

Economical Sustainability Study of Stilt House in Munshiganj as a Proposed Modular House for Cost-efficiency

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Abstract: This research examines the feasibility of a standardized modular façade panel housing system. Research reveals that modular buildings are 20–25% less expensive and 35% quicker to construct than conventional dwellings. The project aims to compare timber species, examine material amounts, labor, and transportation, and evaluate scalability and sustainability, while assessing the economic advantages of modular façades relative to current methods. The literature review, field surveys, and quantitative cost analysis indicate that the proposed 4' × 8' façade panels, which utilize only 1.33 CFT of wood and one galvanized sheet per unit, decrease construction costs by 18–24% due to reduced labor requirements, efficient transportation, and optimized material usage. Substituting imported hardwoods with indigenous species improves local supply chains and cost-effectiveness. The approach saves waste, facilitates flat-packed transportation, and allows for straightforward installation, disassembly, and expansion. The suggested modular façade system provides a scalable, economical, and climate-responsive housing option for the vulnerable populations of Bangladesh.

Keywords: Modular Housing, Façade Panel System, Economic Sustainability, Environmental Sustainability, Scalable Housing.

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I. INTRODUCTION

The worldwide housing deficit has been exacerbated by fast urbanization, population increase, and shifts in economic conditions; demand consistently surpasses supply, elevating prices beyond affordability (Djukanovic et al., 2025). Traditional construction methods, characterized by high costs, labor intensity, and protracted timetables, are increasingly inadequate in meeting evolving needs (Gómez & Sánchez, 2024). As a result, innovative approaches such as modular housing have gained prominence owing to their sustainability, efficiency, and versatility. With technological advancements, modular housing has emerged as a modern alternative to address urgent housing demands (Gómez & Sánchez, 2024). Modular systems realize substantial labor reductions, enhanced material economy, and expedited assembly through the utilization of standardized components produced in factories. Moreover, modular construction adheres to sustainable building principles by utilizing lighter

materials, minimizing the use of carbon-intensive concrete and steel, and facilitating recyclability at the conclusion of the building's lifespan (Barbu & Bârsan, 2022).

Modular building in Bangladesh is mostly unexamined; however, it holds significant promise, especially in climate-sensitive areas like Munshiganj. The region is particularly vulnerable to flooding and riverbank erosion, necessitating people to regularly disassemble and transfer their dwellings (Huda, 2020). Current vernacular methods include timber and tin modular frameworks that may be disassembled in hours and reconstructed in weeks (Billah, 2023). This article examines the proposed standardized 4' × 8' modular façade panel system as a cost-effective, scalable, and durable housing option. Consequently, modular housing improves cost efficiency while bolstering economic and environmental sustainability, providing a feasible solution for inexpensive and climate-resilient housing for low-income people in Bangladesh.

II. RESEARCH BACKGROUND

➤ *Background of the Project*

Modular building, originating from 19th-century prefabricated homes, has developed into a cost-effective and ecological option. Modular systems, via the use of factory-manufactured standardized components, can decrease building durations by as much as 35% and cut costs by 20–25% relative to traditional techniques (Hodbe & Sober, 2019; Maceika et al., 2024). They also reduce material waste, facilitate reuse, and utilize renewable or lightweight materials, consistent with green construction concepts (Barbu & Bârsan, 2022). Modular housing in Bangladesh is underused, despite its considerable potential, particularly in disaster-prone regions such as Munshiganj. The district, situated along significant rivers like the Padma and Meghna, is exceedingly susceptible to floods and riverbank erosion, resulting in the displacement of thousands each year (Islam, 2007; Huda, 2020). Local populations have always depended on movable timber and CI sheet buildings that can be disassembled in hours and reconstructed within weeks (Billah, 2023). This local resilience illustrates the effectiveness of modularity in a climate-sensitive environment.

This article provides a standardized 4' × 8' modular façade panel system that enhances the scalability of cheap, climate-adaptive dwelling options. In contrast to substantial prefabricated façades, which are cumbersome, challenging to manage and install, difficult to transport, and need specialist equipment, the 4' × 8' panel modules are far lighter, easier to handle, and can be transported in compact trucks or even physically conveyed to remote locations. This will reduce the necessity for heavy machinery and specialized workers during installation, hence decreasing expenses and logistical challenges. The approach reduces total costs through expedited building, simplified assembly, and enhanced material efficiency. Its versatility, recyclability, and little environmental effect foster environmental sustainability, while its incorporation of locally obtained lumber enhances economic sustainability. The combination of these properties renders the panel system a feasible and resilient construction method for low-income and disaster-stricken areas in Bangladesh.

➤ *Aim and Objective of the Research*

The principal objective of this project is to create and assess a standardized modular façade panel system as an economical, scalable, and climate-responsive housing option. The objectives are to examine current modular wooden housing practices in Munshiganj and identify constraints in material utilization, construction efficiency, and portability; to propose a standardized façade panel design that maximizes material efficiency, transportability, and assembly; to compare costs, labor, and material requirements between existing construction methods and the proposed modular system; and to assess the viability of local timber species as cost-effective substitutes for imported hardwoods. This study aims to illustrate that modular standardization may improve cost, efficiency, and resilience in housing for vulnerable and low-income populations.

III. LITERATURE REVIEW

The concept of modular construction originated from 19th-century prefabricated house modules, which were shaped by industrial advancements and the growing need for efficiency in the construction sector (Gómez & Sánchez, 2024). Due to its rapidity, cost-effectiveness, and environmental sustainability, modular construction techniques have emerged as a compelling alternative to conventional building methods. Modular systems often consist of standardized components produced in factories, which may be effortlessly moved and assembled on-site. Each module serves as a versatile spatial unit for living, working, or service spaces, capable of expansion, disassembly, or remodeling (Hodbe & Sober, 2019). Modular construction ensures superior cost management, reduces on-site inaccuracies, and delivers uniform quality, achieving factory completion rates of up to 95%.

Economic assessments underscore the efficacy of modular systems. Gómez & Sánchez (2024) discovered that modular projects are executed 35% more swiftly than traditional projects, requiring 10 months instead of 15.5 months, and realize an average cost reduction of 22%. Likewise, prices per square foot are markedly diminished (\$120 compared to \$154 in conventional systems). Maceika et al. (2024) underscore advantages like less waste, enhanced labor distribution, and increased energy efficiency. Off-site prefabricated housing may save utility costs by as much as 25%, water use by 30%, and gas usage by 80%. The selection of materials is essential in influencing both cost and sustainability. In Bangladesh, the cost of modular home varies from BDT 250,000 to 3,000,000, contingent upon the type of timber and facade selections. Frequently utilized components comprise locally sourced wood, galvanized sheets, and corrugated iron sheets, with timber selections having the most significant impact on pricing (Huda, 2020).

Modular construction, despite its benefits, encounters obstacles such as substantial initial investment, a deficiency of competent labor, insufficient institutional capacity, and inadequate policy frameworks (Zhang et al., 2018; Mao et al., 2015; Arif & Egbu, 2010; Tan et al., 2023). Literature indicates that conventional modular systems serve as a cost-effective and sustainable option, particularly pertinent in Bangladesh for inexpensive and climate-resilient housing.

IV. METHODOLOGY

The research will commence with a literature review, succeeded by a field investigation of local housing patterns in Munshiganj. These findings will be utilized to assess material dimensions and established measurements to propose a modular house prototype. The viability of modular housing options will be evaluated by juxtaposing costs with conventional building methods, examining local lumber alternatives, determining wood requirements, and calculating shipping expenses.

V. RESULT AND DISCUSSION

➤ *Existing Practice*

Modular wooden houses in Munshiganj are often built with timber and corrugated iron (CI) sheets, attaining a height of up to three stories. Their design guarantees sufficient lighting and cross-ventilation, rendering the interiors comfortable in both summer and winter. Inhabitants frequently choose for gable or Dutch gable roofs, although foundations differ based on the permanence of the dwelling. Permanent constructions utilize reinforced cement concrete (RCC) foundations, whereas temporary structures employ stilt-based RCC pillars, facilitating dismantling and relocation.

The building method entails the prefabrication of hardwood frames by local artisans utilizing fundamental joinery techniques, nails, and adhesives. Façade panels are constructed by affixing galvanized sheets to timber frameworks, sometimes augmented with ornamental curved boards. After the structural posts are secured to the RCC pillars, the beams, flooring, and façade panels are constructed, succeeded by the roof framing in the conventional chou chala style. The roofing is finalized with CI sheets, occasionally supplemented with insulation (Fig 1). Houses may be single or double-story, with staircases as necessary. A standard unit is around 8 × 15 feet and requires 7 to 10 days for production and 2 to 4 days for assembly.



Fig 1 The Exploded 3D Model of Existing Building by Components; The Axonometric View of Existing Model (Source: Authors).

➤ *Material Use and Issues*

Different species are used depending on budget—Koroi (15–20 years lifespan), mahogany and eucalyptus (≈50 years), and imported azobe/loha wood (up to 100 years). Importing hardwoods from Africa significantly increases costs. Galvanized plain iron and CI sheets, usually sourced from Dhaka, are widely used for façades and roofs. While they are easy to install, they trap heat, requiring additional openings or insulation for comfort. Table 1 shows estimated materials for current practice.

Table 1 Material Estimation (Source: Authors)

Component	Quant.	Size (Inches)	Length (Ft)	Total CFT
Columns	16 pcs	3" × 4"	10 ft	14.00 CFT
Floor Frames	16 pcs	3" × 3"	8 ft	8.00 CFT
Roof Edge Beams	4 sides	3" × 4"	46 ft total	3.83 CFT
Roof Rafters (<i>Chou Chala</i>)	18 pcs	3" × 4"	8 ft	12.06 CFT
Façade Panel Frame	—	2" × 2"	—	16.06 CFT
Ornamental Wood (Façade)	Trims, patterns	1" × 2" (avg.)	~50 ft total	1.25 CFT
Wooden Door (7' × 3'6")	1 pc (2 panels)	1.5" thick panel	~24.5 sq.ft	3.06 CFT
Wooden Windows (2' × 3')	6 pcs (12 panels)	1.25" thick panel	~36 sq.ft	3.74 CFT
Subtotal	—	—	—	45.94 CFT
Wastage & Fitting (10%)	—	—	—	~3.40 CFT
Total Estimated Wood	—	—	—	≈49.34 CFT
Component	Area to Cover (Sq.Ft)	Size	Effective Coverage Per Unit (Sq.Ft)	Quantity Needed (Approx.)
Galvanized Plain Sheet (Façade)	(2 × 8 × 8) + (2 × 15 × 8) = 368	3' × 6' = 18 sq.ft	~16 sq.ft (with overlap)	23 sheets
Corrugated CI Sheet (<i>Chou Chala</i> Roof)	2 slopes × (15' × 8') = 240	3' × 6' = 18 sq.ft	~16 sq.ft (with overlap)	13–14 sheets
Wooden Floor Panels	8' × 15' = 120	1'-6" × 7' = 10.5 sq.ft	~10 sq.ft (after fitting/cut)	12 panels (~15 CFT)

➤ *Identified Issues*

The construction of modular wooden dwellings in Munshiganj has many issues that impact efficiency, cost, and long-term viability. A primary concern pertains to the façade installation method; wherein substantial prefabricated panels are affixed as whole pieces instead of modular sub-components. This hampers handling, shipping, and precise fitting, especially on uneven sites, and causes challenges for rehabilitation or partial replacement, as the entire façade frequently requires alteration. The substantial dependence on imported hardwoods considerably elevates construction expenses and restricts affordability for local populations. Thermal performance is a challenge, as thin galvanized metal sheets absorb and retain heat, rendering indoor comfort reliant on extensive ventilation apertures, which are sometimes inadequate compared to masonry or bamboo walls. Moreover, although conventional joinery methods are utilized, the prevalent application of nails and screws compromises joint longevity and results in damage during repeated assembly and disassembly, particularly when bigger facades require installation or modification. Ultimately, due to the predominantly client-driven designs that exhibit considerable variability, there is less consistency in the building process, which diminishes scalability and compromises the efficiency of the modular system.

➤ *Proposed Modular Design*

In Munshiganj, craftsmen often make full-length prefabricated panels that encompass a whole front of a residence. Although these serve as façades, they lack true modularity due to their size, which complicates extension or change. Panels of 15 feet or 8 feet in length weigh roughly 350 kg and 170 kg, respectively, owing to their Loha wood frames and GI sheet filling. The substantial, enormous panels pose significant obstacles for shipping, packing, and on-site installation, necessitating larger trucks, increased manpower input, and ultimately elevating prices. This research presents a 4' × 8' modular façade system that adheres to the same building methodology while being subdivided into standardized, controllable components to address these limits. Each module necessitates 1.33 CFT of wood and one galvanized plain sheet, with a weight variation of 70–150 kg contingent upon the type of timber utilized. In contrast to traditional full-length panels, these modular modules are more lightweight, facilitate transportation, and expedite installation, therefore markedly diminishing logistical complexity and labor demands (Fig 2).

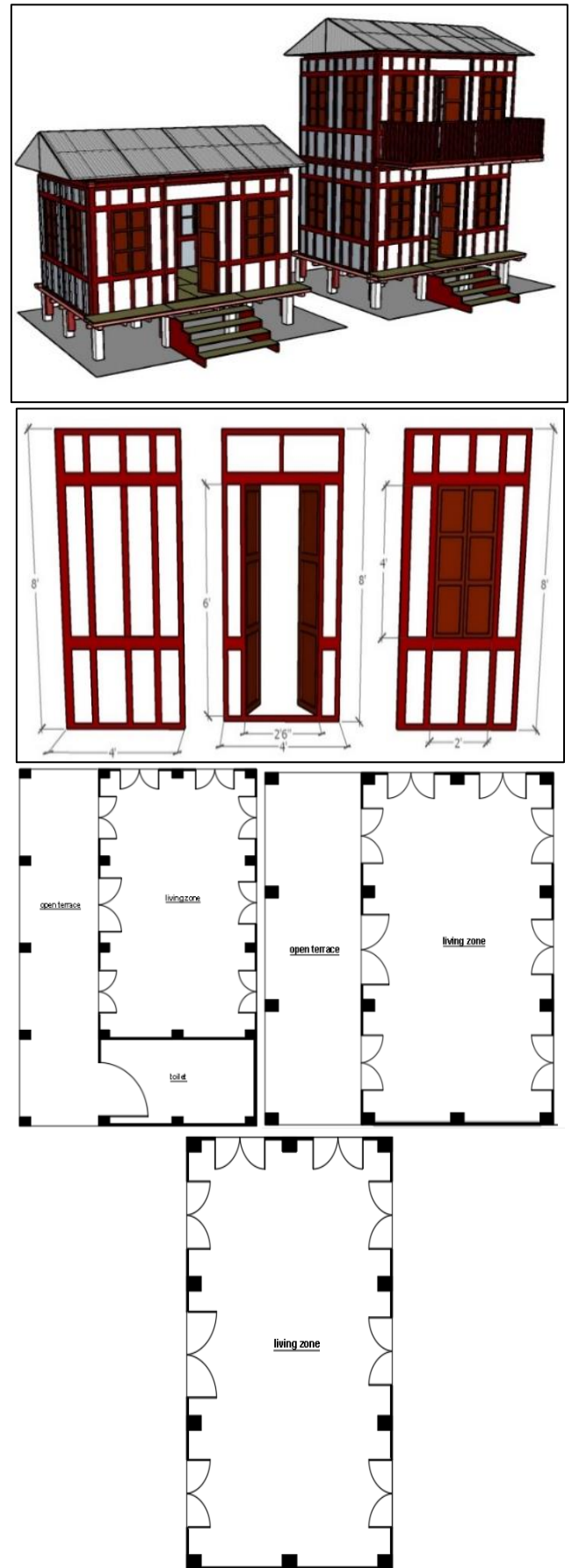


Fig 2 4'x8' Modular Panel Integration in the Munshiganj Modular House (Source: Authors).

The modular system offers architectural freedom and scalability, enabling the overall home size to be dictated by the quantity of modules utilized. An 8' × 12' structure may be constructed using just 10 modules, facilitating ease of extension or alteration. Material analysis (Table 2) indicates that an 8' × 12' modular home necessitates around 13.3 cubic feet of wood and 10 galvanized iron sheets, far lower

than the material intensity of bigger prefabricated systems. The cost comparison (Table 3) underscores that the modular system diminishes wood usage and building costs by 18–24%, rendering it both more efficient and economical. The suggested modular façade design rectifies the inefficiencies of existing practices while providing a cost-effective, lightweight, and versatile housing option for Munshiganj.

Table 2 Material Estimation of Proposed Modular Buildings Components (Source: Authors).

Item	Quant.	Size (Inches)	Length (Ft)	Total Volume / Qty
Wooden Poles (Columns)	10 pcs	3" × 4"	10 ft	8.33 CFT
Wooden Floor Members	14 pcs	3" × 3"	12 ft	10.50 CFT
Wooden Beams	4 pcs	3" × 4"	40 ft	3.33 CFT
Modular Façade Panel Frame	4 short bars	2" × 2"	4 ft	0.44 CFT
	4 long bars	2" × 2"	8 ft	0.89 CFT
	—	—	—	1.33 CFT
Roof Rafters (Chou Chala)	14 pcs	3" × 2"	—	8.00 CFT
Windows (Double Shutter)	—	2' × 4' × 0.083'	—	~1.33 CFT
Solid Wooden Door Panel	—	6' × 2.5' × 0.125'	—	~1.88 CFT
Wooden Floor Volume	—	8' × 12' × 1.5"	—	~12.00 CFT
Corrugated CI Sheet (Roof)	~120 sq.ft roof	—	—	6–7 sheets
Galvanized Plain Sheet (Façade)	—	4' × 8' per module	—	1 sheet/module

The suggested implementation of a standardized 4' × 8' modular façade panel presents several benefits compared to the current method of installing huge, continuous panels as singular parts. Smaller panels are significantly more manageable, transportable, and installable, as they can be carried by two individuals without the necessity for heavy gear and aligned with more precision on uneven foundations. This modular size facilitates the individual repair of damaged pieces, so circumventing the expensive and labor-intensive process of replacing whole façades during refurbishment. From a material efficiency standpoint, 4' × 8' corresponds with the usual dimensions of plywood, galvanized sheets, and other industrial boards, hence minimizing cutting and decreasing material waste during manufacturing. The technique is more economical, as the smaller panel frames necessitate less lumber and facilitate quicker installation. Moreover, the modular repetition optimally distributes structural stresses, enhancing durability and facilitating the dismantling and relocation of the complete home, a crucial attribute for flood-prone areas such as Munshiganj. In summary, utilizing the 4' × 8' panel size guarantees a more lightweight, cost-effective, and versatile building approach in contrast to traditional façade techniques.

➤ *Proposed Materials*

The use of foreign woods, such as azobe or teak, in modular home construction has several drawbacks when contrasted with the employment of native woods like koroi, mahogany, gamari, or Garjan (Table 3). Initially, imported timber substantially elevates the total building expenses due to elevated acquisition costs and supplementary shipping fees. For example, azobe is priced at around 3500 BDT per CFT, and teak Chambal at about 3700 BDT per CFT, whereas local alternatives like koroi (600 BDT per CFT) and gamari (1900 BDT per CFT) are significantly more economical. This price disparity immediately increases the structural budget: in the cost assessment, residences constructed with azobe or teak. Chambal was determined to be around 5–6 times more expensive than koroi and roughly double the cost of building of gamari or mahogany. Secondly, the utilization of imported timber diminishes cost and accessibility for middle- and low-income households, which is vital in rural and semi-urban areas such as Munshiganj. Conversely, local timber diminishes material prices by 18–24% inside the modular system and is more accessible, so bolstering local sawmills and artisans while reducing transportation emissions and costs.

Table 3 Cost Comparison of Different Wood for the Components (Source: Authors).

Current	Azobe	Koroi	Mahogany	Garjan	Teak	Gamari
Structure	\$512	\$88	\$292	\$322	\$541	\$278
Floor & Roof Frame	\$592	\$99	\$329	\$362	\$608	\$312
Floor	\$430	\$74	\$246	\$270	\$455	\$234
Façade	\$461	\$79	\$263	\$290	\$487	\$250
Total	\$1,995	\$339	\$1,130	\$1,244	\$2,091	\$1,074
Proposed	Azobe	Koroi	Mahogany	Garjan	Teak	Gamari
Structure	\$512	\$88	\$292	\$322	\$541	\$278
Floor & Roof Frame	\$592	\$99	\$329	\$362	\$608	\$312
Floor	\$430	\$74	\$246	\$270	\$455	\$234

Façade	\$461	\$79	\$263	\$290	\$487	\$250
Total	\$1,995	\$339	\$1,130	\$1,244	\$2,091	\$1,074
Wood Type	Current		Proposal	Savings	Reduction	
Azobe	\$1,995		\$1,637	\$358	18%	
Koroi	\$339		\$273	\$66	20%	
Mahogany	\$1,130		\$909	\$221	20%	
Garjan	\$1,244		\$1,000	\$244	20%	
Teak	\$2,091		\$1,682	\$409	20%	
Gamari	\$1,074		\$864	\$210	20%	

The suggested 4' x 8' modular façade system needs just 1.33 cubic feet of wood and one galvanized sheet per unit, indicating that a complete 8' x 12' home may be constructed with only 13.3 cubic feet of wood and 10 sheets. Each unit weighs between 70 and 150 kg, depending on the type of wood, making it far lighter and more controllable than traditional full-length prefabricated panels, which sometimes surpass 300 kg. This weight reduction not only decreases shipping and labor expenses but also accelerates and enhances the flexibility of the construction process.

Cost research demonstrates the system's effectiveness, with modular construction being 18–24% more cost-effective across all wood categories compared to existing practices. Koroi wood is the most economical choice (Tk 33,276 modular compared to Tk 41,370 conventional), although Mahogany and Garjan/Jam provide balanced choices in terms of cost and quality. Even high-quality woods such as Teak Chambal and Azobe exhibit significant savings (Table 3). The economic advantage arises from enhanced resource use, reduced waste, and streamlined assembly.

In addition to economic considerations, the modular method facilitates scalability and versatility, allowing dwellings to be effortlessly enlarged or reconfigured by the addition or removal of modules. Through appropriate preservation and treatment, indigenous woods can efficiently substitute costly imported varieties, enhancing resource sustainability. The modular method reduces expenses while improving mobility, efficiency, and long-term flexibility, rendering it a very viable alternative to traditional prefabricated houses.

➤ *Transportation Facilities*

The suggested modular approach facilitates transportation by disassembling the home into detachable, flat-packed sections, which are more lightweight and manageable than cumbersome constructed buildings. This diminishes truck rental expenses in Munshiganj, facilitates the utilization of smaller pickups for short distances, and decreases long-distance transport costs by maximizing load capacity. Modular packing optimizes container efficiency for export, allowing many units to fit into a single 20' or 40' container, hence reducing per-unit expenses in comparison to full-size prefabricated structures. Flat-packing significantly reduces air freight weight and volume fees, rendering international delivery more viable. Consequently, modularity facilitates enhanced management, reduced expenses, and increased scalability on both local and global scales.

➤ *Material Sustainability*

A solitary modular house unit necessitates an approximate total volume of 59.37 cubic feet of wood. This includes structural elements such as posts, floor members, a roof, beams, façade panel frames, rafters, a solid door, several windows, and hardwood flooring (Table 3). Matured mahogany, garjan, sal, and teak trees, after completely felled, seasoned, and processed, yield around 40 to 55 cubic feet of useful timber, contingent upon the tree's diameter, height, and trunk straightness (Table 4). Consequently, one modular home needs around 1.5 to 2 trees, and when accounting for waste, roughly 2 to 3 trees per house are required.

Table 4 Estimated Wood Volume from Mature Trees for Sustainability Check (Source: Authors).

Tree Type	DBH (Diameter at Breast Height)	Height	Estimated Wood Volume (CFT)
Medium tree	12"-18"	20-30 ft	20–35 CFT
Large tree	18"-24"+	30–40 ft	40–60 CFT+
Tree Type	Avg. DBH	Trunk Height	Processed Wood Yield
Mahogany	~18–24"	~25–35 ft	35–50 CFT
Garjan / Shal	~20–24"	~30–40 ft	40–55 CFT
Teak	~18–22"	~30 ft	35–45 CFT

This extent of wood utilization can be sustainable if the construction process emphasizes the use of locally sourced, fast-growing species, employs appropriate wood preservation methods, and incorporates a reforestation or tree planting initiative, such as planting 2 to 3 trees for each unit constructed. The modular method facilitates rapid disassembly and reusability, hence prolonging the material's

lifespan and diminishing the long-term environmental impact within the building sector.

➤ Discussion

The suggested modular dwelling concept exhibits sustainability in several financial dimensions. The utilization of standardized, smaller modules in construction eliminates material waste and decreases on-site construction duration, hence enhancing the speed and efficiency of the building process relative to conventional approaches. Labor expenses are considerably reduced, since small teams may efficiently construct or dismantle the modules without necessitating large expert labor or prolonged onsite engagement. To reduce the frequency of travels and associated expenses, the suggested modules can be flat-packed and consolidated into compact, manageable, and readily assembled parts. This will facilitate the transportation of several units within a single truck or container. The proposed method would efficiently utilize locally sourced wood, like Koroi, Mahogany, or Garjan, which serve as cost-effective alternatives to imported hardwoods regarding material expenses. Each module requires about 1.33 cubic feet of wood, and because to the modular design, materials may be recycled, further reducing long-term costs. This strategy enhances sustainability by optimizing the efficiency of time, labor, transportation, and materials, while providing low-income and disaster-prone communities with a scalable, incremental, and adaptable housing solution that can also serve alternative functions or be implemented in various contexts.

VI. CONCLUSION

The suggested 4' × 8' modular façade system provides a rational, cost-effective, and eco-friendly alternative to the current house building practices in Munshiganj. The technique reduces labor demands, decreases material usage, and accelerates construction by segmenting the structure into lightweight, standardized modules. Modular, disassemblable flat-pack modules that may be aggregated for bulk shipping or conveyed in smaller vehicles enhance transportation efficiency and cost-effectiveness. Employing locally sourced timber, like Koroi, Mahogany, and Garjan, ensures cost efficiency while fostering sustainable forestry practices and supporting local supply chains. Moreover, the modular design facilitates the straightforward and rapid expansion, modification, or reuse of components, hence enhancing long-term durability and flexibility. These properties offer economic, environmental, and logistical benefits, rendering the system an excellent option for scalable, cost-efficient, and climate-resilient housing designed to meet the demands of communities in Bangladesh.

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