Reducing Our Carbon Footprint: Rochester School's Strategies to Reduce Emissions

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ABSTRACT

The following study aims to quantify the carbon footprint of a forward-thinking educational institution that adopts sustainable design principles and practices. The methodology employed was multifaceted, combining mathematical calculations of carbon fixation by vegetation, energy consumption patterns, anthropogenic factors and innovative sustainable practices implemented by the LEED Platinum certified Rochester School. Several tools, such as the GLOBE application and specialized platforms, were relevant in the calculation of the data. Platforms such as iTree Eco and Arc Skoru have defined factors and algorithms that led to the final carbon footprint data.

The objective of the study was to determine the overall environmental impact of the campus and to assess the effectiveness of the combination of its sustainability initiatives; all within the context of the climate change the world is currently experiencing. Within the offset studied on the campus, there are renewable energy sources, such as solar panels, energy-efficient infrastructures that take advantage of natural light and planting trees of native species, which determine their role in mitigating carbon emissions. The results of the study revealed that the school's carbon footprint is significantly lower than the Colombian national average, suggesting that the institution's commitment to sustainability has translated into environmental benefits.

Keywords: *carbon footprint, tree, carbon fixation, sustainability, LEED.*

RESUMEN

El siguiente estudio pretende cuantificar la huella de carbono de una institución educativa con visión de futuro que adopta prácticas y principios de diseño sostenible. La metodología empleada fue multifacética, combinando cálculos matemáticos de fijación de carbono por la vegetación, patrones de consumo de energía, factores antropogénicos y prácticas sostenibles innovadoras implementadas por el colegio Rochester, certificado LEED Platinum. Varias herramientas, como la aplicación GLOBE y plataformas especializadas, fueron relevantes en el cálculo de los datos. Las plataformas como iTree Eco y Arc Skoru tienen factores y algoritmos definidos que condujeron a los datos finales de la huella de carbono.

El objetivo del estudio era determinar el impacto medioambiental global del campus y evaluar la eficacia de la combinación de sus iniciativas de sostenibilidad; todo ello en el marco del cambio climático que experimenta el mundo en la actualidad. Dentro de la compensación estudiada en el campus, se tienen fuentes de energía renovables, como paneles solares, infraestructuras energéticamente eficientes que aprovechan la luz natural y plantación de árboles de especies nativas, que determinan su papel en la mitigación de las emisiones de carbono. Los resultados del estudio revelaron que la huella de carbono del colegio es notablemente inferior a la media nacional colombiana, lo que sugiere que el compromiso de la institución con la sostenibilidad se ha traducido en beneficios medioambientales tangibles. Los resultados subrayan que se puede lograr la mitigación del cambio climático por parte de instituciones que tengan un compromiso serio con prácticas eficientes sostenibles para reducir significativamente sus emisiones de carbono, así mismo, es necesario que estas prácticas sean complementadas unas con otras.

Palabras clave: huella de carbono, *árbol, fijación de carbono, sostenibilidad, LEED.*

RESEARCH QUESTION:

How do the interconnections between infrastructure, natural surroundings, and the daily behaviors of individuals collectively influence and contribute to the carbon footprint of a school?

HYPOTHESIS:

If the school's infrastructure, natural surroundings, and individual behaviors are optimized for sustainability through energy-efficient buildings, ample campus vegetation, and environmentally-conscious daily practices, then the institution's overall carbon footprint will be significantly reduced.

INTRODUCTION AND REVIEW OF LITERATURE:

Ever since the pre-industrial period, between 1850 and 1900, global warming has been observed due to human activities, mostly the burning of fossil fuels. However, it is evident how nowadays common daily activities, such as driving or recharging electronic devices for instance, affect this phenomenon on a larger scale. Global warming (GW) is the result of an increase in Earth's temperature, because of a rise in the amount of greenhouse gasses present in its atmosphere. Some consequences of GW are the increase of natural disasters, storms and droughts, polluted air, greater acidity level in the oceans, and an overall threat to all living organisms found on Earth, whether it is on land or sea. [1]

Colombia, being a developing country, is not a major generator of GHGs, but it does contribute to climate change due to the considerable increase in deforestation that generates the loss of thousands of hectares of oxygen-producing forests on the planet. It is estimated that the loss of forest cover represented 20% of the CO_2 released in 2017 [2].

Human activity created an imbalance in the carbon cycle, contributing to GW. In order to control or mitigate the amount of CO_2 emissions released from activities and decelerate the rate at which the consequences mentioned previously are occurring, a measurement known as carbon footprint was created. This quantification determines how many emissions an individual or community is releasing based on their daily life behaviors such as energy usage, transportation, water management, and even the average number of emissions by breath per person. In the United States, for instance, the average carbon footprint by inhabitant is 16 tons, while globally it is 4, a measurement that is not ideal nevertheless. Several scientists predicted that, by 2050, it is possible for the Earth's temperature to increase 2° C more, which would cause a fatal impact on the environment and, consequently, a faster occurrence of the consequences of global warming. Scientists suggest that, if the average carbon footprint gets reduced by at least 2 tons, the mentioned temperature increase could be prevented. It is crucial to take action immediately. [3]

As Rochester School is a sustainable institution, with a platinum LEED certification (Leadership in Energy and Environmental Design), [4] it is essential to know its carbon footprint to check how well the sustainable practices are being effective. The measurement of the carbon footprint at the school includes: 1) the fixated carbon by plants, 2) anthropogenic impact by the people at the school and 3) campus' infrastructure and design.

RESEARCH METHODS

Study site:

Figure 1. *Image of the location of Colombia in the world.*

Colombia, **Figure 1**, is located in the northwest part of South America, sharing borders with several countries. It is bordered by Venezuela to the east, Brazil to the southeast, Peru to the south, Ecuador and Panama to the west. To the north, it has coastlines along the Caribbean Sea, and to the west, it has coastlines along the Pacific Ocean. The country extends across a broad range of latitudes, from the equator in the south to about 12 degrees north of the equator in the north. The longitude varies, with the westernmost point in the Pacific Ocean and the easternmost point on the border with Venezuela. Colombia is home to a significant portion of the Andes mountain range, which runs through numerous South American countries. The Andes influence the country's climate, topography, and the development of major cities, including the capital, Bogotá. [5]

Figure 2. *Image of Colombia with definitions of its nation.*

Bogotá is situated on the high-altitude Andean plateau, approximately 2,640 meters (8,660 feet) above sea level. This elevation influences the city's climate, making it cooler than expected for its equatorial location. The high elevation of Bogotá results in a subtropical highland climate. Average temperatures are relatively cool, and the city experiences limited temperature variations throughout the year. The city has faced challenges related to air quality and pollution, partly due to its topography and high altitude. Efforts have been made to address these issues through environmental initiatives and sustainable urban planning. [6]

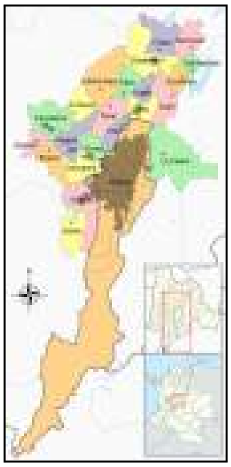

Figure 3. *Image of the Andean region surrounding Bogotá.*

The Andean region surrounding Bogotá offers stunning landscapes, including mountains, valleys, and *paramos* (high-altitude grasslands). The high plateau around Bogotá is known as the "Sabana de Bogotá." This savanna-like plain is dotted with small towns and agricultural areas. The fertile soil in the Sabana de Bogotá supports agricultural activities. There are several towns and cities in the vicinity of Bogotá, including Zipaquirá and Chía, which are known for their plain land and fertile grounds. [7]

The collection of data happened at Rochester School. The school is located in the town of Chia, which is found in Cundinamarca, Colombia, bordering Bogotá. The exact latitude and longitude of the school is 4.8300° N, 74.0318° W, with an address of Vereda Fusca, Chía, Cundinamarca, 250008. It sits at an elevation of 2,554 meters above sea level, and a fertile upland basin surrounded by the Andes mountain. The average weather in this zone fluctuates from 19ºC to 7ºC daily, with this the average precipitation is 52%. [8]

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Figure 4. *Aerial image of Rochester School*

As seen in **Figure 4**, Rochester school has different green areas where the collection of data was done. Most of the trees are located in area A, bordering the soccer field. Area B is found in the North-West of the school, where the water reservoir is. The last study area is the school's gardens that are both indoor and outdoor.

Data Collection

For the collection of the data, the following tools were used: ARC Skoru platform, iTree Tool, GLOBE Observer app, and GLOBE protocols: [9] Tree Circumference Field Guide and Graminoid Biomass Field and Lab Guide.

The used data provided included: Fixed carbon in grass and trees, gases emissions produced and gas used in transportation of Rochester school's community, electric energy and natural gas consumption, water usage, residues generation and management and photovoltaic panels energy compensation.

<u>Carbon Fixation</u>

For the herbaceous carbon fixation, the GLOBE Protocol on Graminoid Biomass was implemented [10]**.** As the Protocol indicates, the sample collection was done by groups of students, each of the groups was assigned a different school's area as shown in **Figures 5 to 10**. One member of the group threw a bean bag on the site with the eyes closed or blindfolded, to guarantee randomness. Students marked a one-meter square around the beanbag to take the grass sample using the grass clippers, as close to the ground as possible. Grass samples were collected in individual bags labeled with name, date, and sample number. The procedure was repeated 3 times per zone. The grass samples were placed in bags where air flowed, for air drying purposes. (**Figures 11 and 12**). The samples were weighed every day (counting from day 5) until the grams of the sample were stable and the final biomass value was multiplied by 0.5 as explained in GLOBE's protocol.

Figure 5. *Area 1 - herbaceous collection.*

Figure 6. *Area 2 - herbaceous collection.*

Figure 7. *Area 3 - herbaceous collection.*

Figure 8. *Area 4 - herbaceous collection.*

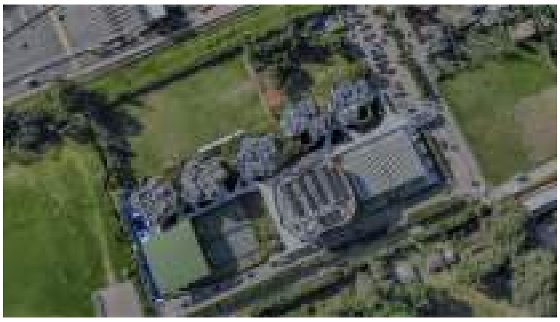


Figure 9. *Area 5 - herbaceous collection.*

Figure 10. *Area 6 - herbaceous collection.*

Figures 5 to 10. *Herbaceous zones at Rochester school where samples were collected.*

For knowing the tree carbon fixation, 132 trees inside Rochester School campus were measured and registered using the GLOBE Observer app in the option "Trees" [**Appendix 1.6 and 1,7**]. Each tree was labeled and listed with a letter and number (**Figure 13**) according to the zone it is planted in.(**Figure 4**).

Figure 11. *Collection of Herbaceous samples.*

Figure 12. *Herbaceous samples air drying.*

To determine a tree's height using GLOBE'S Observer app, the user starts by choosing a tree and employing the device to gauge the angle from the tree's base to its highest point. Proceed to the tree, counting the steps as the person walks to establish the distance, and make observations about the surface conditions. The app will then utilize this data to provide an estimated height for the tree. The user takes a photo of the tree and measures its circumference – these steps are optional but can contribute to a more comprehensive analysis. Other data is also asked by the app like date and time, conditions of the environment in which the tree is located, and any additional observations. GLOBES's app uses the given location to set graphically the trees in the school's map, as shown in **Figure 14**. The tree's circumference, DBH (diameter at breast height), was done using the GLOBE protocol Tree Circumference [11].

Figure 13. *Example of a labeled tree.*

FIGURE 14. *GLOBE'S map with the location of each individual tree at Rochester campus.*

Each tree was identified with the common name and genus or species, to be able to run their data in the iTree tool. The iTree tool determines, per tree and per year, the amount of fixed carbon, oxygen production, CO_2 capture, value of carbon sequestration and value of pollution elimination among others.

Anthropogenic impact:

It was crucial to understand the amount of CO_2 emitted on average in each breath by the whole number of members in Rochester's community (students and staff), as part of the carbon footprint generated by the institution. There are a total of 898 students at the school and 220 people as staff (teachers, security personnel, infrastructure, among others), for a total of 1,118 people going daily to the school. The students were divided in age groups, aiming to find the average quantity of breaths per minute, taking into account that as younger the person is, the greater amount of CO_2 gets generated and released by the person. All adults were categorized in the same age group (18+). In each exhalation of a person, 500ml of air is expired, 3% of which is CO_2, corresponding to about 15ml. [12] This amount was multiplied by the estimated number of breaths of an individual from each age group per day, allowing the derivation of the results for the whole group. It was essential to then calculate the number of people in each group (-18 and 18+), to determine the total amount of CO_2 by respiratory rate at Rochester School (table 1.2).

Operational Carbon:

Operational carbon (OC) refers to the energy consumption or energy balance of the building in use. OC takes into account the consumption of energy, water and natural gas at the school, transportation, and residues generated. The energy consumption is ruled by the Resolution No. 0549 of the year 2015 [13] . The OC is also registered in the Arc Skoru platform.

For knowing the transportation impact, a survey designed by LEED was conducted by the Sustainability Department at the school. 220 people answered the survey between students and staff, since that is the minimum number required by LEED. [14] With the survey, data about distance from work to home and home to work, and the type of vehicle used for transportation to Rochester's facilities were obtained and registered in the Arc Skoru platform for further analysis. [15]

Compensation:

Compensations refers to the strategies the school uses to mitigate the carbon footprint. Rochester School is a LEED platinum certified school that has approaches to reduce energy consumption such as solar panels, motion sensors, LED bulbs, use of energy star electronic devices and use of natural light and solar tubes. Rochester School has a Waste-Water Treatment Plant that recycles the water from the toilets and sinks back to the toilets, and is also used for watering the soccer field with sprinklers and washing floors of the school.

Residues at Rochester School are separated into organic and inorganic. Organic residues go to the compost bin, which are used as compost in the orchard and gardens. Some inorganic residues (40 to 50 percent) are recycled and reused, while the rest that are contaminated, like paper napkins, are disposed of in a legal dumpster. Rochester School does not produce PET bottles, snacks in non recycled packages or any other pollutant material. There's a strict sustainable policy for suppliers, students, and staff.

Also, Rochester School has planted 13,200 native trees in the last 5 years with students, their families from all grades (PK-12th), and staff.

RESULTS AND DATA ANALYSIS

Rochester's carbon footprint will be calculated with the following formula:

$CF_{Roch} = (A + C) - P$

Where P represents carbon fixated by plants, A represents anthropogenic impact (respiration) and C represents campus energetic consumption and compensation.

Grass carbon fixation was obtained by the formula given by GLOBE protocol (see **Table 1**).

Herbaceous Biomass = Mass of Sample and Bag – Mass of Empty Bag

*Herbaceous biomass * 0.50 = Herbaceous Carbon Stock g C/*m^2

Table 1.

Fixated carbon in herbaceous plants at Rochester School.

School's zone name	gC/m^2	Area (m^2)
PK park	2,45	1,544.32
Block 5	2,91	458,81
Gardens 1, 2, 3	3,1	586,57

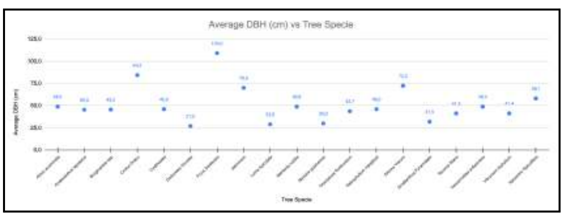
HS park and Garden 4	3,3	552,12
Soccer field	11,1	4,057.68
TOTAL	**22,86**	**7,199.50**

The total grams of sequestered carbon by grass at Rochester's campus (area multiplied by gC/m^2) (see **Table 1**) is equal to 164.436,6 . All values will be used in tons, which means the amount of fixated carbon by grass is equal to: 16,44 Ton/m^2.

The carbon sequestration by trees was obtained by the iTree Eco tool; this tool takes the following data of each individual: species, height and DBH and runs the data with an algorithm that calculates, among others, the carbon sequestration by individual and the monetary value represented by each tree in Colombian money (pesos). The iTree Eco tool does not have registered all the species of tree from the world, this is why there are some tree species recognized as "IVA" which means: indeterminate value. iTree Eco takes the IVA trees as a general species and gives an average value, which is still valuable data for the study that is being held.

Appendix 1.5.

Average DBH (in cm) per Tree Specie

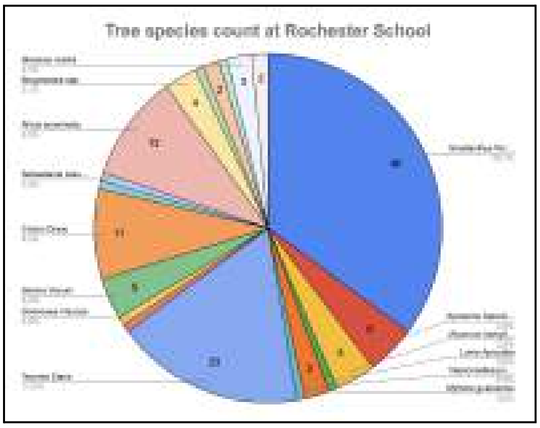


Note: The graph shows the average DBH in centimeters of all the trees (per species) measured for the investigation.

As the results from iTree Eco indicate [**Appendix 1.8**], the total Carbon storage (Kg) from Rochester's trees is: 156.926,9, which represents a total of $96.976.473 Colombian pesos (around 24000 USD). The measured trees were planted around 10 years ago, this carbon storage value represents all the carbon they have stored throughout this time.

iTree also gave the information of the Carbon sequestration (kg/yr) 2.690,6 and its related monetary value, $1.662.846 (415 USD). This data represents the amount of carbon sequestered during the process of photosynthesis, used for the appropriate development and growth of the plant. This value represents the amount of CO_2 that is being absorbed from the atmosphere. Since photosynthesis continues to occur in the trees, the sequestration will continue to increase, so will take both values into account to calculate the final value of carbon fixation from the trees at Rochester School: 159,7 Ton/yr.

Graph 1.1

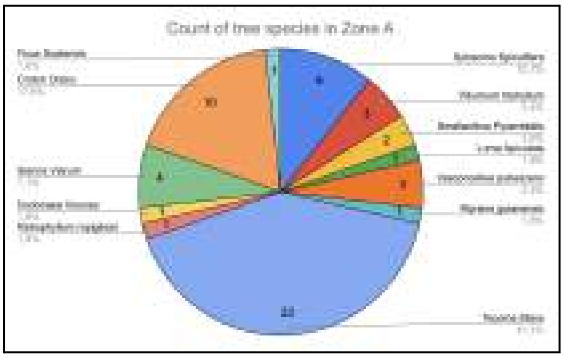


Tree species count at Rochester School.

Note: The graph shows the amount of trees per species that were measured using the Globe Observer app.

Graph 1.2

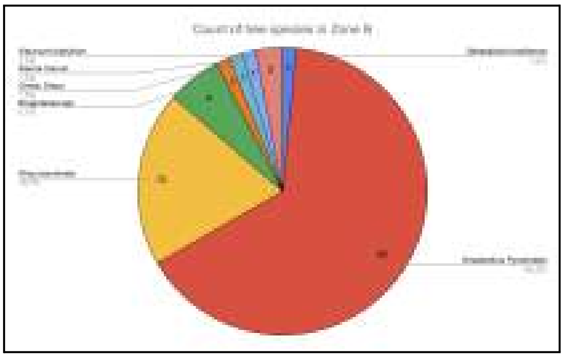
Count of tree species in Zone A.



Note: The graph shows the amount of trees per species that were measured in Zone A using the Globe Observer app.

Graph 1.3

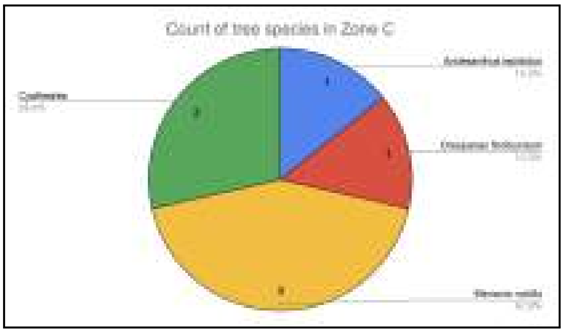
Count of tree species in Zone B.



Note: The graph shows the amount of trees per specie that were measured in Zone B using the Globe Observer app.

Graph 1.4

Count of tree species in Zone C.



Note: The graph shows the amount of trees per species that were measured in Zone C using the Globe Observer App.

The P value for the formula of the Carbon footprint then is

Herbaceous plants + Trees carbon fixation $= 176.14\ Ton/m^2/yr.$

The second value from the formula is the anthropogenic impact, which at Rochester contemplates the CO_2 respiratory rate of each member of the community. As detailed in the following tables (see **Table 1.1** and **Table 1.2**).

Table 1.1: Amount of CO_2 per Day Divided in Age Groups

Age Group	No. of People	Breaths per Minute (One individual)	Breaths per Day (One individual)	Amount of CO_2 per Day (One individual)	Amount of CO_2 per Day (Whole age group)
3 - 6 years old	142	28	40,32	604,800 ml	85,881,600 ml
6 - 12 years old	381	24	34,56	598,400 ml	227,990,400 ml
12 - 18 years old	375	14	20,16	302,400 ml	113,400,000 ml
18+ years old	220	12	17,28	259,200 ml	57,024,000 ml

Table 1.2: Amount of CO_2 of all Age Groups Together

Age Group	CO_2 per Age Groups
3 - 6 years old	85,881,600 ml
6 - 12 years old	227,990,400 ml
12 - 18 years old	113,400,000 ml
18+ years old	57,024,000 ml
3 - 6 years old	85,881,600 ml
Total CO_2	570,177,600 ml
Total metric Tons CO_2/day	**561.05**
Total metric Tons CO_2/yr	**204826**

The last component of Rochester's carbon footprint, C, contemplates the energy, natural gas and water consumptions, transportation, generation of residues and compensation of these impacts by having a LEED Platinum site with different strategies that mitigate carbon footprint.

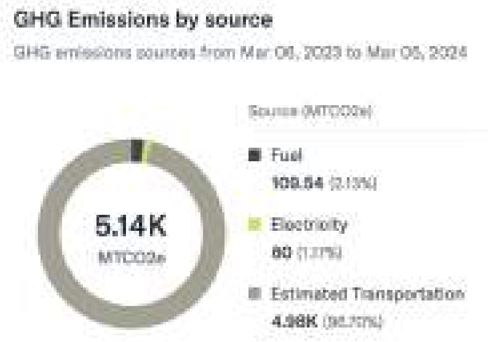
Rochester's information regarding operational carbon is collected by the Sustainability Department and registered in the ArcSkoru platform, which has the necessary factors for calculating the emissions and compensations.

Figure 15.

Environmental performance of Rochester school in Arc Skoru.

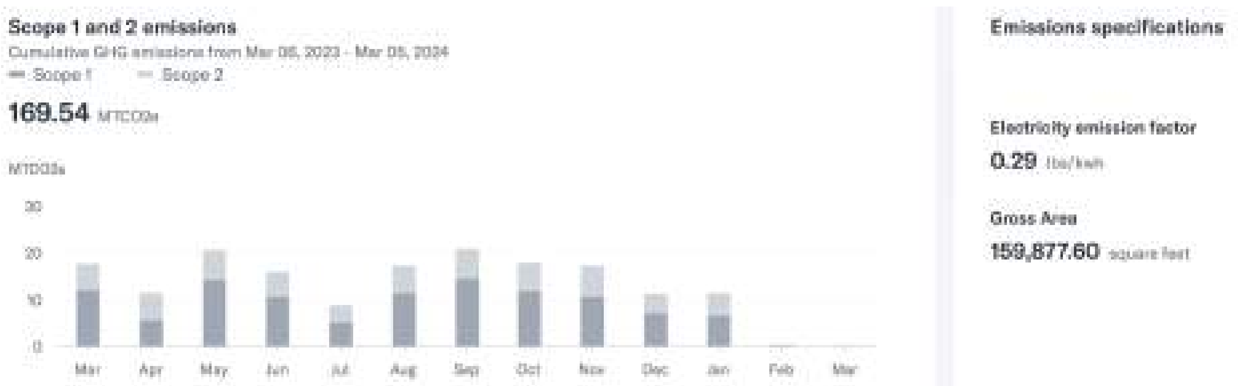
Graph 1.5 *GHG Emissions at Rochester school.*

Note: Fuel refers to the natural gas used in the kitchen.



Graph 1.6. *Energy score in Arc Skoru, measured with given factors.*

Graph 1.7 *Final value of Rochester's emissions at operational level, with compensations included.*



As a result, Rochester Carbon footprint is as follows:

CF_{Roch} = (A + C) - P

CF_{Roch}= (204.826 Ton CO_{2-e}/yr + 1,69×10^8Ton CO_{2-e}/yr) - 176,14 Ton C-e/yr

CF_{Roch}= 169'204,649.86 Ton CO_{2-e}/yr

The Total Emissions ($MtCO_2e$) in Colombia in one year are 270.31, or 270'310,000 Ton CO_{2-e}/yr.

[17]

This means Rochester School is 101'105.351 Tons of CO_{2-e} per year, below the national average.

DISCUSSION:

Interpretation of results:

Rochester's carbon footprint

The carbon footprint final value at Rochester School considered the respiration rate of the human population, but the Arc Skoru platform also includes in their operational processes the users of the campus. It does not take into consideration events or visits or other people. Further studies of the carbon footprint is necessary to revise also if the platform discriminates the values according to age, as was done in this study. Taking this into consideration, it could even be possible to eliminate from the formula the anthropogenic impact of respiration, which will cause the footprint value to be even lower: 168'999.824 Ton CO_{2-e}/yr.

Carbon sequestration and fixation

The number of trees above 4,5m was 132 which was the baseline for calculating carbon fixation and sequestration. There were many other trees close to 4m that could give in a few years a higher value in this aspect. Also, the Sustainability area, in the last 5 years, has planted 13400 native trees in situ and on nearby areas to the school, some of these trees could be now at a height of 2m, (depending on the species) which means in two or three years they could be ready for being measured and calculate with them the carbon fixation and sequestration.

Tree value

The 132 trees used for this study cost 12 years ago around 132 dollars ($528.000 colombian pesos). Today, according to the iTree Eco tool, the same trees have an approximate value of 24660 UDS ($98'640,000 Colombian pesos). This means Rochester School does not have the need of buying carbon credits, which are so fashionable these days. Planting trees has an additional profit that is sharing valuable time as a community towards a good cause. Students, parents and teachers enjoy planting trees as a way to relax and have mental health, which for Rochester, is the essence for happiness and optimal relationships.

Operational emissions and compensations

The school's emissions and compensation are well understood by the Sustainability area, the data is organized and reliable. There could be some improvement in how the users of the campus understand this information and value the school even more as a healthy environment and work towards its maintenance.

Count of tree species in Zone A

Taking into account the data found in the count of tree species in Zone A (**Graph 1.2**), it can be observed that the dominant tree species in this zone is *Tecoma stans* with a majority of 41.1%. The rest of the species are only found in small quantities (10 trees or fewer) and this species is specifically present in 23 trees. The abundant presence of this species in this area is due to the fact that it grows very quickly and has a long duration and resistance. Furthermore, some of these trees were already in this area when the school was built.

Count of tree species in Zone B

Taking into account the data collected in the count of tree species in Zone B (**Graph 1.3**), it can be analyzed that the most dominant species in this area is *Smallanthus pyramidalis* with a majority of 65.2%. It is observed that compared to the other species collected, this species is present much more in the area, unlike the rest of the tree species that are only found in smaller quantities. The high presence of this type of tree in Zone B is due to the fact that these trees grow very quickly, but also have a very short life. This type of tree is used to help repopulate different areas after deforestation. Likewise, this tree was used at Rochester School because it attracts different types of birds and helps with the biodiversity of the ecosystem.

Count of tree species in Zone C

As shown in the graph that summarizes the count of tree species in Zone C (**Graph 1.4**), there is a clear majority of trees of the *Meriania nobilis* species with a value of 42.9%. Likewise, it must be taken into account that in this area there is not much presence of trees since they are gardens throughout the school, for the same reason there is not much data collected in this area. Returning to the analysis, this species of tree is seen much more in this area because when landscaping the school, this species was associated with the virtue of respect. Since in real life, this species is threatened in wildlife, students learn to take care of them and respect them. Likewise, this species is endemic, so it adjusted to the idea of landscaping at school.

Average DBH (cm) vs Tree Specie

To analyze the DBH, it is necessary to take into account that the tree species at the school vary (see **Appendix 1.5** and **Graph 1.1**). This means that all of them can reach a high DBH, since the species only grows up to a certain point. On the other hand, it is important to emphasize that as shown in the graph, there are species with a very high DBH. This means that they have a greater carbon fixation, since the trees with higher DAP tend to be older and larger trees. The larger and older a tree is, the greater its biomass and therefore the more capacity it has to store carbon.

The sustainability Area needs to take into account the growth rate of the species and the adult DBH in order to look for species that could fix more carbon and reduce the greenhouse gas of carbon dioxide.

Possible sources of error:

Sampling bias: The areas surveyed may not be representative of the overall tree population at the school. Only sampling certain zones could skew results if those areas don't reflect the actual distribution.

Identification errors: Mistakes in identifying tree species could lead to incorrect counts and skew dominance numbers. Visual identification can be prone to mistakes.

Measurement errors: Mistakes in measuring DBH with tools or by estimation could affect DBH averages calculated. Systematic measurement errors could skew sizes.

Assumptions on growth rate and carbon storage: The statements about carbon storage capacity given by the iTree Eco tool make generalizations with the not recognized species. This tool better recognizes the North American trees, this could cause a variation in the final result, it is necessary to find a tool for Southamerican trees.

Data entry mistakes: Errors in recording or transcribing data during the survey process could introduce incorrect numbers. Checking raw data can minimize this.

Comparison with similar studies:

The UK Sustainable Development Commission's "Schools' Carbon

Management Strategy" [16] provides a comprehensive five-step approach to help schools reduce their carbon footprints and achieve cost savings through improved energy management practices. The strategy guides schools to commit to action, calculate emissions baselines, identify reduction opportunities, implement carbon-cutting projects like renewable energy and energy efficiency measures, and communicate achievements potentially realizing 30% emissions reductions on average. Key recommendations include appointing an "Energy Champion," conducting audits, pursuing low-cost controls and awareness campaigns, incorporating sustainability into operations and curricula, and leveraging the strategy's benefits of financial savings, embedding environmental ethos, and raising community awareness about sustainability. With detailed implementation guidance, case studies, and resources, the strategy equips UK schools to effectively tackle the 2% of public sector emissions they account for.

The UK strategy provides general guidance that aligns with the goals of the Rochester study, which is conducting a granular assessment of that school's total carbon footprint and environmental impact across multiple areas.

The tree analysis component of the Rochester School study relates to the UK strategy's recommendation for schools to explore renewable energy/carbon offsetting opportunities as part of a holistic carbon reduction plan.

Both documents ultimately aim to reduce emissions and promote sustainability practices in the school environment, but the Rochester study takes a more comprehensive, site-specific approach for that particular institution.

Discuss whether results support the hypothesis or not, and why:

Based on the results presented, the hypothesis that optimizing the school's infrastructure, natural surroundings, and individual behaviors for sustainability through energy-efficient buildings, ample campus vegetation, and environmentally-conscious daily practices will significantly reduce the institution's overall carbon footprint is supported to a large extent.

The presence of various tree species across the different zones of the campus suggests that there is ample campus vegetation, which can contribute to carbon sequestration and reducing the institution's carbon footprint. The analysis of the tree species count in each zone indicates that certain species, such as Tecoma Stans (Zone A), Smallanthus Pyramidalis (Zone B), and Meriania Nobilis (Zone C), are dominant in their respective zones. The reasons for their dominance, such as rapid growth, short lifespan, or being endemic to the area, are discussed.

The analysis of the average Diameter at Breast Height (DBH) versus tree species suggests that larger and older trees have a greater capacity for carbon fixation due to their increased biomass. This implies that the presence of trees with higher DBH on campus can contribute to reducing the institution's carbon footprint through carbon sequestration.

While the results provide valuable information about the campus vegetation and its potential for carbon sequestration, they do not directly address the energy efficiency of buildings or environmentally-conscious daily practices, which were also part of the hypothesis. To fully support the hypothesis, additional evidence demonstrating the optimization of these aspects would be necessary.

Overall, the results partially support the hypothesis by indicating the presence of ample campus vegetation, which can contribute to reducing the institution's carbon footprint through carbon sequestration. However, the evidence provided is limited to the vegetation aspect, and more information on the optimization of infrastructure and individual behaviors would be needed to fully validate the hypothesis.

CONCLUSIONS:

A combination of strategies towards the reduction of the carbon footprint of an educational institution are necessary in order for the result to be significantly noticeable, in this case, having a sustainable site is the base for adding new strategies that sum up.

Rochester School's carbon footprint is 101'105.351 Tons of $CO_{2\text{-}e}$ per year below the national average, due to the amount and complementary strategies that contemplate every possible aspect that could generate an impact, and the constant work of the Sustainable Area to mitigate that impact.

This study must continue to be held every 2 to 4 years from now in order to evaluate the increase of carbon sequestration and fixation by the 13,400 trees that were planted at the school and their surroundings in the last 5 years.

The amount of trees planted at the school not only contributes to mitigating the carbon footprint, but it has shown evidence to become an ecological corridor for birds and other fauna. Since then, there has been an increase from 12 species of birds registered before the building of the new campus and the tree planting, to more than 40 bird species today.

A new bird study could give accurate information about the positive impact of trees as a biological corridor, since the last study was in 2015. During the census of trees, two migratory birds were observed that were not registered before in the campus.

Additional plants with flowers might be planted at school to attract pollinator birds such as the hummingbird that was not common on the bird observations.

It is necessary to have an updated application or tool that measures the carbon fixation of any tree species, since there are some Colombian native species that were not recognized by the tool iTree Eco.

A further analysis on the carbon sequestration per native tree species needs to be done. In order to make an action plan about the species of tree that will be planted more often in the future, according to its rate of carbon sequestration and fixation.

GLOBE BADGES

I am a Collaborator:

The Rochester School carbon footprint study exemplifies collaboration by involving students in clearly defined, interconnected roles that synergistically enabled a comprehensive analysis. Field teams collected tree measurement data using the GLOBE app and the herbaceous samples, which analysts compiled and interpreted to understand carbon sequestration potential.

Other students assessed emissions from energy use, transportation, and other sources. Writers synthesized these components into the final report. If the study involved partnering with students from other schools, that inter-school collaboration could have expanded datasets, shared best practices, enabled comparative analyses across campuses, and fostered a wider community around environmental sustainability.

By outlining how students contributed complementary efforts in a coordinated fashion, leveraging diverse skills and perspectives, the research highlights the advantages of collaborative teamwork over individual efforts alone.

I make an impact:

The Rochester study tackled the local issue of the school's environmental impact by comprehensively investigating its carbon footprint from various sources like energy use, transportation, and lack of carbon sequestration from limited vegetation. By directly measuring trees on campus and analyzing emissions data, the research provided quantitative insights into Rochester's contribution to global climate change.

The study then makes actionable recommendations for the school to reduce its footprint through sustainable infrastructure upgrades, promoting eco-friendly behaviors, and increasing green spaces - detailing how implementing these findings can positively impact the local community. Beyond just study, the report's solutions roadmap empowers the school to take tangible actions that make a meaningful difference in mitigating emissions and cultivating environmental stewardship among students and faculty.

I am a data scientist:

The Rochester study exhibits thorough data analysis by students across multiple domains. They collected and performed in-depth analysis on their own primary tree measurement data from the school campus using the GLOBE app. This tree data was leveraged to quantify potential carbon sequestration and storage. Students also analyzed secondary data sources like utility bills to assess emissions from energy consumption and transportation surveys to estimate emissions from commuting behaviors.

The report discusses limitations in data completeness and measurement accuracy. Students synthesized these diverse datasets to characterize the school's overall carbon footprint, make informed projections about future emissions trajectories under different mitigation scenarios, and ultimately recommend data-driven solutions tailored to the specific emissions profiles identified.

By integrating analysis across empirical and third-party datasets, robustly interpreting results, and using data to pinpoint areas for strategic intervention, the study exemplifies skills critical for an effective data scientist

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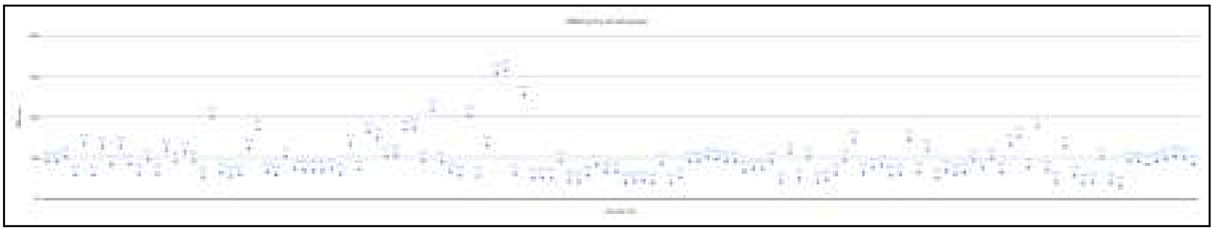
APPENDIXES

Appendix 1.1.

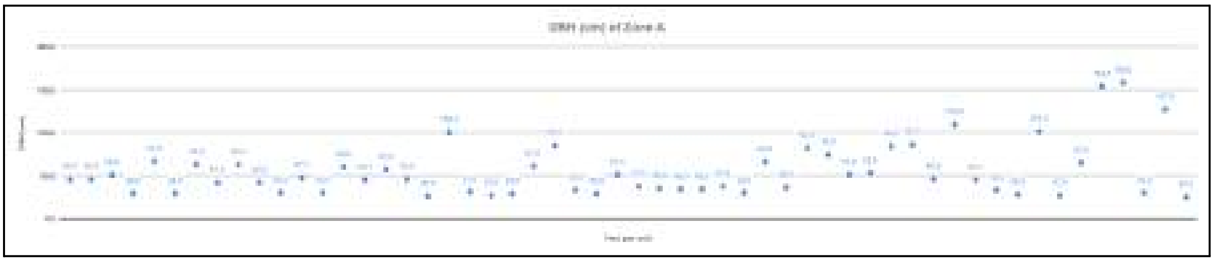
DBH (in cm) of all zones



Note: The graph shows the average DBH in centimeters of all the trees measured for the investigation.

Appendix 1.2.

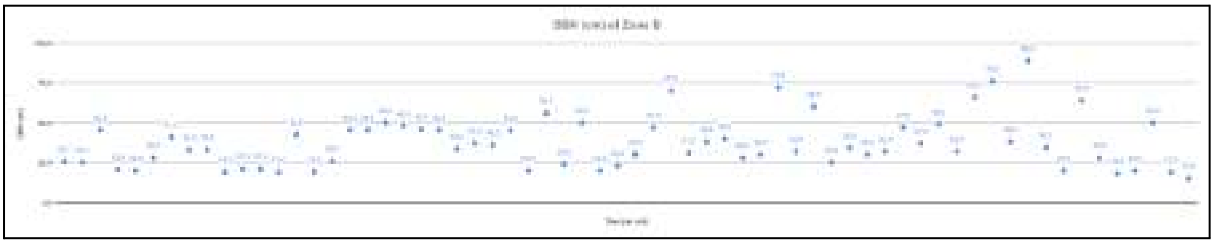
DBH (in cm) of Zone A



Note: The graph shows the average DBH in centimeters of all the trees in Zone A measured for the investigation.

Appendix 1.3.

DBH (in cm) of Zone B



Note: The graph shows the average DBH in centimeters of all the trees in Zone B measured for the investigation.

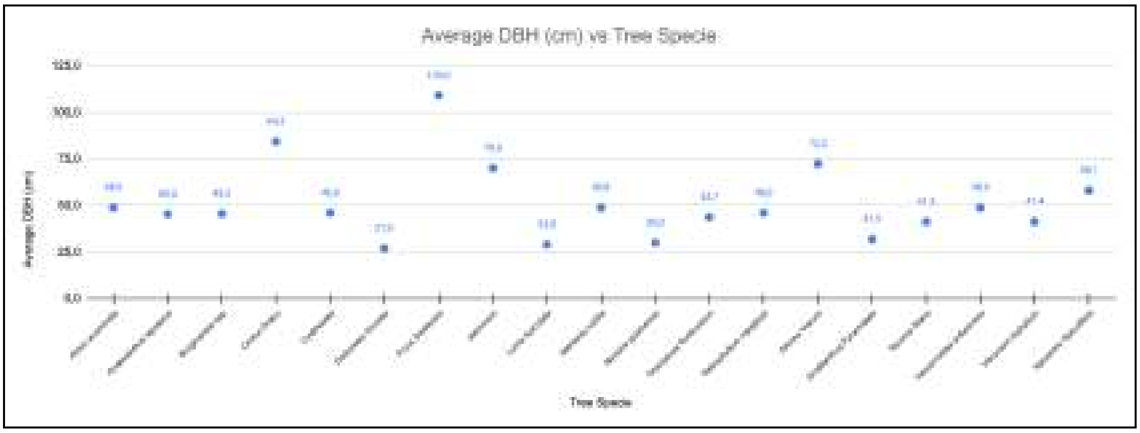
Appendix 1.4.

DBH (in cm) of Zone C

Note: The graph shows the average DBH in centimeters of all the trees in Zone C measured for the investigation.

Appendix 1.5.

Average DBH (in cm) per Tree Specie



Note: The graph shows the average DBH in centimeters of all the trees (per specie) measured for the investigation.

Appendix 1.6.

Link for the pictures registered and given by the app GLOBE Observer with information of each registered tree at Rochester School. (DRIVE FOLDER)

🗀 PICTURES OF THE TREES GLOBE

Appendix 1.7.

Data given by Data Entry in Globe.gov

🗀 GLOBE'S DATA TREES OBSERVATION

Appendix 1.8.

iTree Eco Data Rochester Trees per species.

🗀 **GLOBE'S DATA TREES OBSERVATION**

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