Utilization of Urban Arborization as a Nature-Based Solution (NbS) for CO_2 Offsetting in the Construction Sector

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ABSTRACT

The construction sector is one of the main contributors to global CO_2 emissions. This article proposes urban reforestation, through the planned planting of trees, as a nature-based solution (NbS) for capturing and storing CO_2 generated in urban areas by new constructions. In addition to capturing CO_2, tree planting offers additional benefits, such as improving air quality, reducing energy consumption, combating global warming, and promoting health and well-being. The study examines the gap between the sector's climate performance and the urgent need for decarbonization, considering sustainable practices aligned with ESG principles and the UN's 2030 Agenda guidelines.

Keywords: Urban Reforestation; CO_2 Capture; Construction Sector; Carbon Offset; Nature-Based Solutions (NbS).

INTRODUCTION

The construction sector is responsible for approximately 37% of global energy-related CO_2 emissions, reaching record levels in 2021, with a 5% increase compared to 2020. These emissions have been continuously rising, placing the sector off track to meet decarbonization targets by 2050, as established by the UN's 2030 Agenda. In this context, the search for innovative and integrated solutions to mitigate the environmental impact of the construction sector and contribute to the transition to a low-carbon economy is urgent. Urban arborization, through the planned planting of trees, emerges as a promising nature-based solution (NbS) and, at the same time, as an ancient practice. Besides capturing and storing atmospheric CO_2, trees offer multiple environmental and social benefits: they improve air quality, reduce urban temperatures by up to 8°C, buffer noise, control humidity, and promote the physical and mental well-being of populations. These functions are particularly valuable in dense urban areas, where the negative impacts of construction and urbanization are more pronounced.

The integration of sustainable construction practices with urban arborization strategies can act as a catalyst for decarbonizing the construction sector, promoting a healthier and more resilient urban environment. By encouraging tree planting as a compensatory measure based on the calculation of the carbon footprint of new constructions, we not only capture CO_2 but also advance in fulfilling the UN Sustainable Development Goals (SDGs), particularly SDG 11, which aims to make cities and communities more sustainable, and SDG 13, which emphasizes urgent action against climate change. This approach can provide a foundation for the creation of effective public policies aimed at compensating for and reducing GHG emissions, while encouraging investments in sustainable solutions for the construction sector.

MATERIALS AND METHODS

The present study adopts a multidisciplinary methodological approach to evaluate the impact of tree planting as a nature-based solution (NbS) for the capture and storage of CO_2 in urban areas, aiming to mitigate emissions from the construction sector. The methodology is structured in two main stages: the development of a calculation method to quantify the CO_2 capture requirement based on the GHG Protocol, according to the characteristics of new constructions; and the definition of guidelines for application in different types of constructions: residential, commercial, industrial, and institutional.

1. Support from the GHG Protocol: The CO_2 emissions analysis was conducted based on the GHG Protocol (Greenhouse Gas Protocol), which is the most widely used international standard for measuring and managing greenhouse gas emissions. The GHG Protocol provides guidelines for emissions inventory, helping to quantify direct and indirect emissions associated with construction activities. The assessment considered the direct emissions from construction sites during the execution/construction phase of new buildings.

2. Proposal for a CO_2 Offsetting Calculation Method: A mathematical calculation method (*Eq. 1*) is proposed to estimate the CO_2 capture/offsetting requirement through urban arborization, based on the characteristics of the construction under analysis. The formula takes into account specific variables for different types of constructions (residential, commercial, industrial, and institutional), considering factors such as construction area, base carbon footprint per m² (square meter), materials used in the structure, and location factor.

RESULTS AND DISCUSSION

The application of the proposed method for offsetting the carbon footprint generated by the construction sector in urban areas yields significant results, highlighting the relevance of planned tree planting as a nature-based solution (NbS) to mitigate CO_2 emissions. Using the mathematical formula:

$$F(A) = (A \times Ctm \times L) \times K \qquad \textit{Eq. } (1)$$

where:

. *F(A)*: Required value to offset the carbon footprint of a building based on the built area (in BRL).

. *A*: Built area of the construction under analysis (in m²).

. *C*: Base carbon footprint per m² (in Kg CO_2e/m^2), varying according to the type of building (t) and material used (m).

. *L*: Location factor, which adjusts the impact depending on whether the building is in an urban area (L = 1.2) or rural area (L = 0.9).

. *K*: Monetary offset coefficient (BRL 0.195 per Kg CO_2e).

For residential constructions, the results indicated that the use of wood, with an average carbon footprint of 51.75 Kg CO_2e/m^2, generates a significantly lower offsetting value compared to steel, which has a footprint of 85.30 Kg CO_2e/m^2. When considering different types of constructions, it was observed that industrial buildings had the highest carbon footprint, especially when built with steel (108.30 Kg CO_2e/m^2). Meanwhile, commercial and institutional buildings presented intermediate values, influenced by the required infrastructure and the variability of uses, such as HVAC systems in commercial buildings or large open spaces in institutions. The analysis revealed that the location factor (L) has a significant influence on the offsetting value. Additionally, the compensation coefficient (K) of R$0.195 per Kg CO_2e provides a cost reference for the monetary offsetting of carbon emissions, and can be adjusted according to technological advancements and market rate variations.

Considering that a single tree can capture between 7.4 and 15.6 Kg CO_2/year during its first ten years, the proposed measure emerges as a viable compensatory solution, aligning both environmental and social benefits. In an analysis of a residential building constructed with a conventional concrete structure, with an area of 180m² in an urban location, the result is: $F(180) = (180 \times 75 \times 1.2) \times 0.195 \Rightarrow F(180) = 16{,}200$ kg $CO_2e \times 0.195$ = R$3,159.00, a value corresponding to the payment/donation/fee for planting between 100 and 220 trees, which would be responsible for storing/sequestering the CO_2e emitted during the construction of the building under analysis over 10 years.

The implementation of this strategy in different construction contexts can promote CO_2 capture and significantly contribute to the reduction of greenhouse gas emissions. By combining carbon offsetting with improvements in urban quality of life—such as temperature reduction, humidity control, and increased biodiversity—urban arborization also supports the UN Sustainable Development Goals (SDGs), particularly SDG 11 and SDG 13. Future research can refine the proposed method by including additional variations in building materials, tree planting density, species used, growth rate, and the carbon sequestration capacity of each species, as well as more advanced construction practices.

CONCLUSION

This study demonstrates that planned tree planting, through the analysis of the area of new constructions, is an effective solution to mitigate CO_2 emissions from the construction sector in urban areas. The proposed method quantifies the carbon footprint offsetting based on variables such as built area, type of construction, materials, and location, showing that using wood instead of steel can significantly reduce emissions. In addition to capturing CO_2, urban arborization provides benefits such as improving air quality and increasing biodiversity, aligning with the UN Sustainable Development Goals (SDGs), particularly SDGs 11 and 13. Public policies that encourage these practices can promote the decarbonization of the sector. Future research should refine the method by exploring variations in materials, tree density, and advanced construction practices to enhance the effectiveness of carbon offsetting.

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