Affordable Housing in the Context of Sustainability

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The Economically Weaker Section and Low Income Groups constitute more than 99 per cent share of total housing shortage of 24.71 million in India (figures from Planning Commission Report 2007). This number is further expected to increase to 26.5 million by 2012. This is due to the large number of people at the bottom of the economic pyramid. The business viability of this sector has already been established with market researches. The obvious logic here is that such a large number of people, with limited amounts of cash put together, have a considerable buying potential.

Building Industry and Climate Change:

The climate is changing. The earth is warming up, and there is now overwhelming scientific consensus that this is human induced. With global warming on the increase and species and their habitats on the decrease, chances for ecosystems to adapt naturally are diminishing. Climate change may be one of the greatest threats facing the planet .

The building and construction sector is a key contributor to the phenomena of climate change. The built environment accounts for a large share of energy use (with associated greenhouse gas emissions), waste generation or use of natural resources. Areas of key concern also include production of construction materials, use and recycling, consumption of hazardous materials, integration of buildings with other infrastructure and social systems, water use and discharge, etc. The construction industry is estimated to be responsible for around 40 per cent of the total carbon

	Unit	Cost/unit	Embodied energy/unit	% Energy saving
Mangalore tiles	Sq. ft	Rs 50	14 MJ	46% as compared to Mangalore tiles
MCR tiles	Sq. ft	Rs 45-65	6 MJ	
RCC roofing	Sq. ft	Rs 200	75 MJ	25% as compared to RCC roof
Plank & joist	Sq. ft	Rs 90	56 MJ	
Fly ash brick	No.	Rs 2	1.8 MJ	65% as compared to burnt clay brick
Burnt Brick	No.	Rs 2-2.5	5 MJ	

Energy and Cost Data

emissions globally. Buildings are responsible for large shares of resource use and waste generation: approximately 40 per cent of materials use, 30 per cent of solid waste generation, and 20 per cent of water use. The materials and technologies used in buildings also have a significant impact on their users' health and well-being.

Compared with many other industry sectors, the opportunities to reduce emissions are easier to achieve and also more substantial. Energy use in buildings can typically be reduced by 50 per cent or more using proven and commercialised technologies and approaches. This sector has the potential to lead the fight against climate change.

The huge volume of housing to be constructed, especially that in the affordable sector can have a huge role in this direction towards lowering carbon emissions. It has been seen that typically a house made using appropriate technologies has the potential to reduce at least 25 per cent of energy input itself, which can prove to be a tipping point, considering the scale of construction. With the Prime minister's National Action Plan on Climate Change having a sub-mission on sustainable habitat, the issue takes a completely new dimension in the Indian context.

The Model Eco Village Housing

The village in question is Guru Nanak Dev Nagar, village Gaggar, district Muktsar, Punjab. This project was conceived by the Punjab Government to provide shelter to the BPL families of the village. The project was started by Ambuja Cements Foundation in collaboration with the GoP in 2008 and was completed in August 2009. In all, 129 houses have been constructed with the cost of a single house being Rs 1.7 lakh, at around Rs 470/sq ft. Each house with a covered living and cooking area of 370 sq ft and a bath and toilet of 15 sq ft is built on a plot of 1200 sq ft. A single house has two rooms, a kitchen and a bathing area and toilet. Each plot has space for a cowshed and a cycle/scooter shed and the possibility of vertical expansion with another floor that may be added as the family size increases.

Technology Description

The house has a conventional brick foundation. The walls are made using fly ash bricks in rat trap/rowlock bond. The roof of the main built volume is in precast plank and joists. This is then topped with a weather proof course of brick tiles on mud phuska over bitumen PCC screed. The roofing over verandah and the kitchen is done using Micro Concrete Roofing (MCR) tiles with MS rafters and purlins. Local masons were trained in the usage of these technologies by TARA Nirman Kendra (TNK), a building centre of the Development Alternatives Group specialising in green building materials and habitat design. This training was conducted on a demonstration house at the site.

Roofing: Pre-fabrication for Cost Savings

Incorporating pre-fabricated plank and joist roofing significantly lowered the construction costs. Plank and joist roof with the three layered weatherproof course have worked out to be 20 per cent cheaper than conventional RCC roof. It took two days for roof construction, including finishing the assembly of prefabricated components with screed concrete, saving at least 10 man-days per house in addition to savings on scaffolding and curing period of 21 days for each house, which amounted to further construction efficiencies.

An existing local enterprise of fly-ash bricks, situated around 40 km from the project site, was trained in the production and quality control of planks and joists while MCR tiles were sourced from another small entrepreneur in Chandigarh. The technology transfer was undertaken by TNK. The casting and curing was done at the production facility with strict quality checks.

Walling: Utilisation of Industrial Waste

Waste fly ash generated by the GND thermal power plant at Bathinda was used in making the fly ash bricks for wall construction. The bricks are made using the FaL-G technology which uses a mix of fly-ash (50 per cent), coarse sand (40per cent), lime and gypsum (together 10per cent) and cement (less than 1per cent). The lime and gypsum are also waste materials sourced from an oxygen plant and fertiliser plant respectively.

Gaggar Eco Housing	Affordability	Sustainability
Technology	Pre-fabricated systems (P & J) Industrial waste utilisation- fly ash bricks Optimised structure and construction technique (rat-trap, load bearing walls) Exposed brick work Systems which use local material and are energy as well as water efficient	Low embodied energy Waste to wealth Local material and skill use Micro enterprise setup for increasing the influe footprint Systems which use local material and are ene as well as water efficient Waste debris reuse Use of local mango wood
Environmental Design and Planning	Climatically responsive design reducing operational energy costs Incremental approach for optimum first costs Optimised infrastructure design	Climatic response reduces the operational ene consumption Landscaping using native species Eco sanitation Cultural/aesthetic value: design features to ble with traditional vocabulary Rainwater harvesting
Delivery Process	Local production by small enterprises ensures lower costs Involvement of cement manufacturer directly reduces the costs even further	Replicable and Scalable Government - private partnership Involving local stakeholders ensures long-term sustainability

Affordability and Sustainability of Eco Housing Technology

The house has load bearing 9" thick fly ash brick walls. Red bricks were used in an interspersed manner (up to 10 per cent of the total bricks used in a house) to provide relief from the otherwise grey colour of fly-ash bricks and improve the aesthetic aspect of the house. Usage of Rat-trap bond for wall masonry which incorporates a cavity within the 9" wall thickness reduced the brick requirement by 20 per cent per cubic meter of wall. This reduces the load of the superstructure on the foundation, resulting in savings due to optimised foundation design as well. Similarly, mortar requirement is reduced by 20 per cent (as compared to conventional English Bond) for a 1:4 cement-sand mortar. Apart from this, construction by trained masons ensures superior quality of brickwork, obviating the need for cement plaster. The exposed brickwork has led to 15 per cent of overall cost reduction. Locally made pre-cast cement jaalis have been used to look out into the verandah. Doors and windows were made using local mango wood.

Rainwater from each house is directed through drains to harvesting pits located in the central parks of the settlement. Bathinda region receives approximately 410 mm of rain annually. The water harvesting system designed in the settlement is expected to catch 80 per cent of precipitation on the site (approximately 10,000 cubic meters) both through street drains as well as roof rainwater drains and direct these for recharging the aquifers.

The toilets constructed by Sulabh International have the twin-pit system, which uses each pit alternatively in a cycle of around three years to percolate wastewater and, at the same time, decompose the faecal matter into organic manure. Cost of a complete toilet, including squatting pan, plumbing, finishes, etc., is approximately Rs 7,500.00.

Technology vis-à-vis Sustainability

One of the key measures for ecological sustainability of building technologies is embodied energy. Embodied energy represents the non-renewable energy consumed in the extraction of raw materials, their processing, conversion to building materials (manufacturing), transportation to site and construction using the building material. Low embodied energy of the material signifies that the net carbon emissions during the production, transportation and construction of the building element are also low. So the lower the embodied energy, the higher it ranks in its ecological sustainability.

Pre-fabricated components generally have lower embodied energy in comparison to the cast in situ elements due to both enhanced production efficiency and reduced requirement of high energy raw materials.

The third aspect here is the usage of industrial waste like fly ash for construction. The ecological advantages are twofold, it utilises an industrial waste and prevents the usage of potentially fertile agricultural land. Bricks are hydraulically compressed and not baked, which eliminates both usage of burning fuel and the emissions associated with it. Also, as the quality of the bricks is superior with controlled dimensions, well formed edges and surfaces, it removes the need for plastering, further reducing the embodied energy of the walling system. Unbaked MCR tiles as a replacement for market standard, high energy asbestos sheeting and Mangalore tiles can save up to 46 per cent energy.

Design and Planning

Around 20 houses form a cluster around a central green open space. The central movement spine links the two main access routes to the site. All the roads are soft paved. Rainwater falling on the pavements is drained into the green areas for percolation. Native trees and shrub species were planted to create a wholesome environment.

Incremental Model for the House Design

Each house has been designed to allow for future expansion. A flat roof aids such an incremental approach and also optimises the first costs to the investor, where only the minimum space requirements of the customer are catered to and any future modification and customisation lies at the discretion of the user.

Climatically Responsive Design

The houses are designed to respond to the hot and dry climate of the region. Openings are so designed so as to ensure cross ventilation and adequate shading by chhajjas. Openings on the south side of the houses are avoided. A weatherproof layer has been added on the top of each house.

Optimal Sanitation Systems

The sanitation system provided by Sulabh International under the total sanitation mission uses water efficient pour flush toilets with twin-pit leach pits. Adequate care is taken to ensure that leach-pits are at a suitable distance from the water source – that is piped to the settlement. Vernacular design features like aara (niche) in main entrance wall and traditional brick parapet patterns were incorporated in the house design to integrate it with the cultural psyche. The intention was also to bring about a perception shift in the local community, who associate low-cost housing with bland looking boxes.

Delivery Process

The Ghaggar eco-housing was a government-led project where land and infrastructure were provided by government or quasi government agencies. The land was provided by the Zila Panchayat, the plantation in the green areas was undertaken by the forest department, water supply by the public health department and the roads and park boundaries were set up by the Punjab Mandi board. The government collaborated with the private sector in this case ACF of Ambuja Cement Limited as part of its CSR function facilitated its Foundation for financing and management of the project. ACF hired TARA Nirman Kendra (TNK) of the Development Alternatives Group as a technical consultant to the project. The eco-housing was designed with affordability and sustainability as key concerns. TNK trained the local masons and undertook the technology transfer of appropriate technologies to a local entrepreneur to ensure quality fly-ash bricks and prefabricated plank and joist roofing. Individual plot holders, all in the BPL and landless category, were identified by the local committee formed by the Panchayat. This committee was guided by ACF during the implementation period.

Housing Model	Affordability	Sustainability
Technology	Prefabricated systems	Low embodied energy of construction elements
	Industrial waste utilisation	Waste to wealth technologies
Techniques	Optimised structure and construction as also water efficient.	Systems which use local material and are energy
	Systems which use local material and are energy as well as water efficient	Waste debris reuse
		Minimum usage of non renewable and scarce materials
		Local material and skill use Micro enterprise setup for increasing the influence footprint
Environmental Design and Planning	Climatically responsive design reducing operational energy costs	Climatic response reduces the operational energy consumption
	Incremental approach for optimum first costs	Landscaping using native species Eco-sanitation
	Optimised infrastructure design and planning	Cultural/aesthetic value: design features to blend with traditional vocabulary User health consideration
Delivery Process	Local production by small enterprises ensures lower costs	Replicable and Scalable Government - private partnership
	Accruing carbon credits which can be passed on to the end customers as financial incentives	Involving local stakeholders ensures long-term sustainability Local management committee for ensuring post-occupancy maintenance
	Tax benefits to primary developers by the government	

Proposed Framework for Model Housing

Lessons

The lessons are summarised in the framework where the interconnected criteria of technology, environmental design and planning and delivery processes are evaluated against the affordability and sustainability parameters.

Criteria with Affordability and Sustainability as Parameters

An approach of appropriate systems has affordability as the objective and economic, social and environmental sustainability are the foundation of habitat provision. It becomes even more important to have sustainability as an underlying layer in all affordable housing initiatives. This is because sustainable measures can not only reduce the actual construction cost as well as post occupancy operational costs, but also significantly help in reducing the now, almost certain, (impending) economic offsets of climate change adaptation.

Delivery Mechanism of Affordable and Sustainable Habitat

Affordable housing in the larger sustainable habitat framework implies a three-pronged approach of social, economic and technological interventions in the housing delivery mechanism. This is a complex cyclical process with the policy level interventions forming the overall guiding force. The three interconnected loops converge towards the central objective of affordable and sustainable habitat, of which housing is the most important module. Capacity building of local enterprises is imperative to the process since it makes the model replicable on a larger scale, resulting in even lower costs.

Conclusion

Affordability of housing should be reinterpreted in terms of its social, economic and ecological costs and benefits. The built as well as natural environments are integral to the economic capital of the habitat. Environmental design and planning should take into account the climatic response, waste and water management and eco-sanitation, contributing towards pre- and post-occupancy affordability and sustainability. The overall housing delivery mechanism should take into account the role of different stakeholders and have social, economic and technological measures for affordable housing in the larger context of sustainability. ❑