



## Enhancing Green Plot Ratio In Residential Building Plots In Jos, Nigeria

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### Abstract

*As urbanisation accelerates, there is a consequential loss of greenery in cities as spaces that were once vegetative have become hard surfaces in forms of roofs and pavements. The need to accommodate the rising population results in the creation of more dwelling units in the form of residential buildings. The loss of greenery in residential areas has become a critical concern, leading to reduced biodiversity, increased urban heat island effects and diminished well-being for urban dwellers. The concept of Green Plot Ratio (GPR) offers a quantifiable solution to integrate and compensate for the loss of greenery by the creation of residential buildings on previously vegetative sites. This research explores strategies for enhancing GPR by incorporating vertical gardens and rooftop greenery. This research is domiciled in Jos, an urban city in Nigeria. It examines case studies of two residential buildings (a bungalow and duplex) that successfully incorporated greenery to offset ecological losses and achieve sustainable urban living. It focuses on quantifying the vegetation of the plots of the case studies which were previously grasslands before construction, and were altered after construction to accommodate residential units. Afterwards, the results are looked at to see if the GPR was reduced from what it was naturally, if it had been maintained or even enhanced. Thus, the quantitative research methodology was adopted for this research. By analysing these implementations, the study identifies key parameters influencing GPR, such as vegetation density and plant selection. Findings reveal the possibilities of the greenery in a vegetative land being maintained and enhanced through GPR, though the creation of a residential unit tampered with the natural vegetation. Ultimately, the study advocates for the integration of GPR as a component in urban planning to create environmentally resilient and aesthetically pleasing living spaces.*

**Keywords:** Green Plot Ratio, Landscaping, Residential Buildings, Urban Heat Island, Vegetation

### INTRODUCTION

Urbanisation is aggravating the climatic conditions within urban cities. The development of the natural environment into an urban landscape is gradually eliminating vegetation that is vital to a healthy and sustainable environment (Carter & Fowler, 2008; Lui & Zhao, 2020). City expansion and unplanned urbanization result in cutting large numbers of trees, and replacing vegetative areas with hard surfaces. This increase in urbanisation is associated with many environmental problems such as rising levels of atmospheric carbon dioxide and pollution (Qui, et al, 2020). However, increasing biodiversity and vegetation has been identified as an important criterion for improving the quality of urban life (Blowers, 1993; Lui & Zhao, 2020). Subsequently, residential buildings in Nigeria are classified into low, medium and high-density residential areas. This classification is

done to determine the maximum extent of the building plot ratio (floor area ratio) of any given piece of land (Ademola, 2016). Conversely, there is neither a guideline to determine the loss of vegetation due to these dwellings, nor is there a deliberate plan for incorporating the much-needed biodiversity and vegetation for improving the quality of urban life (Ademola, 2016; Aliyu & Amadu, 2017). As a result, most buildings are surrounded with polished ground cover in the form of interlocking tiles, bare earth, asphalt, and concrete (Lui & Zhou, 2020).

These ground covers become excessively hot by absorbing heat energy during the day due to solar radiation and releasing it at night, thereby increasing the buildings' ambient temperature (Echeta, et. al 2023; Lingiang & Jian, 2021; Bing, Lujian & Lui, 2022). As a response to the global climate crisis, increasing the use of greenery in architectural designs helps influence sustainable development (Bilec, Ries, Mathew & ASCE, 2022; Barto, 2019). New residential dwellings are emerging in Jos, the capital of Plateau State leading to an expansion of neighbourhoods (Oluwole, 2021). As population increases, so does the need for shelter (Mulder, 2006; Edward, 2014; Houghton, 2021). Residential buildings increase as new settlements are created and older ones expanded to house the rising population, thus, vegetative areas are overtaken by hard surfaces. These hard surfaces affect the micro climate and gradually the macro climate as these residential units develops into neighbourhoods (Lui & Zhao, 2020). Jos, Plateau State-Nigeria is experiencing the expansion and development of settlements which has led to an increase in hard surfaces and a reduction in vegetative areas, which according to Blazer (2008) leads to the urban heat island effect.

Jos, the Plateau State capital is located in the middle belt zone of Nigeria; it lies between latitude 9° 55'45.56"N and longitude 8° 05'33.163"E, based on the 2006 census, Jos plateau was said to have a population of 836,910 residents and it is divided into three local government areas: Jos north, Jos south and Jos east. (Brown, 2020). It covers an area of 9400km<sup>2</sup>, it has its highest elevation of about 1829m above sea level at the Shere hills (Brown, 2020). Table 1 shows the population growth in Jos, from 1991 to 2006 and the projected population in 2016.

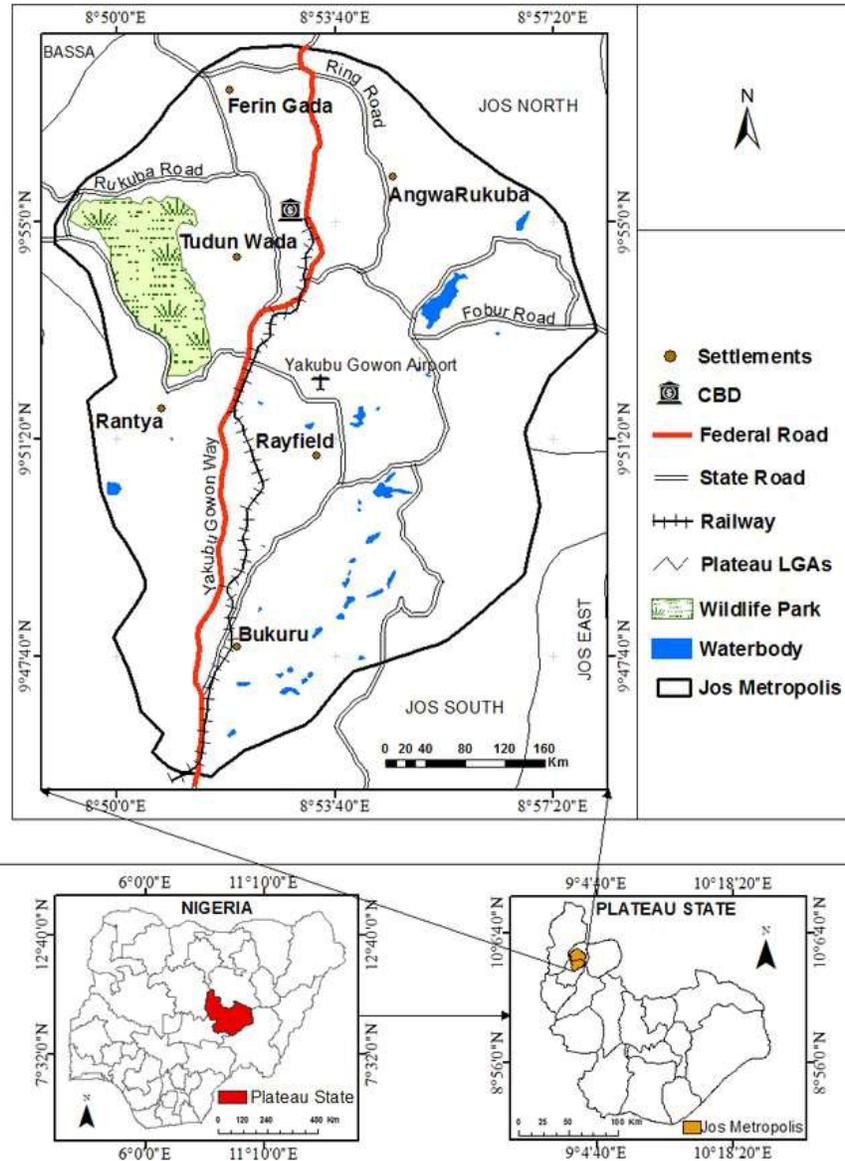
**Table 1: Population Development in Jos, Plateau State**

NAME	Population Census	Population Census	Population Projection
	1991-11-26	2006-03-21	2016-03-21
Plateau	2,104,536	3,206,531	4,200,400
Jos East	...	88,301	115,700
Jos North	...	437,217	572,700
Jos South	237,408	311,392	407,900
Total	237,408	836,910	1,096,300

Source: National Bureau of Statistics (2020)

The city proper lies in Jos north which is the state capital and the heart of the city where most commercial, social and educational activities take place. However, due to urban growth, a lot of commercial activities have been shifted to Jos south and to other nearby local government areas within Plateau state (Brown, 2020). The study area for this paper is the greater Jos-Bukuru area

which encompasses Jos North and Jos South. Figure 1 is the map of Plateau state with the study area cross-hatched in red.

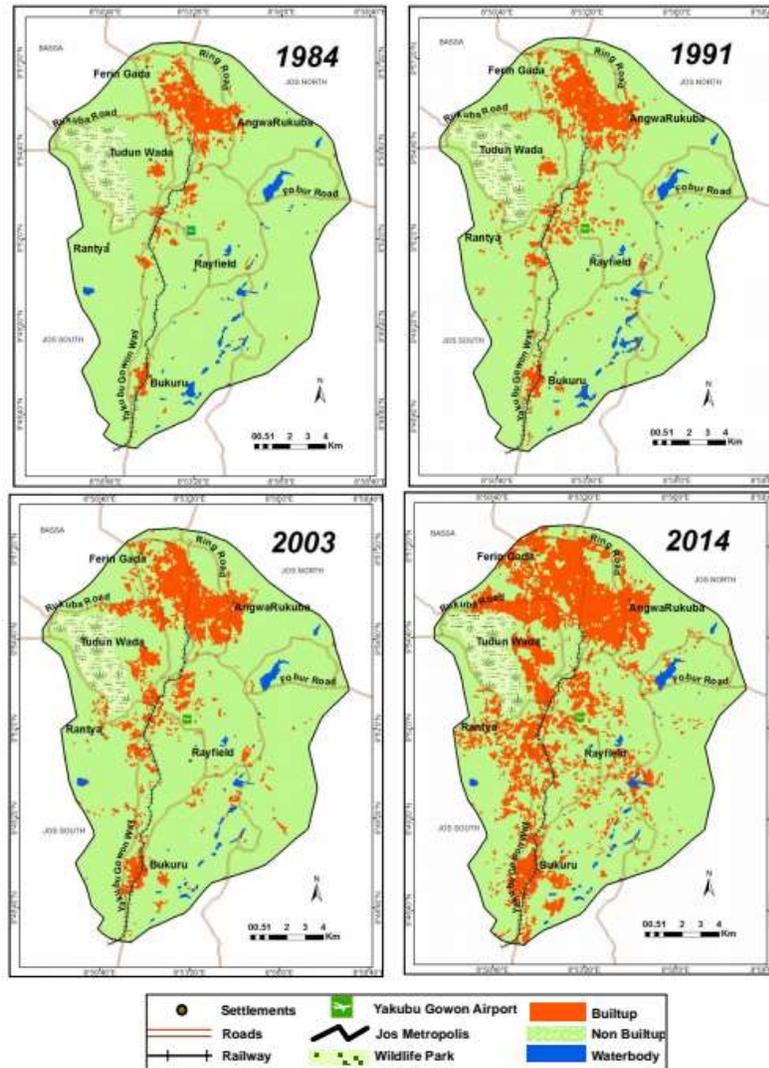


**Figure 1: Greater Jos-Bukuru Map in context with Plateau State and Nigeria**

*Source: Adzandeh, Akintunde, and Akintunde (2015)*

In 1984, the main land use land cover (LULC) type in Jos metropolis was non-built up land accounting for more than 90% of the total landscape (Adzandeh et al. 2015). After 30 years, the LULC in Jos metropolis changed significantly, with rapid urbanization accounting for the loss of greenery such as agricultural land, parks, grasslands, forests, green spaces, bare soil (Adzandeh, et al. 2015). On the one hand, non-built up land decreased from 92.8% of the total area in 1984 to

74.2% in 2014, on the other hand, built up land increased significantly from 5.9% in 1984 to 24.8% in 2014 (Adzandeh et al. 2015). Figure 2 is the increase in the built up area of the greater Jos-Bukuru area from 1984 to 2014. It shows a clear expansion in the built up area in Jos-North, while new settlements emerged and expanded in Jos-South.



**Figure 2: Increase in Built-up Area from 1984 to 2014 in the Greater Jos-Bukuru Area**  
*Source: Adzandeh, et al. (2015)*

The increase in built up land reflects an urban expansion with population and economy growth, opening up a large amount of land for construction (Adzandeh, et. al. 2015). Before 1984, development in the metropolis was more in Jos north, settlements in Angwa Rogo (29.4%), Angwa Rukuba (23.5%) Gangare (30.6%) and Tudunwada (18.8%) dominated in terms of land

development, places like Fobur, Lamingo, Rantya with Rayfield experienced sparse development due to the rugged terrain and the extensive land-dependent nature of its rural economy (Adzandeh, et al. 2015). As urbanization increased, settlements like Lamingo, Rantya with Rayfield had the highest rates of land development increasing by 60%, 51.8% and 57.6% respectively (Adzandeh, et al. 2015). These developments reduced the greenery in the greater Jos-Bukuru area as vegetative surfaces are replaced with hard man-made surfaces in the form of roofs and pavements.

## LITERATURE REVIEW

### Green Plot Ratio

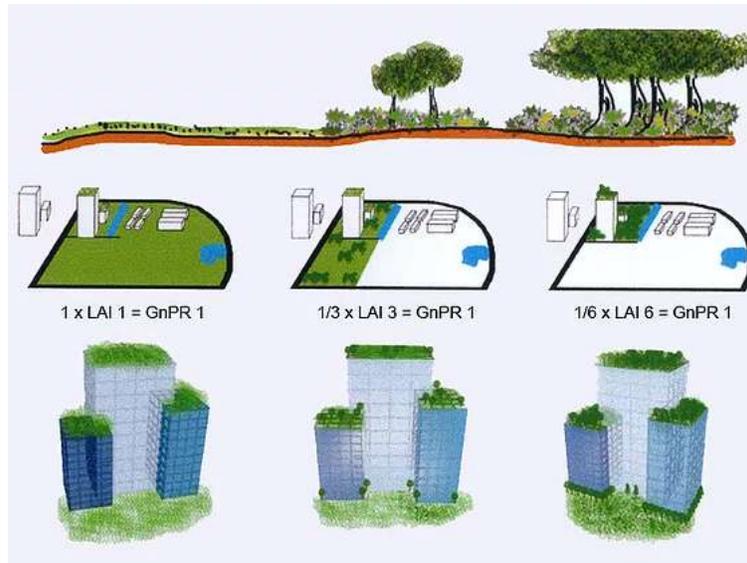
Green Plot Ratio (GPR) was introduced in 2002 by 'Boon Lay Ong', a Singaporean Architect, to draw attention to ecological partnership with plants (Citicene, 2021; Zheng, et al 2024). GPR's motivation is an underlying premise to see the built environment as an ecosystem (Wang *et al.*, 2021). GPR is based on the benefits of greenery being directly related to leaf area and density. The ability of plants to convert CO<sub>2</sub> to O<sub>2</sub>, transpire and thus reduce the surrounding air temperature, provide shade, retain water, reduce wind flow are all dependent on the leaf area index LAI (Brown, 2011; Lovell & Taylor, 2013; Mell, Henneberry, Hehl-Lange & Keskin, 2013; Wang *et al.*, 2021). GPR is based on the principle of minimizing energy use and optimizing natural resource utilization in buildings (Ong, 2003; Ong, 2012). The GPR approach is based on two principles: maximizing building envelope efficiency, and optimizing the use of external natural resources in the building (Ong, Fryd, Hes, Ngo & Aye, 2017). To achieve these principles, GPR encourages the development of buildings with a certain minimum area and the inclusion of green spaces around the structure. These green spaces provide multiple benefits, including reducing surface runoff, moderating temperatures, reducing air pollution (carbon sequestration), providing additional recreational and aesthetic value (Nieuwenhuijsen, 2021). In addition to modifying the environment, the inclusion of green spaces in the environment (public or residences) constitutes a form of trade and a veritable source of economic boost (Umeora, et. al 2023). This is particularly beneficial in Jos, where about 73.8% of the acquired land is for residential purposes (Nimlyat, Gwatau & Ega, 2010).

GPR is a three-dimensional quantification of greenery on a site through the use of the LAI measure. It is the average LAI of the greenery on site, presented as a ratio that is similar to Floor Area Ratio (FAR). The GPR of a given plot is calculated using the equation below:

$$\text{GPR} = \frac{\text{Total leaf area } \{ \text{LAI}_1 \times \text{Canopy Area}_1 + \dots + \text{LAI}_n \times \text{Canopy Area}_n \}}{\text{Site area}} \quad (\text{Ong, 2012}).$$

GPR offers a value-driven conceptual framework to determine the amount of green coverage which ensures a balance of green area on the site as equilibrium is maintained. By so doing (measuring

GPR of the site), green leaf area are retained or even enhanced (Ong, 2003; Zheng, et al. 2024). Different plot sizes can be manipulated with plant species distributions of different LAIs to achieve the same GPR as in Figure 3. An LAI of 1, 3 and 6 are assigned to grasses, shrubs and trees respectively. This shows that the assignment of the LAI is of more importance than the planted area. Furthermore, the building envelope can be used as a means of planting: the façade (green walls and green façade) and the roof (roof garden) (Ong, et al. 2012; Citicene, 2021; Zheng, J., Li, & Zheng, B. 2024; Hien, Yok & Yu, 2007, in Munonye, et. al 2021).



**Figure 3: Distribution of plants according to GPR**  
*Source: Ong (2003)*

GPR integrates greenery in the building envelope. It uses the vertical (walls) and horizontal (roof gardens) as means of planting. It also utilizes the different levels of building to accommodate different means of planting (Ong, 2003; Citicene, 2021). Figure 4 is an example of a building integrated with green. The roof top, the façade (walls), turf and terraces were all used as means of planting.



**Figure 4: Building integrated green.**

Source: <https://archello.com/project/solaris> (Accessed June 17, 2021)

To account for the GPR of a building plot, an on-site observation will be conducted to collect the data related to plant distribution. Built-up area of the plot, the FAR of the building and green areas were measured and recorded (Ong, 2003). From the field survey, the number of trees, areas for shrubs, turfs, and other greenery within the site will be collated. During the site observation, tree planting distributions are observed and tree species identified. The assigned LAI value is determined based on the plants category. The LAI is obtained from a research conducted by Tan & Sia (2010) and represented in Table 2. The LAI value and canopy coverage for each plant is different based on the size of DBH. For shrubs and turf, the areas of the ground cover are measured.

**Table 2: LAI Value and Canopy Area of the Plant**

Sub category	LAI Value	Canopy area to use (m <sup>2</sup> ) according to the tree girth			
		G1 (<0.5m) DBH (<0.159)	G2 (0.5-1.0m) DBH (0.159-0.31m)	G3 (1.0-1.5m) DBH (0.31-0.47m)	G4 (>1.5m) DBH (>0.47m)
Trees					
Dense canopy	4.0	12	36	80	150
Intermediate canopy	3.0	12	26	80	150
Open canopy	2.5	12	26	80	150
Shrubs					
Monocot	3.5	Use planted area of ground cover			
Dicot	4.5	Use planted area of ground cover			
Turf	2.0	Use planted area of ground cover			

Source: Tan and Sia (2010)

After determining the sub-category of the plants and its assigned LAI with canopy area, computation of the total leaf area of trees on sites was done using equation one (Eq 1). For shrub and turf, planted area and assigned LAI value were used to get the leaf area using equation two (Eq 2). Subsequently, the GPR was calculated using equation three (Eq 3).

$$\text{Leaf Area (Tree)} = \text{Canopy Area} \times \text{LAI value} \times \text{No. of trees} \dots\dots\dots (\text{Eq 1})$$

$$\text{Leaf Area (Shrub, Turf)} = \text{Planted Area} \times \text{LAI value} \dots\dots\dots (\text{Eq 2})$$

$$\text{GPR} = \frac{\text{Total Leaf Area (Eq 11+Eq 12)}}{\text{Site Area}} \dots\dots\dots (\text{Eq 3})$$

Source: Ong (2003)

The Solaris Tower in Singapore is an example of the practical application of GPR. It is an office building located in the Fusionopolis hub of central Singapore's one-north business park. The site was originally a military base with most of the natural ecology destroyed. The building sits on a 7,734 metre square site and comprises of two tower blocks separated by a glass-roofed public plaza and connected with a passively ventilated atrium. An extensive spread of planted area allows rich biodiversity, with the building replacing the green footprint of the original site by about 108%, this shows that even after the construction of the building, more greenery was introduced than what was originally available before construction. Hence, the vegetative site was not replaced with hard surfaces in terms of roof and pavement, rather, the vegetation and biodiversity of the building site was improved upon. This is the GPR approach. Figure 5 is an aerial view of the tower.



**Figure 5: Aerial View of Solaris Tower**

Source: <https://archibaseplanet.com/blog/view/4192.html> (Accessed June 23, 2021)

The Tower has a total landscaped area of 8,363 metres square. It includes: Roof gardens; 2,987 metres square, Atrium planter boxes: 304 metres square, Green ramp: 4,115 metres square, Ground

level landscaping; 487 metres square and Green walls; 164 metres square. The percentage of total landscape area above ground level; 95%, Ratio of landscaping to ground floor area; 17% green, Ratio of landscaping to site area; 108%.

## **RESEARCH METHODOLOGY**

The research methodology used for this research was survey design with case study approach. Purposive sampling was used in this research to identify and select information-rich cases that are related to the required quantitative data. Two sets of quantitative data were collected; the other being the quantity of the vegetation types either in area for grasses and shrubs or in numbers for trees. These data were collated and multiplied with their respective LAIs and divided by the areas of the building plots to determine the GPR of each plot. The following different combinations of data gathering strategies were adopted for the above purposes:

- i. Quantitative physical survey of the case study building plots
- ii. Photographs of the case study plots
- iii. Quantitative calculation of GPR

## **Results and Discussion**

The case study approach was used for this research, and the quantitative research methodology was employed to quantify the vegetation types and quantities. Two (2) residential buildings were considered for the purpose of this research; a bungalow and a duplex. The study buildings and the findings are discussed in subsequent sections.

### *Case Study Building*

#### **Case Study 1: Bungalow**

This case study site houses a residential bungalow situated on a plot with an area of 1,350m<sup>2</sup> in Rantya, a medium density residential area in the greater Jos-Bukuru area. The expansion of Rantya birthed this site as it was predominantly grassland before 2019 as seen in Figure 6.



**Figure 6: Google Image of the Aerial View of Case Study 1 in 2017**

*Source: Google Map (2025)*

Since the site was completely covered by grasses or farmland, it is assigned an LAI value of 2.0 (Table 1), the GPR of this site in 2017 is calculated as:

$$\text{GPR} = \frac{\text{Total leaf area } \{ \text{LAI}_1 \times \text{Canopy Area}_1 + \dots + \text{LAI}_n \times \text{Canopy Area}_n \}}{\text{Site area}} \quad (\text{Ong, 2012}).$$
$$\text{GPR} = \frac{1350 \times 2}{1350} = 2.0$$

The natural vegetation of this site was altered to house the residential unit. The ground coverage of the building is approximately 22%. The building plot houses the main building, a block of an office/Guest wing, a dog pen and a gate house. Figure 7 is the Google image of the aerial view of this case study.



**Figure 7: Google Image of the Aerial View of Case Study 1**

*Source: Google Map (2024)*

This building site has a significant vegetative cover. The hard landscape (concrete interlocking tiles) is minimal and restricted to the driveway; which doubles as the walkway, and the car park (Figure 8). Buffalo grass is used as the turf of the green area as seen in Figure 9.



**Figure 8: Concrete Interlocking Tiles on Driveway**  
*Source: Fieldwork (2024)*



**Figure 9: Buffalo Grass on Green Area**  
*Source: Fieldwork (2024)*

There is a good variety of trees on this site as seen in Figure 10, some of which are: Masquerades, Tujars, Conifers, King's Palms, Whistling Pines, Eucharria and Travelling Palms. At the entrance porch (veranda), there is a variety of flowers in some pots as seen in Figure 11. The hedges and shrubs on this site include: Crown of thorns, Ixora, Army green and Yellow Bush. Further details are given in Tables 3 and 4.



**Figure 10: Variety of Trees in Green Area**  
*Source: Fieldwork (2024)*



**Figure 11: Potted Plants on Entrance Porch**  
*Source: Fieldwork (2024)*

**Table 3: Physical Characteristics of Case Study 1**

**Case study 1**

Location	Rantya, Jos North
Completed	2019
Percentage of built area	22%
FAR	0.22
Percentage of un built area	78%
Site (Plot) area	1,350m <sup>2</sup>
Total number of occupants	5
Total number of floors	1



**Source:** Author’s Research

**Table 4: Building Design Attributes and Green Integration of Case Study 1**

Plantation Description	Vertical Green wall	Green Façade	Building Design Attributes				
			Roof	Terrace	Mandatory Open Space	Veranda / balcony	Sun-shade
Number of trees,	60,	-	-	-	-	-	-
(Average GBH: m)	0.45m	-	-	-	-	-	-
Shrub Area (m <sup>2</sup> )	18m <sup>2</sup>	-	-	-	-	-	-
Turf Area (m <sup>2</sup> )	192m <sup>2</sup>	-	-	-	-	-	-

Source: Source: Fieldwork (2023)

**Case Study 2: Duplex**

The second case study building is a five-bedroom duplex situated on a plot with an area of 1,797.39m<sup>2</sup> in Dura, one of the new residential neighbourhoods in the Rayfield area, in the low-density residential area of the greater Jos-Bukuru area. This site was before now a farmland during the farming seasons and grassland when there are no farming activities. Figure 12 is the Google image of the virgin site before the construction of the residential building.



**Figure 12: Google Image of the Aerial View of Case Study 2 in 2018**

Source: Google Maps (2025)

Since the site was completely covered by grasses or farmland, it is assigned an LAI value of 2.0 (Table 1), the GPR of this site in 2018 is calculated as:

$$\text{GPR} = \frac{\text{Total leaf area } \{ \text{LAI}_1 \times \text{Canopy Area}_1 + \dots + \text{LAI}_n \times \text{Canopy Area}_n}{\text{Site area}}$$

Site area

(Ong, 2012).

$$\text{GPR} = \frac{1797.39 \times 2}{1797.39} = 2.0$$

The construction of the building altered this GPR by removing the existing vegetative surface to accommodate the building. The ground coverage of the residential building is approximately 9.83 %. Besides the main building, other structures on this building plot are: a covered car park, poultry and a fish pond, all of which are temporary structures. On this building plot is a designated farm area which houses the commercial fish pond, an orchard and some domestic farm animals. Figure 13 is the Google image of the aerial view of this case study.



**Figure 13: Google Image of the Aerial View of Case Study 2**

Source: Google Maps (2024)

The landscape is diverse; the hard landscape on bare earth and concrete interlocking tiles. While the driveway is finished with concrete interlocking tiles (Figure 14), the farm area which houses an Orchard, a Fish farm and some domestic animals has bare earth as its hard landscape as seen in Figure 15. A dog pen is also sited on the hard landscape.



**Figure 14: Interlocking Tiles on Driveway**  
*Source: Fieldwork (2024)*



**Figure 15: Bare Earth in Farm Area**  
*Source: Fieldwork (2024)*

There are two different grass types as lawn on this site: Buffalo and Turkish grasses. There is a wide variety of ornamental trees which include: Golden, King's and Queen's Palms. Other trees on this site are: Masquerades, Tujars, Conifers and Eucharria trees. Flowering plants were used as hedges (Figure 16), and decorative potted plants were placed on the entrance porch (veranda) as seen in Figure 17.



**Figure 16: Flowering Plants as Hedges**  
*Source: Fieldwork (2024)*



**Figure 17: Potted Plants on Veranda**  
*Source: Fieldwork (2024)*

A little presence of a green façade is seen in some parts of the perimeter wall, Passion Fruit is planted and groomed to grow over the fence at some point (though still tender) as seen in Figure

18, a creeping plant (periwinkle-common name) is also seen growing over the fence as in Figure 19. The fruit trees on this site include: Guava, Mangoes, Avocado Pear, Paw-Paw, Coconut, Orange and Lemon Trees. Further details for this case study are summarised in Tables 5 and 6.



**Figure 18: Growing Vertical Façade on Perimeter Wall**  
 Source: Fieldwork (2024)



**Plate 15: Passion Fruit Growing on Wall**  
 Source: Fieldwork (2024)

**Table 5: Physical Characteristics of Case Study 2**

**Case study 2**

Location	Dura, Rayfield Area, Jos South
Completed	2018
Percentage of built area FAR	9.83% 0.0983
Percentage of unbuilt area Site (Plot) area	90.17% 1,797.39m <sup>2</sup>
Total number of occupants	6
Total number of floors	2



Source: Fieldwork (2024)

**Table 6: Building Design Attributes and Green Integration of Case Study 2**

Plantation Description	Vertical Green wall	Green Façade	Building Design Attributes				
			Roof	Terrace	Mandatory Open Space	Veranda/balcony	Sun-shade
Number of trees, (Average GBH: m)	35, 0.41m	-	-	-	-	-	-
Shrub Area(m <sup>2</sup> )	80.6m <sup>2</sup>	-	-	-	-	-	-
Turf Area(m <sup>2</sup> )	197m <sup>2</sup>	-	-	-	-	-	-

Source: Fieldwork (2024)

Tables 7 and 8 show the computed GPR of case study 1 and 2 respectively. It reveals an improvement in the GPR of the building plots from 2.0 in both cases to 9.8 in case study 1 and 5.3 in case study 2. The LAI values used are from table 2.

**Table 7: GPR for Case Study 1**

<b>Case study 1</b>							
<b>GPR accounting for Trees</b>							
Species	Sub-category	LAI Value	Canopy Area(m <sup>2</sup> )			Quantity	Leaf Area (m <sup>2</sup> )
		A	B		C		
			<0.159	0.159-0.31	0.31-0.47	>0.47	
Trees	Dense canopy	4.0	12	36	80	150	
	Intermediate canopy	3.0	12	26	80	150	37
	Open canopy	2.5	12	26	80	150	15
Palms	Solitary	2.5	12	26	80	150	8
	Cluster	4.0	12	26	80	150	
Total						60	12,855.00
<b>GPR accounting for Shrubs</b>							
Species	Sub-category	LAI Value	Floor Details		Planted Area	Leaf Area	
		A			B	A×B	
Shrub	Dicot	4.5	Ground floor		15.9	71.55	
	Monocot	3.5			0	0	
	Dicot	4.5	Wall		0	0	
	Monocot	3.5			0	0	
	Dicot	4.5	Potted plants		2.1	9.45	
	Monocot	3.5					
Total					18.0	81.00	
<b>GPR accounting for Turfs</b>							
Species	Sub-category	LAI Value	Floor Details		Planted Area	Leaf Area	
		A			B	A×B	
Turf	Carpet grass	2.0	Ground floor		192.00	384.00	
			Roof		0	0	
Total					192.00	384.00	
Total Leaf Area (15,615.00+81.00+384.00)						13,320.00	
Site Area (m <sup>2</sup> )						1350.00	
<b>GPR = Total Leaf Area/Site Area</b>						<b>9.87</b>	

Source: Fieldwork (2024)

**Table 8: GPR for Case Study 2**

Case study 2								
GPR accounting for Trees								
Species	Sub-category	LAI Value	Canopy Area (m <sup>2</sup> )				Quantity	Leaf Area (m <sup>2</sup> )
		A	B					
			<0.159	0.159-0.31	0.31-0.47	>0.47		
Trees	Dense canopy	4.0	12	36	80	150		
	Intermediate canopy	3.0	12	26	80	150	20	4,800.00
	Open canopy	2.5	12	26	80	150	9	1,800.00
Palms	Solitary	2.5	12	26	80	150	6	2,250.00
	Cluster	4.0	12	26	80	150		
Total							35	8,850.00
GPR accounting for Shrubs								
Species	Sub-category	LAI Value	Floor Details			Planted Area	Leaf Area	
		A				B	A×B	
Shrub	Dicot	4.5	Ground floor			77.8	350.10	
	Monocot	3.5				0	0	
	Dicot	4.5	Wall			1.0	4.50	
	Monocot	3.5				0	0	
	Dicot	4.5	Potted plants			1.8	8.10	
	Monocot	3.5						
Total						80.6	362.70	
GPR accounting for Turfs								
Species	Sub-category	LAI Value	Floor Details			Planted Area	Leaf Area	
		A				B	A×B	
Turf	Carpet grass	2.0	Ground floor			197.00	394.00	
			Roof			0	0	
Total						197.00	394.00	
Total Leaf Area (10,200.00+362.70+394.00)							9,606.70	
Site Area (m <sup>2</sup> )							1797.39	
<b>GPR = Total Leaf Area/Site Area</b>							<b>5.34</b>	

Source: Fieldwork (2024)

With the inclusion of hard surfaces from the construction of the residential buildings in the form of pavements and roof, the greenery of both building plots were significantly reduced by the area

the buildings covered and the attendant hard surfaces for driveways, car parks and walk ways. However, GPR was used to compensate for this loss by reloading the sites with plant species of different LAI.

Ong, (2003) and Zheng, et al. (2024) opined that by green inclusion in buildings through the use of GPR, it is possible to reload (replace) building plots with a 'green value' across the vertical or horizontal surfaces. By so doing, the loss of greenery from its removal to accommodate buildings can be compensated for (Ong, 2003; Ong, et al. 2012; Zheng, et al. 2024). From the two plots considered, there has been an improvement in the GPR of the building plots from 2.0 in both cases to 9.8 in case study 1 and 5.3 in case study 2. This agrees with the assertion of Ong, (2002); Myneni, et al. (1997); and Wang *et al.*, (2021) that by measuring GPR of a given site, green leaf area can be retained or even enhanced. From the case studies, the building plots were all reloaded with different types of greenery and accounted for using GPR as illustrated in (Figure 1). Consequently, GPR has been used to compensate for losses of greenery on both case study plots. It is therefore imperative that GPR should be incorporated as a component in urban planning to create environmentally resilient and aesthetically pleasing living spaces.

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