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Sustainable Interiors for Mobile E-Fruit Kiosk in Delhi

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Abstract
This research focuses on developing a sustainable interior design for a mobile electric vehicle kiosk tailored specifically for fruit vendors in Delhi. The aim is to integrate locally sourced, natural, and environmentally friendly materials to address the challenges of Delhi's extreme temperatures and humidity. The design will prioritise extending the shelf life of fruits and vegetables by creating an interior environment that minimises spoilage. The study will evaluate various material options and design strategies, including the potential use of green roofs, to ensure optimal performance in preserving freshness and quality. In addition to enhancing product longevity, the design will incorporate energy-efficient systems and waste-reduction practices to support environmental sustainability. By combining innovative, green design with practical solutions, this research aims to advance sustainable practices in mobile food vending. The outcomes are expected to offer valuable insights for improving mobile fruit sales' efficiency and environmental impact, ultimately aiding vendors in delivering high-quality, fresh produce to urban consumers while contributing to broader sustainability goals.
Keywords: *Electric Vehicle, Environmentally Friendly, Kiosk, Green Roof, Sustainable Design*

1. Introduction
Delhi's vegetable vendors deal with a lot of difficulties when operating in harsh weather. In addition to making their task physically difficult, the extreme heat and humidity hasten the rotting of fruits and vegetables, which frequently results in financial losses. Vendors struggle to keep their products fresh throughout the day without proper storage facilities or safety precautions, which has a direct impact on their livelihoods. These difficulties draw attention to the critical need for creative solutions that take into account the practical and environmental problems that mobile fruit and vegetable vendors encounter. This research focuses on developing a sustainable interior design for a mobile electric vehicle (e-kiosk) specifically tailored for fruit vendors in Delhi. The design incorporates natural, eco-friendly, and locally available materials to create an interior space that prolongs the shelf life of fresh produce and minimises spoiling. The use of a green roof on the e-kiosk is one of the important design features being investigated. Green roofs are well renowned for their capacity to insulate, lessen heat absorption, and enhance air quality—all of which can be quite helpful in making the kiosk's inside feel cooler. To further assist environmental sustainability and waste-reduction initiatives, the research will assess several material possibilities and energy-efficient systems in addition to the usage of green roofs. Combining realistic solutions with green design principles will provide insightful information on how to improve the effectiveness and environmental impact of mobile fruit vending. The ultimate purpose of this research is to support food distribution industry sustainability goals while assisting vendors in providing fresh, high-quality produce to urban consumers.

2. Literature Review
2.1. Status of Street Fruit Vendors in Delhi
Street vending plays a crucial role in India, especially for individuals who move from rural areas to urban centers in search of better economic opportunities. Many of these vendors, driven by poverty and limited educational opportunities, contribute significantly to the urban informal sector. They offer a diverse range of goods and services, from fresh food to everyday necessities, adding vibrancy and accessibility to city life. The Indian Constitution's Article 19 (1) (g)

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upholds their right to engage in such occupations, ensuring they can work and support themselves despite various challenges. In Delhi, street vendors face significant difficulties due to the city's extreme weather conditions. During the intense summer heat, vendors contend with high temperatures that can be both physically exhausting and harmful to their health. Perishable items they sell, like fruits and snacks, are especially vulnerable to spoilage in such conditions. Conversely, the cold winter months present their own set of issues. Reduced foot traffic due to the cold means less business, impacting their daily income. Additionally, prolonged exposure to cold weather can lead to health problems such as respiratory infections. Despite these hurdles, street vendors exhibit remarkable resilience and adaptability. They often find innovative ways to protect themselves and their goods from the harsh weather, such as setting up temporary shelters or using portable heating and cooling devices. Their perseverance underscores their essential role in the urban economy and highlights their ability to overcome adversity while contributing to the city's dynamic landscape. [1]

2.2. Problems in Street Vending

Street vendors are often criticized for blocking pathways, causing traffic congestion, and sometimes contributing to unhygienic conditions. Despite these concerns, they play a crucial role in providing easy access to a wide range of products for city residents. Their presence helps meet the everyday needs of urban populations conveniently. However, vendors face numerous challenges, including regulatory hurdles and health issues, which complicate their efforts to sustain their businesses while serving the community. [5,9]

2.2.1. Wastage Loss of Perishable Items

Perishable fruits and vegetables need specific temperatures and humidity for longevity. Street vendors, working in open areas without proper storage, face accelerated spoilage. To combat this, they use temporary methods like spraying water and covering produce with wet cloths. However, inadequate infrastructure leads to significant product loss. (Refer Figure 1)

Figure 1 Illustration of a Fruit and Vegetable Vendor on the Street

2.2.2. Supply Chain Issue

Vendors acquire vegetables from wholesale markets early each morning. Lacking their transport, they hire vehicles to move the produce from the market to their selling locations. Often, these vehicles exceed their weight limits, causing damage and resulting in vegetable spoilage. Vendors bear these losses personally. Additionally, storing unsold vegetables poses a significant challenge due to limited storage space in their homes. [8]

2.2.3. Expulsion and Exploitation

Due to the absence of officially designated vending zones, street vendors often face eviction campaigns by authorities, leading to their displacement. During these drives, goods are frequently confiscated, resulting in heavy fines. To cover these costs or to restart their business, vendors often resort to high-interest loans from informal sources. To avoid further confiscation, many vendors fall prey to extortion, paying bribes to officials. This practice, though silently accepted, burdens vendors with additional monthly costs of ₹500-1,000 just to continue their work. [7]

2.2.4. Health and Safety Related Issues

Street vendors often lack adequate social protection and face challenging working conditions in open spaces. Their daily exposure to sun, dust, and noise can lead to significant health problems. With limited income and no financial buffer, taking a break from vending is not an option. Vendors work through these

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harsh conditions until they become too overwhelming to endure. (Refer Figure 2)

Figure 2 Illustration Depicting Health Hazards of the Produce Laid Out In the Open

2.2.5. Competition from Emerging Global Models

In today's digital age, numerous established companies now offer doorstep delivery services for products like fruits and vegetables through e-commerce platforms. This service provides the convenience of receiving items at a preferred time without the need to leave home for shopping. (Refer Figure 3)

Figure 3 Illustration of a Couple of Vendors Unable To Make Sales

2.2.6. Pandemic Hit

The survey from February 26 to March 25, 2021, reflected a period when the COVID situation was relatively stable. However, the surge in cases in April and May significantly changed the scenario for street vendors, leading to reduced attention to the PM SVANidhi scheme by local officials and the imposition of new localized lockdowns. Consequently, since the survey's conclusion, vendors have likely experienced severe disruptions to their livelihoods, heightened infection risks, and additional difficulties. [2]

3. Methodology

3.1. Enhancing Urban Sustainability and Climate Adaptation Using Green Roof

The construction industry is increasingly emphasizing sustainable practices, and green roofs have become a prominent solution, especially in urban environments. These roofs, which feature vegetation covering the building's roof, offer numerous environmental and economic benefits. They have gained traction in Europe and the U.S., where they are now common in both private and public buildings. Germany, a pioneer in green roof technology, has been incorporating them into buildings since the 1960s. Today, Germany adds approximately 13.5 million square meters of green roofs annually and has set a global example for their use. In cities like Stuttgart, Düsseldorf, Zurich, Tokyo, and Paris, green roofs cover extensive areas, demonstrating their effectiveness in urban greening. Despite these successes, the adoption of green roofs varies significantly across the globe. Wealthier nations lead in research and implementation while developing countries are slower to adopt these technologies. Recent studies highlight that green roofs can reduce heat gain, improve energy efficiency, and support urban biodiversity. In the context of Delhi's climate, characterized by extreme temperatures and high pollution levels, green roofs can offer substantial benefits. Delhi experiences intense heat during the summer months, with temperatures often exceeding 40°C. Green roofs can mitigate the urban heat island effect by providing insulation and reducing heat gain through water evaporation and plant shading. This can lead to cooler indoor temperatures, lower energy consumption for air conditioning, and improved overall comfort. [3] According to the monthly results, it was observed that the green-roofed huts reduced the indoor temperature by ~10 °C, compared to the control hut, while the

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maximum temperature difference was 12.1 °C and was never less than 4.2 °C. At the same time, when the three huts with green roofs were compared among themselves, it was determined that the hut with bush species lowered the indoor temperature more than the other huts with green roofs. As the plants grew, the green roof hut with the bushes that grew the most showed the greatest difference. (Refer Figure 4)

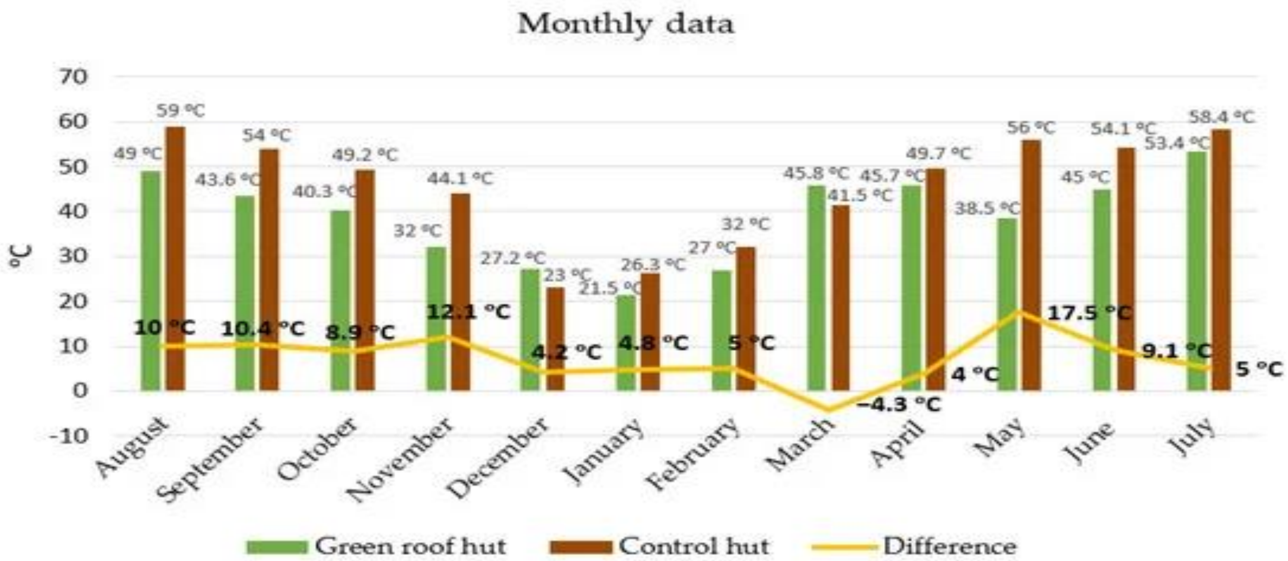

Figure 4 **Temperature Variation And Difference between the Green-Roofed [15]**

3.1.1. Green Roof Benefits and Research in Delhi

Green roofs in Delhi can contribute to better air quality by trapping dust and pollutants. They also support urban biodiversity by creating habitats for birds and insects. Research specific to Delhi could further explore how various green roof designs and vegetation types perform in such a hot, dry climate. This would help optimize green roof technology for Delhi, enhancing its role in sustainable urban development and climate adaptation.

3.2. Green Roof System for Hot and Humid Climates: Design and Components

In hot and humid climates, such as those found in tropical and subtropical regions, designing an effective green roof system requires careful consideration of high temperatures, high humidity, and heavy rainfall. An optimal green roof for such environments incorporates several key components to address these challenges. [14-17]

3.2.1. Plant Selection

Choose species that thrive in high temperatures and humidity, and are capable of handling occasional waterlogging. Recommended plants include tropical ground covers like Pilea and Fittonia, succulents such as Kalanchoe and Echeveria, native shrubs like Ixora and Hibiscus, and vines such as Passionflower and Bougainvillea, which provide both aesthetic appeal and resilience. In the context of Delhi's extreme climate—characterized by intense heat and high pollution—native plants like Pride of India (Lagerstroemia speciosa), Neem (Azadirachta indica), and Indian Jujube could be particularly beneficial. These species are well-suited to Delhi's hot, dry conditions and can help mitigate the urban heat island effect, reduce cooling costs, and improve air quality. Nevertheless, adapting native plants to Delhi's harsh environment requires careful selection and management to ensure successful integration and performance. [6]

3.2.2. Carrier Layer

use a substrate mix of lightweight aggregates like expanded clay pellets, coconut coir, and perlite to ensure good drainage and aeration while retaining adequate moisture. A depth of 100-200 mm is ideal to support root growth and moisture retention.

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3.2.3. Filter and Drainage Layer

This layer includes perforated drainage mats or gravel to effectively manage excess water and prevent waterlogging, complemented by a geotextile fabric to keep soil particles in place.

3.2.4. Protective Layer

The protective layer is essential to safeguard against mechanical damage and humid conditions; high-density polyethylene (HDPE) or similar materials can be used for this purpose.

3.2.5. Waterproof Membrane

Helps in preventing root penetration and protects the underlying roof structure. Proper waterproofing, using UV-resistant materials, is crucial to handle heavy rainfall and avoid leaks, while ensuring the roof structure can support the weight of the green roof, including substrate and plants.

3.2.6. Irrigation System

Drip irrigation or rainwater harvesting should be integrated to provide consistent moisture and optimize water use. Regular maintenance is also vital to monitor for water accumulation, ensure proper drainage, and address plant health issues. This comprehensive green roof system is designed to enhance building insulation, manage stormwater runoff, and improve urban biodiversity, addressing the specific needs of hot and humid climates. [3]

4. E-Vehicle as a Futuristic Approach

The automotive industry faces significant challenges related to energy inefficiency and environmental contamination. In recent years, electric vehicles (EVs) have garnered increasing attention as a promising solution to these issues due to their potential for zero emissions and energy efficiency. The mini electric vehicle, in particular, has gained popularity due to its compact size, energy efficiency, and affordability. Despite its advantages, the high cost remains a barrier to widespread adoption. A key component of electric vehicles is the motor drive and control system. Induction motors are commonly used in this field because they are relatively simple, cost-effective, and low maintenance. They also operate effectively across a broad range of power levels. For mini-electric vehicles, the motor drive system must provide high starting torque, a wide range of constant power operation, and efficiency across all speed ranges. However, these motors often face challenges due to the low supply voltage and high current, which can lead to increased heat generation and energy losses. [11] To address these issues, it is crucial to focus on reducing the losses and temperature rise in induction motors. The primary types of losses in these motors include copper loss in the stator and rotor windings, iron-core loss, mechanical loss, and stray loss. Copper loss is proportional to the resistance of the windings and the square of the current. This can be represented by the following equations:

\[P_{Cu1} = I^2 R_{Cu1} \]
\[P_{R2} = I^2 R_{R2} \]

Reducing copper loss can be achieved by increasing wire diameter, but this is limited by the slot filling factor. Mechanical loss is generally minor and often neglected in efficiency calculations. Iron loss, including eddy current and hysteresis losses, can be minimized by using laminated core materials. Rotor losses are influenced by rotor resistance, which is ideally minimized by using materials with lower resistivity. Enhancing the efficiency of induction motors for mini-electric vehicles involves reducing losses and managing heat generation. By choosing appropriate materials, such as copper for rotors, and optimizing motor design, it is possible to improve the performance and reliability of these vehicles, making them a more viable option for the future of clean transportation. [10]

4.1. Evaluating Motor Types for Electric Vehicles

Currently, most electric vehicles (EVs) with power ratings of 4 kW or less typically use DC motors. However, for higher-power EVs, specifically those over 5 kW, induction motors have become a popular choice due to their robustness and efficiency. These motors often employ vector drives to manage torque and acceleration effectively. In contrast, low-power EVs frequently use Brushless DC (BLDC) motors. Batteries play a crucial role in EVs as the primary energy storage component. Recent advancements have significantly improved battery technology, with

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lithium-ion batteries now being widely adopted in the latest generation of EVs. Different types of motors offer various advantages, making it essential to evaluate them based on specific criteria to choose the most suitable one for a particular EV. Key attributes of electric motors in vehicles include ease of design, high efficiency, low maintenance costs, and precise control. Commonly used motors in the EV industry include DC motors, induction motors, synchronous motors, switched reluctance motors, and permanent magnet brushless motors. Each type of motor has its unique characteristics, influencing their suitability for different EV applications. [4]

4.2. The Environmental Benefits of Electric Vehicles

4.2.1. EVs: Reducing Emissions

Electric vehicles (EVs) play a crucial role in reducing greenhouse gas emissions when compared to traditional combustion engine vehicles. By utilising electricity instead of fossil fuels, EVs cut down the carbon footprint associated with transportation. This reduction in emissions is a vital step in combating climate change, as it helps lower overall greenhouse gas levels in the atmosphere. As the adoption of EVs increases, their positive impact on the environment becomes more pronounced, contributing significantly to efforts aimed at mitigating global warming and promoting cleaner, more sustainable transportation solutions.

4.2.2. Advancing Eco-Friendly Transportation

Promoting electric vehicles (EVs) supports the goal of sustainable transportation by decreasing reliance on fossil fuels and cutting emissions. This shift helps create a more eco-friendly future by reducing the environmental impact of travel. By embracing EV technology, we move towards a transportation system that prioritizes sustainability and lowers our carbon footprint, contributing to long-term ecological balance and cleaner energy use.

4.2.3. Government Incentives Boost EV Adoption

Governments worldwide are encouraging the adoption of electric vehicles (EVs) by offering incentives and implementing supportive policies. These measures aim to make EVs more affordable and accessible to the public. By reducing costs and providing benefits to consumers, these initiatives help accelerate the shift toward electric transportation. As more people embrace EVs, the transition to cleaner, sustainable mobility is further accelerated, driving progress towards a greener future.

4.2.4. Enhancing Energy Stability through Reduced Oil Dependence

Electric vehicles (EVs) enhance energy stability by reducing reliance on oil, which is vital as oil supplies become more unpredictable. By shifting away from fossil fuels, EVs help diversify energy sources and lessen the impact of fluctuating oil availability. This transition supports a more stable and resilient energy landscape, crucial for maintaining energy security in an era of growing uncertainty about oil resources.

4.2.5. Investing in Charging Infrastructure for a Greener Delhi

Developing a strong charging infrastructure for electric vehicles (EVs) presents a significant investment opportunity, particularly for enhancing Delhi's environment. By investing in this infrastructure, we can improve service quality and convenience for EV users, making electric mobility more accessible and practical. This development not only supports the growing demand for EVs but also contributes to cleaner air and a more sustainable urban environment in Delhi, aligning with broader goals of reducing pollution and promoting green energy solutions. [2]

4.2.6. E-Fruit Kiosk for Vendors In Delhi

These kiosks, powered by EV technology, offer a sustainable solution for fruit vendors by minimising the carbon footprint associated with traditional vending methods. By using clean energy sources and reducing reliance on fossil fuels, these electric kiosks help lower air pollution in Delhi. Additionally, they provide vendors with a modern, efficient platform that improves operational convenience and aligns with the city's goals for a greener environment. This initiative represents a practical step towards integrating eco-friendly practices into everyday commerce while supporting the broader vision of a smart, sustainable Delhi. [12, 13] (Refer Figure 5).

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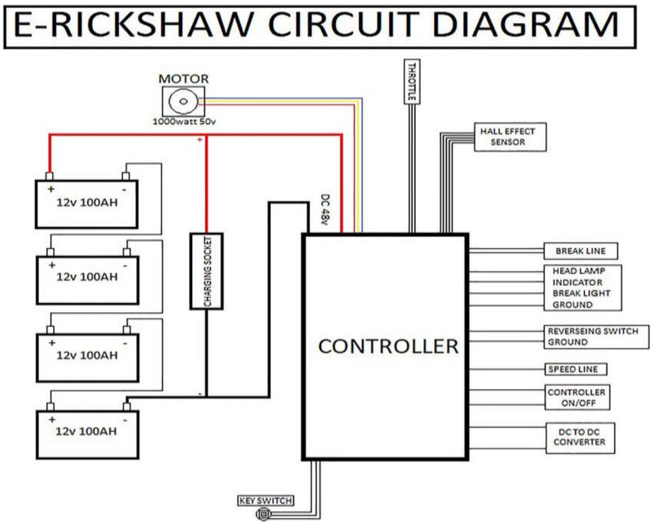

Figure 5 Block Diagram of E-Rickshaw Working [13]

5. Design Result And Discussion

5.1. Design Result

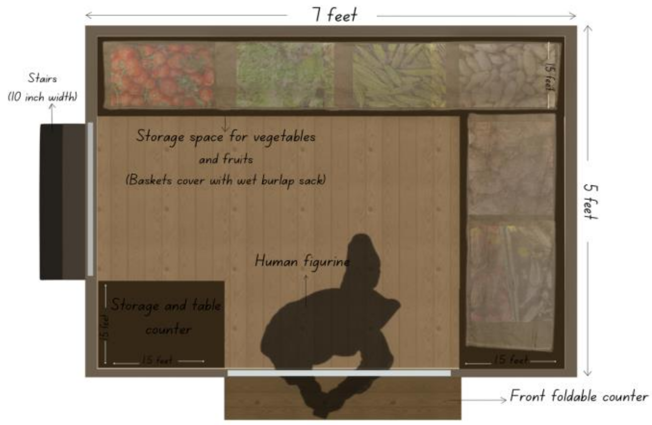

Figure 6 The Interior Layout of the Kiosk (Top View)

Figure 7 Exploded View of the Kiosk (Front View)

Figure 8 Integration of Green Roof

6. Discussion

The design strategy entails integrating a bamboo kiosk with electric vehicle technology for improved mobility. The design additionally incorporates a green roof, which helps to regulate the indoor environment, promotes sustainability, and promotes the kiosk's overall efficiency. The kiosk employs sustainable materials and natural ventilation techniques to preserve the freshness of produce, ensuring it remains intact even in Delhi's intense heat.

6.1. Ultimate Outcome and Layout

The basic proposal calls for the creation of a bamboo kiosk with dimensions of 7 feet by 5 feet and a height of 8.5 feet. The interior layout features a 2 feet by 7 feet door on the left side for entry. Inside the kiosk, storage racks extend 1.5 feet from the right corner and along the right-hand wall, allowing for plenty of produce room. These racks are covered with wet burlap sacks, which are strategically used to maintain a cool interior environment. The sacks' excellent water-retaining properties help regulate the temperature, ensuring that the produce remains fresh despite external heat conditions. The front of the kiosk is designed to optimise customer interaction, featuring 3 feet by 4 feet window and a foldable front counter, which facilitates easy access for customers making purchases. The front of the kiosk is equipped with a control cabin that houses the essential operational components. The cabin includes an electric motor that powers the kiosk, enabling it to move between locations efficiently. A handle is integrated into the design to provide precise directional control, while the inclusion of a drum brake system ensures reliable and conventional braking capability. This combination of features reflects a versatile approach to both functionality and sustainability, making the kiosk an effective solution for mobile vending while preserving the quality of the produce and minimising environmental impact. (Refer Figure 6, 7)

6.1.1. Experimentation

In the initial design phases, a concept was developed to construct a kiosk utilising a series of bamboo baskets covered with wet burlap sacks. This approach aimed to maintain produce freshness by regulating temperature. To enhance mobility, the design integrated an electric bicycle attached to the stack of baskets. Additionally, the incorporation of a green roof was explored to further align with sustainable practices. However, upon further evaluation, it became evident that the proposed design was inadequate in addressing key concerns related to storage efficiency, mobility, and weight distribution. Consequently, the design had to be revised to better meet the functional requirements of the kiosk, ensuring improved performance in all aspects.

6.2. Integration of EV Technology and Green Roof

The integration of electric vehicle (EV) technology into the design of a bamboo kiosk offers an innovative, environmentally friendly solution for vegetable vendors in Delhi. This portable kiosk, powered by a compact electric motor, allows vendors to move effortlessly across the city without contributing to air pollution or greenhouse gas emissions. To enhance the cooling effect, the kiosk incorporates green roof technology. The green roof, composed of plant-based materials, absorbs sunlight, provides natural insulation, and maintains a cooler internal temperature. It also contributes to reducing the urban heat island effect, promoting a healthier microclimate. Together, these design elements create a mobile, eco-friendly kiosk that not only supports the livelihood of vendors but also helps preserve the quality of their produce, all while minimising environmental impact. (Refer Figure 8)

6.3. Bamboo as Green Building Material

Bamboo is increasingly recognized as a sustainable building material due to its rapid growth cycle of three to five years, making it a highly renewable resource. Its exceptional strength-to-weight ratio, with tensile strengths ranging from 150 to 500 MPa, and high compressive strength of 40 to 80 MPa, make it suitable for diverse structural applications. Bamboo's natural flexibility, biodegradability, and low embodied energy contribute to a reduced carbon footprint. Additionally, its carbon sequestration capabilities and potential for local sourcing enhance its appeal in green building practices. While untreated bamboo offers moderate durability against pests and decay, its lifespan is significantly extended with

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preservative treatments. Its versatility extends to laminated boards, fibers, and composites, benefiting various industries. [Ayesha Syeda, December 2014]

Conclusion

In conclusion, this research introduces a sustainable electric vehicle kiosk for mobile fruit vending in Delhi, addressing challenges like spoilage and environmental impact. By integrating eco-friendly materials, energy-efficient systems, and green roofs, the kiosk extends produce shelf life and reduces waste, offering practical solutions for vendors in extreme weather conditions. This project not only enhances the quality of urban fruit sales but also advances broader environmental goals, setting a new benchmark for sustainable and resilient mobile vending practices. This kiosk exemplifies advanced design by integrating electric vehicle (EV) technology and bamboo materials, thereby optimising its quality, functionality, and sustainability. Measuring 5 feet by 7 feet AND 8.5 feet in height, the kiosk provides substantial storage and operational space, surpassing traditional carts, and ensures improved accessibility for both customers and vendors by incorporating a foldable front counter, fostering enhanced interaction and increased sales potential. The usage of electric motors optimises mobility while diminishing carbon emissions, translating to enhanced overall environmental quality. Furthermore, the kiosk's design elevates its aesthetic appeal, creating a more engaging and appealing environment for users.

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