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# Climate Positivity of Urban Public Parks – A Case of Thiruvananthapuram City

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***Abstract***— ***The need for urban public parks has become majorly significant with rapid increase in urbanization. The potential of green infrastructures in reducing the atmospheric carbon dioxide levels is widely known but very few studies address their climate positivity. Climate positivity addresses the ability of a project or activity to overpower its carbon emission levels. Setting of a park should involve careful selection of tree species and land cover. This study provides a case study of the climate positivity of a selected park in Thiruvananthapuram district in Kerala and aimed to discuss the influence of the design on climate positivity. The park is known as the lungs of the city and an attempt was made to estimate its efficiency. The carbon sequestration rate was calculated from field data inventory and climate positivity was assessed in Pathfinder 2.0. The outcome of the study is the optimization of climate positivity with different strategies. The findings can give informed decisions among people and a green practice in the design of landscapes.***

***Index Terms—carbon sequestration, climate positivity, landscape design, material impacts, urban public parks.***

## I. INTRODUCTION

In the present world, urban areas act as net sources of greenhouse gases and the trend of increase in urbanisation tends to feed further growth of GHG emissions. The enhanced drawdown of $CO_2$ from the atmosphere in quantities exceeding 1,000 Giga tonnes of $CO_2$ is critical for meeting the targets to control climate warming, even though the reduction of emissions of greenhouse gases (GHGs) needs to be the primary goal [1]. An increase of 0.18°C per decade is observed in the earth's temperature since 1981 while the rate of warming was 0.08°C per decade since 1880. Though $CO_2$ is not the most high-powered greenhouse gas, it is the huge contributor to climate change due to its abundance in the atmosphere. Significant measures to reduce as well as neutralise the current emissions are essential along with negative emission technologies. Open green spaces are an efficient and cost-effective means for achieving the balance. It not only adds to the psychological well-being of people but also enhances the overall well-being of people as well as the planet. In today's world, the need for such spaces has become increasingly important especially for combating climate change and global warming. The green patches are getting rare amidst the concrete jungles with the rapid growth of urbanisation. Nature based solutions and green built environment in cities not only improves the quality of urban life but also yield both environmental and social benefits. Urban vegetation and soil provide ecosystem services like improved storm water management and recreation for inhabitants along with being a potential carbon sinks and stores.

## II. LITERATURE STUDIES

### A. Carbon sequestration

Carbon sequestration can be defined as the process of capturing, securing and storing carbon dioxide from the atmosphere [2]. The reservoirs that retain carbon and keep it from entering the earth's atmosphere are known as carbon sinks. The different forms of carbon sequestration include:

- Biological carbon sequestration - It is the process in which carbon dioxide is stored in the biological components like soil, water, vegetation, etc.
- Geological carbon sequestration – It is the process by which carbon dioxide is stored in underground geologic formations or rocks.
- Technological carbon sequestration – This is an emerging type of carbon sequestration type in which carbon dioxide from the atmosphere is minimised using innovative technologies. The captured carbon can be used as resource.

#### *1) Plant carbon sequestration*

Plant carbon sequestration, a form of biological carbon sequestration, can be defined as the process by which plants take carbon out of the atmosphere through photosynthesis and process it and incorporate the carbon into above ground biomass (AGB) and below ground biomass (BGB) and facilitate the formation of organic matter and carbon storage in the soil through microbial activity which forms soil organic carbon.

#### *1.1) Estimating plant carbon sequestration*

The method to determine carbon sequestration can be destructive or non-destructive. This study involves non-destructive method where the biomass was calculated from diameter of the tree trunk and height, without damaging

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the trees. It uses allometric equations and landscape scale method. The field measurement data involved the following information: species, number of trees, tree height diameter at above the ground height (DBH) at a height of approximately 130cm above the ground. This information was used to calculate the carbon stock. Calculation of tree biomass using allometric equations is as follows [3]:

$$W = 0.0509 \times \rho \times DBH^2 \times h$$

where, W = the total biomass (kg)

DBH = diameter at above the ground (approximately 130 cm)

ρ = wood density (gr / $cm^3$)

h = height (m)

**Above ground carbon = W x 0.5**

### B. Climate positivity

Climate positivity addresses the ability of a project or activity to overpower its carbon emission levels through its sequestration capacity or minimal emissions. It can be defined as the net impact of a product on climate change mitigation. Currently reducing the emissions along with absorbing the existing carbon dioxide in the atmosphere is very important for climate change mitigation.

## III. OBJECTIVES AND METHODOLOGY

The objective of the study is to find the influence of design of parks on climate positivity. Kanakakunnu park of Thiruvananthapuram, also known as the lungs of the city, was chosen for the study. Carbon sequestration potential of the park was estimated through field data inventory using biomass equations and climate positivity was assessed in Pathfinder 2.0. The flow chart of the methodology is as follows (Figure 1):

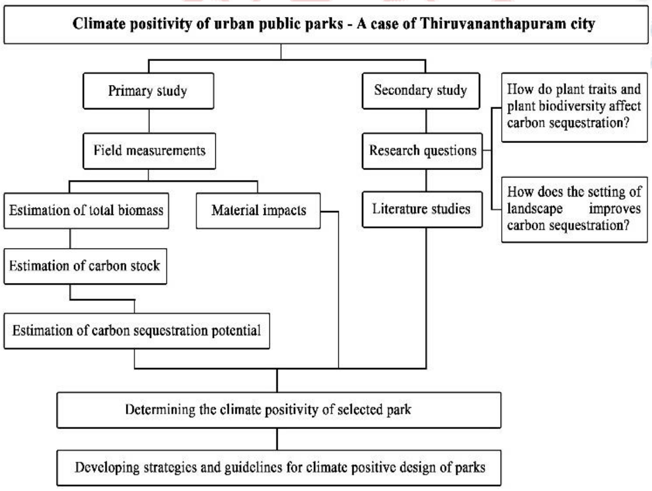


**Figure 1:** Methodology chart

### A. Location

The chosen area of study is in Thiruvananthapuram district, India. The site is located near Vellayambalam junction i.e., 8.5107°N, 76.9582°E. The park premises function as the green lungs of the city. The park consists of about 126 flora species. Most of the species are exotic. Some of the trees were imported from Central American region during the reign of Sri Moolam Thirunal Rama Varma. It also includes indigenous trees, herbs and shrubs. The place is most preferred by denizens for their evening and morning walks. The thick carpet of green grass spread under the tree shades continues to be a hangout spot for every generation.


**Figure 2:** Site plan (Credits: Vastushilpalaya Consultancy Pvt. Ltd.)

### B. Calculation of carbon sequestration

The total carbon sequestration by the trees and shrubs of the park was estimated to be 8,69,567.75 kg $CO_2$. The top ten species which contributed to higher carbon sequestration included *Ficus benghalensis* (34, 723 kg $CO_2$), *Ficus elastica* (26158 kg $CO_2$), *Ficus religiosa* (20179 kg $CO_2$), *Tabebuia rosea* (18780 kg $CO_2$), *Syzygium cumini* (16552 kg $CO_2$), *Peltophorum pterocarpum* (14096 kg $CO_2$), *Swietenia macrophylla* (11595 kg $CO_2$), *Albizia lebbeck* (10838 kg $CO_2$), *Citharexylum spinosum* (9549 kg $CO_2$), *Terminalia catappa* (9070 kg $CO_2$).

The top ten native species which contributed to higher carbon sequestration included *Ficus benghalensis* (34, 723 kg $CO_2$), *Syzygium cumini* (16552 kg $CO_2$), *Albizia lebbeck* (10838 kg $CO_2$), *Tectona grandis* (7795 kg $CO_2$), *Diospyros buxifolia* (7015 kg $CO_2$), *Carallia brachiata* (6071 kg $CO_2$), *Artocarpus hirsutus* (5451 kg $CO_2$), *Azadirachta indica* (5183 kg $CO_2$), *Mangifera indica* (4590 kg $CO_2$), *Artocarpus heterophyllus* (3756 kg $CO_2$).

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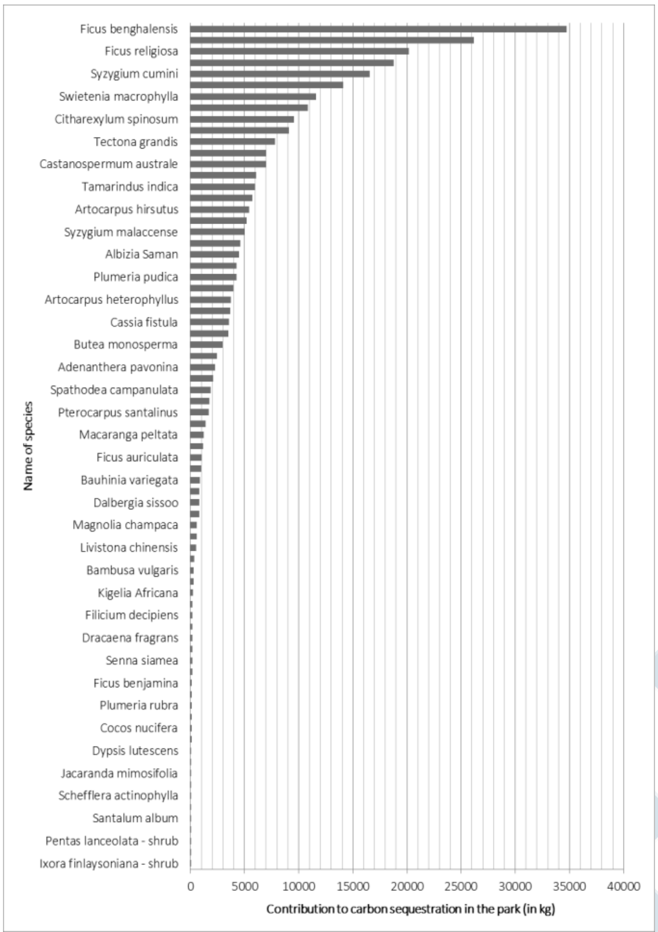


**Figure 3:** Carbon sequestration by different species

## C. Determining the Climate positivity of the park

The material impacts and the carbon sequestration potential of the park were assessed in the Pathfinder 2.0 application, and it is found that the project takes 28 years to be climate positive.

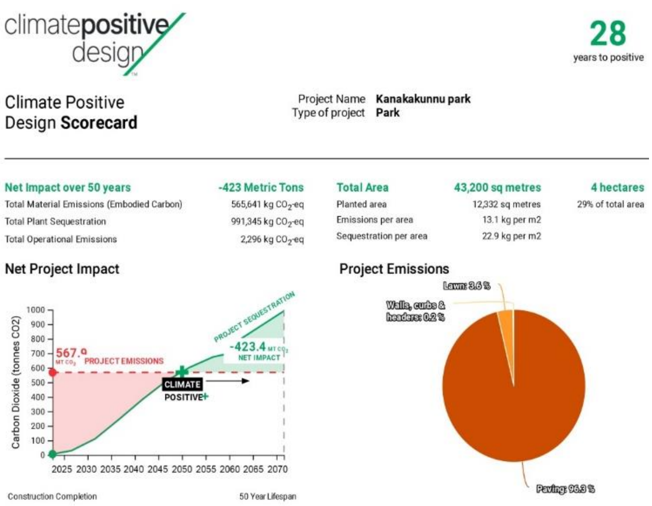


**Figure 4:** Climate positivity score card from Pathfinder 2.0 (a)

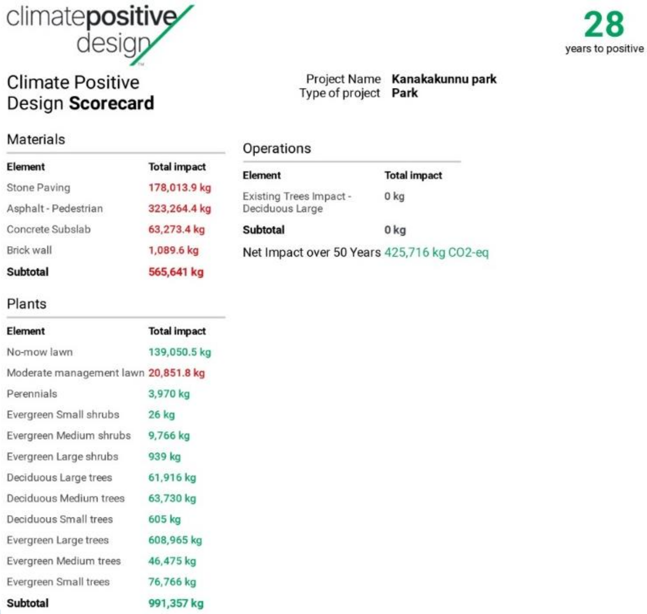


**Figure 5:** Climate positivity score card from Pathfinder 2.0 (b)

## D. Analysis

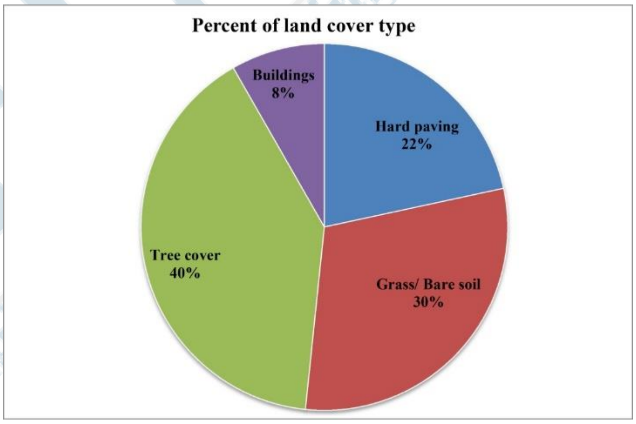


**Figure 6:** Percent of land cover types in the park

The land cover types in the park included asphalt paving, stone paving, Grass, Bare soil, Tree cover and buildings. The role of the parks as a source of carbon uptake gets limited due to the distribution of large grass and impervious areas.

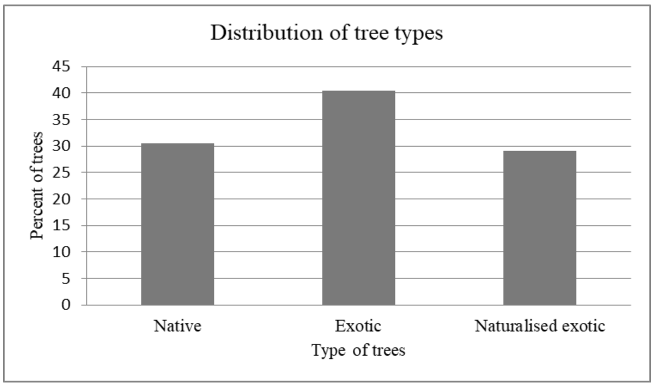


**Figure 7:** Distribution of tree types (Akhilesh, Gangaprasad, 2021)

Though biomass is the major parameter of carbon sequestration, planting trees requires consideration of the entire web of interactions that determines how these will affect the overall carbon balance. Dominance of exotic trees can alter the soil properties and affect the symbiotic fungi and can have long term consequences on the carbon storing capacity of soil [4].

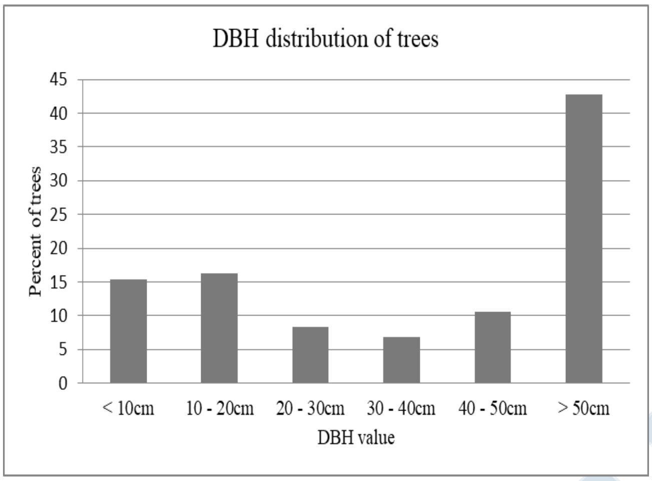


**Figure 8:** DBH distribution of trees

The park is dominant with trees of DBH greater than 50cm and it adds to the increased carbon sequestration due to its higher biomass. As the biomass increases with increase in the tree size, it corresponds with a progressively larger increase in the carbon storage potential of the tree.

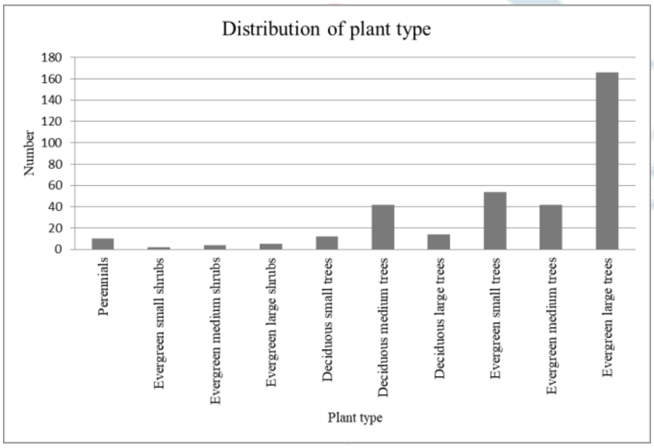


**Figure 9:** Distribution of plant types

The tree types of the park were categorized to Evergreen large trees, Evergreen medium trees, Evergreen small trees, Deciduous large trees, Deciduous medium trees, Deciduous small trees, Evergreen large shrubs, Evergreen medium shrubs, Evergreen small shrubs, Perennials. Carbon sequestration of each tree type was found. Figure 10 shows that the contribution of evergreen tree species towards carbon sequestration is greater when compared to other tree types.

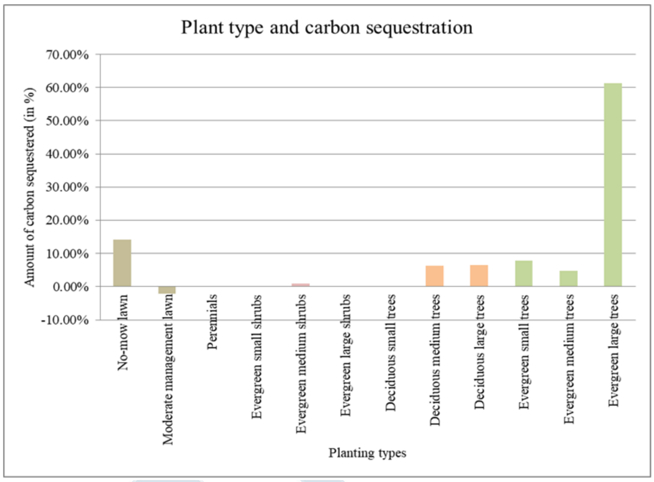


**Figure 10:** Plant type and carbon sequestration

In the case of turf grass, energy consumption due to the usage of mowers and other machines, irrigation, usage of pesticides and fertilizers could offset their carbon sequestration benefits as their maintenance requirement is more when compared to the other grass types seen in the park.

### E. Strategies

#### *1) Materials*

When the asphalt for road is replaced with stabilized crushed stone paving and stone paving is swapped with permeable pavers, the project can reduce carbon emissions by 3, 96, 186 kg $CO_2$.

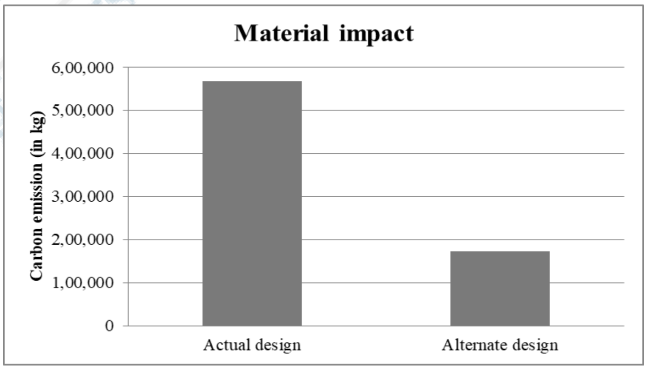


**Figure 11:** Material type and carbon sequestration

#### *2) Green cover*

- *Increased biomass*

The rate and amount of carbon that trees sequester depends on its size, height, wood density. Trees like *Santalum album, Filicium decipens, Diospyros buxifolia, Mesua thwaitesii, Syzygium caryophyllatum* have higher wood densities (greater than 0.72). Choosing plant species that are large sized, long lived, and fast growing helps to sequester more carbon. Longer lived species will store carbon in the biomass for a longer period of time. Preference can be given to species that require low maintenance (irrigation, pruning, mowing, etc.)

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- *Include more evergreen trees*

Evergreen trees produce high root biomass and appear superior to other plant types in terms of the carbon sequestration potential. It is due to the fact that these trees photosynthesize more months of the year than deciduous trees. However, diversification of trees is important to help support other ecosystem services. In a study conducted in China, it was found that the species diversity is associated with increased soil carbon sequestration, due to the increased productivity and below ground biomass [5]. Hence, evergreen trees can be mixed with other deciduous trees while planting to increase the efficiency.

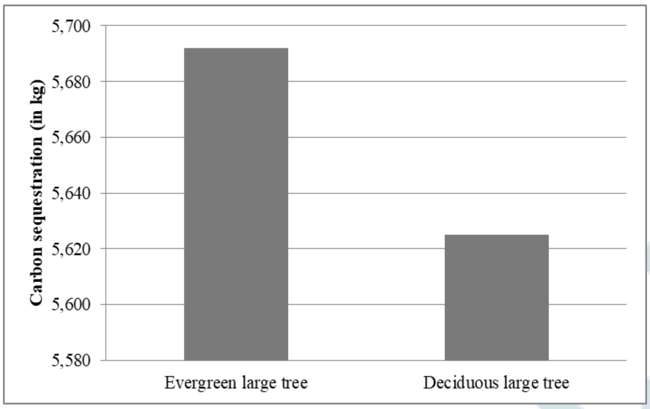


**Figure 12:** Average carbon sequestration rate (Pamela, 2020)

- *Enlargement of the area of tree planting by minimising the unnecessary grass and non-permeable areas*

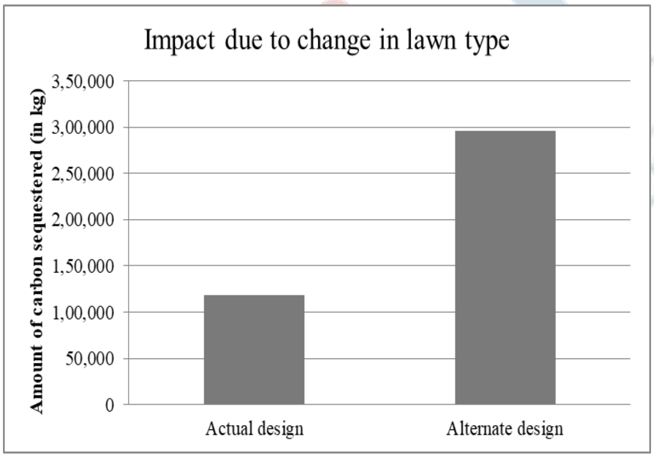


**Figure 13:** Impact on carbon sequestration due to change in lawn type

The project sequesters an additional carbon of 1, 77, 763 kg when 50% of the moderate management lawn (turf grass) is converted to no-management lawn (buffalo grass).

By adding 60% more trees in the lawn area, the park can sequester an additional carbon of 26, 70, 816 kg as shown in Figure 14. The tree planting density of the park then becomes 0.015 trees/m$^2$.

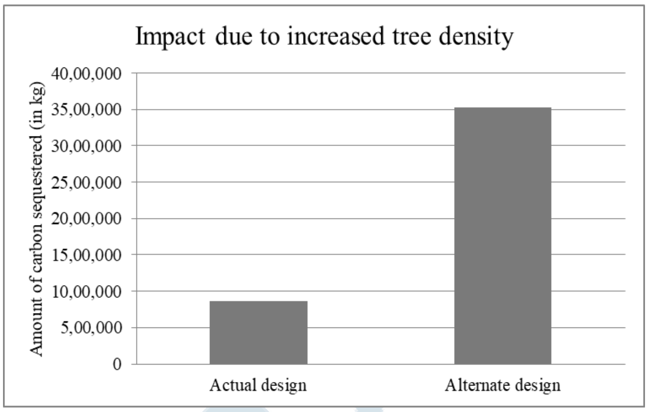


**Figure 14:** Impact on carbon sequestration due to increased tree density

In case of space constraints in a park, where number of trees cannot be increased, trees can be selected based on their tree type. In the studied park, evergreen small tree types are more after Evergreen large tree types. 40% of these were swapped with large evergreen and deciduous tree types to understand the increase in carbon sequestration. The result showed that in that case only 35% more trees are required to be planted to achieve the climate positivity in 5 years.

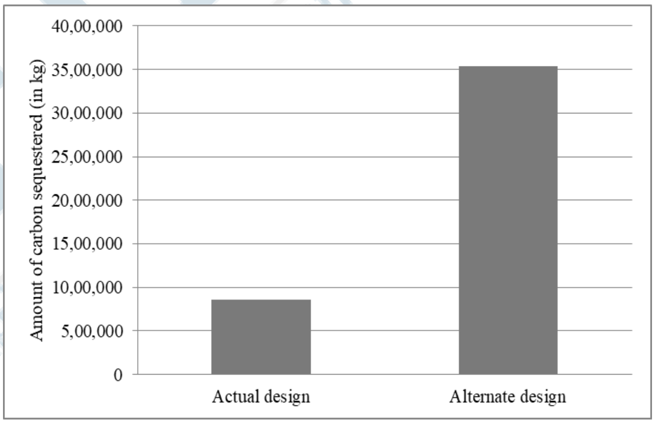


**Figure 15:** Change in carbon sequestration due to switching of tree types

- *Multi-layered planting clustered with large trees can increase the efficiency of carbon capture.*

Vertical layering means that incorporating a canopy layer, shrub layer, and ground layer in a woodland. It not only helps to achieve visual interest but also enhances carbon sequestration by increasing the functional diversity. It also helps to achieve pollinator habitat throughout the year. Planting trees at a range of different heights more efficiently can utilise the available sunlight to photosynthesize and space to grow.

### F. Results and discussion

The application of different strategies has reduced the overall emissions and increased the carbon sequestration capacity. The time taken for the park to be climate positive is reduced from 28 years to 5 years.

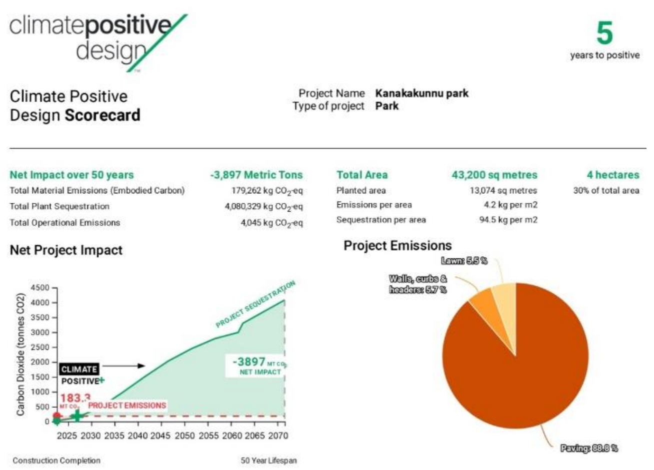


**Figure 16:** Climate positivity score card from Pathfinder 2.0 (a)

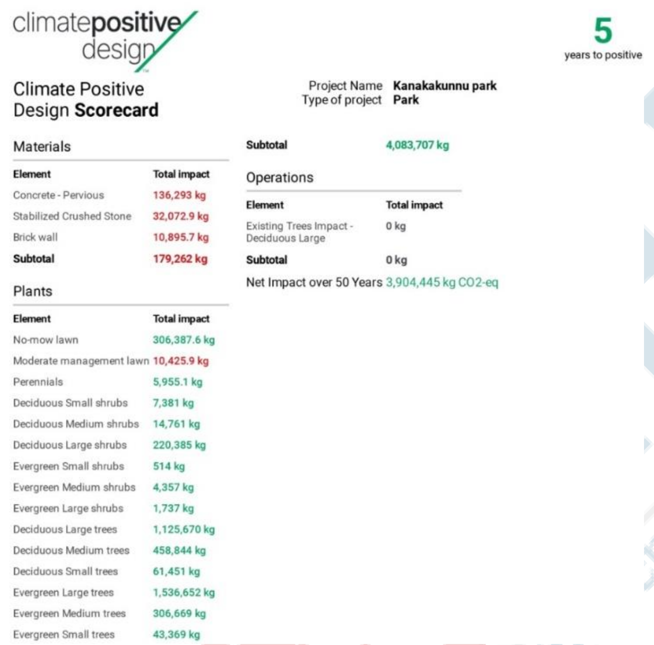


**Figure 17:** Climate positive score card from Pathfinder 2.0 (b)

## IV. CONCLUSION

Generally, the landscape that is often seen in public parks is a monoculture of lawn with scattered trees. The amount of tree cover may be similar to natural woodland but the functionality of each one is different. The landscape limits carbon storage because of the lack of diversity of species resulting in empty niches above and below ground. Additionally, the high maintenance of lawn mowing releases carbon emissions. Carefully planned designs and planting with proper implementation of strategic designs can reduce the overall negative impacts as well as minimize the time taken to achieve climate positivity. The applied strategies in the design have lessened this time from 28 years to 5 years. More parks need to be assessed in a similar way to ensure that the urban parks are well planned and utilized to ensure not only natural carbon sequestration but also in being an efficient green space for the neighborhood around.

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