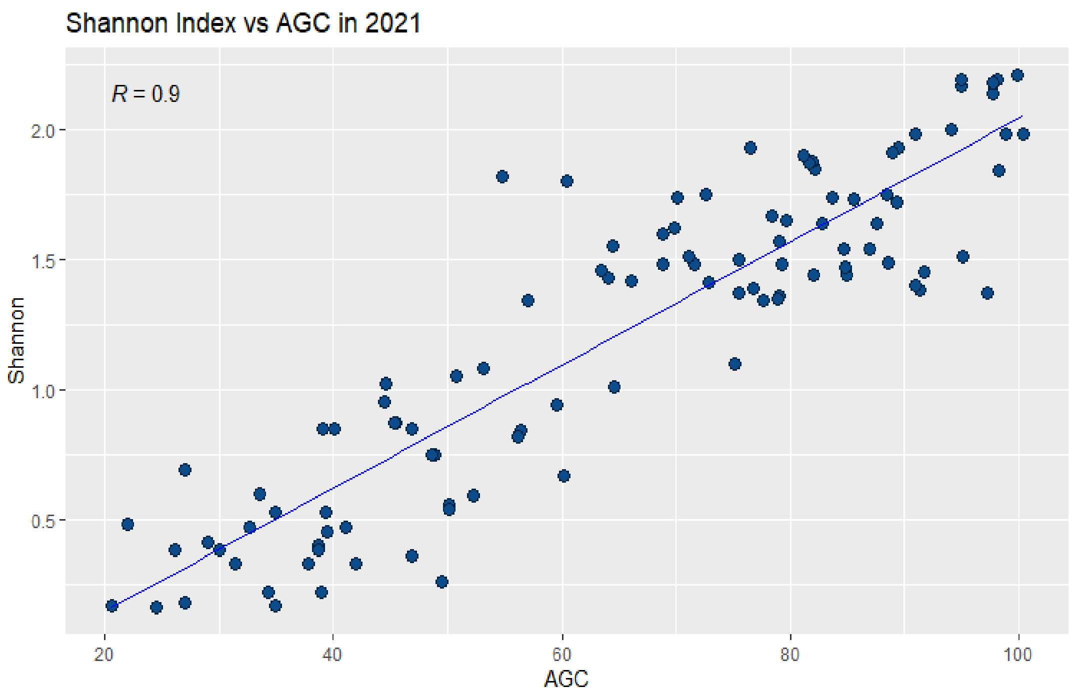


Figure 9 Shannon Index Vs AGC in 2021

4 Comparison between the AGC map and Google Imagery

The relationship between the AGC and sentinel-2 imagery of the study area can be seen. The Google image shows that it is bare land thus the AGC expected is low. The map below illustrates that the AGC along the road leading to Naro Muro River lodge is very low.

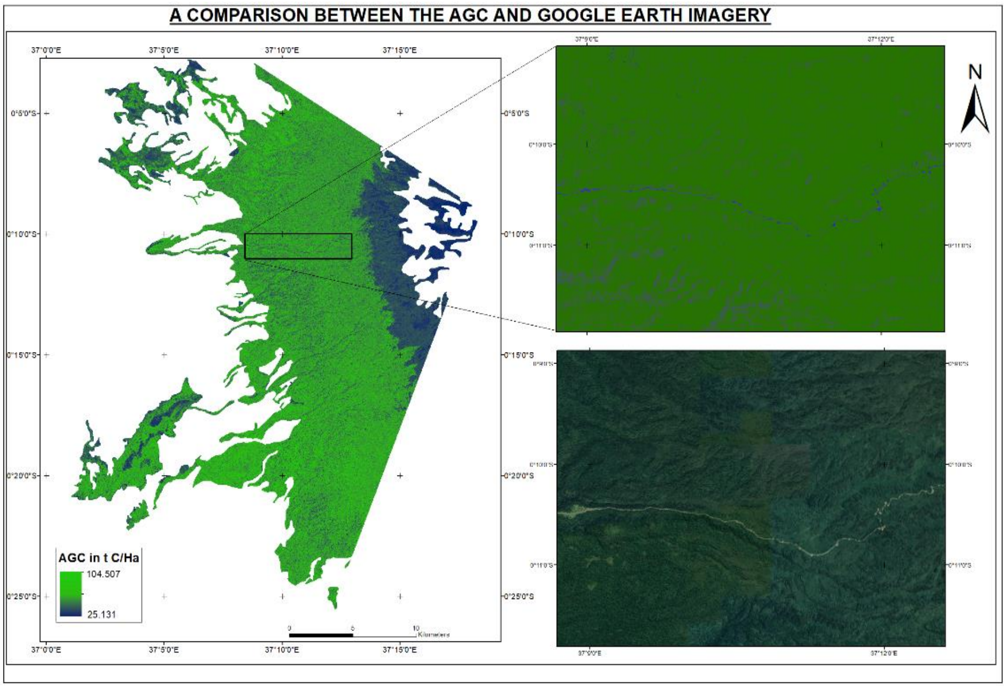


Figure 10 Comparing AGC map and Google imagery

5 Discussion and Conclusion

A positive relation between tree diversity and carbon stock largely depends on presenting highly productive species in multispecific communities(Tilman, 1999). Any positive correlation between biomass and species diversity has important policy implications, as it can be used to support the assertion that REDD schemes can provide significant co-benefits for biodiversity conservation.
The biomass estimates we produced are within the range found for other studies within Mt Kenya Forest (Rodríguez-Veiga et al., 2020). According to the results of this previous study, the highest Carbon stock recorded was 125t C/ha in Mt Kenya.
Tree AGC is mainly determined by biophysical factors such as diameter at breast height and tree height. Fieldwork was carried out to determine tree heights and DBH which were very important variables for biomass and carbon assessment. The correlation between the AGC and tree species diversity was found to be a strong and positive one. Thus, there is a need to plant various types of tree species because this will lead to higher carbon stocks in our forests.

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Biographies

Joy Christine has recently completed her degree in Geomatic Engineering and GIS. She is working to better her skills in research, particularly in remote sensing. Data science is also one of her favourite topics. She’s also interested in learning new things and solving problems through code.

Dr. Eunice Nduati completed her Ph.D. study at Chiba University in the field of Remote Sensing and GIS. Her research focuses on the application of GIS and Remote Sensing towards agriculture. One of her goals is to create awareness about emerging technologies for the monitoring and management of agriculture.