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A Low Embodied Energy Approach for Early Design Decisions in Agritourism Centers in Pune

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Abstract

Agritourism is an idea that empowers and trains the rural family, organization, or individual to generate alternative sources of income by transforming their traditional agricultural land into a tourist attraction. Agritourism is the practice of attracting visitors to an area used primarily for agricultural purposes. It could be described as – rural/agricultural environments + farm commodities + tourism services = agritourism. It gives visitors an experience to stay in a countryside setting and experience firsthand the production processes of their own food! Agritourism settings are established in a village, in close proximity to farmers, making it easy for them to manage the activities. However, being away from cities puts challenges for maintenance in terms of resource utilization as well. This is where energy efficiency becomes urgent. In Maharashtra, there has been a significant increase in agritourism initiatives that attract city residents looking to reestablish a connection with the environment and help boost rural economies. Nonetheless, obstacles like remote areas, scarce resource control, and infrastructure deficiencies highlight the importance of implementing sustainable, energy-efficient strategies in agritourism projects to guarantee the lasting success of nearby populations. The concept of agritourism should focus on minimized energy during planning, construction and operation ensuring its financial viability for farmers. But 60% to 80% of energy consumed by a building is the energy required to manufacture the building materials. High initial embodied energy building materials showcase extensive energy for extraction, manufacturing, processing, and transportation leading to higher carbon emission, whereas, materials with lower initial embodied energy, not only exhibit reduced energy consumption during its manufacturing stages, but often demonstrate superior thermal performance, resulting in reduced operational costs and environmental impact as well. So, to address this challenge, a holistic approach is required that takes into account the life cycle of building material from its manufacture to disposal, also considering its source, nature, recyclability, and environmental impact. The study follows a literature-based approach to put forward the design strategies for the agritourism center concerning building materials within the scope of architecture, in the context of a site situated in Gohe Bk. village, Pune district, Maharashtra and supports Maharashtra's agritourism policies, which promote the use of energy efficient and low carbon footprint building material in agritourism infrastructure development.

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INTRODUCTION

"Agri tourism is the practice of attracting visitors to an area used primarily for agricultural purposes. It could be described as – Rural/Agricultural Environments + Farm Commodities + Tourism Services = Agri tourism" [1].

In the past, agricultural communities formed the backbone of the international economy. In India, more than 80% of the population was directly or

indirectly dependent on this sector for livelihood, contributing 26% of the gross domestic product (GDP) [2]. Similarly, this close connection between land and human, formed the core of many agrarian societies in Europe showcasing values of self-sustenance. Traditionally, farmlands were seen as places of production. However, as many rural farmers faced challenges, considering the increasing migration from rural to urban settings, farmers were left with lack of human and material resources, bound to look for alternative sources of income. On the other hand, urbanization has led to growing desire for village life among city dwellers, as they have become increasingly disconnected from traditional rural life. This longing can be witnessed in the growing urban trend of owning farmhouses to reconnect with nature and countryside.

In the late 19th and early 20th century, countries like Italy, Switzerland, France, Europe began practicing agritourism, allowing urbanites to visit farms in rural settings as part of a recreational experience. It offered fresh product markets, field visits, harvest, etc. with accommodation facilities in the form of guesthouses, farmhouses, cottages, dorms, and inns. This led to a more mechanized and structured shift in the practice of agritourism, offering a variety of services such as bed-and-breakfast, cultural, art, and craft exhibitions, etc.

In India, agritourism was founded by Pandurang Taware from Baramati, Maharashtra, who later came to be known as the father of agritourism. He launched the Agritourism and Development Corporation (ATDC) with the aim of providing an alternative income source for farmers, making them less reliant on farming alone. It offers training programs which focus on management skills like how to host tourists, manage accommodations, market products, provide tour guidance, food services, promote sustainable innovative agriculture and make public relations. The idea emerged to be beneficial in a multifaceted way by bridging the gap between urban and rural communities, boost in rural tourism economy, improvement in transport infrastructure, promotion of organic food, sustainable agricultural practices, respect for village life, local art and culture. As a result of ATDC, Maharashtra saw tremendous increase in the number of agritourism centers between 2005 and 2016 with more than hundred setups by the end of the year making it a leading state in the field.

Current Scenario

But the harsh reality of farmer hardship persists in Maharashtra, despite the existence of multiple agritourism establishments and government programs meant to boost rural economies. With over nine farmers dying every day, Maharashtra had an alarming 3228 farmer suicides in 2015—the highest number since 2001. This figure highlights the gravity of the state's agricultural community's predicament and is comparable to the terrible death toll from international terrorism, particularly the 3477 persons murdered by the Taliban in 2014. In 2014 also, the states of Maharashtra, Chhattisgarh, Karnataka, Madhya Pradesh, and Telangana contributed to 89% of farmer suicide cases in the country where Maharashtra contributed the highest number of 2570 suicide cases. The fundamental problems of poor income, restricted access to resources, and the constant strains of farming in a fragile environment have not been adequately addressed by programs to promote agritourism as a possible remedy.

Dr. Jayashree Upadhye's research uncovered that a major obstacle in the growth of agritourism in Maharashtra is the insufficiency of infrastructure, poor transportation and restricted resource availability. In rural Maharashtra, characteristics like inadequate per capita income, limited land ownership, and limited access to education hinder innovation and dissuade farmers from pursuing new agritourism enterprises. Many farmers stick to traditional cropping patterns because they are hesitant to embrace entrepreneurial methods due to the potential risks and uncertainties involved. The absence of a professional mindset and the financial limitations experienced by farmers with low incomes worsen the obstacle, hindering them from fully tapping into the benefits of agritourism. As a result, the architectural setting does not facilitate the creation of appealing and easily accessible agritourism areas, which could promote economic advancement and community involvement in rural regions [3].

Problem Formulation

The agricultural industry in Maharashtra requires a push. This can be done by combining it with the thriving tourism sector of Maharashtra. In this manner, the agricultural industry can experience a notable increase. By utilizing their expertise in agriculture, they can benefit from tourism by offering unique experiences to city tourists, resulting in both economic aid and a break from their everyday routine.

METHODOLOGY

The study follows a literature-based approach to put forward the design strategies for the agritourism center concerning building materials within the scope of architecture, in the context of a site situated in Gohe Bk. village, Pune district, Maharashtra.

Agritourism Checklist

To set up such a center in India, there are guidelines and checklists that should be followed, although they vary from state to state. Figure 1 illustrates the states with agritourism initiatives/policies/schemes in the country. While some states like Maharashtra, Karnataka, and Rajasthan have well-drafted policies, others have yet to formalize this approach. Maharashtra is the pioneering state to propose the state agritourism policy.

Land Requirement

- *Maharashtra*: As the pioneering state to formulate the agritourism policy, Maharashtra mandates minimum land availability of 1 acre and 5 acres in case of educational value added to the center. This land to be at least 1 km away from a city to be able to offer genuine rural experience. The infrastructure to be developed in an ecofriendly and vernacular manner.
- *Rajasthan*: According to the Rajasthan Rural Tourism Scheme, a minimum 0.5 acre of land is required out of which 90% of it should be dedicated to agricultural purposes. It emphasizes on traditional Rajasthani architecture to promote rural tourism.
- *Karnataka*: Specific land criteria for establishing agritourism businesses are outlined in the "Agritourism Policy" (part of the 2015 Tourism Policy). A minimum of 5 acres of land must be owned by a farmer or a farmer-producer organization in order to establish an agritourism destination. Two zones must be established on the property: one for agricultural or cultivation uses and the other for agritourism-related activities.

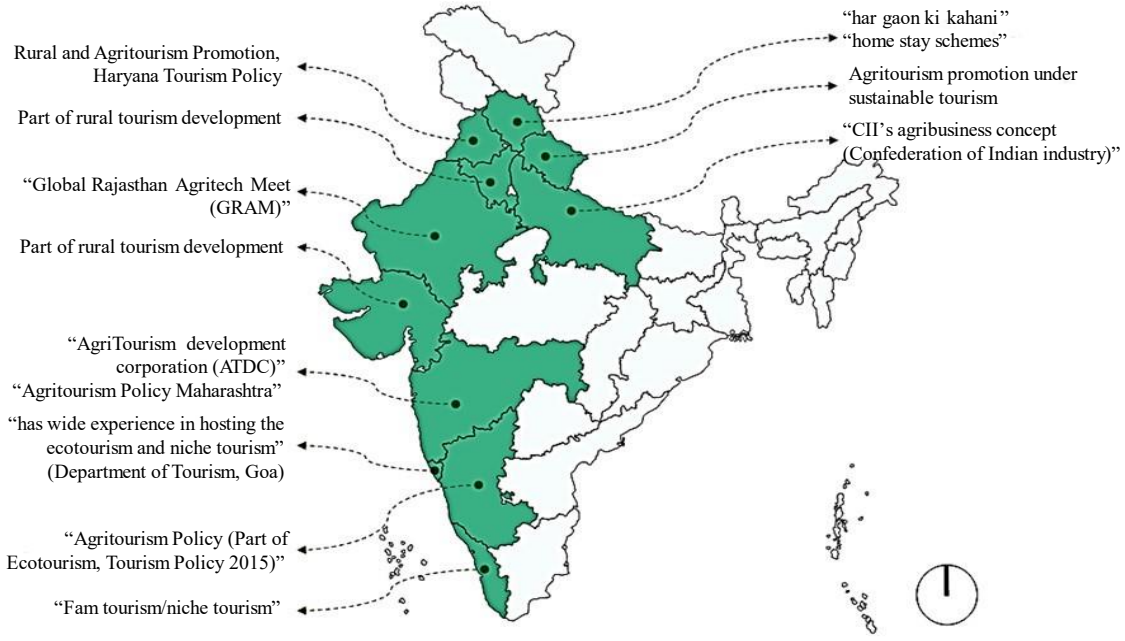

Figure 1. States with agritourism initiatives/policies/schemes in India.

User Groups

The segregation can be done by grouping various types of visitors and workers of the facility. The Figure 2 illustrates the segregation of these various user groups to cover every aspect of the facility before designing, during pre-planning.

Infrastructure Guidelines

This section outlines the types of structures permitted in agritourism establishments and the criteria they must meet. In accordance with the Agritourism Policy of Maharashtra, permitted structures include cottages, agricultural camping tents, guesthouses, dormitories for students and researchers, all made with eco-friendly and locally sourced materials. Figure 3 shows various types of accommodations that can be offered to the users: the visitors and farmers of the facility. The Agritourism Policy of Maharashtra also highlights traditional or vernacular designs that display the cultural legacy of the state. It also requires essentials for attaining self-sufficiency in water, waste management, and energy generation. Other areas which could be included are the kitchen, first aid room, fire safety room, and vehicle parking.

In the Rajasthan Rural Tourism Scheme, guestrooms and farmers' houses must be provided for accommodation, along with ancillary spaces like parking areas spanning between 1000 square meters and 1 hectare. With a camping space size between 1000 square meters and 1 hectare, 10% of the area can be allocated for tents.

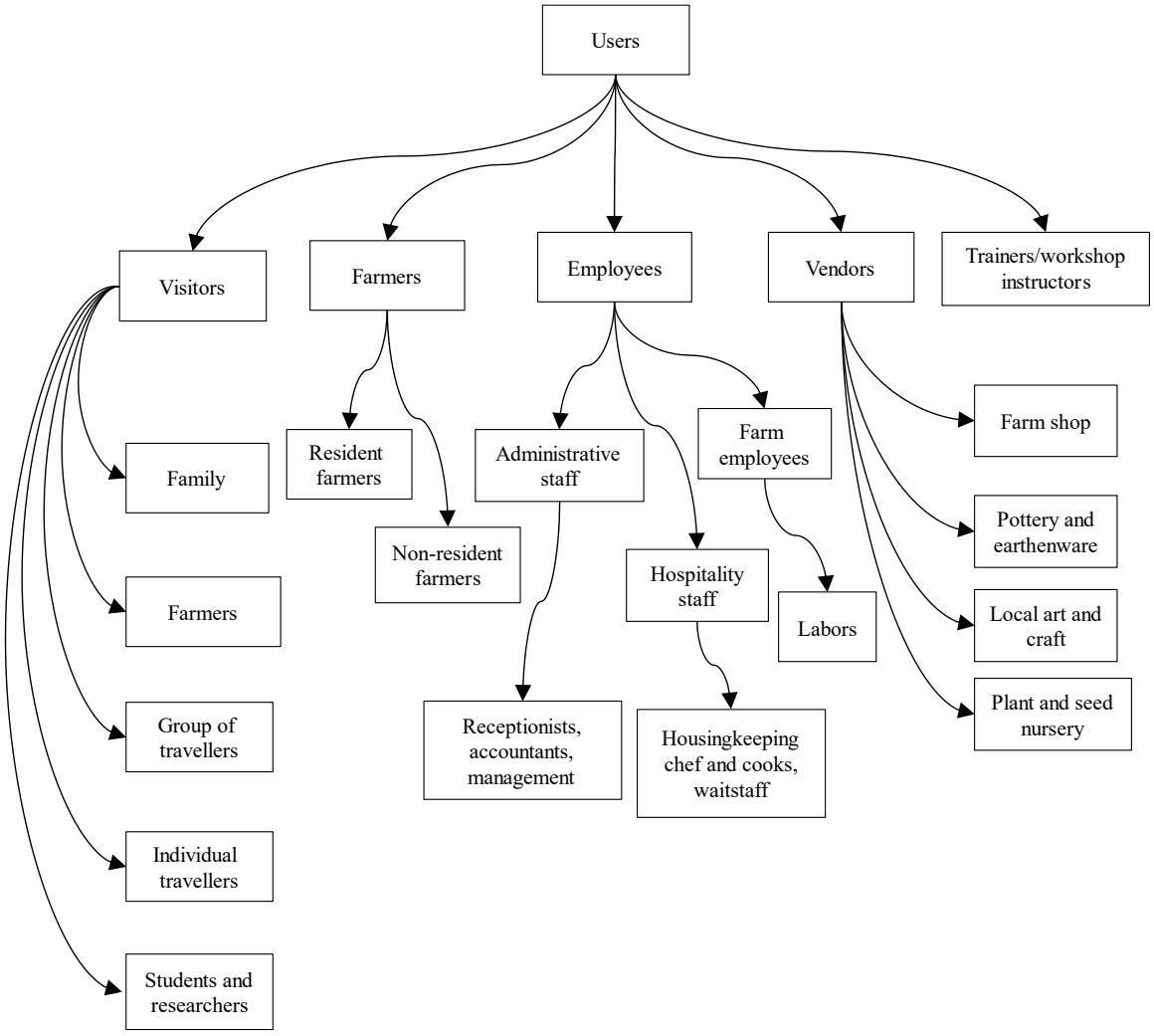

Figure 2. User group segregation.

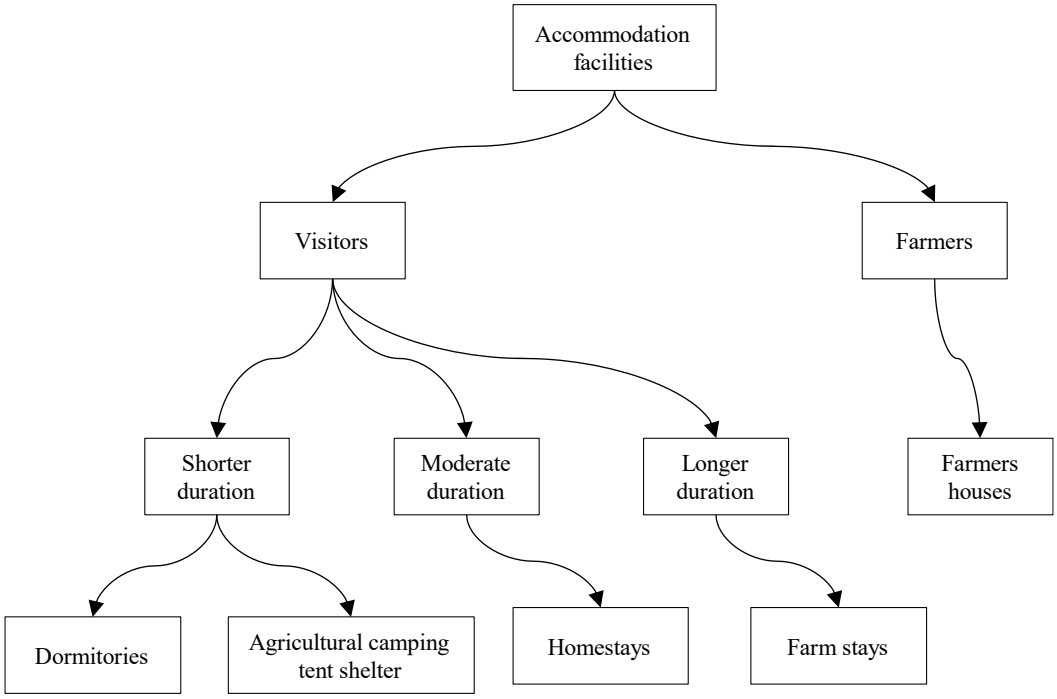

Figure 3. Accommodation types.

Activities Offerings

As per the agritourism guidelines in Maharashtra, agritourism centers are required to offer activities like farmers' markets for selling fresh produce, as well as dining options. These centers may provide other activities such as bullock cart rides, horseback riding, and horse-drawn carts, as well as traditional rural games, including *vithidandu*, *hututu*, *langadi*, and *jhoka*. Shows like *powada*, *gondhal*, and *jagaran* can improve the guest experience at a venue, while areas like open-air theaters can be suggested for participatory events. Moreover, participating in organic farming and harvesting activities can enhance the overall agritourism experience.

A successful agritourism instance called the Farm of Happiness or Anandache chet is the 20-acre organic farm stay in Phungus village, Ratnagiri district. Situated 15 kilometers away from the closest local facilities, the farm offers a peaceful retreat within Ratnagiri's farming community. The homestay includes a Konkani house with traditional design, featuring clay floors and wooden structures that enhance the cultural experience for guests. This farm provides a range of options like tours, hikes, stargazing, bird watching, and wellness activities like yoga and detoxing. Figures 4 and 5 (Farm of Happiness, n.d.) [4] show the insights of the Konkani styles bedroom and trekking activities offered as part of the package.

Figure 4. Konkani Style of bedroom.

Figure 5. Anandache chet insights.

BUILDING MATERIALS AND ENERGY EFFICIENCY

A building's energy usage can be categorized into three key phases: before construction, during operation, and after construction. Approximately 60% to 80% of a building's total energy consumption over its lifespan is associated with production and transportation of building materials [5]. Architects play a distinct role in reducing preconstruction energy through mindful selection of building materials during project planning and initiation, despite the management of operational energy with efficient planning and technologies like automation systems.

Embodied Energy

The total embodied energy of a building can be determined by adding up the embodied energy of all materials utilized. Embodied energy (EE) includes the total non-renewable energy used throughout the entire life cycle of materials, starting from extraction and processing all the way to manufacturing, construction, utilization, disposal, and recycling [6].

TE = ∑(EE of Material 1 + EE of Material 2+ … +EE of Material n)

Initial Embodied Energy

Initial embodied energy (IEE) is used up while materials are extracted, processed, transported, and during the construction phase [6]. Architects can reduce energy demands by making significant decisions in the early design phases with a focus on IEE.

IEE = E extraction/processing + E construction + E transportation

The energy efficiency and environmental impact of particular building materials are impacted by the factors shown in Figure 6.

- *Locally sourced:* Decreases energy used for transportation and boosts the economy in the area. Materials sourced locally for the site at Gohe Bk. village, Pune, would result in reduced transportation expenses and emissions.
- *Minimally processed:* Materials such as natural stone or wood that go through minimal industrial processing usually have a smaller energy footprint than highly processed materials.
- *Renewable source:* Sustainable choices like bamboo or wood from well-managed forests are renewable materials that have the potential for reduced embodied energy.
- *Biodegradability*: Organic materials like adobe or clay, which decompose naturally, lessen the energy footprint during disposal and provide an environmentally friendly lifespan.
- *Durability*: Durable materials such as stone or fired brick lessen the necessity for replacements, leading to reduced future energy costs.
- *Reusability/ recyclability:* Materials that can be reused or recycled, like steel or reclaimed wood, aid in waste reduction and lower energy needed for making new materials.
- *Thermally efficient*: Materials like adobe or insulated concrete can lower operational energy needs by naturally maintaining indoor temperature.

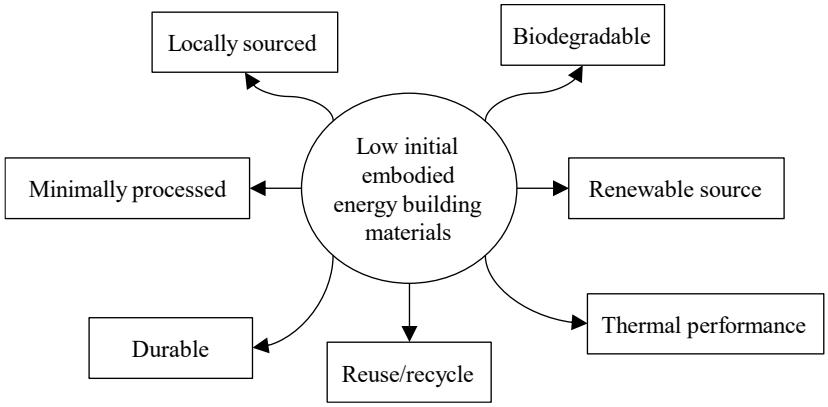

Figure 6. Material properties.

These criteria are used to choose appropriate building materials for the agritourism center near Khadakwasla Lake, which covers 12.2 acres. By focusing on materials that are found nearby, have good thermal properties, and are minimally processed, the structure can minimize its initial embodied energy. This approach conforms with sustainable practices and helps reduce environmental impacts right from the start.

SITE AND CLIMATE

The location of the site is in Gohe bk. Village located in the Haveli taluka of Pune district, adjacent to the Khadakwasla Lake reservoir. It comprises a combined area of 12.2 acres, serving as farmland for multiple crops as shown in Figure 7. The primary road's width is 9 meters. As per the Unified Development Control and Promotion Regulations for Maharashtra state, agricultural tourism projects must have a minimum road width of 9 meters for connectivity. The branch road measures 5.6 meters across.

Agro-climatic Zones

The subdivision of Maharashtra into nine agroclimatic zones, each with distinct topographical and environmental features as is illustrated in Figure 8, is essential for making energy informed choices in sustainable construction. The climate, soil makeup, rainfall, and humidity of these zones differ greatly, all of which have a significant impact on how materials perform and last over time.

The site falls in Maharashtra's Zone 4 in Pune district, where materials must endure moderate rainfall of up to 2500 mm annually, high humidity, and temperatures of 28°C to 35°C. The nitrogen-rich soil in this zone may affect foundation design and external wall treatments, especially in agricultural settings involving frequent interaction with the soil. Selected materials should be resistant to moisture to avoid weathering or deterioration, efficient in terms of heat to cope with temperature changes, and easily accessible in the local area to cut down on transportation expenses and energy consumption.

The distinct qualities of Zone 4 enable a favorable living environment throughout the year, accommodating a variety of traditional and natural materials that can combine durability with reduced embodied energy. Architects can reduce long-term maintenance and environmental costs by selecting materials that align with agro-climatic data, ensuring structures blend into the local environment.

Figure 7. Site location.

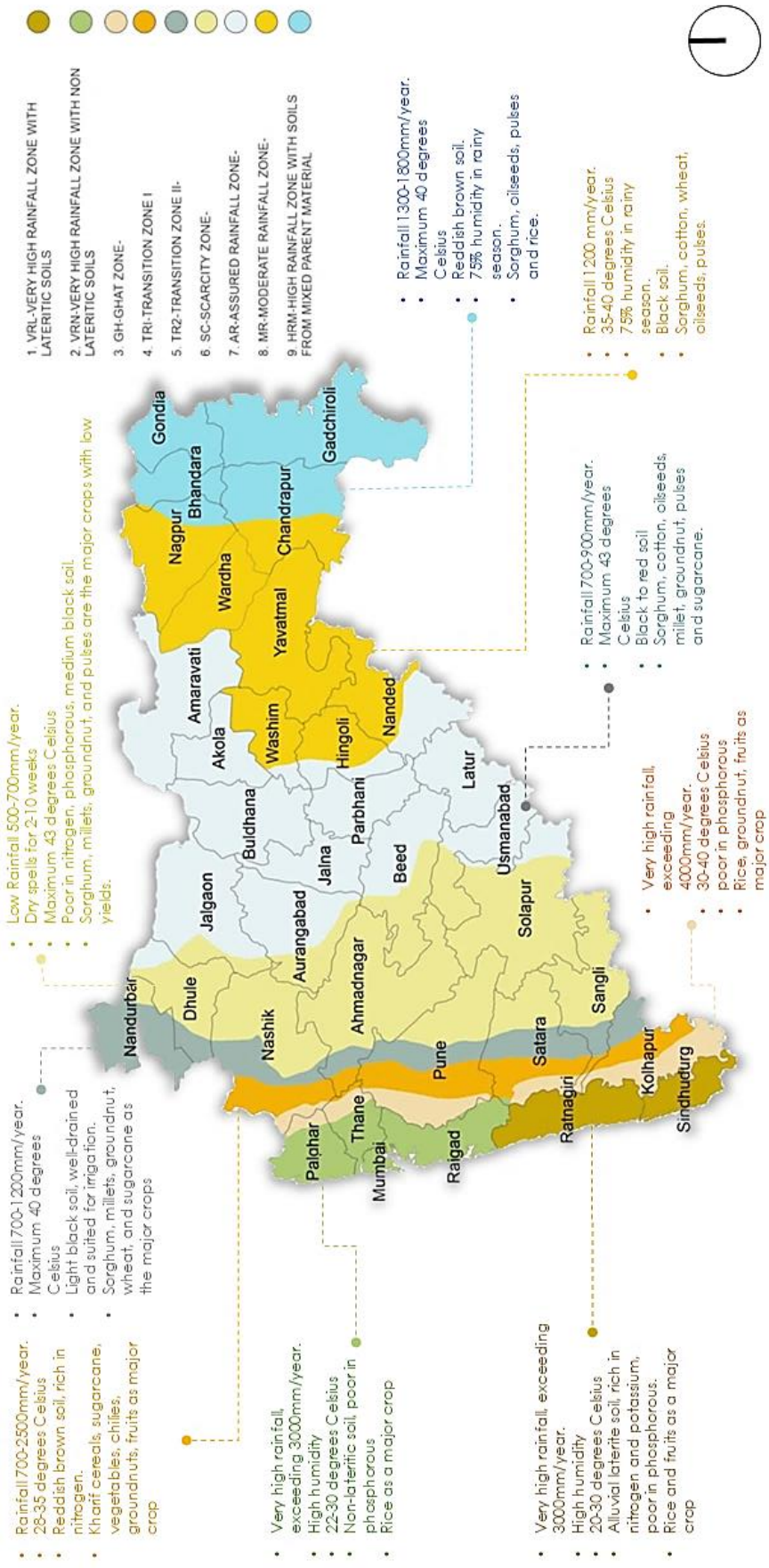

Figure 8. Agro-climatic zones of Maharashtra.

Temperature

As illustrated in Figures 9 [7] and 10 [8], the temperatures soar to 38°C in April and May with maximum sunshine in May, resulting in a hotter month.

Rainfall

As illustrated in the rainfall map in Figure 11 [9], the site is marked in the rainfall zone of 1200 mm. In an area with 1200 mm of rainfall, where rainfall is moderate, different crops can be grown efficiently. Important crops consist of essential items like rice, sugarcane, and maize, as well as vegetables like tomatoes, eggplants, and okra. Growing fruits such as mangoes, guavas, bananas, pomegranates, and papayas is also possible and successful in this environment. Furthermore, chickpeas and lentils, along with millets such as jowar and bajra, are suitable for the area. Floriculture, including roses, can also be done because of the moderate rainfall and yearly changes in humidity.

In Figure 12 [10] it is illustrated that on average, the yearly humidity reaches about 47%, with a high of 79% in August and a low of approximately 21% in March. In addition, plants such as basil and lemongrass, as well as forage crops, can thrive in this climate.

Soil

Figure 13 illustrates the soil map of Haveli district and type on the site marked, that is well drained, loamy soil. The balanced composition and excellent support for crop growth in well-drained loamy soil

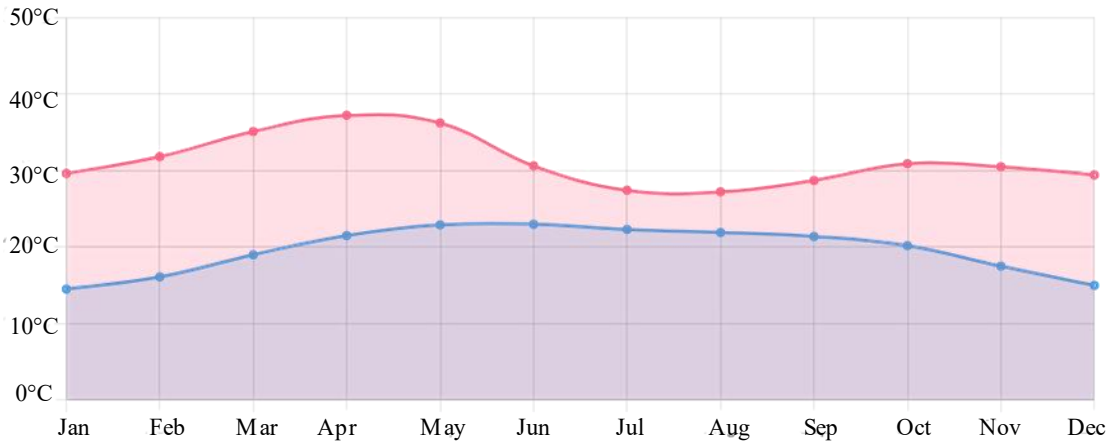

Figure 9. Month-wise day and night temperature.

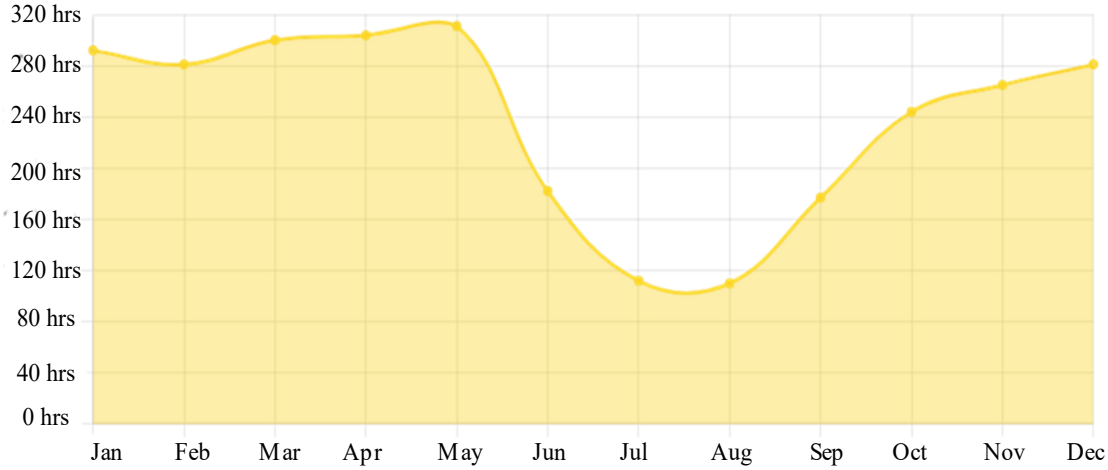

Figure 10. Month-wise hours of sunlight receiving.

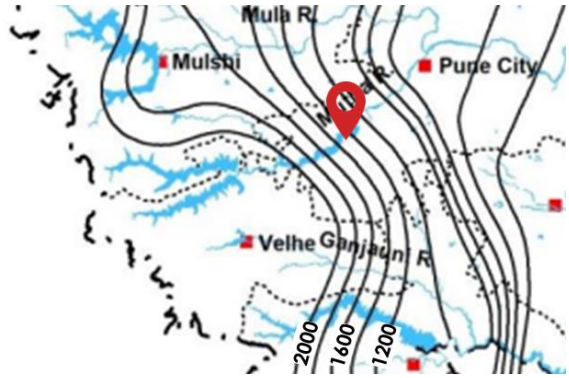

Figure 11. Rainfall zone near site.

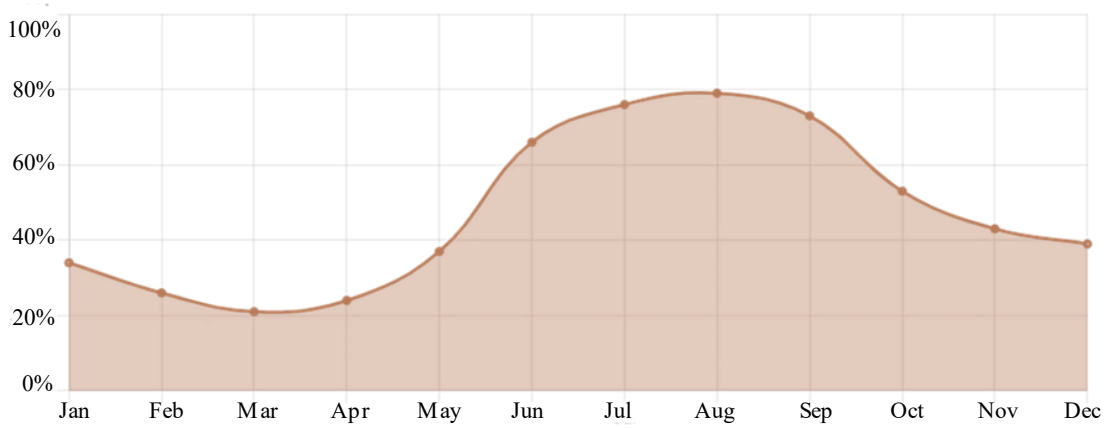

Figure 12. Rainfall data of Pune district.

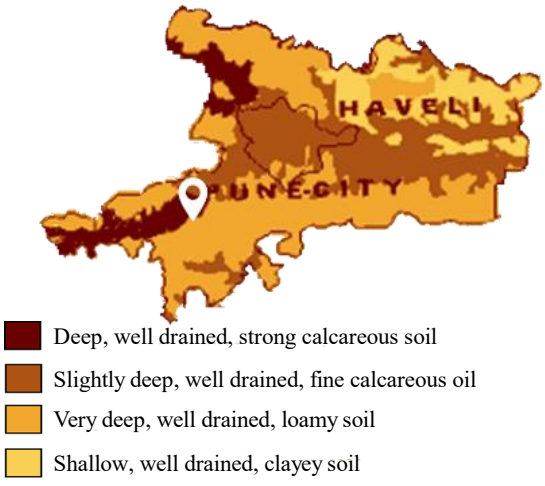

Figure 13. Soil type map.

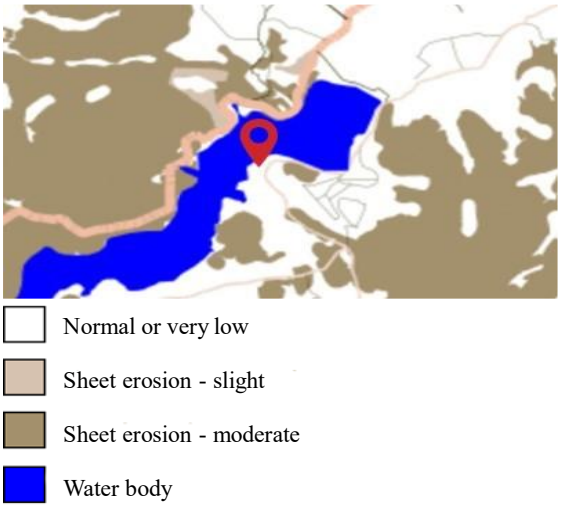

Figure 14. Soil erosion map.

make it an ideal environment for agriculture due to its deepness. The combination of sand, silt, and clay in its composition offers necessary nutrients and retains water, supporting the growth of crops with deep roots. The excellent drainage of this soil prevents water buildup, decreasing the chances of root rot, and ensures a steady supply of oxygen to plant roots, promoting strong root growth and nutrient absorption.

The fertile characteristics of loamy soil make it ideal for agriculture, as it holds onto crucial minerals necessary for plant development while also facilitating drainage to prevent nutrient overload. Its ability

to retain moisture while also providing good drainage allows it to accommodate various crops, supporting both surface and deep-rooting varieties. The durability and stability of loamy soil provide a stable base for long-term, efficient farming that can sustain various crops without requiring extensive soil improvements.

The stability of the site is maintained by its minimal soil erosion as illustrated in Figure 14 in the erosion map, preventing land degradation and promoting long-term environmental sustainability. This stability decreases the frequency of maintenance required, enabling steady plant growth and lessening the chance of soil erosion and nutrient depletion, critical for a robust agritourism operation.

POTENTIAL BUILDING MATERIALS

Basalt stone, found in abundance in the Western Ghats near Pune, is perfect for a variety of structural and aesthetic uses like load-bearing walls, flooring, and foundations [11]. Famous for its toughness and resilience, basalt is a durable material that needs little processing, making it ideal for eco-friendly construction. Although basalt is a nonrenewable and nonbiodegradable material, its ability to be reused extends its lifespan in construction projects, where it can be repurposed for various purposes like paving and wall cladding. Moreover, the thermal characteristics of basalt assist in controlling indoor temperatures, enhancing energy efficiency in constructed spaces.

Bamboo is another great option for a variety of building uses, such as structural components, walls, roofing, and interior embellishments. Widely available in various areas of Maharashtra and Karnataka, bamboo is a sustainable material that has a remarkable ability to sequester carbon in the long term. Being biodegradable makes it ideal for sustainable design goals and it requires minimal industrial processing. Bamboo has the ability to be reused or recycled, which helps to prolong its life cycle in construction projects. Although it has only moderate durability, it can be made highly resistant to termites through treatment, thus greatly extending its lifespan. Furthermore, bamboo's ability to insulate heat helps to regulate indoor temperatures, promoting energy efficiency in constructed spaces.

Another material is laterite bricks which are appropriate for both partition walls and structural elements, and can be easily found in Maharashtra, particularly in the districts of Ratnagiri, Raigad, and Thane [11]. A sustainable, compostable substance, it needs limited manufacturing steps and is frequently utilized without being fired. It is very resilient and resistant to weather, particularly in humid regions, while also offering excellent insulation.

Adobe mud bricks, made from abundant soil found locally, are well-suited for constructing walls and small structures in Pune. This eco-friendly, sustainable material needs little processing, mainly through labor-intensive techniques [12]. Adobe gains moderate durability when stabilizers such as straw or lime are added. It has the ability to be returned to the earth for recycling while also providing great insulation, making it a sustainable option.

Using natural lime mortar is an environmentally friendly option for plastering, bonding masonry, and performing restoration projects. Widely found in Maharashtra, it is eco-friendly and needs little processing. Its ability to be recycled and its strong resilience make it a sustainable option that continues to strengthen as it absorbs CO_2 from the atmosphere. Despite not being renewable, natural lime mortar has great insulation abilities and can effectively control moisture, making it ideal for a variety of construction purposes [13].

Terracotta tiles, commonly made by local manufacturers in Pune and nearby regions, are flexible materials ideal for roofing, flooring, and wall cladding. They are able to decompose naturally and have minimal processing needs, making them environmentally friendly. Moreover, terracotta tiles can be reused and are long-lasting, retaining their strength when well-maintained [14].

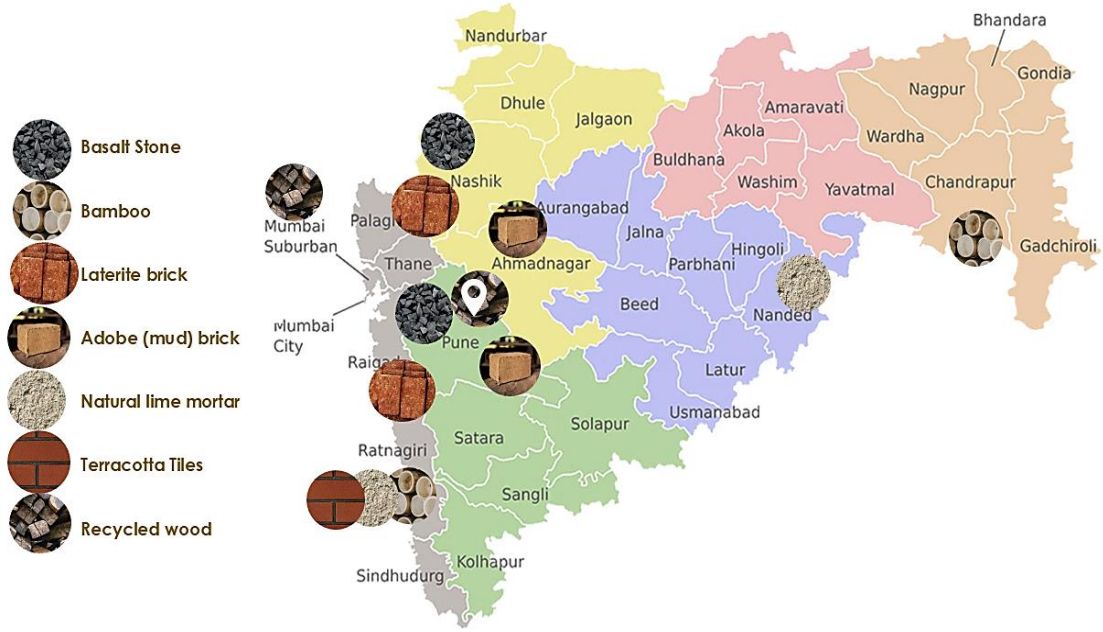

Figure 15. Resource availability map across Maharashtra.

Recycled wood is utilized as a sustainable material for interior finishes, flooring, furniture, and door/window frames, obtained from old buildings and suppliers throughout Maharashtra. Because it is biodegradable, it can be used with minimal processing if saved, which enables it to be reused in new constructions. The longevity of repurposed wood depends on the grade and kind of wood, and it serves as a renewable material with great insulation capabilities, especially for indoor use. Figure 15 demonstrates a map of raw material or resource availability across the state of Maharashtra for building construction.

DISCUSSION

It is important to choose building materials with low initial embodied energy and that are locally available to promote sustainability [4, 7]. The examination of different materials shows that those with decreased embodied energy—like laterite bricks, mud blocks, bamboo, basalt, terracotta, recycled wood and natural lime—are both eco-friendly and ideal for the local weather conditions. These materials come from local sources, reducing transportation effects and benefiting the local economy, establishing a cycle that helps strengthen community resilience.

For example, bricks made of laterite, which are plentiful in Pune, have low embodied energy and offer great thermal efficiency, decreasing the need for mechanical cooling. Likewise, bamboo, which grows quickly, is in line with sustainability objectives because it requires minimal energy for processing and has excellent carbon sequestration abilities. Compressed earth blocks provide benefits, with minimal energy needed for production, particularly if sourced locally [8–10].

Furthermore, choosing materials with efficient transport logistics can also reduce the project's environmental impact. This not only improves sustainability but also serves as a blueprint for future agritourism developments, showing how utilizing local resources can result in more genuine and environmentally conscious architectural approaches.

CONCLUSION

Agritourism plays a vital role in advancing sustainable practices in the Pune district, benefiting both the economy and the environment. This article emphasizes the importance of using the initial embodied energy approach in the beginning stages of designing an agritourism center, focusing on choosing locally sourced low-energy materials. The suggested building design employs laterite bricks, mud

blocks, bamboo, and basalt, terracotta, recycled wood, and natural lime, reducing environmental harm while promoting community involvement and backing local businesses. The incorporation of these materials establishes the agritourism center as a prototype for upcoming projects, demonstrating how conscientious architectural decisions can improve sustainability and elevate the cultural environment. In the end, the suggested materials offer a strong basis for developing a successful agritourism site in Gohe Bk village, promoting a more sustainable future.

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