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Carbon in the Canopy: An Aboveground Carbon Stock Assessment Using Remote Sensing and Forest Inventory Data of Reforested Sites in The City of Koronadal

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ABSTRACT

Reforestation is an important component to mitigate climate change because trees absorb carbon from the air and store it in their biomass. But even though people know that reforestation is good for the environment, there isn't enough local data on how much carbon is stored in these areas, which makes it hard to tell how well they work to fight climate change. This study helped to fix the deficiency of local carbon stock data in reforested areas within the City of Koronadal by employing forest inventory data and remote sensing techniques. The study employed a quantitative research design that integrated field-based forest measurements with remote sensing analysis. NDVI results showed a positive relationship with field data, indicating that remote sensing is a useful tool in measuring NDVI. Measurements were done on tree species, diameter at breast height (DBH), height, and wood density in 200 m perimeter Barangay San Isidro, Barangay Assumption and Barangay San Jose. Allometric equations were used to determine aboveground biomass, which was further transformed into carbon stock according to IPCC. The Landsat 9 satellite images were provided in QGIS and used to compute the Normalized Difference Vegetation Index (NDVI) and to evaluate vegetation cover. The findings indicate a difference between the sites with Barangay San Jose (0.16 t C/ha) and Barangay Assumption (NDVI 0.50) having higher biomass and carbon stock which are dominated mainly by Swietenia macrophylla (Mahogany) for monitoring forest biomass. The findings provide baseline information that can help local government units improve forest management such as the National Greening Program and support climate change mitigation efforts.

INTRODUCTION

Climate change is a significant global issue that is caused by human-induced activities such as deforestation, changes in land use, greenhouse gas emissions, burning of fossil fuels, and natural causes. Deforestation, one of the leading causes of climate change, has led to an unprecedented increase in carbon dioxide in the atmosphere over the past few years. Deforestation activities contribute to an increase in carbon dioxide in the atmosphere, which in turn contributes to the thinning of the ozone layer, leading to intensified climate change. Forests play a crucial role as natural filters, absorbing carbon dioxide from the atmosphere (Fakana, 2020). Assessing the aboveground carbon stock is crucial for determining areas suitable for reforestation, which will also help in mitigating human-induced carbon emissions. It will also help implement forest management strategies for the growth of forests capable of carbon storage (Stein, 2023).

Urban areas are considered among the highest contributors to global warming and climate change (United Nation, nd). Mainly due to human activities, such as the burning of fossil fuels and deforestation, which led to the accumulation of greenhouse gases, primarily carbon dioxide (Matiza *et al.*, 2024). Forest biomass, however, plays an important role in carbon sequestration, as 37.8% to 48.9% of tree biomass is carbon (Zhou *et al.*, 2023). This means that the amount of carbon sequestered by forests is estimated through the amount of carbon absorbed by the trees, and is calculated from the majority of a forest's total biomass as AGB becomes the primary focus in field measurements (Ma *et al.*, 2023). Remote sensing technologies, including optical satellites, radar, and LiDAR, have been wide and accurate measurements of forest biomass (Harris *et al.*, 2021). These data enable researchers to efficiently calculate AGB in comparison with traditional ground-based methods, leading to a more reliable estimation of carbon stocks (Zhang *et al.*, 2025). Estimating AGB is important in assessing carbon stocks, as it reflects the forest's contribution to the global carbon (Vicharnakorn *et al.*, 2014). Additionally, it would provide opportunities to improve aboveground forest carbon mapping, which could help develop better solutions to nature's problems, such as mitigating climate change.

One of the most trending issues today is the increase in greenhouse gas (GHG) emissions worldwide, especially carbon dioxide (CO_2), mainly caused by the burning of fossil fuels and deforestation (Raihan *et al.*, 2021). A study in Malaysia shows that tropical forests play a crucial role in reducing climate change by absorbing carbon dioxide (CO_2) and storing it as biomass carbon (Bera *et al.*, 2024). Another study in India shows that the total carbon stored in forests and its economic value decreased from 2006 to 2021, and this decline is expected to continue until 2030 due to forest conversion into agricultural lands (Bera *et al.*, 2024). This emphasizes a global issue where forest loss weakens the planet's ability to reduce greenhouse

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gases. Economic and environmental significance of forests should also be emphasized to ensure the sustainability of practices and safeguard of forest ecosystems. In addition, a study conducted in Ethiopia revealed that the agroforestry system of parklands is able to absorb up to 59.65 megagrams of carbon per hectare, but this capacity is not consistent as a result of local management, tree density and human activities like illegal logging and free grazing (Tsedeke *et al.*, 2021). Evaluation of forest carbon stock and its economic value Assistance in the minimization of climate change effects and appropriate forest management (Dahy *et al.*, 2020) . Using hyperspectral and high-resolution imagery, remote sensing integrated with Geographic Information Systems (GIS) enables large-scale analysis of tree height, biomass, leaf area, and species composition (Choudhury *et al.*, nd). It is widely known that planting trees helps fight climate change, yet local data on carbon storage, especially in the City of Koronadal's reforested areas, remains scarce. This study aimed to determine the aboveground biomass, carbon stock, and vegetation cover of selected reforested sites in Barangay San Isidro, Barangay Assumption, and Barangay San Jose in the City of Koronadal. It specifically sought to identify tree species composition, quantify biomass and carbon storage, and generate baseline data to support local forest management and climate change mitigation planning.

Specifically, this study 1) identified tree species inventory in Purok Upper Acub, Barangay San Isidro, Barangay San Jose, and Barangay Assumption in the City of Koronadal as reforested sites; 2) assessed the aboveground biomass, carbon stock, and carbon sequestration in the selected reforested sites through field-based allometric measurements; 3) assessed the vegetation cover, carbon stock and aboveground biomass distribution in reforested sites using remote sensing; and 4) developed a policy brief based on the baseline data on aboveground carbon stocks in reforested sites in the City of Koronadal.

Assessing the carbon stock is significant because it is the first step in addressing climate change and is critical because it aids in identifying forests that act as carbon sinks, which are essential for reducing carbon levels in the atmosphere. Identifying carbon sinks might encourage conservation activities to minimize deforestation and also facilitate participation in carbon markets through carbon trading. The study promotes transparent reporting and tracking of carbon emissions, both of which are critical to SDG 13: Climate Change Action.

MATERIALS AND METHODS

Materials

This study utilized a 50 m measuring tape, a clinometer, a digital compass application, a GPS application, and permits. The study also utilized software such as PictureThis, Quick Map Services, Google Map Engine, SWMaps and QGIS Software. For site sampling, the SWMaps were used to measure and mark the plot. In identifying tree species, the study utilized the PictureThis application, as well as the dichotomous key in the verification of the tree species.

Measuring tools were used to measure tree distances and height, whereas navigation applications were utilized during the mapping process. Fieldwork also involved travelling a distance of 10-40 km in each designated site within Koronadal city. The study also utilized QGIS softwares, Quick Map Services and Google Maps Engine in mapping and assessing vegetation cover.

Research Design

This study utilized a quantitative field research design to address the lack of actual carbon stock data in reforested areas of the City of Koronadal. A quantitative approach was appropriate as it allowed for the accurate and systematic characterization of a population, situation, or phenomenon, and it could employ various research methods to investigate one or more variables (McCombes, 2022). The field-based nature of this design aimed to identify tree species composition, estimate above-ground biomass (AGB), and determine carbon stocks in randomly sampled 200 m perimeters plot within the aforementioned reforested sites. Remote sensing was also used to map and assess vegetation cover, estimate biomass, and assess changes in carbon stock, providing accurate and reliable information on biomass and carbon storage.

The study was conducted from November to January 2026. Tree species, diameter at breast height (DBH), tree height, and wood specific gravity served as the independent variables, while carbon stock was the dependent variable. It focused on observing naturally occurring trees in reforested sites, without the use of controlled groups. The existing tree population in these sites served as the basis of observation. To ensure statistical reliability, three simulation runs were conducted in assessing vegetation cover, along with the assessment of the carbon sequestration capacity of all tree species.

Procedure

In order to estimate the aboveground biomass and carbon stock in a few chosen reforested areas in the City of Koronadal, this study used a methodical set of procedures to gather data from both fieldwork and remote sensing.

Study Sites

The research was conducted in three (3) reforested sites within the City of Koronadal, South Cotabato. The sites were selected based on criteria, where selected forests must have a history of deforestation and must have been reforested for more than ten (10) years. Barangay San Isidro, Barangay Assumption, and Barangay San Jose were reforested in 2011 through the National Greening Program (NGP), covering 100.0 hectares under the Acub, Bulol, Saravia Cooperative (ABESCO). The project received two (2) years of maintenance and protection, lasting until 2013, following the plantation's establishment.

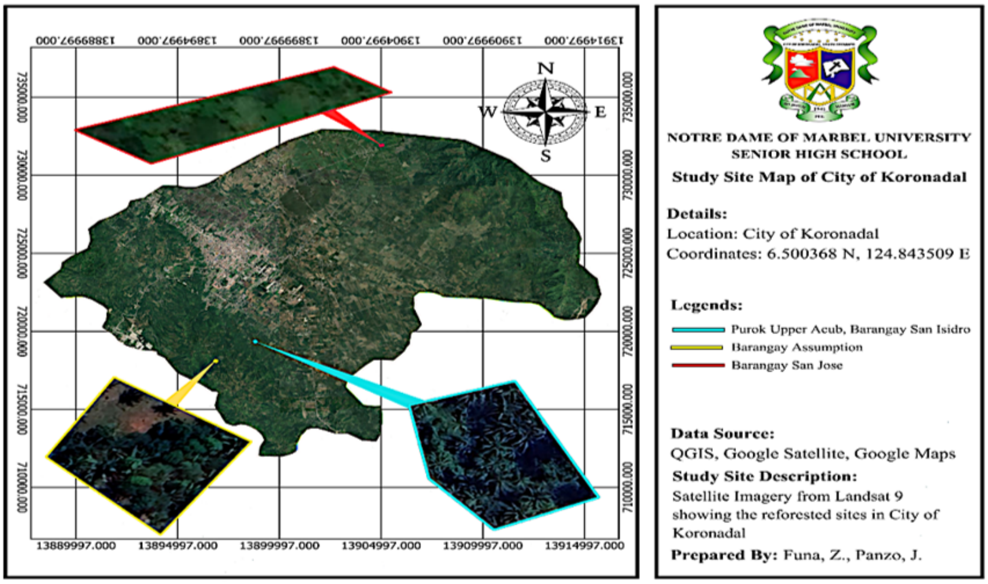

Figure 1: Study Site Map of City of Koronadal

Entry Protocol and Permits

Before doing fieldwork, each location's barangay officials received written requests for permits for site access. Guidance from experts would also be consulted beforehand. Forest measurements were carried out with permission from the Community Environment and Natural Resources Office - Banga (CENRO - Banga) and the official officers of each barangay. The researchers were then guided by the representatives of the barangay captain for them to safely arrive at the study site.

Sampling Site

Random sampling was used to select one site with a total of 200m perimeters within the allowed parameters set by the National Greening Program (NGP). This probability-approach ensured that every potential plot in the study area had an equal chance of being chosen, minimizing chances of bias. A third-party individual was asked to randomly identify an area in the site, and all standing trees within the boundaries of the chosen plots were surveyed. To guarantee accuracy and prevent overlap, the layout of each plot was established by first determining its four corners using GPS coordinates, which were processed in QGIS. These coordinates were verified on-site, with distances measured using an SWMaps application. Finally, four (4) wooden stakes were placed on the ground to clearly mark the boundaries of each 200m perimeters plot.

Tree Species Inventory

Tree Species Identification and Validation

Tree species within the established 200 m perimeter plot were recorded according to both local and scientific names. A mobile application, PictureThis, was used for preliminary identification. Based on observable morphological traits, including leaf form, arrangement, bark texture, and fruit or flower features, species were distinguished using a dichotomous key. Registered Philippine Foresters from CENRO - Banga verified the final species identification to guarantee accuracy. Each tree with a DBH equal to or greater than 15 cm and a height greater than 1.3 m above the surface level within the 200m perimeter plot was tagged with information including tree species, measurement, and respective number for proper tracking and to match measurement records (Vicharnakorn *et al.*, 2014).

Tree Species and Specimen Preservation

Leaves from every species encountered in the study plots were collected for preservation. Specimens were ensured to be intact, not damaged, and not dried out to ensure accurate representation of each species. A herbarium set up was used to press each specimen between two (2) sheets of newspaper. To exclude the possibility of mold growth, the pressed samples were dried in a properly ventilated place until they were completely dry. All specimens were dried and fixed on cardboard frames and subsequently kept under standard herbarium preservation conditions, which guarantee long-term reference as well as stable identification.

Field Measurements for Aboveground Biomass

Aboveground biomass (AGB) was computed using allometric equations suited for tropical forests, incorporating DBH, height, and wood density values. Diameter at Breast Height (DBH) was measured at the standard 1.3 m above the ground using a measuring tape and must be ≥ 15 cm. Trees with burls at DBH were then measured by their dimensions to calculate their volume. Tree height was calculated from the ground to the highest point by measuring the person's eye height, the distance from the person to the tree, and the angle of elevation using a clinometer. Added the eye height and height of the tree, then multiplied by the tangent of the angle of elevation as shown in equation 1.

$$\text{Tree Height} = \text{Eye Height} + (\text{Distance from Person to Tree} \times \text{Angle of Elevation}) \quad (\text{Eq. 1})$$

Data on wood density was collected from the Global Wood Density Database. Biomass values was solved by using Eq. 2.

$$AGB = a \times (p \times D^2 \times H)^b \quad (\text{Eq. 2})$$

Where AGB is the tree's biomass, D is the DBH, H is the tree height, p is the wood density, and 'a' and 'b' are species-specific or site-specific parameters. It was then multiplied by the mean carbon fraction for tropical trees, which is 0.47 (47%) as shown in e.q. 3, as recommended by the IPCC, to estimate the carbon stock per site. A standard aboveground carbon stock per hectare is ≥20 Mg C/ha for mature sites at 10 years, while 10–20 Mg C/ha is moderate.

$$\text{Carbon Stock} = AGB \times 0.47 \quad (\text{Eq. 3})$$

Carbon Sequestration

Carbon stock was calculated considering that 47% of the total biomass was considered as carbon. To estimate the amount of CO_2 absorbed, Eq. 4 was used multiplying the carbon stock by 3.67 (Salunkhe *et al.*, 2023)

$$\text{Weight of } CO_2 = \text{Carbon Stock} \times 3.67 \quad (\text{Eq. 4})$$

Remote Sensing and Data Acquisition

In QGIS, the Semi-Automatic Classification Plugin (SCP), QuickMapServices, and Google Earth Engine were used to analyze raster data, add background maps, and access satellite imagery. Landsat images of the City of Koronadal were requested from DENR and processed via USGS Earth Explorer. Then the obtained sampling sites via SW maps will be used as a shape file to the area of interest. The City of Koronadal shapefile was processed under the set criteria tab, applying a 10–20% cloud cover filter for clearer imagery. Landsat 9 images from 2025 were then selected . Landsat 9 remote sensing and QGIS were used to estimate aboveground biomass (AGB) and carbon storage by analyzing vegetation cover. Landsat 9 imagery provides 30-meter resolution multispectral data, which were processed to compute the Normalized Difference Vegetation Index (NDVI), a key parameter for biomass estimation. NDVI was calculated in QGIS using Band 5 (Near Infrared, NIR) and Band 4 (Red) with the formula shown in eq. 5 (Israel *et al.*, 2025).

$$NDVI=(NIR-RED)/(NIR+RED) \quad (\text{Eq. 5})$$

In QGIS, the NDVI formula ("Band5" - "Band4") / ("Band5" + "Band4") was applied in the Raster Calculator. The output GeoTIFF displayed NDVI values from -1 to +1, where low or negative values indicated water or bare areas, near-zero values showed sparse vegetation, and higher values (0.6–0.9) represented dense, healthy cover. Land cover was classified using the Random Forest method through the Semi-Automatic Classification Plugin. About 50,000 sampling points with three trials each ensured data reliability. The empirical model was applied to estimate biomass, where a is the scaling constant and b the sensitivity exponent calibrated for specific forest types. Carbon stock was calculated by multiplying AGB by a conversion factor of 0.47. This model data is usually used to compare the data from field measurements to ensure validity between data as it is widely used by various studies for predicting forest biomass and vegetation density, due to its simplicity, timely, and efficient biomass estimates (Israel *et al.*, 2025 & USGS, 2024).

Development of Policy Brief

To connect the study's findings with practical policy actions, the researchers prepared a policy brief based on the key findings. Data from tree inventories, biomass estimates, and carbon stock measurements across reforested sites in the city were organized and analyzed which served as the scientific basis for assessing forest's ecological and economic value. Normalized Difference Vegetation Index (NDVI) data from remote sensing, together with field observations, were used to assess forest growth and overall forest condition. These results guided the policy recommendations that Local Government Units (LGUs) and communities could act on. The policy brief also included the city's potential participation in carbon markets using carbon stock data. Carbon stocks can be converted to carbon dioxide equivalents using the formula shown in eq.6 (Salunkhe *et al.*, 2023).

$$CO_2\ (t) = \text{Carbon Stock} \times 3.67 \quad (\text{Eq. 6})$$

It can be then expressed as carbon credits, with one credit equivalent to one metric ton of CO_2 (Salunkhe *et al.*, 2023). These credits can be valued using the 2025 average voluntary carbon market price of USD 6.34 per ton and converted to Philippine pesos at the 2026 exchange rate of PHP 59.34 per USD, resulting in an estimated value of PHP 374.88 per carbon credit (Ecosystem Marketplace, 2023 & Development Bank of the Philippines, 2020). Forest carbon revenues can support sustainable land use and community environmental stewardship (Bhatia, 2024). The brief was reviewed by an expert in the field, who provided feedback to ensure that the recommendations were clear, practical, and based on the study's data to guide future forest management and policy development.

Data Analysis

Field data were collected for individual trees, including species, diameter at breast height (DBH), total height, and wood density. These variables were used to estimate aboveground biomass, which was then converted into carbon stock. At the plot level, stand characteristics such as mean DBH, mean tree height, stem density, and species richness were calculated to describe forest structure and composition. In addition to field measurements, remote sensing techniques were applied. The Semi-Automatic Classification Plugin (SCP) was used to generate vegetation maps, which supported the assessment of vegetation cover, as well as the spatial distribution of biomass and carbon stock across the study area. Data analysis involved descriptive statistics, including mean, variance, standard deviation, and root mean square error (RMSE). The findings were presented in tables produced using JASP software. These tables illustrated the distribution of DBH, tree height, and carbon stock, compared carbon stock among different species, DBH classes, and sites, and examined the relationships between stand variables and carbon stock. They also facilitated comparison between field-based estimates and those obtained through remote sensing methods.

Ethical Considerations

This study was conducted with strict compliance to the given ethical guidelines to ensure transparency, credibility, and responsibility. This study included, obtaining all necessary permits and approval letters mainly a letter of approval to conduct the study, signed by the school principal and barangay officials of Barangay San Isidro, Barangay Assumption and Barangay San Jose, and authorization from the Department of Environment and Natural Resources (DENR) to ensure a legal conduct of the study and a parent's consent was then secured before conducting data add period after In terms of plant ethics, the study prioritized non-destructive methods before, during, and after the data collection to prevent harm to trees and surrounding vegetation. The researchers carefully planned the procedures and conducted responsibly, avoiding disturbance with a forester assisting to ensure proper methods and restoration. All information was honestly documented and clearly reported for verification, with disclosed conflicts of interest. Results will be shared with relevant users to support climate change mitigation, forest conservation, and sustainable land management.

RESULTS AND DISCUSSION

Tree Species Composition and Inventory Assessment

The results of the inventory provide essential data on the ecological condition of the reforested sites, which were initially established under the National Greening Program (NGP) in 2011.

Table 1: Forest Inventory Data for Species Richness

Site	Tree Species	Number of Individuals	Mean height(m)	Mean DBH (m)
Barangay Assumption	Mahogany	17	10.12	0.98
	Gemillina	6	9.17	0.63
	Ipil-ipil	3	8.67	0.82
	Santol	2	12.5	0.57
	Durian	2	8.5	0.58
	Pomelo	2	7.5	0.55
	Guyabano	2	4.5	0.52
	Lansones	2	3.5	0.16
	Mango	2	3	0.29
	Madre de cacao	2	2.5	0.29
Barangay San Isidro	Mahogany	21	4.45	0.26
	Mango	2	7.75	0.40
	Guyabano	2	3.5	0.16
	Cacao	2	1.62	0.25
Barangay San Jose	Mahogany	75	8.11	0.75
	Kakawate	3	3.33	0.25
	Kape	2	4.55	0.31
	African Tulip	2	3.85	0.20
	Magnolia Grandiflora	5	58.44	0.86

The forest inventory data are summarized in Table 1, showing the number of individuals, total mean height and total mean diameter at breast height (DBH) per individual tree species in each site. Table 1 indicates that the reforested areas are dominated by Swietenia macrophylla (mahogany), Mahogany exhibits substantial early growth performance in plantation settings, supporting its use in large reforestation efforts (Abarquez *et al.*, 2015 & Villegas, 2024). However, in many plots, most other species are represented by only a few individuals, leading to low species evenness and limited structural complexity in the early stages of stand development. Such patterns are consistent with other plantation studies in the Philippines, which also report mahogany dominance due to its fast growth and survival, and note that low diversity in early-stage plantations may limit biomass accumulation (Zhou *et al.*, 2023 & Chave *et al.*, 2005).

Field-Based Aboveground Biomass and Carbon Stock

The results present the field-based estimation of aboveground biomass and carbon stock derived from tree inventory measurements. Using DBH, tree height, and wood density, AGB was calculated through allometric equations and converted to carbon stock following IPCC guidelines (Chave *et al.*, 2005). The data for aboveground biomass and carbon stock were summarized in Table 2, presenting the number of individual trees, mean height, mean DBH, aboveground biomass, and carbon stock. The overall Carbon sequestration is presented in Table 3.

Table 2: Aboveground Biomass and Carbon Stock of Reforested Sites

Site	No. of Individuals	Mean Height (m)	Mean DBH (m)	AGB (t/ha)	Carbon Stock (t C/ha)
Barangay San Jose	87	8.11	0.47	0.35	0.16
Barangay Assumption	40	8.43	0.78	0.29	0.14
Barangay San Isidro	27	4.41	0.27	0.02	0.04

Table 2 reveals that there was a considerable variation in aboveground biomass and carbon stock among the three (3) reforested sites, the variation in aboveground biomass and carbon stock across the reforested sites demonstrates that stand density and species growth characteristics strongly regulate total carbon accumulation in tropical plantations (Asmussen *et al.*, 2025 & Menyailo *et al.*, 2022). Low-density stands often store less carbon due to limited canopy cover and leaf area, while denser stands capture more biomass through greater stem volume and canopy interactions. Environmental and management factors, including planting design and site conditions, also affect tree growth and total carbon stock (Ma *et al.*, 2023; Menyailo *et al.*, 2022; Anderson *et al.*, 2023). These results complement the idea that stand density affects the results for the total biomass and carbon stock within forestries, greater tree diversity in plantation optimizes plantation management practices in alignment with national and international carbon neutrality goals (Asmussen *et al.*, 2025; Menyailo *et al.*, 2022; Anderson *et al.*, 2023).

Table 3: Carbon Stock and Carbon Sequestration of All Sites from Field Data

Sites	Tree Species	Total Individuals	Carbon Stock (t C/ha)	CO2 Sequestration (t CO2/ha)
Barangay Assumption	Santol	2	0.3982	1.4614
	Mahogany	17	0.2173	0.7975
	Ipil-ipil	3	0.1174	0.4309
	Gemillina	6	0.0664	0.2437
	Durian	2	0.0573	0.2103
	Pomelo	2	0.042	0.1541
	Guyabano	2	0.0163	0.0598
	Mango	2	0.0057	0.0209
	Madre de cacao	2	0.0043	0.0158
	Lansones	2	0.0021	0.0077
Barangay San Isidro	Mango	2	0.0372	0.1365
	Mahogany	21	0.0055	0.0202
	Cacao	2	0.0013	0.0048
	Guyabano	2	0.0013	0.0048
Barangay San Jose	Magnolia Grandiflora	5	0.4111	1.5087
	Mahogany	75	0.1628	0.5975
	Kape	2	0.0092	0.0338
	Kakawate	3	0.0051	0.0187
	African Tulip	2	0.0027	0.0099

Table 3 shows that carbon stocks differed among the study sites due to variations in tree density, species, and maturity of the trees. Barangay San Jose and Barangay Assumption recorded higher carbon stock values, mainly because of higher numbers of mature and large-diameter trees that contribute greater biomass and carbon storage Pragasan (2016). The presence of high biomass species enhanced their capacity to function as effective carbon sinks. In contrast, Barangay San Isidro showed lower values of carbon stock, this is due to the site having fewer tree individuals and smaller or younger dominant trees. Although fruit-bearing species were present, in comparison to the timber species, the small size and lower biomass of such trees resulted in lower carbon storage. Overall, these results indicate that carbon sequestration is strongly influenced by the stand structure and species selection. The findings confirm that reforestation efforts are more effective with higher tree density and mature, high biomass species in long-term carbon storage and climate change mitigation (Stein, 2023; Lasco & Pulhin, 2003).

Remote Sensing–Based Biomass and Carbon Estimation

This section presents biomass and carbon stock estimates derived from remote sensing analysis using Landsat 8 imagery calculated through QGIS to solve the NDVI. NDVI is widely used as a proxy for vegetation vigor and biomass due to using the sensitivity of the plant cover to solve for canopy density and chlorophyll content (Dahy *et al.*, 2020). The results shown in Table 4 shows the spatial variation in the NDVI and biomass across the sites and the validated data of the field measurement data to remote sensing data calculated.

Table 4: NDVI-Derived Vegetation Cover, Biomass, and Carbon Stock of Reforested Sites

Sites	Mean NDVI	AGB (t/ha)	Carbon Stock (t C/ha)	R2	RMSE(Mg/ha)
Barangay San Jose	0.35	0.372	0.175	0.97	0.022
Barangay Assumption	0.50	0.266	0.125	0.93	0.024
Barangay San Isidro	0.51	0.023	0.011	0.96	0.005

Table 4 shows the clear differences in vegetation cover, biomass, and carbon stock among the three (3) reforested sites. Barangay Assumption showed a moderate biomass and carbon storage, which reflects the vegetation cover, but having the least accuracy from other sites. Barangay San Isidro, despite having similarly high vegetation cover, showed having very low biomass and carbon stock, but showed a high accuracy that may imply that vegetation may reflect on the species on the site. Barangay San Jose has the highest biomass and carbon accumulation even with moderate vegetation cover and having a high accuracy, which meant that the area's vegetation is composed of high biomass species of trees, considering the importance of mature trees and higher stem density in carbon storage (Israel *et al.*, 2025 & Anees *et al.*, 2024). These results indicate that the AGB and carbon stock cannot always reflect on vegetation cover alone due to the species limitations present in the area. but may be used for accuracy. While minor uncertainties may arise from NDVI saturation or the recent use of Landsat 9, the data can remain reliable for monitoring long-term forest growth and density and carbon dynamics (Israel *et al.*, 2025 & Pettorelli *et al.*, 2005).

The Figure 2 shows the generated NDVI values from QGIS for each area. Brgy. San Isidro observed high NDVI values ranging from 0.4997 to 0.5225, indicating the area has very dense vegetation. While Brgy. Assumption recorded NDVI values from 0.485 to 0.552, showing an area mix of very moderate and a high dense vegetation. Meanwhile Brgy. San Jose has NDVI values ranging from 0.258 to 0.353, which shows an area with mostly showing moderate vegetation, with only a small area showing high vegetation.

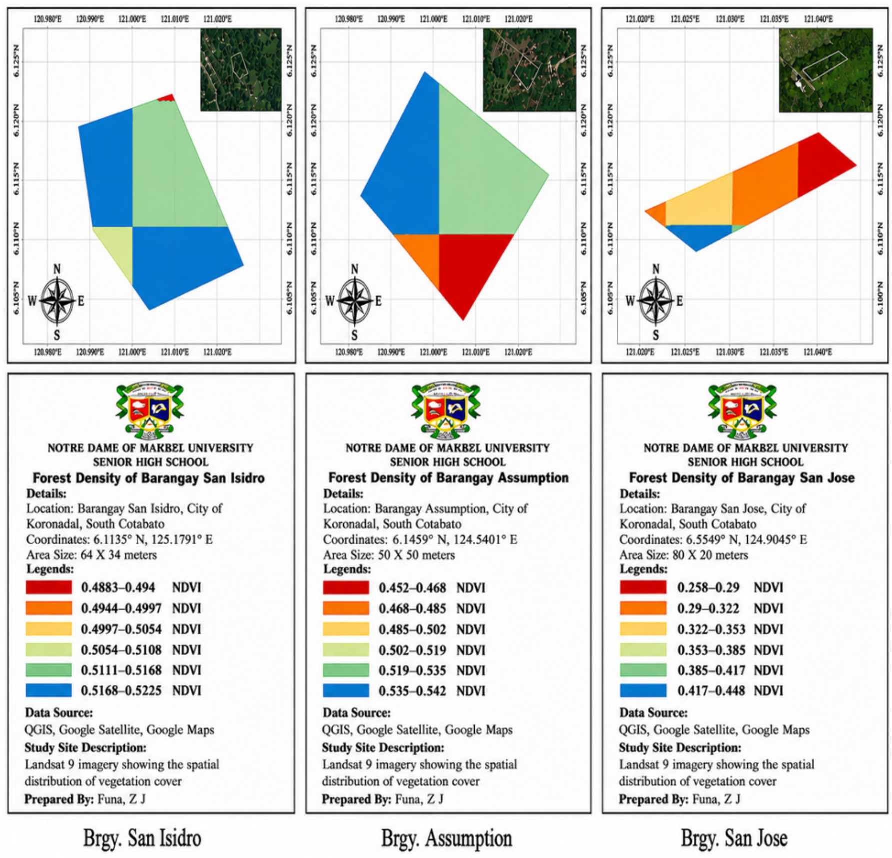

Figure 2: Forest Density of Each Reforested Site

Policy Brief

Based on the data collected from the reforested sites in Koronadal City, a policy brief was proposed to improve forest management and carbon storage. It presented the study's background, summarized the key findings, showed how they relate to carbon trading and forest management, and provided clear recommendations that Local Government Units (LGUs) and communities can apply. Policy briefs are recognized as effective tools for synthesizing scientific evidence and presenting clear recommendations that support informed decision-making in forest management and climate-related initiatives (Horn, 2025). Such evidence-based policy instruments are particularly important in addressing forest governance challenges, as clear and accessible information can help guide appropriate policy responses and management actions.

CONCLUSION

This study assessed the aboveground biomass and carbon stock of selected reforested sites in the City of Koronadal in line with the research objectives using field inventory and remote sensing analysis. The tree species inventory showed that the sites were largely dominated by *Swietenia macrophylla* (Mahogany), particularly in Barangay San Jose and Assumption. Barangay Assumption recorded the highest species richness, while Barangay San Isidro showed the lowest diversity and forest structure. Results from field measurements revealed differences in aboveground biomass and carbon stock among the sites. Barangay San Jose had the highest carbon storage due to higher tree density and the presence of mature trees, whereas Barangay San Isidro recorded the lowest values because of younger and smaller trees. These findings indicate that tree maturity and stand density strongly influence carbon storage capacity. Remote sensing analysis further confirmed variations in vegetation cover across the areas, with San Jose showing the most developed forest condition, followed by Assumption, while San Isidro remains in an early stage of forest growth. Based on these findings, a policy brief was developed recommending the protection of high-carbon areas, assisted regeneration in developing sites, and the exploration of voluntary carbon market opportunities to support sustainable forest management.

Recommendation

This study recommends strengthening reforestation management and monitoring efforts in the City of Koronadal through the combined use of field-based forest inventories and remote sensing technologies. Integrating these methods can improve the accuracy and continuity of monitoring aboveground biomass and carbon stocks, allowing local authorities to better track forest growth and support sustainable environmental planning. Local Government Units (LGUs) and the Department of Environment and Natural Resources (DENR) are encouraged to use the baseline carbon data from this study to guide conservation programs and climate mitigation strategies. Strengthening the implementation of the National Greening Program (NGP) through regular monitoring, field validation, and consistent reporting is also recommended to ensure long-term environmental benefits. Future reforestation efforts should prioritize increasing tree species diversity and selecting species with high carbon sequestration potential to improve both carbon storage and ecosystem resilience. Community involvement through environmental education and stewardship programs is also important to promote long-term forest protection. Future studies are encouraged to include belowground biomass and soil organic carbon for more comprehensive assessments. Finally, the use of standardized 50 × 50 meter sampling plots and consistent species representation is also recommended to improve data reliability and comparability across sites.

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