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Eco-Sustainable Bridging of Housing Deficit – A Case Study of Nigeria

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HIGHLIGHTS

- Greenhouse gas emissions is not only limited to products of combustion of fossil fuels.
- Depletion of the forest cover can affect the volume of atmospheric greenhouse gases
- Bridging housing deficits can require the depletion of forest cover
- Appropriate building units distribution is key to limiting loss of greenhouse gas absorption potential.

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ABSTRACT

Keeping the average global temperature rise below the 1.5oC value over the pre-industrial era requires all hands to be on deck. The energy sector, transportation sector, and the agricultural/land use segment are significant contributors to greenhouse gas emissions responsible for global warming. While there is an ongoing campaign for tree planting to reduce atmospheric CO2 volumes, it is imperative to note that the population explosion in some climes is pushing up the demands for land. The housing deficit in Nigeria is more than twenty million units. Building units are required to bridge the deficit; hence, an attendant forest cover loss. The study aims to propose an eco-sustainable means of bridging the shortfall. Sticking to the practice of a building unit per plot will lead to a CO2 absorption potential loss of about 1.11 billion tonnes over twenty years. However, building more units per plot will be a respite. Ten building units per plot can push down the figures to 0.1115 billion tonnes over the same period and was the best for the considered scenarios. The study showed that the loss of CO2 absorption potential from forest cover loss could be minimized by building more housing units per plot of land.

1. Introduction

We now live in a world where the average temperature increment over just a decade approaches 1oC [1, 2], no thanks to global warming caused by the emission of greenhouse gases. The emission of greenhouse gases from the combustion of fossil fuels receives more attention. The justification has its root in available data. It contributed to about 65% of the CO2 gas emission in 2010 [3]. The transportation sector has continued to be in the eye of the storm regarding greenhouse gas emissions from fossil fuel combustion [1]. Although many countries are now moving toward renewable electricity generation and away from the dependence on fossil fuels to reduce greenhouse gas emissions [4,5], some are still at the crossroad yet to decide which to adopt [6]. The electricity generator sector enjoys less criticism than the transport sector despite higher global greenhouse gas emissions [3]. Many governments that seek to migrate an electrified transportation sector still generate the bulk of their electricity from fossil fuel plants. It is worth considering these two sectors simultaneously for an appreciable gain in greenhouse gas reduction from them [1].

The other major contributor to greenhouse gas emissions by sector is; industrial and agriculture/land use [7]. The greenhouse gas emissions contributions of agriculture/land use are only second to electricity and heat generation [1, 3]. It is not far-fetched because vegetation and oceans are the two most critical carbon sinks. Therefore, the agriculture/land use sector is crucial to the quest for addressing global warming by reducing greenhouse gas emissions. The soil acts as a short/long-term carbon sink with a storage capacity more than the combined capacity of terrestrial vegetation and the atmosphere [8]. Oceans and water bodies are also great carbon sinks and sequestrate carbon from the atmospheric Carbon IV oxide. The oceans absorb about twenty-five (25%) of the annual human-generated Carbon IV oxide [8].

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The global population is on an increasing trend. Catering to the growing population will require clearing the forested areas to make way for farmlands and building structures. Deforestation causes the emission of greenhouse gases by depleting carbon sinks and can lead to the release of stored carbon into the atmosphere through combustion processes. A loss of forest cover globally between the study duration of 1990 to 2020 resulted in a reduction of carbon stock of 6 gigatonnes [9]. A study of the forest cover in Nigeria between 1990 and 2010 revealed an average annual loss of about 2.38% [10]. An indication of her carbon sink loss. The improvement in greenhouse gas emissions reduction from the transportation sector might not be enough to bring the average temperature increment over pre-industrial periods below 1.5oC because its contribution to the total stands at around 14% [1]. However, reducing emissions from all sectors can guarantee average temperature values over the pre-industrial period below this threshold [11]. A focus on the agricultural/land use sector in the face of the increasing need to open-up forests for farming and the erection of structures to meet the global population growth will in no small way help mitigate global warming. Nigeria is currently grappling with a deficit in its housing requirements.

The housing deficit estimates of Nigeria in the year 2018 was about Twenty million units averaging 23 units per 1000 inhabitants [12], and the estimated number of households in the country in the year 2020 was about Forty-Three million. The deficit has been increasing over the years with a correlation with her population increase, as depicted in Table 1.

Table 1: Nigeria Housing Deficit

Year	Population (millions)	Housing Deficit (million units)
1991	97+	7
2007	146+	12
2014	176+	14
2018	200+	20

With a compact area of 923,768 km^2, it questions one's imagination to note that one of the main constraints to overcoming the country's housing deficit is access to land [13]. The land ownership structure might be complicit in this. However, this is not the focus of this study. Overcoming her housing deficit will require sacrificing her forest covers if a workable plan is not in place. The country lost a forest cover of about 12.5% over 20 years from 2001 to 2020 [14]. Figure 1 presents the percentage of forest area in the year 2020 to her un-forested compact area.

The country can meet its shortfall in housing needs by opening up new areas through deforestation and rebuilding existing opened-up areas/new openings. Land divisions in Nigeria appropriate a plot for house construction to (0.03 x 0.015) km^2. With the common practice of a housing unit per plot and a deficit of about twenty million units as documented in 2018 [12], the country will need about 9,000 square kilometers of land. This study is committed to estimating the amount of greenhouse gas (CO_2) absorption potential through proper land-use practices in Nigeria in the face of her increasing population. Therefore, the study is limited in scope to the loss of greenhouse gas-absorption potential of land use and not from building materials, construction processes, and the buildings when inhabited.

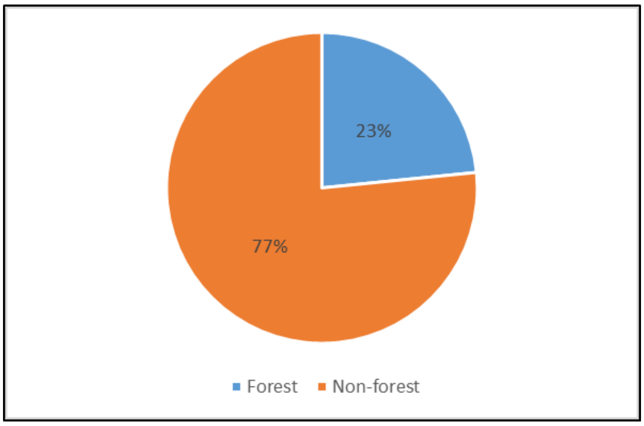

Figure 1: Nigeria's compact area by segment

2. Estimated CO_2 gas emission due to forest cover erosion (2001 – 2020)

Much literature has stated separate CO_2 absorbing capability of forest cover depending on the forest type. Nigeria's rainforest consists of a multi-tiered tropical forest with the highest rate of CO_2 absorption. The wet tropical areas have a documented annual absorption value of about 15 tonnes of CO_2 per acre and are the highest absorption rate [14]. Nigeria lost about 12.5% of its forest cover between 2001 and 2020 [15]. This translates to the emission of greenhouse gas that, hitherto, served as a sink. Loss of forest cover causes a loss of a continuous carbon sink and results in the emission of stored carbon [16].

$$\text{The loss of absorption in terms of CO2 per annum} = \frac{\text{Forest Cover loss in km}^2}{0.004} \text{ x absorbing rate of an acre of forest cover} \tag{1}$$

An acre is equivalent to 0.004 sq. km.

$$\text{the cumulative loss of absorption} = \left[\frac{\text{Time span}}{2}[2 + (\text{time span} - 1)]\right] \text{x} \frac{\text{Average Forest Cover loss in km}^2}{0.004} \text{ x}$$

$$\text{absorbing rate of an acre of forest cover} \quad (2)$$

Working with a conservative value of 10 tonnes of CO2 absorption per acre annually for the Nigeria forest cover, the twenty years span of 12.5% loss in forest cover resulted in the net amount of 814.5 million tonnes of CO2 with the assumption of the non-release of the trapped carbon in the trees.

However, the forest cover loss was for 20 years. Thus, the loss of its absorption tendency is cumulative over the period. The assumption of an equal depletion rate over the period is employed. Equation 2 is derived using the basic arithmetic progression formula and adapting for cumulative absorption tendency.The forest cover loss for the period was 31,027 sq. km [12], and the average annual forest cover loss is;

$$\frac{31027}{20} = 1{,}551.35 \text{ sq. km}$$

Since one acre does absorb 10 tonnes of CO2, 31,027 sq. km loss of forest cover loss over the 20 years would lead to unabsorbed CO2 values using Equation 2;

$$\frac{20}{2}[2 + (20 - 1)]\, x \frac{1551.35}{0.004}\, x10 = 814.5 \text{ million tonnes.}$$

3. Bridging Nigeria Housing Deficit

Studies on the country's housing deficit put it at about 20 million units [9]. The building of the housing units requires land. Reducing the forest cover to make land available will result in the reduction of greenhouse gas absorption. While access to land is still possible in some built-up areas, this study will consider what the country stands to contribute in net values to CO_2 volume by reducing her forest cover only to bridge the deficit. This study presents three scenarios and assumes meeting the required housing units in five years in equal installments -

- The practice of building units per plot
- Four sets of flats per plot
- High-rise buildings that can house ten units of flats per plot

4. Results and Discussion

4.1 Scenario One – Common Practice of A Building Unit Per Plot

Based on the earlier estimates, if the practice of a building unit per plot plays out in bridging her housing deficit, about 9,290 square kilometers of land will be required. The assumption is to provide an equal number of housing units per annum over the five years. As a result, the country will lose 1858 sq. km of forest cover annually. The cumulative loss of CO_2 absorption due to the forest cover loss over the period using equation 2 amounts to 69.7 million tonnes. Afterward, the resultant impact of the land use is an annual CO_2 absorption loss of 69.7 million tonnes.

4.2 Scenario Two – Four Sets of Flats Per Plot

It is also common to have four building units of a two-flat per floor story buildings in the country. Therefore, adopting this model to bridge her housing deficit will require about 2,322.5 sq. km of forest cover depletion. As taken for scenario one, "assumption of the provision of an equal number of housing units per annum over the five years, the country will lose 464.5 sq. km of forest cover annually". The corresponding cumulative loss of CO_2 absorption due to the forest cover loss for five years obtained using equation 2 will be 17.42 million tonnes. Afterward, the annual loss in CO_2 absorption due to the forest cover loss, while other things are held constant, will be 17.42 million tonnes.

4.3 Scenario Three – High-Rise Buildings That Can House Ten Units of Flats Per Plot

Although the erection of high-rise buildings is not common in this part of the world, things are now changing as some estate developers are already embracing multi-story structures. Having ten units of flats on a plot will reduce the area of forest cover required to offset the housing deficit to about 929 sq. km. The implication of this is an annual requirement of 185.8 sq. km over five years. The cumulative loss of CO_2 absorption potential due to the loss of forest cover using the relation in Equation 2 will be equivalent to 6.97 million tonnes.The aftermath effect of the adoption of any of the three scenarios is presented in Figure 2.

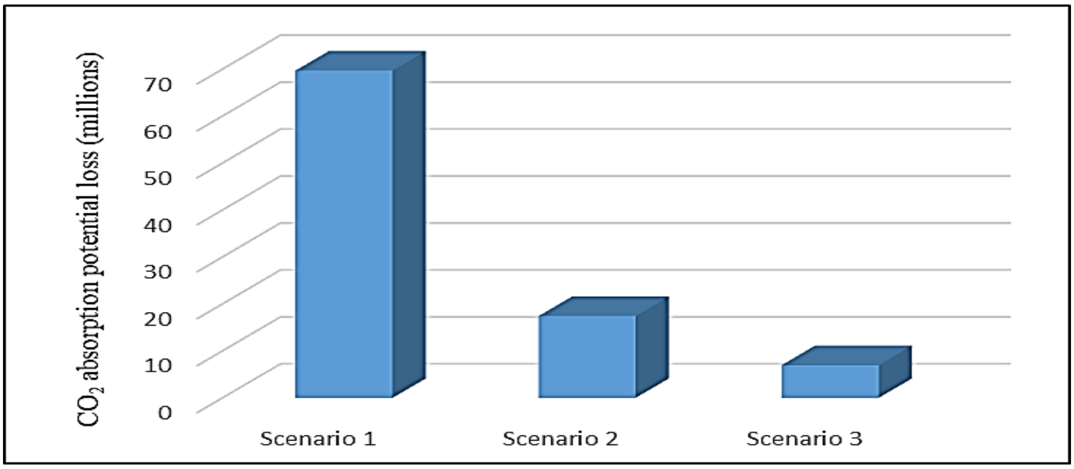

Figure 2: Building units pan impact on CO_2 absorption potential loss

While it is imperative to meet the housing needs of her citizens, the method of achieving this will contribute to global warming through the depletion of the forest cover. The three scenarios presented show that adopting multi-story buildings will reduce the impact on greenhouse emissions. The loss in CO_2 absorption potential due to the highlighted scenarios becomes pronounced when it is required to estimate the cumulative effect over a long number of years as presented for the period 2001 - 2020, which was 814.5 million tonnes. The impact will be as presented in Figure 3.

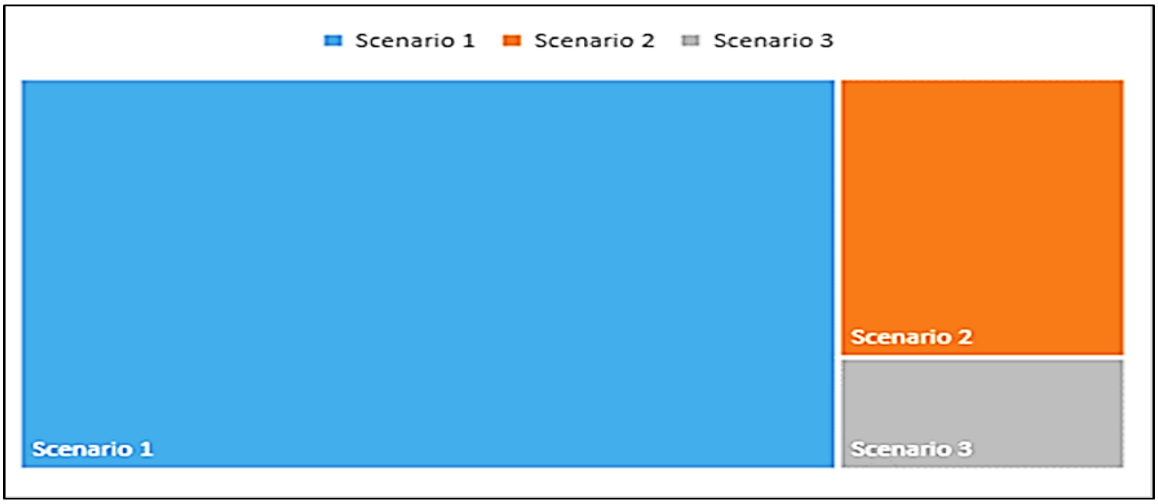

Figure 3: Contribution of the studied scenarios to CO_2 absorption potential loss

The large portion covered by scenario one in Figure 2 indicates the potential loss in CO_2 absorption potential if it is adopted over the other considered scenarios. It is a pointer to what lies in wait for us if we refuse to conserve our forest cover while meeting our housing needs.

5. Conclusion

Climate change is real, and a notable cause is global warming arising from greenhouse gas emissions. Human needs are numerous, and the process of meeting these needs in most cases contributes to greenhouse gas emissions. Meeting the housing needs of Nigerians will involve the depletion of her forest cover that serves as a carbon sink. However, the adopted means of bridging this deficit is a crucial determinant of greenhouse gas absorption. The study considered three scenarios of meeting the country's estimated housing needs and provided an estimate of the CO2 absorption potential loss over 20 years;

- 1.11 billion tonnes of CO_2 absorption potential for a building unit per plot
- 0.2787 billion tonnes of CO_2 absorption potential for four building units per plot and,
- 0.1115 billion tonnes of CO_2 absorption potential for ten building units per plot

The study has based its estimate on forest cover depletion and not on emissions from building materials, construction processes, and the buildings when inhabited. Therefore, the more housing units erected on a plot, the lesser the forest cover loss will be and the better for a greener society.

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Author contribution

The first author conceptualized and prepared the manuscript. The second and third authors assisted in sourcing literature, and the last author proofread the manuscript.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Conflicts of interest

The authors declare that there is no conflict of interest.

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