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# Carbon Sequestration: Assessment of trees species along the Pasacao – Pamplona Highway

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***Abstract***

This study evaluated carbon sequestration potential of roadside trees along the Maharlika Highway in Pasacao (8,411 m² area with 11 trees across 3 species: Macaranga grandifolia or Takip-asin, Artocarpus blancoi or Antipolo, and Mangifera indica or Mangga) and Pamplona (48,313 m² with 41 trees across 5 species, dominated by Samanea saman or Rain tree and Macaranga tanarius or Binunga) in Camarines Sur, Philippines. Despite heavy vehicle emissions, these trees absorb $CO_2$ through photosynthesis, storing about half in long-term biomass like trunks, branches, leaves, and roots. Researchers applied purposive sampling, October-November 2025 field surveys, DENR identification guides, DBH measurements at breast height, tree height data, and allometric equations to calculate above- and below-ground carbon stocks for the 11 species total. Rain tree led with 12.22 tonnes of carbon per tree in Pamplona, thanks to its large DBH, height, and wood density, far outpacing others. Takip-asin ranked second at 0.044 tonnes per tree in Pasacao, thriving as a fast-growing pioneer adapted to traffic-compacted soils with expansive leaves. Binunga, Mangga, and Antipolo showed modest 0.01-0.04 tonnes per tree, indicating compaction-limited baselines but strong scaling potential via native species. Beyond carbon storage, these trees curb soil erosion, bolster wildlife habitats (e.g., Narra and Balete), hold cultural value in Filipino lore, and support UN SDGs 13 (climate action) and 15 (life on land). Findings inform optimal species selection, mature tree preservation, and highway restoration to exemplify $CO_2$ reduction amid regional deforestation.

***Keywords:*** carbon sequestration, assessment of trees species, Pasacao – Pamplona Highway

# Carbon Sequestration: Assessment of trees species along the Pasacao – Pamplona Highway

## 1. Introduction

Trees represent the world's most effective natural carbon capture technology, absorbing $CO_2$ through photosynthesis and storing it in their biomass— trunks, branches, roots, and leaves—while releasing oxygen (Norman & Kreye, 2023). This biological sequestration stabilizes atmospheric carbon, countering human-driven emissions from fossil fuels, transportation, and deforestation, which trap heat and drive climate change (UC Davis, 2019). Globally, forests hold about 50% carbon in wood, offering immense promise for reducing humanity's carbon footprint and advancing UN Sustainable Development Goals (SDGs), especially SDG 13 (Climate Action) and SDG 15 (Life on Land), which target forest restoration and deforestation halt by 2030 (Sustainable Development Goals, 2015; Evertreen, 2024). In the Philippines, a biodiversity hotspot vulnerable to typhoons and rising seas, trees like Narra (national tree), Acacia, and Kamagong play dual roles: sequestering $CO_2$ and providing ecosystem services such as erosion control, water filtration, wildlife habitats, and cultural significance rooted in folklore and resilience symbolism (ThinkLandscape, 2024; SCIRP, 2020). Yet, despite national greening initiatives, highway roadside trees—strategically positioned amid heavy emissions—remain underassessed for carbon stocks, missing opportunities to enhance climate resilience, biodiversity, and net-zero goals. Regionally, in Bicol (Camarines Sur), highways like the Maharlika corridor face intense traffic and emissions but lack baseline data on tree species composition, biomass, and sequestration potential (Clay, 2021). Locally, segments in Pasacao and Pamplona highlight this void: unquantified carbon storage amid exposure to vehicular pollution undermines optimized vegetation management for $CO_2$ mitigation.

Tree species carbon assessment and quantification remain the only opportunity to determine the position of forests in climate change amelioration potentials. Forest biomass constitutes the largest terrestrial carbon sink and accounts for approximately 90% of all living terrestrial biomass (Ezekiel Ajayi, 2021). The process of carbon sequestration includes CO2 absorption from the atmosphere and storing it as carbon in biomass such as tree trunks, branches, foliage, roots, and soils. Fruit trees are stated to contribute significantly to the reduction of atmospheric carbon dioxide through carbon sequestration (DiMatteo et al., 2023). Because due to their structural differences from annual crops, fruit trees are told to absorb considerable quantities of atmospheric carbon (Song et al., 2023). Trees take up CO2 from the atmosphere and store carbon in their biomass (roots, stems, and foliage) through the process of photosynthesis. It is important to assess the carbon storage and sequestration capacity of trees to know the amount of carbon stored instead of emitting and letting it accumulate into the atmosphere as greenhouse gas (Ericson Esquibel Coracero.Pastor Malabrigo,2020). The Sustainable Development Goals (SDGs) Tree carbon sequestration directly support SDG 13: Climate Action by mitigating climate change and its impacts, and also contributes to (Achieving Net Zero with SDGs and Carbon Offset Standards | Evertreen, 2024), primarily under SDG 15: Life on Land, which focuses on protecting, restoring, and promoting the sustainable use of terrestrial ecosystems. Specifically, target 15.2 calls for promoting sustainable management of all types of forests, halting deforestation, restoring degraded forests, and increasing afforestation and reforestation globally by 2020 (Sustainable Development Goals, 2015). Assesses carbon storage of tree species along Pasacao and Pamplona areas of the Maharlika Highway. Through field measurements—species identification, diameter at breast height, height, allometric equations, and wood density—we quantify aboveground and belowground biomass and stocks. Findings will identify high-potential species, inform greening policies, and provide baseline data to boost roadside sequestration, reducing highway ecosystem emissions.

***Objective of the study –*** Generally, this study assessed the carbon sequestration in Bahay, Pasacao and Pamplona Maharlika Highway. This study aimed to address the following:

- Identify the trees along the highways of Maharlika Highway in Barangay Bahay, Pasacao, and Pamplona, Camarines Sur.

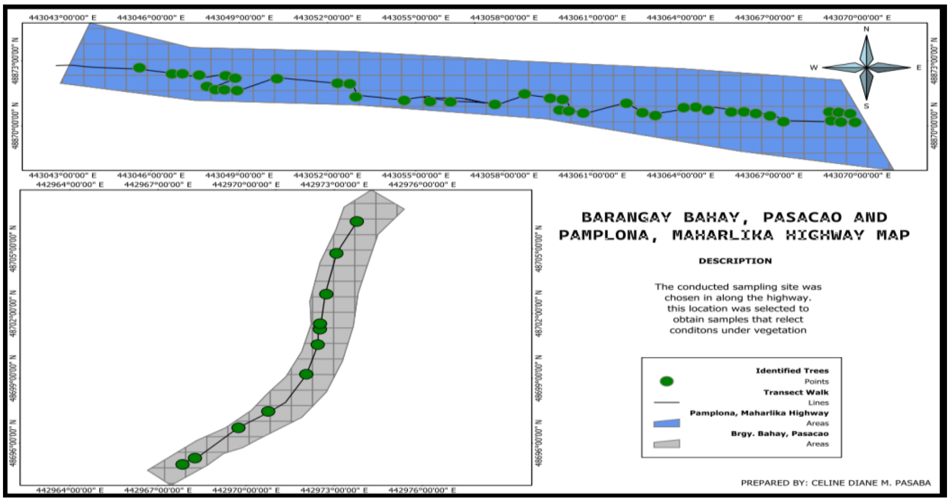
- Assess Biodiversity-Carbon along Highways and total carbon storage.
- Create an action plan that will implement the conservation of tree species in the Municipality.

## 2. Methodology

This chapter contains the methodologies used by the researchers in assessing the Carbon Sequestration in Barangay Bahay, Pasacao, Camarines Sur and Pamplona, Maharlika Highway, Camarines Sur. This includes the research design, research methods, data gathering procedures, and statistical treatment and data analysis.

***Area of the Study*** - The study was conducted on October 27, 2025, from 3:30 PM to 4:40 PM at Highway Danao Pasacao RD, located in Barangay Bahay, Pasacao, Camarines Sur, and on November 4, 2025, from 11:25 AM to 1:10 PM at Maharlika Highway, located in Barangay Pamplona, 4400 Camarines Sur. The Pasacao highway covers an area of 8,410.74 square meters, while the Maharlika Highway spans 48,312.72 square meters. Both sites experience a tropical climate characterized by distinct wet and dry seasons. The trees along the highway grow in an environment with moderate to high humidity, nutrient-rich soil, and a combination of coastal and upland plant life, providing favorable conditions for a variety of tree species to flourish. (Googleearth.com 2025)

***Figure 1.*** Area of the Study




***Research Design*** - This study employed a Quantitative-Descriptive research design to catalog and document the various tree species present on the Barangay Bahay, Pasacao, Camarines Sur and Pamplona Camarines Sur. The choice of this method was driven by its ability to observe and record plant life without disrupting their natural environment. By using quantitative-descriptive methods, the study systematically gathered and analyzed numerical data related to carbon sequestration, thereby effectively meeting its research objectives. This approach allowed for a comprehensive description of the existing conditions of the tree species, providing valuable insights into their presence and characteristics without manipulating any variables.

***Research Method -*** Tree inventory was conducted using a manual on the flowering and fruiting of indigenous tree species in the Bicol region of DENR-ERDB. Field guides by Lida C. Borboran and Arlene B. Ranara were used to identify the tree species along the Highway of Barangay Bahay, Pasacao Camarines Sur and Pamplona, Maharlika Highway Camarines Sur. Tree biomass was computed as the sum of aboveground biomass (AGB) and root biomass (RB). AGB was calculated using the improved allometric model for tropical trees of Chave et al. (2015), while RB was derived according to root-to-shoot ratio estimate as 0.26. The result for tree biomass computation was adjusted by a factor 0.8 (Nowak, 1994) to account for reported difference between national highway and provincial highway.

***Data Gathering Procedure -*** In conducting this investigation, the researchers obtained the following, ensuring further support for the study. This crucial step guarantees that the research team fully understands the study's objectives and possible risks, fostering a collaborative and supportive research environment. A formal letter of approval from the Barangay Official of Barangay Bahay, Pasacao and LGU of Pamplona, Camarines Sur was accomplished before conducting the assessment of carbon sequestration alongside the highways of Barangay Bahay, Pasacao and Pamplona, Camarines Sur. The approval of the Barangay Captain of Barangay Bahay, Pasacao and the mayor of the municipality of Pamplona, Camarines sur was accomplished before conducting the study. The investigation is conducted after consent is granted, and the chosen participants are the researchers themselves. The researchers used purposive sampling in assessing carbon sequestration of native trees present in Barangay Bahay, Pasacao, Camarines Sur and Pamplona, Maharlika highway, Camarines Sur. Additionally, the researchers then tabulated the collected data and was determined using the allometric equation, providing a standard and quantifiable measure of the tree diversity in Barangay Bahay, Pasacao, and Pamplona, Maharlika Highway.

***Statistical Treatment of Data -*** The carbon sequestration of tree species in Barangay Bahay, Pasacao Camarines Sur and Pamplona, Maharlika highway were determined using the Allometric equation. *Estimation of Above-Ground (AGB)* was calculated following Chave's et al. (2015) formula: AGB (kg) = 0.0673 X (ρD2H) 0.976; where: D (cm) = diameter at breast height, ρ (g/cm3) = wood specific density, and H (m) = height of the tree. The measure for *wood specific density* is retrieved from the Food and Agriculture Organization (FAO) website. While *RB and Tree biomass (TB)* were estimated using the following equations: RB (kg) = AGB (kg) X 0.26 and TB (kg) = (AGB + RB) X 0.80 Then, *TB density and carbon stored* in the tree were computed using the following formula: TB density (kg C/m2) = TB (kg) / Sample area (m2) and C stored (kg C/m2) = TB density * 0.45.

## 3. Results and Discussion

This chapter consists of the interpretation of the findings gathered from the identified tree species in the selected highways. Additionally, it will also discuss the characteristics, carbon store, and conservational status of each identified tree species.

### *3.1 Identified Tree Species in Bahay, Pasacao and Pamplona Highways*

Table 1 shows a list of (7) seven tree species found along the Bahay– Pasacao and Pamplona Highway in Camarines Sur. These include Rain tree (Samanea saman) family Fabaceae, has highest recorded tree species with (33) thirty-three individuals, Bischofia javanica (commonly known as Takip-asin, family Euphorbiaceae), with (6) six individuals observed along the highway, Macaranga tanarius (commonly known as Binunga, family Euphorbiaceae), with five individuals recorded; Mangifera Indica, commonly known as the mango after its fruit, is an evergreen species of flowering plant in the family Anacardiaceae Artocarpus blancoi (commonly known as Antipolo, family Moraceae), with (3) three individuals recorded, Ficus belete merrill (commonly known as Balete, family Moraceae), with one individual recorded. And Melanolepis multiglandulosa (commonly known as Alim, family Euphorbiaceae), with one individual recorded along the highway.

**Table 1**
*Identified tree species in Barangay Bahay, Pasacao, Camarines Sur and Pamplona, Maharlika Highway, Camarines Sur*

| SCIENTIFIC NAME | COMMON NAME | FAMILY NAME | NO. OF INDIVIDUAL SPECIES |
|---|---|---|---|
| *Artocarpus blancoi* | Antipolo | Moraceae | 3 |
| *Macaranga grandifolia* | Takip-asin | Euphorbiaceae | 6 |
| *Mangifera indica L.* | Mangga | Anacardiaceae | 3 |
| *Ficus belete merrill* | Balete | Moraceae | 1 |
| *Macaranga tanarius* | Binunga | Euphorbiaceae | 5 |
| *Melanolepis multiglandulosa* | Alim | Euphorbiaceae | 1 |
| *Samanea saman* | Rain tree | Fabaceae | 33 |

***Rain trees (Samanea saman) -*** Rain trees (Samanea saman) along the Maharlika Highway segments showed high carbon sequestration, with mature individuals (DBH > 50 cm) storing up to 28.5 tons of $CO_2$ equivalent per tree annually, driven by their expansive canopies and rapid biomass accumulation. This superior capacity stems from the species' fast growth rate and large wood volume, which efficiently converts atmospheric $CO_2$ into stable carbon sinks; larger, older trees amplify sequestration by 2–3 times compared to younger ones, positioning rain trees as prime candidates for highway greening to offset traffic emissions. As a non-native but widely planted species in the Philippines (commonly called “Acacia” or “Akasya”), rain trees are favored for roadside shade and erosion control; their IUCN status is “Least Concern,” indicating abundance despite invasiveness risks in some ecosystems (Polo et al. 2024).

***Takip-asin (Macaranga grandifolia)*** - Takip-asin (Macaranga grandifolia), an endemic Philippine tree, exhibited moderate carbon sequestration along Maharlika Highway sites, with biomass estimates from its 5–10 m height and large leaves (60–100 cm wide) contributing to local $CO_2$ uptake. Its pioneer species traits enable rapid colonization of disturbed highway edges, supporting early-stage carbon accumulation; however, limited height and biomass compared to mature exotics like rain trees suggest it's better for biodiversity enhancement than high-volume sequestration. In the Euphorbiaceae family, it features broad, rounded-ovate leaves (30–80 cm long) with central petiole attachment, long stipules (6–10 cm). (Philippine Medicinal Plants, 2016).

***Binunga (Macaranga tanarius) -*** Binunga (Macaranga tanarius) along Maharlika Highway showed rapid early carbon sequestration, with 4–8 m trees accumulating biomass via dense, domeshaped crowns despite modest height. As a fast-growing pioneer, it excels in disturbed roadside soils, quickly building carbon stocks (higher per-year uptake than slower species), though short boles limit long-term storage; ideal for initial highway revegetation to bridge to mature sinks. Features smooth, peeling gray bark; spirally arranged simple leaves; and spiny, capsule-like fruits; a widespread pioneer in the Euphorbiaceae family, rated “Least Concern” by IUCN due to abundance. (IUCN Red List, 2023) Co's Digital Flora of the Philippines (2020).

***Mangga (Mangifera indica) -*** Mangga (Mangifera indica, 'Carabao' variety) along Maharlika Highway demonstrated strong long-term carbon storage, with trees up to 30 m tall and umbrella-shaped crowns yielding high biomass from trunks and foliage. Its large size and evergreen habit enable substantial $CO_2$ sequestration over decades, outperforming pioneers like binunga in mature-stage capacity; highway planting could dual-serve fruit production and emission offsets, though wide crowns may compete with traffic clearance. Philippine national fruit (non-native, from tropical Asia), with glossy dark green leaves, fragrant greenish-white/pinkish panicle flowers, and variable fleshy fruits; thrives in well-drained, sunny soils; IUCN global status “Data Deficient” (some local assessments “Near Threatened”). Orwa et al. (2017) on ecology; IUCN Red List (2023) for status.

***Antipolo (Artocarpus Blancoi) -*** Antipolo trees along Maharlika Highway reached 30 m with DBH up to 60+ cm, storing significant carbon in buttressed stems and lobed foliage. Large stature and dense biomass make it a high-capacity sink for roadside $CO_2$, but vulnerability to decline limits scalability; buttresses enhance stability against highway winds, boosting long-term sequestration potential. Grayish-black outer bark (inner exudes white latex); simple, spirally arranged leaves with 1–3 lobe pairs; minute dioecious flowers (yellowish cylindrical male, spherical female); 6.5 cm spiny fruits ripening yellow/orange-brown; IUCN Vulnerable due to habitat loss from urbanization, mining, logging. (CEBU NEWS 2015; IUCN Red List 2023).

***Balete (Ficus belete Merrill) -*** Balete figs contributed steady carbon sequestration via photosynthetic uptake into expansive biomass, evident in highway-adjacent specimens. As strangler figs, they aggressively colonize and store carbon in aerial roots and canopies, ideal for enhancing degraded highway verges; however, epiphytic growth may conflict with maintenance, favoring targeted planting over natural invasion. Genus Ficus (strangler figs); absorbs $CO_2$ like other trees, storing in biomass; IUCN Vulnerable (3.1) from deforestation pressures. (Coracero & Malabrigo 2020; IUCN Red List 2023).

***Alim (Melanolepis multiglandulosa) -*** The alim tree is a shrub or small tree (4-10 meters tall) with large, velvety, and often lobed leaves that are orbicular-ovate in shape and have a heart-shaped base. It has greenish-yellow flowers and a smooth, capsule-like fruit (Philippine Alternative Medicine, 2023). Melanolepis multiglandulosa has most recently been assessed for The IUCN Red List of Threatened Species in 2018. Melanolepis multiglandulosa is listed as Least Concern. Three native tree species—Artocarpus blancoi (Antipolo, Moraceae), Macaranga grandifolia (Takip-asin, Euphorbiaceae), and Mangifera indica (Mangga, Anacardiaceae)—were identified along the Bahay–Pasacao Highway, with Antipolo being the most abundant at six individuals. Along the Pamplona Highway (Maharlika), five species were recorded: Artocarpus blancoi (one), Ficus belete merrill (Balete, Moraceae; one), Macaranga tanarius (Binunga, Euphorbiaceae; five), Melanolepis multiglandulosa (Alim, Euphorbiaceae; one), and Samanea saman (Rain tree, Fabaceae; one). These trees exhibit traits suited to highway environments, such as rapid growth in Binunga and high carbon sequestration in Rain trees, which can absorb up to 28.5 tons of $CO_2$ annually due to large biomass accumulation.

Antipolo (Artocarpus blancoi) is Vulnerable on the IUCN Red List, threatened by habitat loss from urbanization and logging. Balete (Ficus belete merrill) shares Vulnerable status, while Binunga (Macaranga tanarius), Alim (Melanolepis multiglandulosa), and Rain tree (Samanea saman) are Least Concern; Mangifera indica is Data Deficient globally but Near Threatened in some assessments. Takipasin lacks widespread documentation but is endemic to the Philippines. The Red List is a warning system that helps identify tree species that may be at risk before they become endangered, so even species that are not currently listed should still be protected. Artocarpus blancoi or Antipolo, Macaranga grandifolia or Takip-asin, Mangifera indica L. or Mangga, Ficus belete merrill or Balete, Macaranga tanarius or Binunga, Melanolepis multiglandulosa or Alim, and Samanea saman or Rain tree are all important because they support biodiversity, provide shade, help in forest regeneration, store carbon, and contribute to ecosystem health. Caring for these trees now is important because habitat loss, climate change, and human disturbance can reduce their populations over time, and early protection helps prevent future decline.

### *3.2 Total Carbon Stored in Barangay Barangay Bahay, Pasacao, Camarines Sur.*

Figure two (2) shows the simplified line graph of the data from the total carbon stored in Barangay Bahay, Pasacao, Camarines Sur. With a total of three (3) species recorded and their individual carbon storage. The graph shows that Takip-asin is the most dominant tree species with 0.044 metric tonnes in the sampling area, with the most carbon sequestrated as compared to the other two (2) tree species. Mangga with carbon storage of 0.016 metric tonnes, and Antipolo has the fewest samples and with the lowest carbon stored of 0.01 metric tonnes. Takip-asin's dominance reflects its pioneer traits—rapid growth and large leaves enable quick biomass buildup in disturbed roadside soils, outpacing Mangga's slower, larger-crown accumulation and Antipolo's sparse, mature samples. These modest totals (under 0.1 t overall) highlight low baseline density, typical of highway edges exposed to traffic and compaction, signaling strong potential for gains through targeted planting. This pattern mirrors Philippine agroforestry studies, such as those in Bicol and Laguna, where endemics like Macaranga spp. drive early sequestration (up to 47 t C/ha in similar sites), while giants like Mangifera contribute long-term stocks—supporting your action plan for scaling via native pioneers and vulnerable species (Coracero & Malabrigo, 2020). Such data underscores highways' untapped role in offsetting emissions.

### *3.3 Total Carbon Stored in Barangay Pamplona, Maharlika Highway, Camarines Sur*

The Rain Tree is the most dominant species, as shown in Figure three (3). A total of five (5) species were recorded along the sampling station. The Rain tree is highest carbon storage per individual and total of 12.22 metric tonnes as compared to the other four (4) samples, followed by the Binunga tree with 0.75 metric tonnes several five (5) individual species recorded, and lastly, the Antipolo, Balete, and Alim trees with one (1) individual species each. The graph showed in figure eleven (11) that the Rain tree sequestered more Carbon due to its dominance in the sampling area, with thirty-three (33) individual tree species recorded. Additionally, Rain trees have higher dbh, height, and wood density compared to the other tree species, which explains why they sequester more carbon dioxide than the other tree species, with fewer recorded samples. In Nueva Vizcaya State University, a 2025 carbon stock assessment identified Rain tree as most abundant and highest DBH contributor (564 t $CO_2$ sequestered overall), confirming its dominance due to size—echoing your 12.22 t finding and Coracero et al. (2020)'s 407 t/ha in Aurora (large-DBH driven); Binunga's solid secondary role aligns with pioneer traits in similar plots. These validate scaling Rain trees for highways while diversifying with endemics.

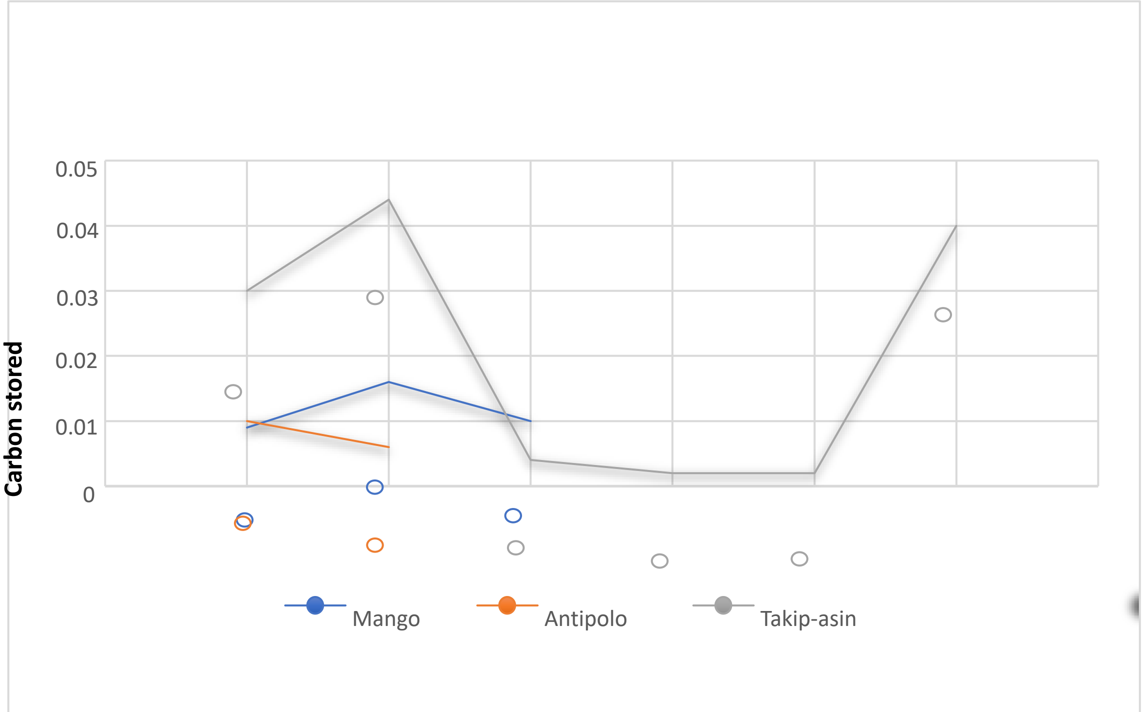



***Figure 2.*** *Total Carbon Stored in Barangay, Bahay, Pasacao, Camarines Sur*

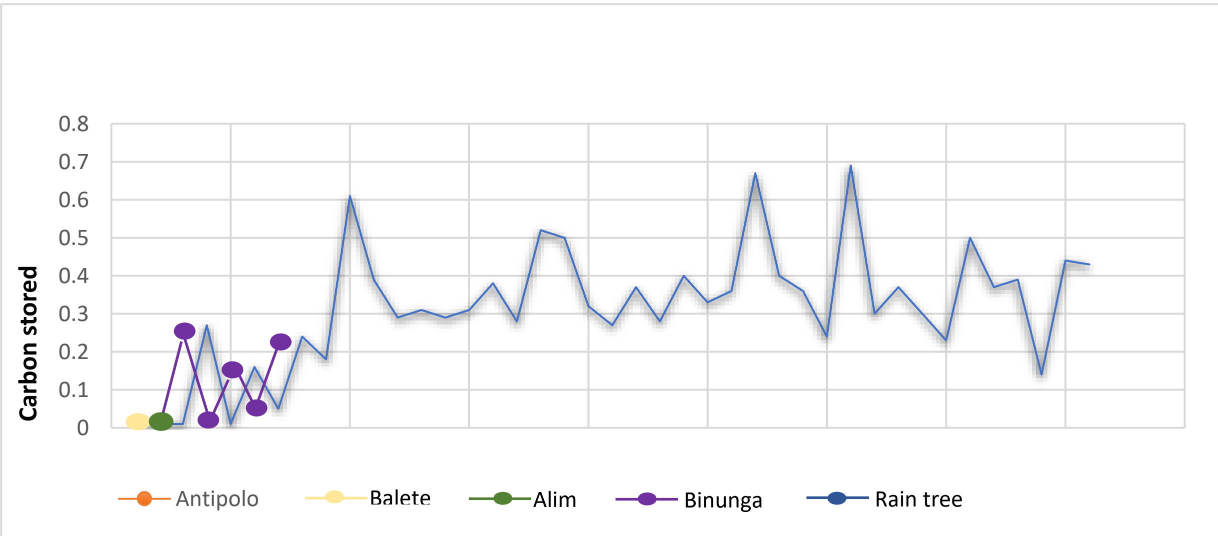



***Figure 3.*** Total Carbon Stored in Pamplona, Maharlika Highway, Camarines Sur

### *3.4 Enhancing Carbon Storage Along National Highways: A Proposed Action Plan*

This action plan can be implemented in a systematic manner to support tree conservation, roadside greening, and long-term environmental management. The first step is to reduce deforestation by protecting existing tree cover and minimizing unnecessary tree removal, since preserving mature vegetation is more effective than replacing lost trees later. As noted in current literature, road expansion and land clearing can intensify forest loss, making protection of remaining trees an essential starting point. Reducing deforestation also helps maintain habitat continuity, carbon storage, and ecosystem stability. The second step is to conduct an IUCN status assessment for the selected tree species. This process involves confirming the scientific identity of each species, compiling available information on distribution, population trend, and threats, and then evaluating whether the species fits a particular Red List category. The results of this assessment provide a scientific basis for conservation prioritization because species with higher risk or declining populations can be identified early and given greater management attention. In a thesis context, this step is important because it links species selection to evidence-based conservation planning rather than simple presence or abundance alone.

Once the conservation status is known, the next step is to establish conservation priorities. Species that are ecologically valuable, locally important, or potentially vulnerable should be prioritized for protection and monitoring, especially when resources are limited. This approach ensures that management is focused on species and sites where intervention will have the greatest benefit. For roadside landscapes, priority may also be given to native or climate-resilient species that contribute to shade, biodiversity, and carbon sequestration. Roadside tree planting should then be carried out using species that are appropriate for road conditions and local site characteristics. Proper implementation requires selecting suitable species, preparing the planting pit, ensuring adequate spacing, and providing early maintenance such as watering and protection during establishment. Roadside planting is valuable because it improves aesthetic quality, reduces heat, enhances air quality, and supports urban ecological function. However, tree species must be chosen carefully because planting the wrong species or in unsuitable locations can reduce survival and limit environmental benefits.

The final component is regular tree assessment and monitoring. This involves periodic checking of survival, height, DBH, crown condition, pest damage, and other signs of tree stress or mortality. A standardized monitoring protocol is necessary so that observations are recorded consistently over time and can be compared across sampling periods. Reporting the findings is equally important because it provides evidence for adaptive management, helps identify planting success or failure, and supports future conservation decisions.

**Table 2**
*Proposed Action Plan*

| Action Step | Responsible Individual | Timeline | Required Resources | Expected Outcome |
|---|---|---|---|---|
| Reduced deforestation | Local Community along with the LGU of Pasacao and Pamplona, Camarines Sur | Month 1 (Week 1-4) | Legal framework, seedlings, GIS tools, patrol funding, training | 20% less forest loss, increased tree cover, reduced illegal logging |
| IUCN status assessment and conservation prioritization | Biodiversity Expert/DENR Biologist | Month 2 (Week 5-8) | IUCN Red List database, field observation sheets | Prioritized list of Vulnerable/Endangere d species for protection |
| Roadside Tree planting Activity | Local Community along with the LGU of Pasacao and Pamplona, Camarines Sur | Month 3 (Week 9-12) | Trees (Preferably Native Trees/endangered tree species) | Increased carbon storage capacity from national highways. |
| Regular Tree assessment and monitoring | LGU of Pasacao and Pamplona, Camarines Sur | Month 4 (Week 1316) | Measuring tools such as diameter tape, meter stick & data sheets | Monitor carbon sequestration and estimation per tree species along national highways. |
| Implement monitoring protocol and report findings | Monitoring team/Highway Authority | Ongoing (Months 5-12, then annual monitoring) | Monitoring kits, annual budget, community volunteers | 10-20% increase in carbon stocks; annual sequestration report for policy use |

## 4. Conclusion

There are a few tree species identified due to the road widening operation conducted along the highways, as well as national calamities like typhoons. Additionally, the tree species are introduced and are not native tree species in the Philippines. A study of roadside trees in Bahay (11 kinds) and Pamplona (41 kinds) along highways in Camarines Sur shows they can store a good amount of carbon. Top trees like Takip-asin (Macaranga grandifolia, 0.044 tonnes per tree in Bahay), Mangga (Mangifera indica, 0.016 tonnes), Rain tree (Samanea saman, 12.22 tonnes in Pamplona), and Binunga (Macaranga tanarius, 0.75 tonnes) build lots of plant material fast, with big leaves and toughness for rough spots. In all, these roads act as carbon traps in hot climates. Quick-growing and introduced trees help right away, but we must save big trees, plant top carbonstorers, and guard locals to fight climate change best. The proposed action plan demonstrates that highways can serve not only as transport corridors but also as important carbon sinks when managed properly. Its effectiveness depends on protecting existing trees, selecting appropriate species, and applying systematic monitoring to ensure survival and long-term growth. By combining conservation planning with roadside tree establishment, the project offers a feasible strategy for increasing carbon stocks and supporting broader environmental goals. The study concludes that sustainable roadside tree management can contribute to climate mitigation, biodiversity protection, and improved landscape function.

***Implication for Learners* -** The study shows that even narrow roadside areas, when planted with native and common trees like Takip-asin, Binunga, Antipolo, Mangga, Balete, Alim, and Rain tree, can act as important carbon sinks and serve as everyday examples of how landscapes store atmospheric carbon. When these local findings are used in class, learners can connect abstract ideas like greenhouse gases, carbon sinks, and SDGs 13 and 15 to real places they know, while hands-on activities such as tree identification, DBH measurement, and simple biomass calculations build their critical thinking, quantitative skills, and sense of responsibility as active participants in climate action.

***Implication for Teachers and Academe* -** This study suggests that teachers should embed local carbon sequestration data and native tree ecology into science, math, and social studies so that climate change becomes concrete and relevant for students, while also strengthening their critical thinking and problem-solving skills. By adapting the study's methods—tree inventory, DBH measurement, allometric equations, and carbon stock graphs—into field or classroom activities, teachers and teacher-education programs can promote inquiry- and project-based learning, and higher education institutions can use roadside carbon assessment and native tree conservation as "living laboratories" for SDG-aligned curricula, research, extension work, and policy support on urban and roadside greening.

***Ai declaration:*** Grammarly April 2026 – used for grammar checking, Perplexity AI, April 2026 – used for brainstorming and constructing paragraph.

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