A comprehensive investigation on carbon stored in the vegetation of our schoolyard through the measurement of carbon in a non-standard site.

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Table of content

Table of Figures and Tables

Earth Sphere: Biosphere

Carbon Cycle Protocol, with the focus in measuring carbon storage in the vegetation of the schoolyard using GLOBE's Non-Standard Site Carbon Cycle Protocols.

Protocols involved:

- Site selection and scaling protocol (A supporting protocol)
- Tree protocols
- Shrub/Sapling protocols and
- Herbaceous protocols

Objective

To measure the amount of carbon stored in the vegetation of our schoolyard.

Research Question

How much carbon is stored in the vegetation of our schoolyard?

Hypothesis

Green vegetation in our school comprises of trees, shrubs/saplings and herbaceous. We believe that a greater proportion of these vegetation present in our site will help in storing a greater amount of carbon. It is also important to consider that the trees having greater biomass than the other types of vegetation, stores larger portion of carbon in our site.

Abstract

Carbon is one of the most important and abundant elements found in nature. Carbon dioxide, is one of the most important oxides among other oxides of carbon. It is important for the plants to photosynthesize. Photosynthesis is one of the biological processes that sustains life on earth. As important as carbon dioxide is for the living beings, the excess amount of the gas can also result in some severe negative impacts on earth's climate. Thus, it is important to maintain the amount of carbon dioxide present especially in the earth's atmosphere. One of the easiest methods we can adopt is to maintain our own carbon footprint.

In completing this research, we were able to estimate the amount of carbon stored in the vegetation of our school yard. Through the GLOBE program's *Non-Standard Site Carbon Cycle Protocol,* we were able to measure the carbon stored in the trees, shrubs and the herbaceous present in our schoolyard. Based on the measurement of their biomass, we obtained an estimate of 3756 g C/m^2. The school stands on an area of 33 acres (133,547.3 m^2), thus the amount of carbon stored in the vegetation of the whole school area would amount to approximately 5.02×10^8 gC. However, this amount can change depending on the amount of vegetation present in the school compound per year.

Introduction

Our surroundings comprise of both vegetations and human interference (i.e. a local park, city block, or some kind of structure). Therefore, we felt the measurement of carbon would be more realistic and accurate for a non-standard site than a standard one.

Our school stands on an area of 33 acres (133,547.3 m^2), of which approximately 50% of its area is under human interference due to the construction of classroom blocks, assembly courts, games and sports facilities, car parks and teachers' quarters. The other 50% contains trees, shrubs and herbaceous.

Pelrithang Higher Secondary School was established in 1981 as a community school with the grades ranging from pre-primary (PP) to six. With the increase in community population, the need for school upgradation was felt by the education ministry, thus the school was upgraded to Pelrithang Middle Secondary School in 2007, and then to Pelrithang Higher Secondary School in 2020. The school annually enrolls about one thousand students and seventy staffs altogether.

It is located at 26.903259^{o} N and 90.490304^{0} E with an elevation of 292.2 m above sea level.

Key words:

Non-standard site, Trees, Shrubs/Saplings, Herbaceous

Background information

Life on earth would not be possible without carbon. Carbon dioxide, which is one of the oxides of carbon is an important gas for life on the planet.

Carbon dioxide is also crucial to maintaining the protective blanket that is Earth's atmosphere. It is one of the primary greenhouse gases on Earth. Greenhouse gases trap heat from the Sun. Without greenhouse gases, that heat would escape Earth's atmosphere and go back into space. (NASA, 2022)

Figure 1. Some importance of Carbon

Carbon is found and is exchanged between global reservoirs: the atmosphere, the ocean, terrestrial plant biomass, and soil. The balance of carbon between these reservoirs is important for life.

The Global Carbon Cycle is the movement of carbon between the atmosphere, land, and oceans. The global carbon cycle is a key regulator of Earth’s climate system and is central to ecosystem functioning.

For example, if there were no carbon dioxide in the atmosphere, photosynthetic organisms like plants would have no source of carbon and die out. In the long term, the exchange of carbon between the different reservoirs is balanced so this does not occur. However, changes in atmospheric carbon on geological timescales have been shown to drive (and be driven by) changes in global temperatures. (Doheny-Adams, 2023)

Human activities, such as burning fossil fuels and cutting down forests, are changing the balance between how much carbon is in the air and how much carbon is stored in plants and the ocean. These activities cause the amount of CO_2 in the air to rise. Big increases in CO_2 in our atmosphere can negatively affect Earth's climate.

Understanding how ecosystems cycle and store carbon is key to understanding solutions to climate change. (The GLOBE Program, 2022)

Methodology

The method to carry out the measurement of carbon contained in the vegetation in a non-standard site is summarized in Figure 2, which is obtained from the GLOBE carbon cycle protocol.

It involves investigation of four protocols, namely site selection and site setup protocol, tree protocols, shrub/sapling protocols and herbaceous protocols depending on the vegetation present in the site during the time. (The GLOBE Program, 2022)

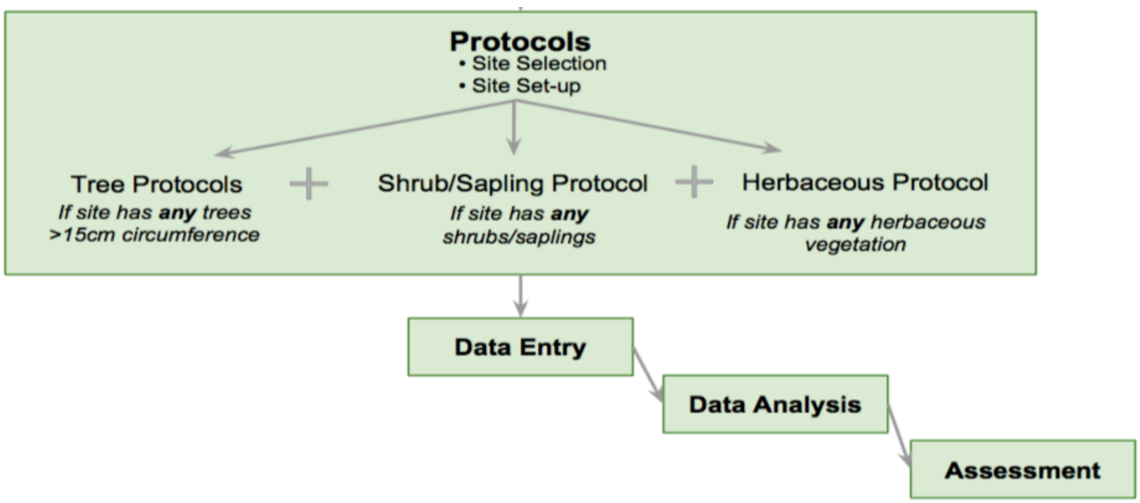

Figure 2. The overall procedure for Carbon measurement in a site

A. Site selection and site set-up

Figure 3. Determining **map : ground** ratio

Determining scale and calculating area is the first and mandatory step in selecting a carbon site for the project.

We determined a scale for the selected feature from the aerial photo and measured the actual ground length of the same feature. In our case, we selected a basketball court for the measurement. With these measurements, a photo distance/ground distance ratio was obtained.

We obtained the ratio as **1 cm : 1826.8 cm**

Using this ratio and the equation given below, we could easily calculate the ground distance and the area of our carbon site (the non-standard carbon site in the schoolyard).

$$\frac{\text{Photo distance}}{\text{Ground distance}} = \frac{\text{Photo distance of carbon site}}{\text{(X)ground distance of carbon site}}$$

Our Carbon Cycle Site

Site Details

- **Total area:**
  = 91.34 m x 91.34 m
  = **8,342.99 sq. m**
- **Area of each quadrant**:
  =45.67 m x 45.67 m
  = **2085.75 sq. m**

Figure 4. Our site in schoolyard with the relevant specifications

For the site setup, we worked in teams with specific tasks:

a. Perimeter team: We divided the site and took the measurements of the quadrants and recorded bearing and paces.

b. Photography team: We took the photographs of the site in nine directions and entered the photo numbers in the data sheets.

c. Data recording team: We filled up the data entry sheets and competed the site selection forms.

B. Trees protocol

The following GLOBE procedure was used to collect and estimate the carbon contained in trees in our schoolyard. (The GLOBE Program, 2022)

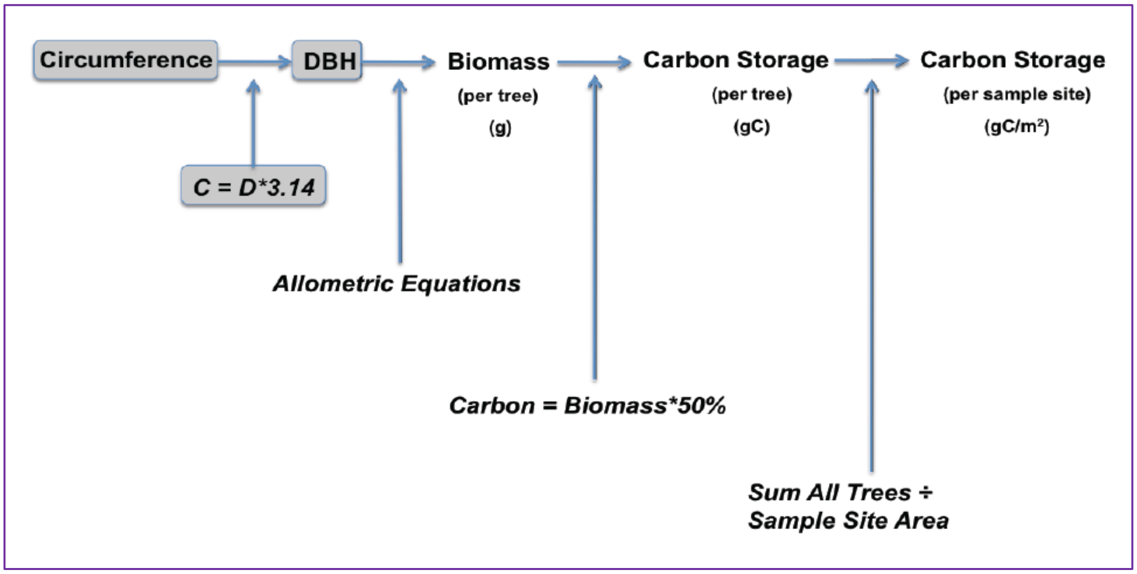

Figure 5. Steps involved in calculating Carbon stored in trees

To carry out the procedure, we started with mapping the trees in our site. We worked in three groups, each with the specific role(s).

a. Tree verification group: we used *Aerial Map* to identify the trees in each quadrant. We gave appropriate numbering to the trees.

b. Tree species group: we used *Tree Identification Guide* and *Species Groups List* to identify the tree species and their scientific names.

c. Tree circumference group: we measured the circumference of the trees and filled up the *Tree Data Entry Sheets*.

For each tree, three sets of 'circumference at breast height (CBH)' were recorded and the average was taken for more accurate measurement. The circumference was used to calculate the diameter at breast height (DBH) of the tree. The measurements were recorded in *GLOBE Carbon Cycle – Tree Data Sheet for Non-Standard Sites.*

Using the MUC field guide, we were able to identify the species group of the trees in our site. As per the description, the woodland comprises of open stands of trees at least 5 metres tall with crowns not interlocking. The tree canopy covers at least 40% of the ground. Thus, we concluded that the group species in our site is Woodland, because the vegetation we have is mainly evergreen with a mixture of broad-leaved and needle-leaved trees (MUC 111 and MUC 1121). After which, the allometric equation for the species group list was used to estimate the biomass of the trees. The estimated biomass was then used to calculate the carbon contained in each tree. Further, the carbon stored in the site was calculated by finding the total carbon stored in all the trees in the site and dividing it with the site area. (The GLOBE Program, 2022)

We took measurement of 75 trees in our site and entered all the data in the GLOBE database.

Species Group List

(Reproduced from Jenkins et al. 2003, Figure 1)

Species Group	Common name	Genus	Species
Aspen/Alder	Balsam poplar	Populus	balsamifera
Aspen/Alder	Bigtooth aspen	Populus	grandidentata
Aspen/Alder	Black cottonwood	Populus	trichocarpa
Aspen/Alder	Black willow	Salix	nigra
Aspen/Alder	Cottonwood (general)	Populus	spp.
Aspen/Alder	Diamond willow	Salix	eriocephala
Aspen/Alder	Eastern cottonwood	Populus	deltoides
Aspen/Alder	Fremont cottonwood	Populus	fremontii
Aspen/Alder	Narrowleaf cottonwood	Populus	angustifolia
Aspen/Alder	Peachleaf willow	Salix	amygdaloides
Aspen/Alder	Plains cottonwood	Populus	sargentii
Aspen/Alder	Quaking aspen	Populus	tremuloides
Aspen/Alder	Red alder	Alnus	rubra
Aspen/Alder	Silver poplar	Populus	alba
Aspen/Alder	Speckled alder	Alnus	rugosa
Aspen/Alder	Swamp cottonwood	Populus	heterophylla
Aspen/Alder	White alder	Alnus	rhombifolia
Aspen/Alder	Willow (general)	Salix	spp.
Cedar/Larch	Alaska-cedar	Chamaecyparis	nootkatensis
Cedar/Larch	Atlantic white-cedar	Chamaecyparis	thyoides
Cedar/Larch	Baldcypress	Taxodium	distichum
Cedar/Larch	Eastern redcedar	Juniperus	virginiana
Cedar/Larch	Giant sequoia	Sequoiadendron	giganteum
Cedar/Larch	Incense-cedar	Calocedrus	decurrens
Cedar/Larch	Larch (general)	Larix	spp.
Cedar/Larch	Pondcypress	Taxodium	distichum var. nutans
Cedar/Larch	Port-Orford-cedar	Chamaecyparis	lawsoniana
Cedar/Larch	Redwood	Sequoia	sempervirens
Cedar/Larch	Softwoods (general)	Softwood	spp.
Cedar/Larch	Southern redcedar	Juniperus	silicicola
Cedar/Larch	Subalpine larch	Larix	lyallii
Cedar/Larch	Tamarack (native)	Larix	laricina
Cedar/Larch	Western larch	Larix	occidentalis
Cedar/Larch	Western redcedar	Thuja	plicata
Cedar/Larch	White-cedar	Thuja	occidentalis
DougFir	Bigcone Douglas-fir	Pseudotsuga	macrocarpa
DougFir	Douglas-fir	Pseudotsuga	menziesii
Fir/Hemlock	Balsam fir	Abies	balsamea

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Figure 6. Team work in collecting tree data for biomass measurement

C. Shrub/sapling protocol

Shrubs are any woody plants with multiple stems, while sapling is a tree with a diameter at breast height less than fifteen centimeters.

We used *Shrub/Sapling measurements - Non-Standard -Student Field Guide* to make ourselves familiar with the procedures to carry out the measurements. Using the guide, we made multiple groups with three members each. We then started recording the shrub's crown length (longest sides and shortest sides). We also recorded if it is deciduous or evergreen and estimated the representative height of the whole shrub.

We took measurement of about 25 shrubs in our site and entered all the data in the GLOBE database.

D. Herbaceous protocol

Figure 7. Students collecting herbs for biomass measurement

We used *Herbaceous Vegetation Measurements -Student Field Guide* in collecting herbaceous from the site. We identified three random sites within our carbon site to collect the herbaceous.

We made three one-meter square sample sites. Using grass clippers, we clipped all the vegetation close to the ground within the squares and placed them in paper bag(s). The bags containing the herbaceous were labelled accordingly and kept in safe place for the herbaceous to dry properly.

Once the herbaceous were dried, we used the *Herbaceous Vegetation -Lab Protocol and Data Sheet* to keep record of the measurements. The *Herbaceous Biomass Data Sheet* was then used to calculate the average biomass of the site and carbon stock.

The data was also entered in the GLOBE database.

Data Analysis and Interpretation

All data were entered into the GLOBE website, from which the analysis was easily done using the visualization system. Alternately, we also used the *Tree Biomass Analysis Template* and *Shrub Sapling Biomass Analysis Non-Standard Template,* both Microsoft Office Excel Templates downloaded from the GLOBE website for the analysis. These templates contain all the instructions for the correct usage, and had all the data entry fields and self-analyzing tables and graphs. The rest of the analysis were also done automatically with all the preinstalled formulas.

Given below are the screenshots of the summary of the analysis we obtained from these Microsoft Excel templates.

Table 1. Summary of the carbon storage in the trees in our site.

Table summarizing the tree data below	
	Total Aboveground
Plot Biomass (g/plot)	12,024,224
Plot Carbon Storage (g C/plot)	6,012,112
Biomass (g/m2)	1,441
Carbon Storage (g C/m2)	721

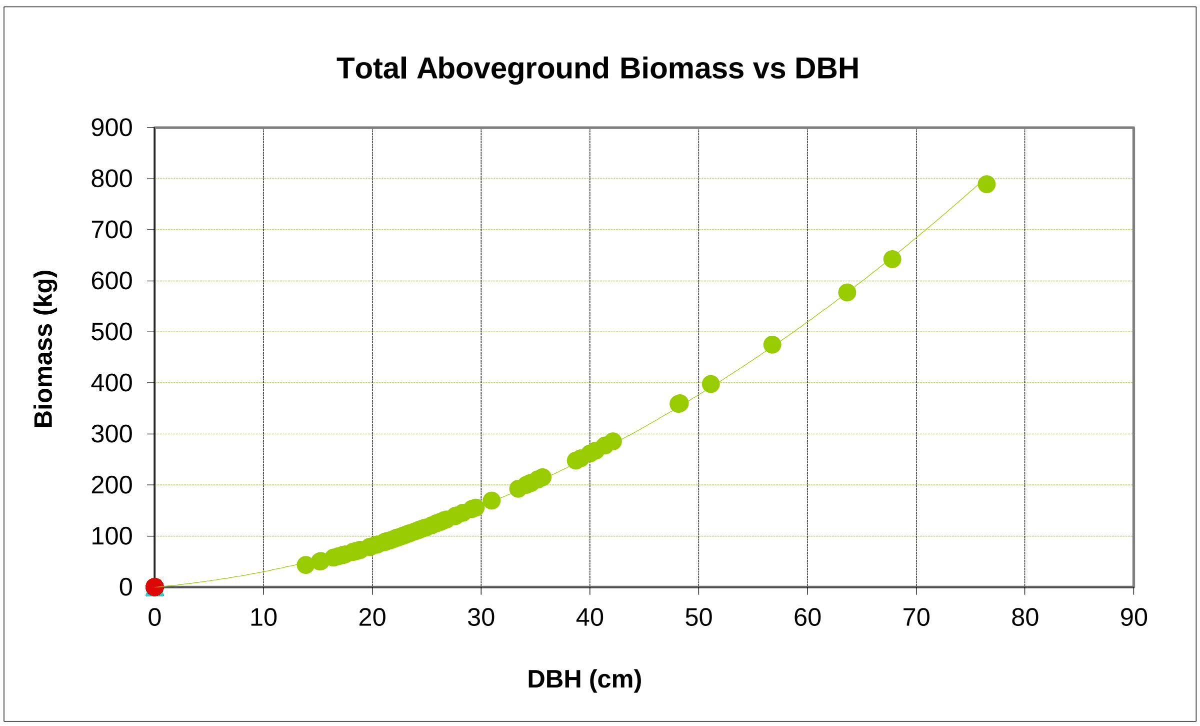

Figure 8. Graph showing the relation between the biomass and DBH

Table 2. Summary of the carbon storage in the shrubs/sapling in our site

Shrub/Sapling Biomass Table	
	Total Aboveground
Deciduous Biomass (g/m2)	0.16
Evergreen Biomass (g/m2)	1.17
Total Biomass (g/m2)	1.33
Total Carbon Storage (g C/m2)	0.67

Table 3. Summary of the carbon storage in the herbaceous in our site

Herbaceous Biomass Table	
	Total Aboveground
Herbaceous Biomass per sample (g/m2)	205.7
Average Herbaceous Biomass (g/m2)	68.6
Herbaceous Carbon Stock (g C/m2)	34.3

Data visualization using GLOBE Visualization System

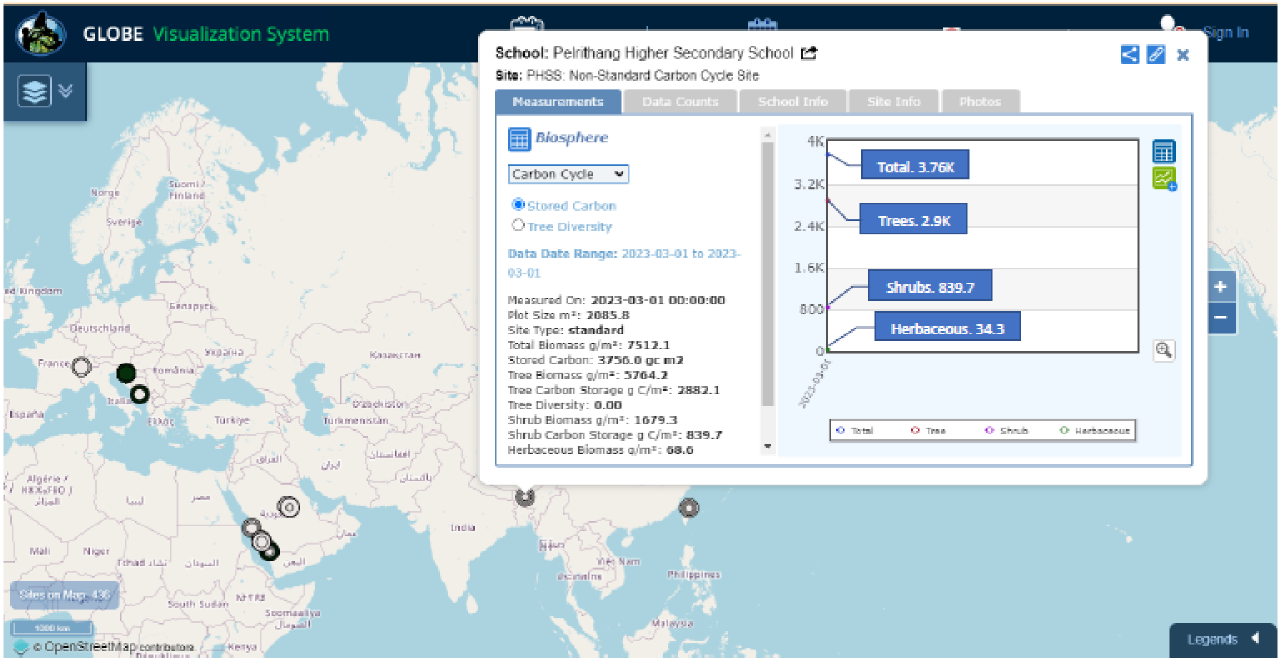

Figure 9. Data analysis as obtained from the GLOBE visualization system

Table 4. The details from the GLOBE visualization system.

School Name	**Pelrithang Higher Secondary School**
Site Name	PHSS: Non-Standard Carbon Cycle Site
Userid	85378938
Latitude	26.90234
Longitude	90.49045
Elevation	289.4
Measured On	1/03/2023 0:00
Plot Size (m^2)	2085.8
Site Type	standard
Total Biomass (g/m^2)	7512.1
Total Carbon Storage (gC/m^2)	3756
Tree Biomass (g/m^2)	5764.2
Tree Carbon Storage (gC/m^2)	2882.1
Shrub Biomass (g/m^2)	1679.3
Shrub Carbon Storage (gC/m^2)	839.7
Herbaceous Biomass (g/m^2)	68.6
Herbaceous Carbon Storage (gC/m^2)	34.3

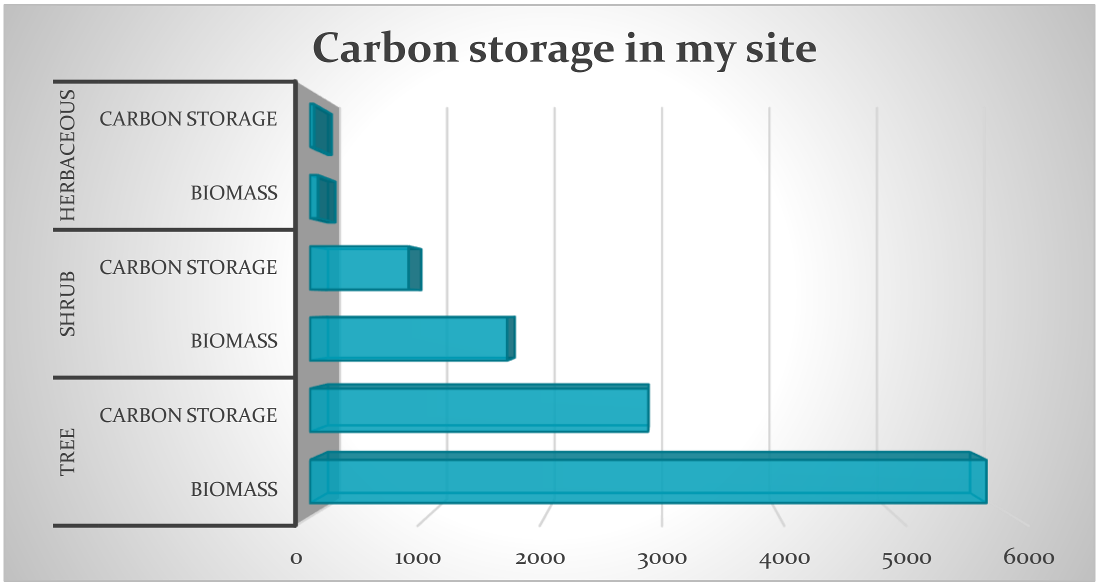

Figure 10. Summary of the carbon storage in the vegetation in my site.

With all of the above data analysis, we could draw the following conclusions:

i. The amount of carbon stored in the schoolyard is directly proportional to the amount of vegetation present in the schoolyard. Further, the trees account for the maximum biomass, thus the trees absorb larger portion of the carbon.

ii. The larger the trees, larger is the amount of carbon stored in them. Thus, we could also conclude that preserving the fully grown and aged trees are more important.

iii. Based on the measurement of their biomass, we obtained an estimate of 3756 g C/m^2. The school stands on an area of 33 acres (133,547.3 m^2), thus the amount of carbon stored in the vegetation of the whole school area would amount to approximately $5.02 x 10^8$ gC.

iv. The carbon stored in the vegetation of our site is likely to change due to human interference. Thus, it is important to keep track of the biomass of these vegetations and calculate the carbon stored in them annually.

v. It is only when we are able to estimate the amount of carbon emitted by the school, that we will be able to actually estimate and regulate our carbon footprint.

Conclusion

One of the pertaining environmental issues which is of the global concern nowadays is the ever-increasing global temperature leading to global warming and the climate change. It is known to everyone that the main cause of the global warming is the increase in carbon dioxide in the atmosphere. It is the mankind who is responsible for the severe deforestation, desertification, urbanization, emissions of GHGs which are the main causes of the global warming.

This research aims to help people understand how important it is to preserve the vegetation in our surrounding as they would help in reducing the amount of carbon dioxide we emit into the atmosphere. Through this research, we also come to understand the importance of ancient trees; the bigger the trees, the greater the amount of carbon it absorbs.

We believe that our research will inspire and motivate other GLOBE schools to carryout similar projects on the topic so that globally we will be able to regulate our own carbon footprints and reduce the amount of carbon dioxide which is already in excess in the atmosphere.

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Badges selection

I MAKE AN IMPACT

Through this research, we are able to educate people on maintaining our own carbon footprint, so that we reduce the carbon dioxide emission into the atmosphere, thus reducing the cause of global warming.

I AM A DATA SCIENTIST

This research involves a thorough measurement of carbon stored in the trees, shrubs and herbaceous of our schoolyard.
We have tried to provide the in-depth analysis of the data.

I AM A COLLABORATOR

Throughout the research work, we have been collaborating with each other, with each member having a specific task to complete. We also collaborated with the two globe teachers, one also being the GISN member.