BUILDING GREEN

IIFL Home Loans' Guide to Sustainable Affordable Housing

IIFL HOME LOAN

As professionals, we have a dual responsibility. We must serve, in the best possible way, the legitimate need of our client.

Equally, we must see that the means and ends of the building design solutions we propose, also serve a larger beneficial purpose.

We believe that the creative practice of architecture would seek to converge this duality into a unity.

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IIFL HOME LOANS'

BUILDING GREEN

GUIDE TO
SUSTAINABLE AFFORDABLE HOUSING

ASHOK B. LALL ARCHITECTS, IN COLLABORATION WITH CDD SOCIETY

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FOREWORD

Nirmal Jain

Founder
IIFL Finance Limited

India needs millions of affordable houses for people without own homes. World needs sustainable development to protect natural resources for our future generations. The corporates can no longer ignore their societal and environmental responsibilities. IIFL Home Loans has done some innovative work, attempting to achieve both affordability and sustainability. We are pleased to share our learnings in this guide book for people and institutions concerned about these issues, to use them freely and provide feedback as well.

India's more than a billion people can dream of a better tomorrow only if the country rapidly urbanizes. This may sound like a paradox as urban living conditions appear much worse. Yet, the inconvenient truth is that the only effective way to increase farm income is to reduce people dependent on the agriculture. Per capita farm productivity in India is a tiny fraction of the same in the developed countries. Therefore, to uplift masses at the bottom of pyramid, we need to create jobs in industrial and services sector, essentially migrating people out of villages to towns and cities.

In the last seven decades since independence, the imperative to seek higher income and livelihood has driven millions of people to India's cities with woefully poor infrastructure. The unplanned migration has led to widespread eruption of slums. The overcrowded and unsafe nature of these dwellings makes it near impossible to maintain standards in hygiene, clean water and sanitation. We witness spread of diseases and inhuman living conditions. This defeats the very purpose development and welfare state.

It is therefore clear that we need to aggressively invest in affordable housing and smart cities. Thankfully, the Government under our Prime Minister's leadership has embarked upon a very pragmatic and successful subsidy scheme to drive construction and ownership of affordable houses by relatively weaker segments of the society. We took up the gauntlet and emerged as second largest provider of finance for subsidy eligible affordable houses. Our focus on small-ticket affordable home loans, entails higher processing costs affecting margins but is aligned to our values and vision.

Our efforts and achievements in affordable housing is only half the story. What we really take pride in as you will discover in the ensuing pages, is our pioneering work in green construction. Under the guidance of Mr. Ashok B. Lall, renowned for his revolutionary work in this field, we have undertaken initiative named 'Kutumb' to construct, using locally available low-cost material, yet resulting in no depletion or degradation of natural resources and causing no

harm to the environment.

The Covid-19 pandemic has altered our lives in many ways. One of its lasting impact is stronger focus on adoption of sustainable environment friendly building practices which will reshape the world in the coming decades. IIFL is committed to lead by example. We undertand that it is important to generate adequate returns for shareholders to remain a sustainable enterprise, it is no less essential to fulfil your obligations to help natural system and ecosystem for making a sustainable world with better quality of life for our children and grandchildren.

This handbook, aims to disseminate knowledge in a simple language that can be understood not by architects and construction professionals alone but even by homemakers and students. Let us join forces for the mission of sustainable development of affordable houses and May the Force Be With Us All.

NOTE

S. Sridhar

Chairman and Independent Director
IIFL Home Finance Limited

India is an enthusiastic proponent of the United Nations Sustainable Development Goals (UNSDGs). The Government of India has been formulating national development policies in alignment with the UNSDG. Notably, India has been an early and passionate advocate of climate change measures. Indeed India has emerged as a global thought leader in climate change, announcing and implementing aggressive programs in the country. Renewable energy power generation, both on grid and off grid, solar pumps for agriculture and electric mobility are areas of high priority, for Central and State Governments.

Another UNSDG goal viz. Affordable Housing has emerged as a primary national focus. In 2007, Government of India unveiled an Affordable Housing Policy, for the first time. Together with supporting financial policies of the Reserve Bank of India, National Housing Bank and well delivered by banks and housing finance companies, Affordable Housing has come to stay in India. The Pradhan Mantri Awas Yojana (PMAY) launched in 2015, built on the earlier initiatives and executed a thoughtfully designed and well calibrated program. So far over the last decade, an estimated 20 million Affordable Housing dwelling units have been made available to the lower income segment of the population. Undoubtedly this initiative is amongst the largest and most successful programs of its kind in the world.

The time is now ripe to graduate to another dimension – sustainable housing. Sustainable housing in essence is affordable housing developed and built in an eco-friendly manner. Thus it combines a number of UNSDGs. A number of macro and micro level benefits for sustainable housing can be identified. First, in the aggregate, sustainable housing improves the quality of our habitat creating long term sustainable impact, particularly for the lower income groups who tend to live more densely. Secondly, sustainable housing can be more affordable than conventional affordable housing. Thirdly, given the inexorable trend of urban agglomeration, the younger populace and in fact, succeeding generations can hope to live a healthier and fulsome life. Fourthly, with some imaginative firm level business and financial programs, sustainable housing can encompass productive housing, i.e. the house is not merely a dwelling unit but also a production unit and a source of income for the family. For instance, home based workers engaged in weaving, stitching etc., back office remote work such as IT services, education etc., or merely paying guest accommodation. Finally, it generates employment, leads to income additionality for women in particular, contributes to poverty alleviation, promotes sustainability through use of local materials, natural products, etc.

The housing finance industry in India has traversed a remarkable journey from scratch to 10% of GDP in less than fifty years. The main providers viz. commercial banks and housing finance companies outdid one another in rolling out housing loan products from the plain vanilla mortgages for the salaried class to innovative products for the informal income earners and even where ownership rights are difficult to establish legally due to a variety of factors. Thus, the vast populace of unserved and underserved in housing are being substantially addressed and continue to be addressed given India's burgeoning population. Home ownership in India has dramatically increased and housing deficit reduced significantly.

IIFL Home Finance (IIFL HFL) was one of the earliest HFCs dedicated to Affordable Housing under the new registration policy of NHB started about a decade ago. Over the last decade, IIFL has consistently delivered on its mandate financing about 1.15 lakh homes and catalyzing investment in housing stock of about ₹39,000+ cr.It was amongst the first lenders in the country to develop and maintain a focus on informal income earners and striking a balance between asset quality and social benefit. IIFL has done so on a pan India basis and has emerged as a leading housing finance company in Assets under Management (AUM), innovation, outreach and credit rating.

As part of its continuing innovative approach and commitment to societal goals, IIFL has introduced a new financial program titled **'Kutumb'** which offers Affordable Housing loan for housing that are environmentally friendly. It is thus an appropriate example of sustainable housing and conforms to a number of UNSDGs.

In this publication, IIFL team has sought to put together a number of architectural designs and technical features relating to the habitats that are aligned with the Kutumb program. This publication has been curated by Dr Ashok Lall, an eminent architect, schooled in the best traditions of modern global architecture, and imbued with our ancient wisdom and social conscience.

I am confident that this initiative of IIFL HFL, arguably the first of its kind in India, would resonate in our habitat community of policy makers, regulators, real estate developers, architects, bankers, housing finance lenders and other connected professionals such as valuers, agents etc.
I hope that this baby step of IIFL would translate into a giant leap for our country in the area of sustainable housing in due course.

My thanks to Mr. Ashok Lall and the entire team of IIFL led by Monu Ratra, the shareholders of IIFL and my fellow Board Members for their valuable support and guidance.

INTRODUCTION

Monu Ratra

Executive Director and CEO
IIFL Home Finance Limited

The year 2021 greets us with, amongst other things, a realization that we need to immediately and collectively address climate change by reducing pressure on natural resources. COVID-19 pandemic has taught us important lessons for the future of urbanisation in India. We need to distribute our population densities. Overcrowded conditions that result from intensive high-rise high-density housing are as much prone to rapid spread of human transmission of infections as crowded slums of big cities are. The focus must shift to the growth Tier II and Tier III cities. Housing densities should have an upper limit of 250 dwelling units per hectare. Policy must address this factor in devising land development norms and managing land markets to protect the long-term well being for citizens.

The construction industry is one of the biggest consumers of non-renewable resources, and a massive producer of waste. Even after completion, most buildings continue to be responsible for huge CO_2 emissions. It was found in developed countries that 30-40% of the natural resources were used by the construction industry. Adding to this, 50% of produced energy was used just for heating and cooling buildings, and these figures will only surge upwards in the coming years, as income rises and urbanization spreads in developing nations[1].

The solution lies in Green Housing or green construction, which refers to construction methods that adopt environmentally responsible and resource-efficient materials and processes. The concept permeates throughout the phases of a building's lifecycle from siting, design, construction, operation, maintenance and renovation, all the way to deconstruction. Green buildings promote sustainability without disturbing natural habitats, and can drastically cut down environmental harm.To quantify the benefits, green construction has the potential to reduce global CO_2 emissions by as much as 84 gigatonnes by 2050.[2]

India has had a successful start in its adoption of Green Housing, but no stone should be left unturned in galvanizing its universal adoption. This is how IIFL Home Finance's Kutumb was birthed. It is a platform that brings together industry experts, government bodies, financial agencies and housing developers in an effort to create sustainable infrastructure and an exemplary model for Green Housing, providing financial support as an incentive. Five chapters of Kutumb, in Ahmedabad, Indore, Pune, Bengaluru and Hyderabad have already been held with extensive participation

1 www.witpress.com/Secure/elibrary/papers/ST11/ST11002FU1.pdf
2 www.worldgbc.org/benefits-green-buildings

from various industry experts and developers.

To further incentivize the adoption of Green Housing, Kutumb provides free consultation on green building methodologies and assists developers right from the conception stage to certification. We also help them understand the advantages of investing based on life-cycle analysis rather than first-cost criterion. Developers may shy away from Green Housing at the notion of additional costs unless they are made to realize that eco-friendly methods of construction reduce costs significantly in the long run. Developers must also keep in mind the phenomenal opportunity that lies ahead of us – just the demand for affordable housing is set to grow by 70% in India, as the economy grows and its middle classes get stronger. Even as we do our bit to promote and incentivize green housing concepts, we know this mission needs many warriors and a large united front. Through Kutumb, we are engaging with national and international bodies to promote green building programs and have also formed a synergetic association with the Indian Green Building Council (IGBC). Affordable housing was our core focus area, but we have crossed boundaries to incorporate green building technologies, imperative to a sustainable future.

In addition to Kutumb, IIFL HFL has introduced two more programmes – PURPOSE and Green Value Partner — to form a troika of catalysts to accelerate green building adoption in India.

PURPOSE (**P**latform for Green Affordable Ho**U**sing & Finance, Through **R**esearch, **P**olicy & Techn**O**logy, for **S**ustainable **E**co-System) has set up an Advisory Council of experts in building construction, finance and sustainability to influence policies at all levels of implementation pertaining to green affordable housing.

Our **Green Value Partner** (GVP) initiative seeks to provide end-to-end assistance to the developer through a project's lifecycle to ensure successful realization of the project's intended vision and efficiencies. GVPs also ensure that all criteria are understood and met in order to successfully achieve a Green Building Certification.

Going forward, IIFL HFL aims to take the concept of eco-friendly construction to Tier-2 cities and the rest of India, and continue the various initiatives, strike meaningful partnerships and together be the change that we want to see.

Our attempt to present the Sustainable Housing Handbook is another important initiative in this quest. We are extremely grateful to Mr. Ashok B. Lall, whose expertise in environmentally and socially sustainable development has driven a large portion of the Industry's shift toward Green Housing. This handbook is an embodiment of his vision and an authoritative and comprehensive work that can guide all stakeholders interested in adopting Green Housing concepts and help the environment. I am grateful to CDD for contributing the chapter on Water Efficiency, where they provide critical inputs to building industry on how to efficiently use this increasingly scarce resource. This handbook provides insights on design and construction for projects so that developers can obtain a green rating. In addition to helping developers, this handbook would be an extremely useful tool for architects, construction engineers and homeowners.

At IIFL, our motto is to be the most respected financial services company in India; not necessarily the largest or most profitable. We have come this far only because of our core values that serve as a moral compass in all our dealings. Our lifelong endeavour is to deliver duly on all fronts to all our stakeholders. With this in mind, it is only natural that we strive to influence our Industry and its allied businesses to adopt earth-positive methods in their operations.

We hope the Handbook will serve as a force multiplier in our efforts to mitigate the environmental impact of construction in India.

Happy Reading!

1. Sustainable Housing: Indian and Global Perspectives

1.1 Global Concerns

We see it on the news every day. The intensity of rain storms is increasing, causing floods and destruction. Glaciers are melting and this will change the river systems. Cities and agriculture are going thirsty. The climate is becoming hotter and the sea levels are rising. This is due to climate change that is affecting the entire globe and people everywhere.
In large part, climate change is caused by the way we build buildings and cities and the way we live in them! So, we must build and live in ways that are energy efficient, conserve water and natural resources, and do not pollute the environment. This is a task we in India share with all other nations.

Globally, buildings and construction together account for 36% of global final energy use and 39% of carbon dioxide (CO2) emissions. While strides are being made towards sustainable buildings and construction, improvements are still not being able to keep up with the ever-growing buildings sector and rising demand for energy services. Apart from being a major consumer of global natural resources, buildings are the largest energy consumers and greenhouse gas emitters in both, developed and developing countries. With climate change and its disastrous consequences already starting to show, it is about time that the world shifted its attention to possible counter-actions and solutions.

Since buildings and construction contribute the most to pollution, it only makes sense to neutralize the biggest threat to our environment. Sustainable and eco-friendly housing aka 'green homes' could be the solution if global communities, countries and governments make it their mandate. With the world rapidly urbanising, particularly in developing economies like India, the need for construction of buildings is huge. Statistics reveal that more than 70% of the buildings that are planned for completion in India by 2030 are yet to be built, which implies that India would be burning through its natural resources at break-neck speed

The seeds of green building revolution were sown thousands of years ago. Nearly 5000 years ago, the Indus-Saraswati valley civilisation showed a remarkably advanced sense of town planning, water management and sanitation, which extended to entire cities. The codification of building principles in Vastu Shastra about 2000 years ago still inform building layouts in India. Elsewhere, in 400 BC, the ancient Greek philosopher Socrates used something called passive solar heating to keep his people warm in winter and cool in summer. The native american tribes of Southwest Colorado used similar principles to construct the Cliff Palace at Mesa Verde in 1200 AD, the prevalence of similar principles can even be seen at the ancient Nalanda University, in Bihar, India. Housing and building designs and the materials used in various parts of the country also display an understanding of local conditions and the need to construct accordingly.

Figure 1. **Sustainable Development Goals**

The affordable housing challenge is being guided by the following four SDGs:

GOAL 10	Reduced Inequalities
GOAL 11	Sustainable Cities and Communities
GOAL 12	Responsible Consumption & Production
GOAL 13	Climate Action

in the coming years, a clear reason why decisive action towards adoption of sustainable housing models needs to be taken today.

1.2 Global Green Housing Movement: A Brief History

The green building movement began in the early 70s in the United States after the price of oil witnessed a sharp increase. As a way to counter this, researchers began looking into more energy-efficient systems. A plethora of organisations was formed in the 90s to promote green buildings and housing solutions. Some organisations even worked to improve consumer knowledge so that more people understand the economic and ecological benefits of adopting a 'green' approach to housing.

In 1987, the UN World Commission on Environment and Development set the first definition of 'Sustainable Development', paving the way for Green Building Principles as we know today. BRE's rating system, Building Research Establishment Environmental Assessment Method (BREEAM) was the UK's first green rating system, launched in the 1990s, followed by the US' Leadership in Energy and Environmental Design (LEED) rating system in 2000.

In India, we have three different agencies, recognized by the Government of India, which conduct Environmental Performance Assessment for construction projects. They are GRIHA, set up by Ministry of Environment, Indian Green Buildings Council (IGBC)/CII and GBCI/IFC. A Housing project may be assessed by any one of these.

1.3 Building Energy Codes: An International View

Today, the green building movement has started taking root globally, each year, more and more developed countries are becoming more conscious and aware of the problems regarding sustainability. Energy efficiency in construction standards is universally recognized as a practical and

cost-effective way to achieve energy savings in residential and commercial buildings. Across the globe, countries are independently designing and implementing energy efficiency policies and programs in residential and commercial buildings to decrease energy waste in the new building stock. In many countries, the government has the authority to mandate energy efficiency in buildings by creating national building energy codes that are often implemented by regions or municipalities. But the effectiveness of these codes is disparate across different countries.

Several countries such as Australia, China, Canada, France, Germany et al. not only have elaborate building codes but have also deployed stringent enforcement mechanisms. Efficiency experts agree that enforcement is one of the most important elements of the building energy code because it ensures compliance and effective savings.

1.4 Green Buildings In India: Ground Realities

Buildings in India use upto 40% of all energy, 30% of all raw materials and 20% of all land use and thereby generate 40% of all carbon emissions, 30% of all solid waste and 20% of all water effluents.[3] Apart from being poorly regulated, the building construction industry gobbles up natural resources. With almost 70% of the building stock yet to be completed, the country needs to expedite the adoption of environment friendly practices.

The Government of India has committed to follow the guidelines of the United Nations' Sustainable Development Goals, and has framed many policies that encourage and enable development while ensuring care for the environment. This is why large projects require Environmental Clearance from the Ministry of Environment. The Bureau of Energy Efficiency (BEE), under the Ministry of Power, has devised a code for energy efficiency in residential buildings. Also, there are schemes offering financial support for affordable housing which are designed and built on the principles of Green Building.

However, local authorities also need to ensure that these rules are successfully implemented on-ground. There is a need to weigh in the economic impact of a project against its ecological effect, and cities need to be built as per the region's geographical requirements. For instance, Chennai is known for its hot and humid climate. It can do away with airtight glass buildings and instead encourage bringing in

The Affordable Housing Challenge is Being Guided by the Following Four SDGs:

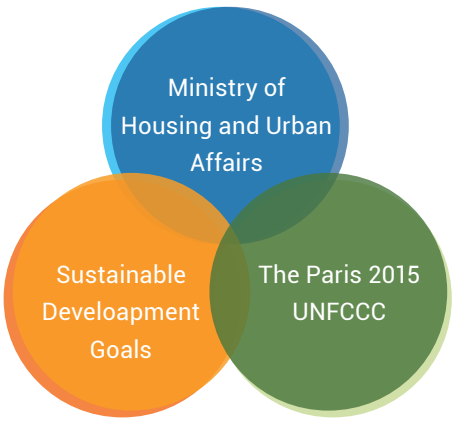
Goal 10 **Reduced Inequalities**
Affordable homes at locations of employment and economic opportunity with access to public transport and social amenities

Goal 11 **Sustainable Cities And Communities**
Livelihoods in an inclusive economy with energy equity, and environmental security - conserve water and air purity, recycle waste, enhance public space with greenery.

Goal 12 **Responsible Consumption & Production**
Use of low-carbon and resource-efficient modes of production for construction of housing and selecting building types for minimum operational energy.

Goal 13 **Climate Action**
Build-in robustness against infrastructure failure, shade outdoors against heat waves, intensify rain harvest and water efficiency. Minimize hard ground and motor vehicles for low UHI

3 www.cseindia.org/latest-report-of-the-centre-for-science-and-environment-buildings-earthscrapers-environment-impact-assessment-of-buildings-3585



some traditional solutions of the earlier Chettinad homes such as verandas for sufficient cross-ventilation.

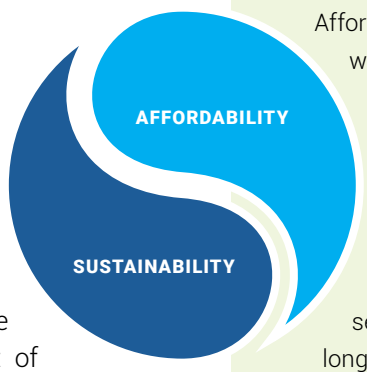
There is also a need to adopt a mandatory building energy code if sustainable housing is to scale. India is adopting new designs to improve the quality of buildings and is emulating initiatives of the Indian Government. Following such initiatives can create new solutions and develop new principles and policies for the country.

One large-scale example of success is the Cochin Airport, which is the world's first airport to run completely on solar power. Recognised by the United Nations in 2019, the installed solar plant can produce 18 million units of power every year, enough to meet the energy needs of 10,000 homes[4]. This, technically, makes it completely power neutral. Some Indian cities are also developing transit-oriented infrastructure for future-ready urban centres.

As the idea of green building practices is laying hold in India, there is still a large section of Indians that remains unaware of green buildings' enduring benefits, perceiving them as financially unfeasible. Also, current market conditions have made developers sceptical about the usage of any technology that increases the cost of construction. Even as setting standard codes and ensuring their implementation through incentives and enforcement is the need of the hour, 'Behaviour Change' communication and dissemination of awareness is also very important.

To catalyse understanding and financing, IIFL Home Finance Limited has established 'Kutumb', a platform that brings together industry experts, government bodies, financial agencies and housing developers to create a sustainable infrastructure and a know-how model of Green Buildings. This platform is part of the solution set. It leverages its network to convince homeowners and stakeholders alike that an increasing focus on certification and building retrofits, a spotlight on water conservation and energy efficiency and a move to 'Net Zero' buildings is the key to a sustainable future.

We need to move towards a pollution-free planet as soon as possible, to tackle climate change and to push sustainable development. This can only be achieved through decisive action in the buildings and construction industry. Technologically and commercially viable solutions are available, but there is a need for stronger ground-level policies and collaborations to scale them rapidly. The objective of this handbook is to serve as a ready reckoner of steps that all of us can follow or be mindful of to make the idea of sustainable housing in India a reality.



Affordable Housing today requires intelligent solutions which make homes comfortable and environmentally sustainable in the long term, at costs that we can afford today. We need to build future proof, resilient, affordable housing as this will be a foundation for the quality of life to be enjoyed by the next generations of our urban citizens. We must not fall into the trap of technologies that seek to merely lower prices but may cause negative long term environmental consequences. If we do, we will pay for the costs of the mistake for seventy years.

4 www.bbc.com/news/world-asia-india-34421419

2. About the Handbook

2.1 Why this Handbook

We know that homes that are designed and built to be comfortable and healthy and cause **minimal harm to the environment** will be good for the residents and good for society at large. We call these homes 'GREEN HOMES'. What improvements to our usual ways of designing and buildings can we bring to make them Green, and how do we implement them! This handbook provides step-by-step guidance.

As mentioned, in India, a rating certificate can be obtained from any of the following three agencies: GRIHA, IGBC Homes and GBCI. This handbook provides guidance on design and construction to enable projects to obtain a good rating, be environment friendly and avail concessional financial assistance as well as associated services.

2.2 Who is the Reader

This handbook will be useful for developers, architects, construction engineers and homeowners. It helps home owners understand the technical aspects of GREEN HOMES. Architects and construction engineers get practical tips on various aspects of design and construction to achieve the desired green rating. With this guidance the developer's task in building green homes is made simpler, the Handbook provides a simple way for all those in charge of the processes of design and construction, to have a common and clear understanding of goals and methods.

2.3 How to Use this Handbook

The first step is to get an overview of the three Environmental Performance rating systems that are available in India from Section 3 of the Handbook: Understanding Rating Systems. In Section 3.7 there is a comparison between the three rating systems. This Section explains what actions are required under each environmental parameter for gaining credit points along with their respective cost impacts to reach the desired overall rating for the proposed project design. With the help and guidance from experts such as a representative from IIFL, one of the rating systems can be selected and design and construction suggestions adopted. Sections 4, 5 and 6 give tips on integrated design that result in economy while meeting many credit requirements simultaneously. These sections also result in energy efficiency of the Project, leading to reduced energy demand. These sections can be a great help at the time of designing a project. Section 7 shows how to gain the required water related credits, with water conservation, treatment, and recycling. With all the suggestions given for design and construction, there is an indication of costs to help in taking cost-effective decisions.

3. Understanding the Rating System

3.1 Introduction to Rating Systems in India

Green Buildings are structures that ensure efficient use of natural resources like building materials, water, energy and other resources with appropriate management of waste. In India there are four green building rating systems IGBC, GRIHA, LEED and EDGE respectively. The focus of this handbook will majorly be on the following three:

— IGBC Green Homes for Affordable Housing
— GRIHA for Affordable Housing
— EDGE for Homes

3.2 IGBC Green Homes Affordable Housing

Confederation of Indian Industry (CII) formed the Indian Green Building Council (IGBC) in the year 2001. The vision of the council is, "To enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025". Different levels of green building certification are awarded based on the total credits earned. However, every Green Affordable Home should meet certain mandatory requirements, which are non-negotiable. IIFL's Green Value Partner (GVP) can assist the developer to aim for at least a **Gold Rating**.

The threshold criteria for certification/pre-certification levels are as under:

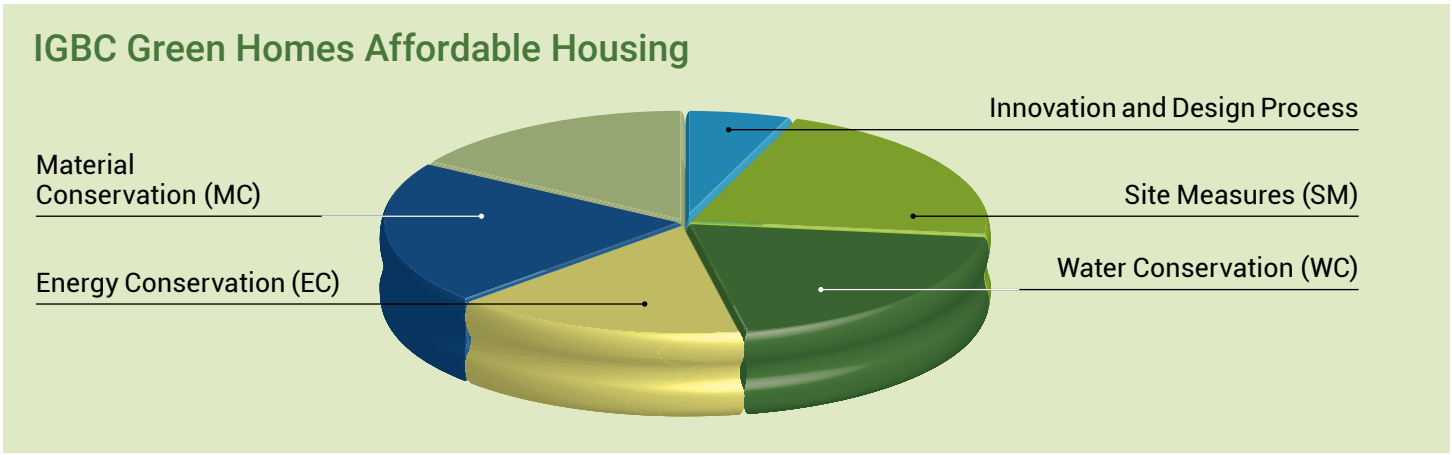
Certification Level	Multiple Units	Recognition
Certified	38 - 44	Best Practices
Silver	45 - 51	Outstanding Performance
Gold	52 - 59	National Excellence
Platinum	60 - 75	Global Leadership

IGBC Affordable Housing category is a simpler version designed especially for affordable housing. It is this category that is our focus here.

3.3 IGBC Green Homes

Indian Green Building Council (IGBC) Green Homes is the first rating program developed in India, exclusively for the residential sector. It is based on accepted energy and environmental principles and strikes a balance between known established practices and emerging concepts. IGBC Green Homes Rating System is a measurement system designed for rating new and major renovation of residential buildings.

IGBC Green Homes is a more stringent rating designed for new and existing residential buildings.



3.4 GRIHA

Green Rating for Integrated Habitat Assessment (GRIHA) is India's own rating system jointly developed by The Energy and Resources Institute (TERI) and the Ministry of New and Renewable Energy, Government of India. It is a green building design evaluation system where buildings are rated in a three-tier process. The process initiates with the online submission of documents as per the prescribed criteria followed by on site visit and evaluation of the building by a team of professionals and experts from GRIHA Secretariat.

The GRIHA V 2015 rating system consists of 31 criteria categorized under various sections such as Site Planning, Construction Management, Occupant Comfort and Wellbeing, Sustainable Building Materials, Performance Monitoring and Validation, and Innovation. GRIHA is a performance-oriented 100 point system consisting of some mandatory core points, and some optional points. Different levels of certification (one star to five stars) are awarded based on the number of points earned.

3.5 GRIHA for Affordable Housing

GRIHA has developed a new rating variant called "GRIHA for Affordable Housing" (GRIHA AH) which enables low-income households to reduce operational costs and GHG emissions by improving resource efficiency. The rating evaluates the environmental performance of residences holistically over its entire life cycle. The rating is a dedicated assessment cum rating tool with a pre-fed calculator based system and thus provides a definitive standard for " green building".

GRIHA AH is a 100 point rating system consisting of 30 criteria categorized under six sections - Site Planning, Energy & Occupant Comfort, Water Savings, Waste Management, Sustainable Building Materials, and Social Aspects. Different levels of certification (one star to five stars) are awarded

Rating Threshold	Griha for Affordable Housing Rating
25-40	★
41-55	★★
56-70	★★★
71-85	★★★★
86 and above	★★★★★

based on the number of points earned. The minimum points required for certification is 25.

3.6 EDGE for Homes

International Finance Corporation (IFC) created EDGE in 2014 to respond to the need for a measurable and credible solution to prove the business case for building green and unlock financial investment. EDGE includes a cloud based platform to calculate the cost of going green and utility savings. The state-of-the-art engine has a sophisticated set of city based climate and cost data, consumption patterns and algorithms for predicting the most accurate performance results. A global network of certifiers and accredited EDGE experts support the collective ambition to mainstream green buildings and help fight climate change.[1]

EDGE is a software application, a global standard, and a green building certification system for more than 130 countries. EDGE offers a set of technical measures that when selected, reduce a building's operational and embodied energy and water use. Only a handful of measures are required for better building performance that result in lower utility costs, extended equipment service life, and less pressure on natural resources. To comply with the EDGE standards, a building must achieve a 20% reduction in all three areas when compared to a local benchmark.

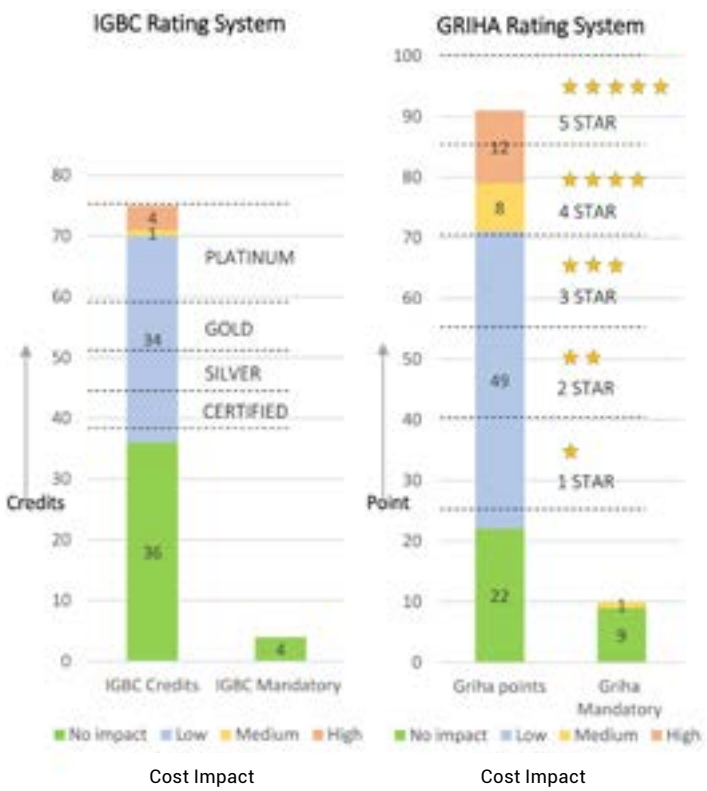
Through, the use of an online calculation software where the location, type, use and size, and construction materials as well as electrical and water systems are entered EDGE will show whether a project has achieved 20% savings in water, energy and materials in its design. This qualifies the project for EDGE certification.

3.7 Comparison between IGBC Green Homes. GRIHA for Affordable Housing and EDGE for Homes

The graph demonstrates the distribution of credits/points of various parameters under IGBC and GRIHA rating systems and their associated incremental cost impacts. For detailed understanding of the respective rating systems, Annexure 1, 2 and 3 may be referred.

EDGE, being an online analysis based software, integrates combined effects of multiple parameters on the project's performance and therefore cannot be tabulated based on individual point based system.

Efficient design can enable the developer to achieve a reasonable rating with negligible/minimal incremental cost.



[1] edgebuildings.com/about/about-edge

4. Building Plans and Orientation – Influencing Thermal Comfort

4.1 Site Planning

4.1.1 Building Orientation

Minimize solar exposure on vertical surfaces

Building orientation often plays a crucial role in passive strategies for reducing heat gains in the building through building envelope. The buildings should preferably be oriented such that the longer façade faces North-South to help minimize solar heat gains.

The following graphs show the average data for incident solar radiation for the cooling period for cities in north and south India. As it is evident from the data, if the buildings are oriented such that the longer facades are oriented towards North-South the incident solar radiation is lesser. Thus, the heat gain is less and energy expended to cool the building is consequently decreased too.

Figure 2. **Site plan of Mahindra Happinest, Avadi, Chennai. Few blocks in pink colour face East-West. Most blocks in yellow colour face North-South | Mahindra Life Spaces**

Building Orientation
Orientation is the positioning of a building in relation to seasonal variations in the sun's path as well as prevailing wind patterns. Good orientation can increase the energy efficiency of your home, making it more comfortable to live in and cheaper to run. Good orientation, combined with other energy efficiency features, can reduce or even eliminate the need for auxiliary heating and cooling, resulting in lower energy bills, reduced greenhouse gas emissions and improved comfort.

However, often the site profile is such that ideal orientation of the building may be compromised to maximize density or to achieve more ground coverage. Thus, to counteract the heat gain due to the sun falling directly onto the walls- the heat resisting property of the building envelope becomes critical. The walling materials with low U-value like AAC/CLC blocks, fly-ash bricks, hollow clay blocks, could be considered.

Delhi

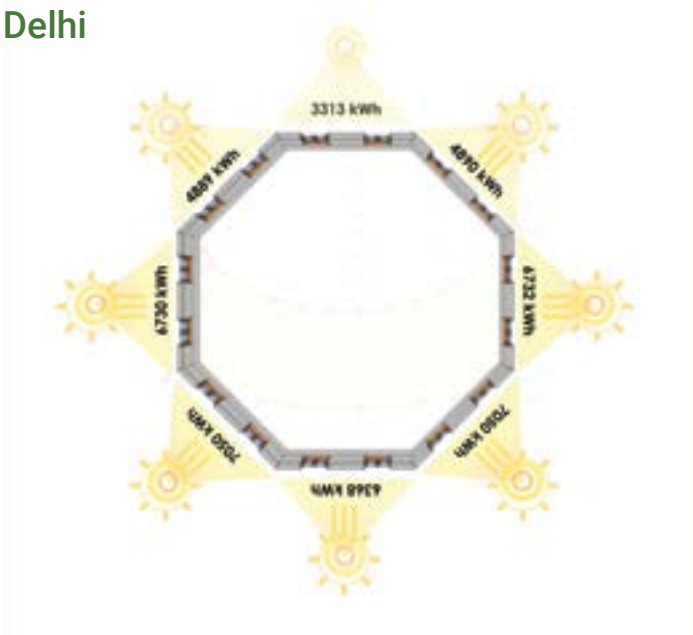


Figure 3. **Incident solar energy [kWh] falling on different faces of the building during the warm period when we need to avoid solar heat gains.**

Chennai

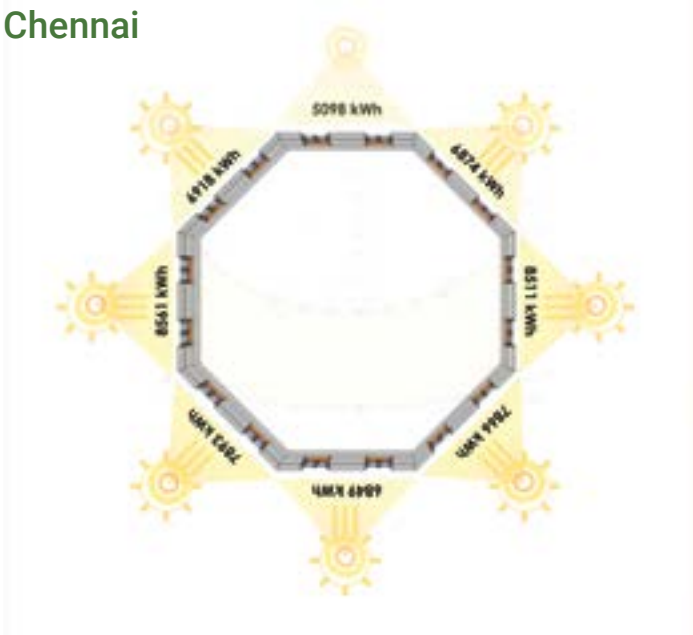


Figure 4. **Incident solar energy [kWh] falling on different faces of the building during the warm period when we need to avoid solar heat gains.**

Ahmedabad

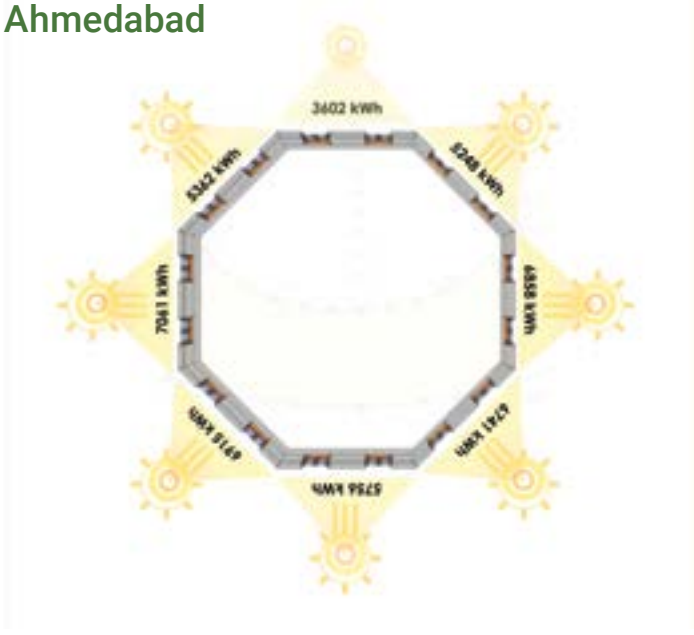


Figure 5. **Incident solar energy [kWh] falling on different faces of the building during the warm period when we need to avoid solar heat gains.**

Nagpur

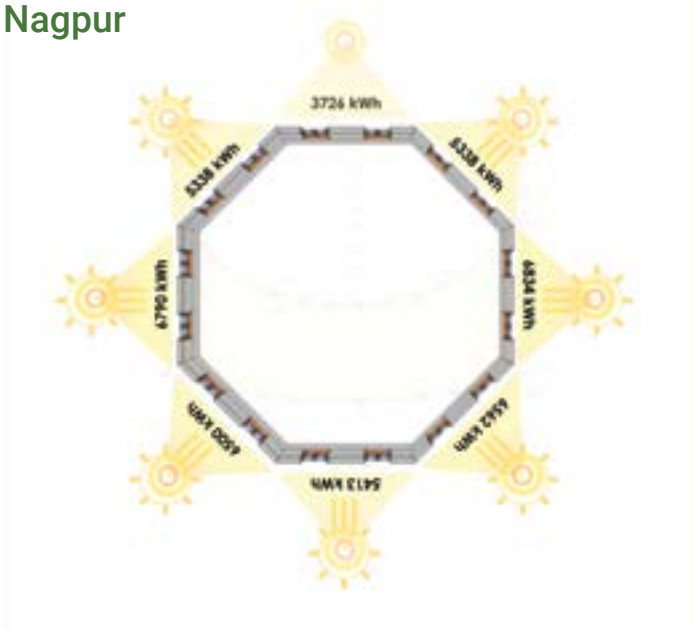


Figure 6. **Incident solar energy [kWh] falling on different faces of the building during the warm period when we need to avoid solar heat gains.**

4.1.2 Optimizing Soft Ground and Hard Paved Surfaces, Minimizing UHI

Urban Heat Island (UHI) Effect: This phenomenon occurs in dense urban areas:

- Paved surfaces, mostly provided for parking and roads, and tall crowded buildings absorb the Sun's rays and retain heat, making the local microclimate warmer in the evenings and nights.
- Slow moving motorized traffic as well as heat emitted by machines such as outdoor AC units, also heats up the space around buildings.

Therefore, minimizing outdoor hard paved surfaces and vehicular movement while maximizing soft ground areas helps in keeping the urban environment cool.

In housing layouts we often see peripheral circulation in the setbacks for vehicular movement/fire tender. The overall hard surface combined with parking requirement and internal roads, thus, increases and contributes to at least 20-25% of the total plot area. This surface is essentially impervious and re-radiates more heat resulting in urban heat island effect.

While planning a large project with internal vehicular circulation one should focus on minimizing vehicular circulation hence the paved surface. Try to use the setback spaces for permeable soft ground and tree cover.

Tucking car parking in stilts under the buildings is a good strategy.

Example: (**See Figure 7**)

Figure 7. **Effect of increasing FSI on soft ground**

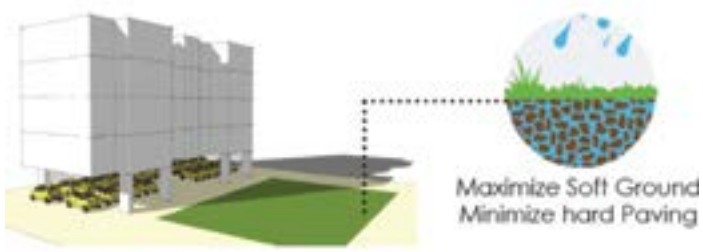


Figure 8. **Tucking car parking in stilts under the buildings to increase permeable soft ground**

Urban Heat Island (UHI)

An urban heat island (UHI) is an urban area or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities. Heat islands form as vegetation is replaced by asphalt and concrete for roads, buildings, and other structures necessary to accommodate growing populations. These surfaces absorb—rather than reflect—the sun's heat, causing surface temperatures and overall ambient temperatures to rise. The urban heat island effect concerns scientists since warmer air temperatures "can impact air quality, public health and the demand for energy," according to NASA.

This layout shows a central main road and a secondary narrow road for vehicular traffic. The last branches are lanes for two wheelers and pedestrians. Following this branching method reduces the amount of paved area for roads.

A good layout will have at least 30% soft ground and not more than 13% of paved roads for vehicular traffic. Lanes and paths can be designed with pervious paving.

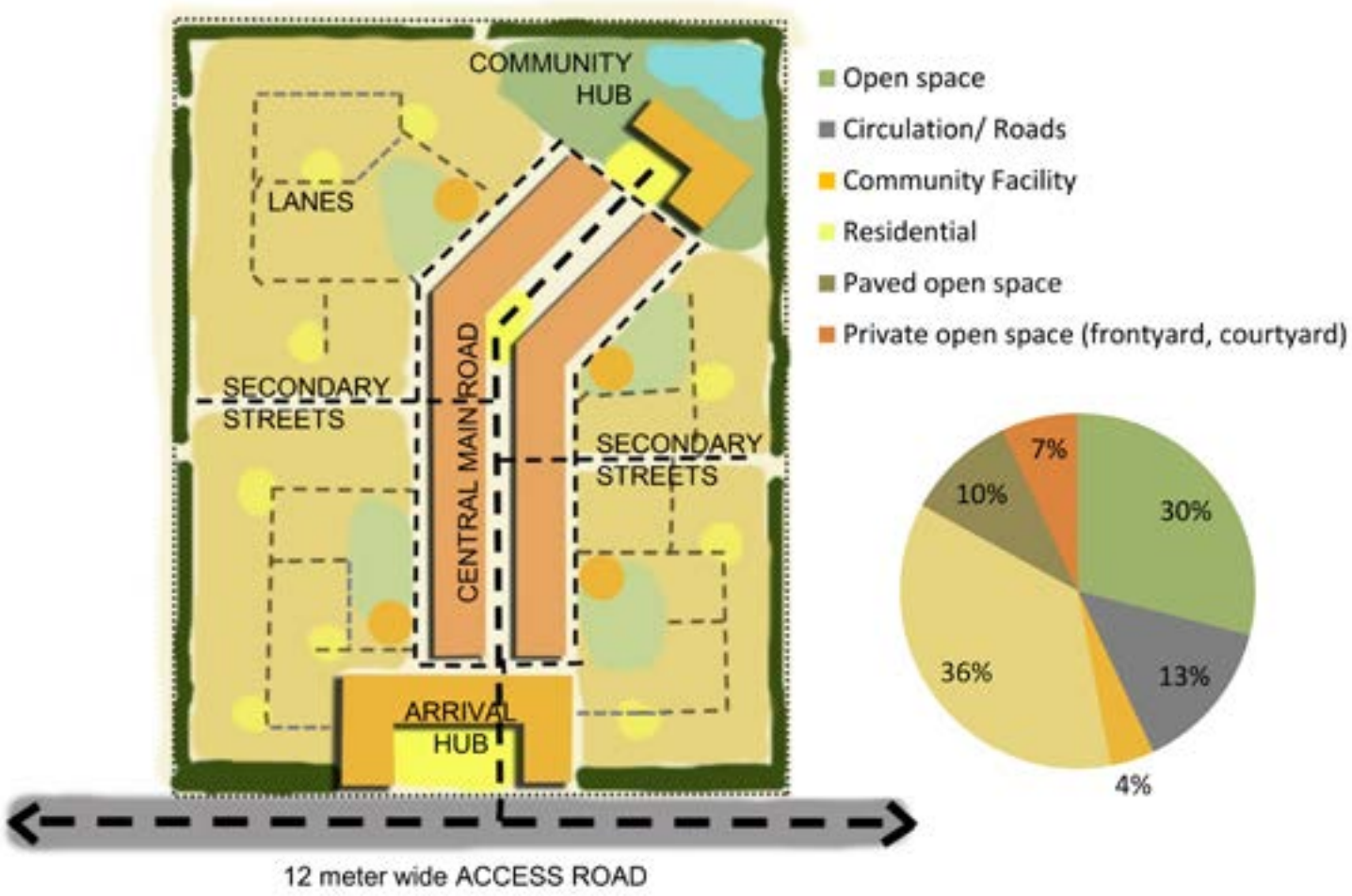


Figure 9. **Optimizing EPS through land-use**

Figure 10. **Types of softscape**

4.1.3 Efficient Use Of Plot Area for Environmental Benefit

The plot area generally gets consumed in the following categories:

1. **Building Footprint**
2. **Hardscape** (Parking, pathway, roads etc.)
3. **Softscape** (Open area, lawns, kids play area)

The hardscape does not allow for rainwater percolation and constantly absorbs and radiates more heat. On the other hand, soft scape helps maximize the 'Environmentally Productive Space (EPS) and provides opportunity for recreation.

Maximizing ground coverage enables one to achieve a high density with low-rise buildings. Stilt+4 typology optimizes area of building footprint, soft ground and hard paved area (roads and parking). This typology releases more soft ground as EPS.

Thus, for optimization of EPS and density S+4 typology makes the best case.

Environmentally Productive Space
Environmentally Productive Space (EPS) is essentially a permeable soft ground that could have space for vegetation, planting etc. and that allows for rain water percolation to the ground thereby also recharging the ground water table. It further helps reduce Urban Heat Island Effect.

EPS can also be increased by utilizing the available rooftop area optimally for plantation, kitchen gardening etc. These activities could also serve the dual purpose of sunshade at roof level, further reducing heat gain in roofs.

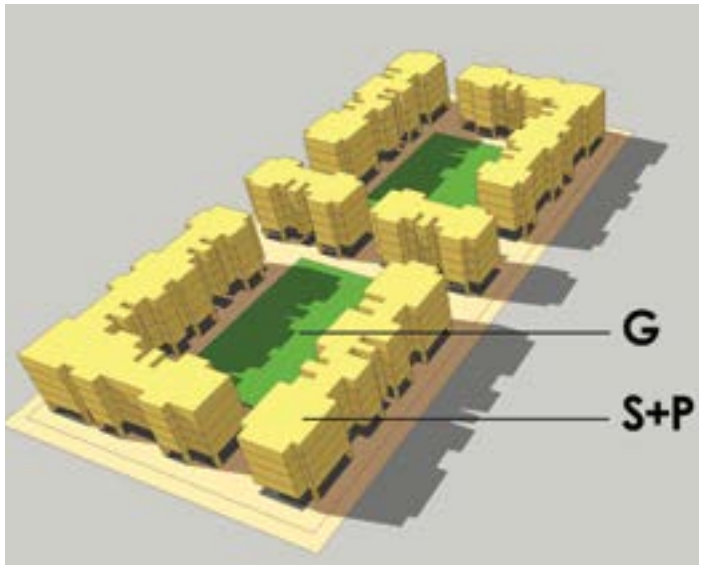


Figure 11. **S+4 typology, maximum EPS**

4.1.4 The Economic and Environmental Implications of Building Tall

It is now well established that the cost of construction, building operation and maintenance goes higher and higher as we build taller and taller. It is also established that the environmental impact of buildings increases as we build taller.

It is found that from the point of cost and affordability as well as environmental impact, 4-5 storey buildings are optimal solutions.

The comparative chart in figure 12 summarizes the relative economic and environmental performance of building low rise, medium rise and high-rise.

However, the reason why taller buildings are built is due to the market cost of land and high FSI. This is a dilemma that needs to be resolved. For a better understanding to make a decision considering cost of land, FSI and number of storeys to be built, you can refer to **Annexure 4**. In case due to the high price of land it becomes essential to increase FSI and

build taller than 4-5 stories, a mixed building height strategy can be economical and environmentally beneficial. This is illustrated in illustration below.

Figure 12. **Comparison of low-rise, medium-rise and high-rise typology**

Figure 13. **Strategies for using higher FSI**

CASE 1 (Base case)

With low-rise structures (S+4)

Land cost: **Low**
Ground Coverage = **30%**
Parking: **Accommodated under Stilt.**
Cost Impact: - **Base Case**
F.S.I. = **1.2**

CASE 2

With mid-rise structures (S+5)

Land Cost: **High**
Ground Coverage = **30%**
Parking: **Stilt and Open**
Cost Impact: **Medium - High**
F.S.I. = **1.5**

CASE 3

With **partial** low (S+4) and mid-rise structures (S+7)

Land Cost: **High**
Ground Coverage = **30%**
Parking: **Stilt**
Cost Impact: **Low**
F.S.I. = **1.5**

The above illustration shows that when land prices are high and there is a possibility to use higher FSI, then a mix of low and mid-rise structures (Case 3) prove to be more economical with higher EPS as compared to building all mid-rise structures (Case 2).

5. Building Envelope

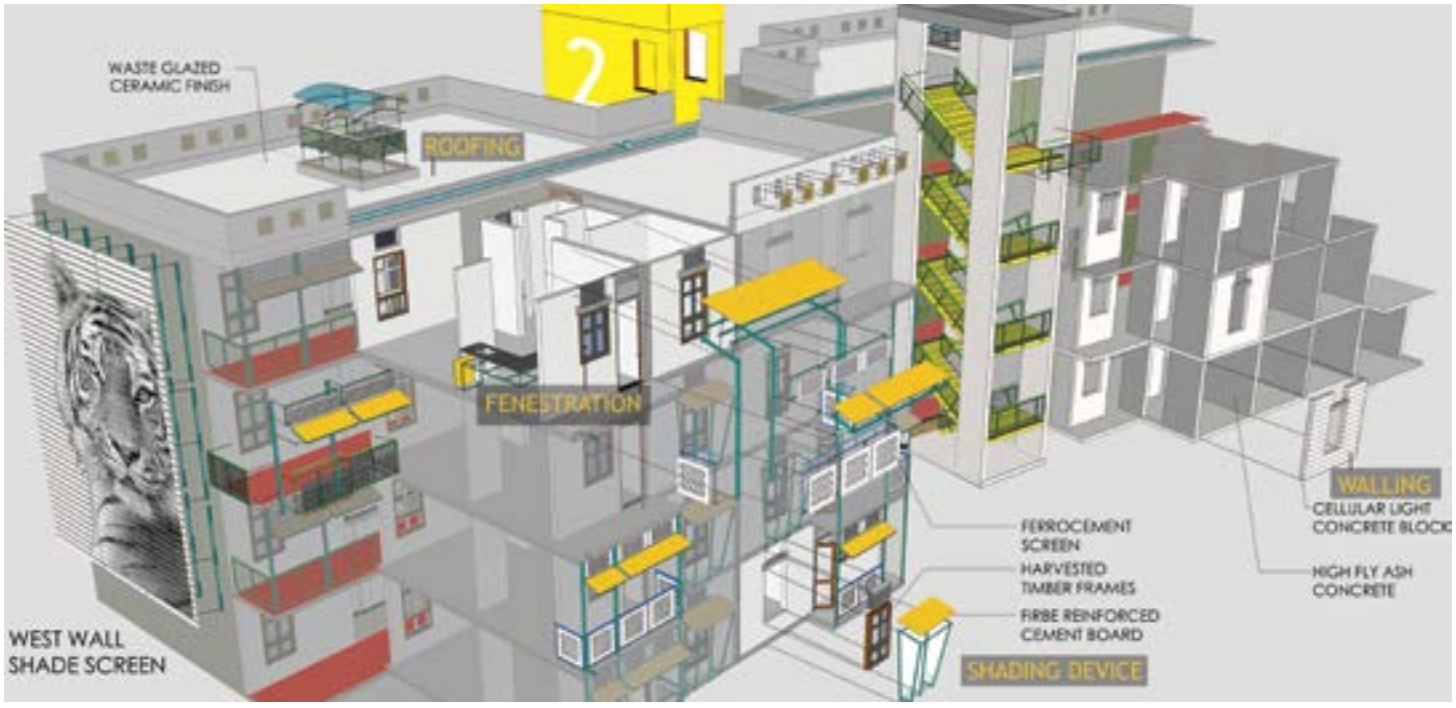


Figure 14. **Components of building envelope**

The building envelope consists of 3 major components:

a) Walls
b) Fenestration (e.g.: window, door, ventilator etc.)
c) Roof

The design of building envelope including type of walling material, sizes of fenestration and roofing insulation together influence solar heat gains, daylighting, ventilation and thermal comfort inside a building.

Building Envelope
Building envelop is the physical separator between the conditioned and unconditioned environment of a **building including** the resistance to air, water, heat, light, and noise transfer. The **building envelope** of a usual residential building consists of its roof, sub floor, exterior doors, windows and exterior walls.

5.1 Minimizing Envelope Heat Gains by Optimizing the Perimeter Wall to Floor Area Ratio

5.1.1 Building Typology in Affordable Housing

The housing typology is of the following 4 major types:

a) Tower Typology

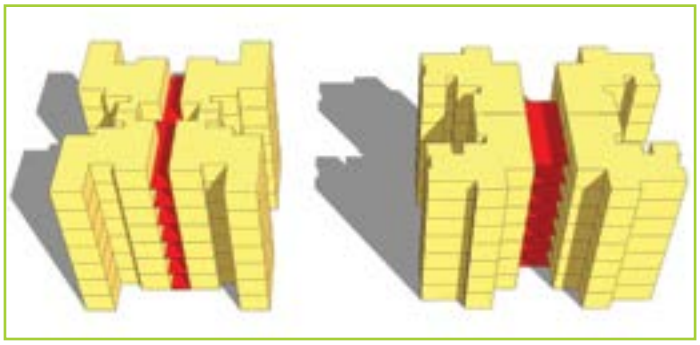


Figure 15. **Tower typology**

This type generally has a central service core with a cluster of 3 to 8 units around it. Generally, there is none or little sharing of walls between adjacent units in this type.

b) Doubly Loaded Corridor Typology

Figure 16. **DLC typology**

The doubly loaded corridor has a common shared passage in the middle with dwelling units on both sides. This type generally has 2 common sharing walls between adjacent units. The passage allows for installation of lifts at an affordable price as the cost can be distributed among a greater number of units.

c) Row Houses Typology

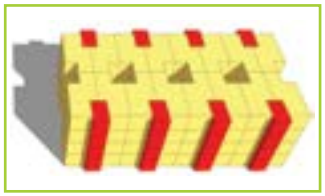


Figure 17. **Rowhouse with upto 3 shared walls**

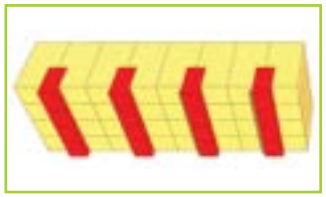
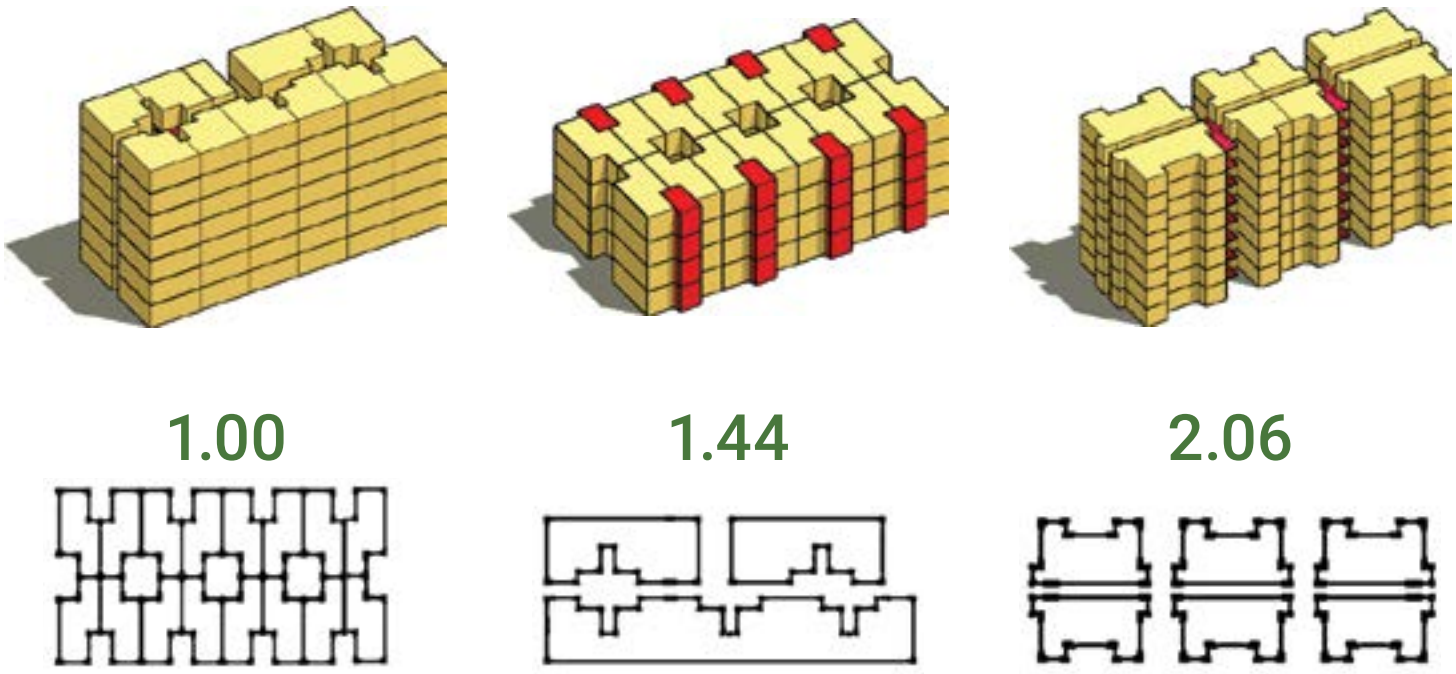


Figure 18. **Rowhouse with minimum 2 shared walls**

- The row house typology are a series of houses that generally share at least two common walls between the adjacent units
- Row house typology with a shared common access staircase helps to minimize exposed envelope as the walls get shared on 3 sides between adjacent units. .
- This typology also helps in reducing cost and time of construction substantially.
- This is ideal for a low-rise high-density development (up to G+3/S+4). This typology is not applicable for buildings taller than G+3 / S+4 height.
- The rear courtyard is shared by 4 houses and has sufficient area to allow for cross ventilation.

In principle, when outdoor temperature is uncomfortably high, we need to ensure the interior of the house does not gain heat through the walls. The lesser the external wall area for a dwelling unit, the more protected it is from heat. Incidentally, greater the sharing of walls among adjacent dwelling units, cheaper the cost of construction too!

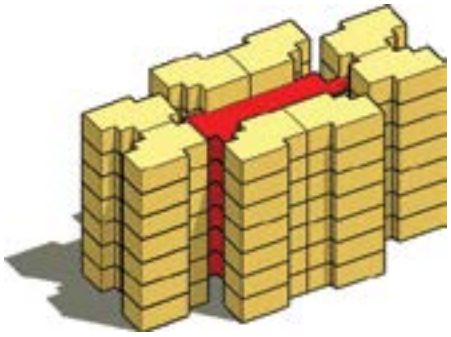
Figure 19. **Comparison of exposed envelope area to floor area for various typology with respect to 4 storey row house**

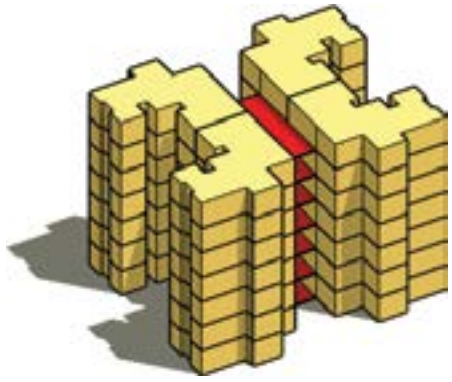


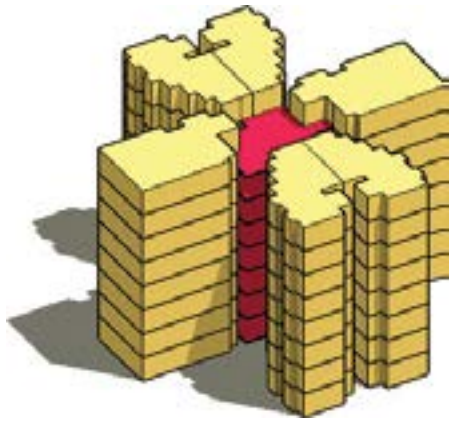
Least Envelope Heat Gain

The housing form should avoid staggered shapes, so that the exposed envelope surface area is minimized. The simple geometry of form also reduces the perimeter of the building block and thus subsequently the cost of construction.

$$\text{EP/A}\ (\text{Envelop Wall Area to Floor Area Ratio}) = \frac{\text{EP}\ (\text{Exposed Envelope Area})}{\text{A}\ (\text{Floor Area})}$$







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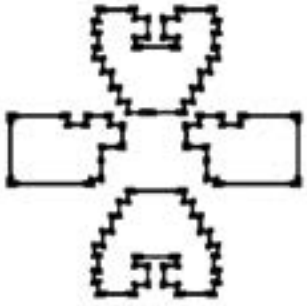

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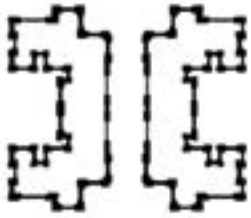

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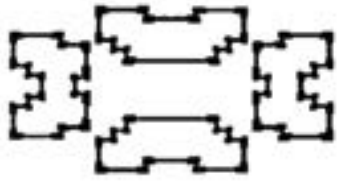


Greater Envelope Heat Gains

The envelope wall area to floor area ratio (EP/A) for a dwelling unit is an indicator of its exposure to heat gains from the outside as well as the cost of making the envelope. In the floor plans shown above, the tower typology in the last case has about 3 times more envelope area to floor area ratio (Refer **Annexure 4** for calculations). This implies 3 times the heat gains as compared to a typical row house and 3 times the cost of construction! We choose building plan types towards least envelop heat gain.

Below are some examples of how dwelling units can be planned to minimize cost as well as heat gains, minimizing the exposed external wall area in relation to the floor area of the dwelling unit.

Figure 20. **Double loaded corridor typology. Same structural configuration is adapted to form larger houses**

Figure 21. **Row house typology, with back to back stacking of units to get better space efficiency**

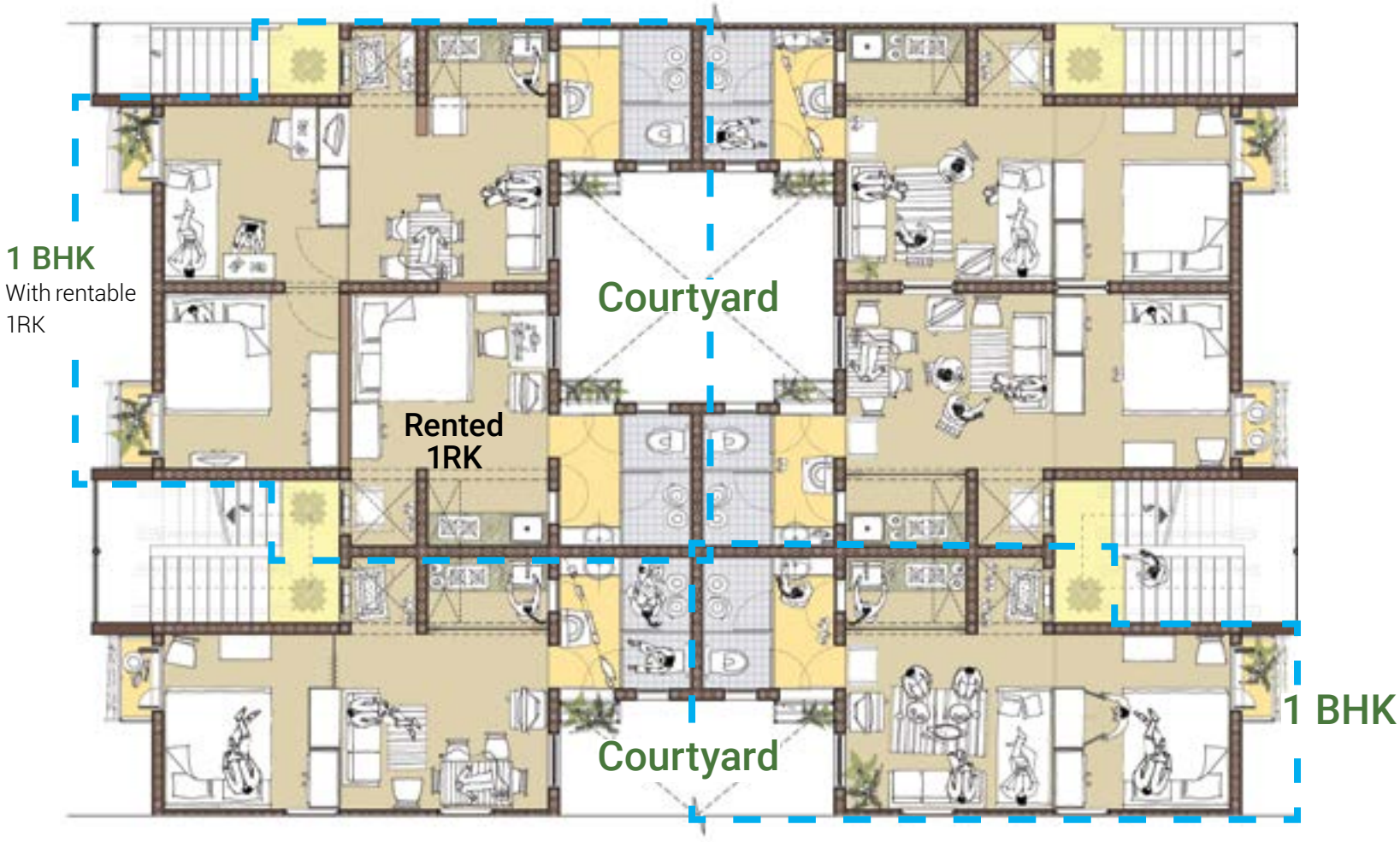
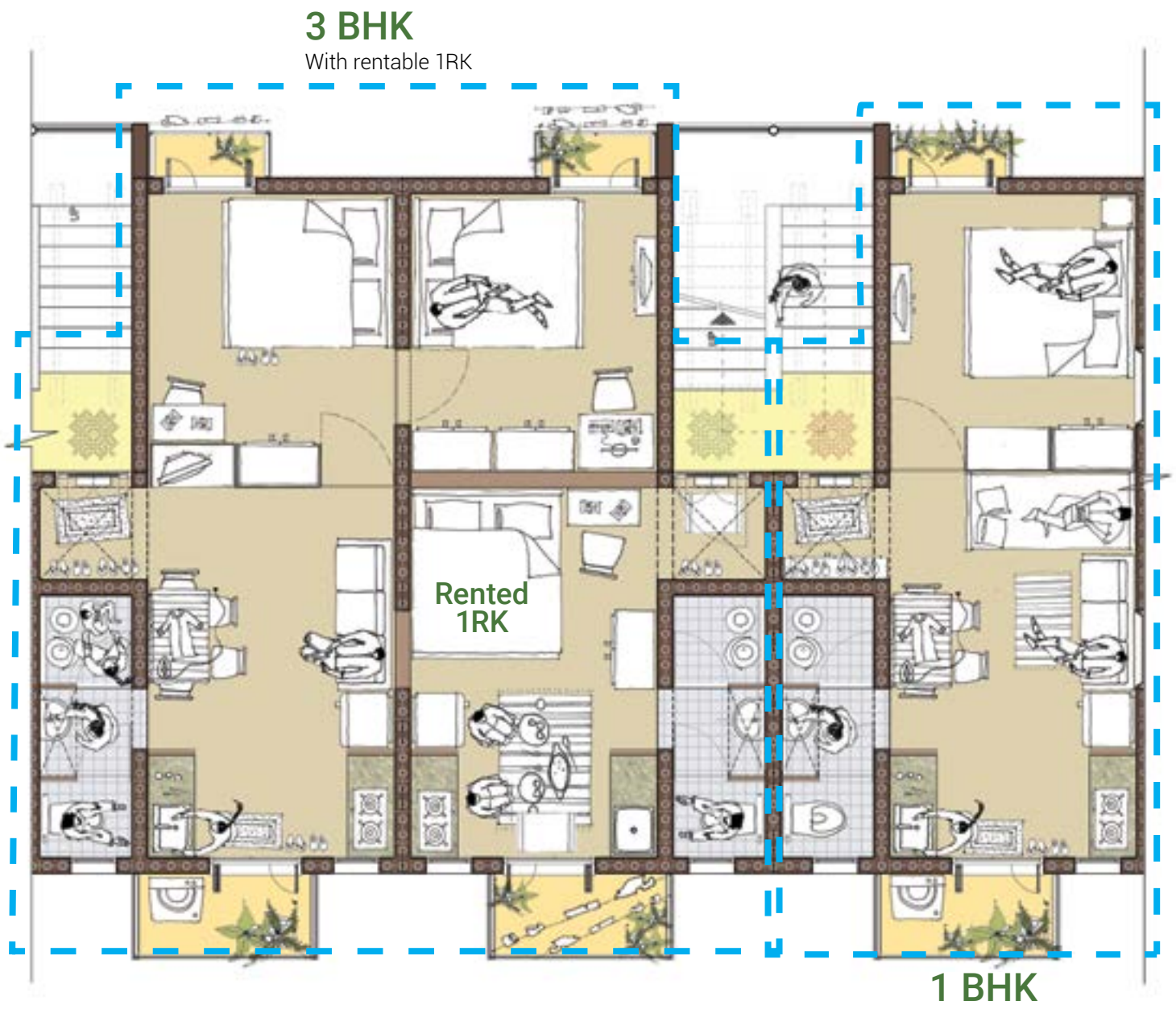


Figure 22. **Row house typology with back to back stacking of units to get better space efficiency**



5.1.2 Walling Material (Opaque Façade)

The opaque part of the building envelope generally consists of the structural frame and the infill walls. The thermal property of conduction of the envelope plays a major role in determining the difference between inside and outside temperature of the building. Walls form the major part of the envelope and thus a low U-value(<1) material helps ensure better thermal comfort in the buildings.

While choosing a walling material one should look for:

a) **U-value:** This represents the rate of heat gain through conduction. A low U-value keeps the indoors relatively more comfortable during the hot and cold seasons. More importantly, the amount of air-conditioning needed to be comfortable can be reduced by about 30% by choosing a walling construction material with low U-value.

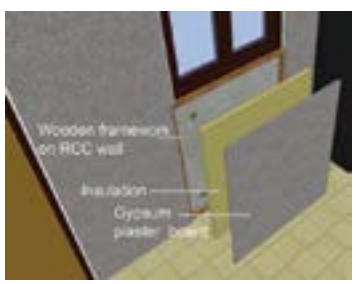
b) **Embodied energy:** Embodied energy is the energy consumed by all of the processes associated with the production of a material, from the mining and processing of natural resources to manufacturing, transport and product delivery. The higher the embodied energy of a material, the greater the CO2 emissions caused by it. A low embodied energy causes less harm to the environment.

c) **Density:** In multi-storey frame construction where we have non-load bearing infill walls, it is beneficial to have a low density walling material as it reduces the dead load of the structure and therefore reduces the requirement of concrete and steel of the RCC structure. This brings down the embodied energy of construction and also the cost of the RCC structure.

Table 1 Types of Walling Construction with U-value.

The lower the U-value of a walling construction, the less heat is transmitted through the wall. **A 150 mm RCC (U-value = 3.3 W/m^{2}K)** and a **230 mm plastered burnt clay brick wall (U-value= 2.1W/W/m^{2}K)** do not give the required thermal performance).

Below are options of walling methods to achieve the desired thermal performance.

S.N.	Material	U-value W/m^{2}K	Approximate Cost[5] Rs/sqm of wall area	Visual Representation
1	**150mm RCC wall + 40mm mineral wool board insulation + 12mm fibre cement board** Cement fibre board has a density of 1355.8 kg/m^3 and a thermal conductivity of 0.14 W/m^{2}K	0.50	2,150	

S.N.	Material	U-value W/m^2K	Approximate Cost[5] Rs/sqm of wall area	Visual Representation
2	**115mm brick + 40mm mineral wool board insulation + 12mm cement board** 115mm brick wall is not sufficient resistance to heat. Adding an insulation layer on the inside overcomes this problem.	0.57	1,850	
3	**200mm hollow clay bricks** Hollow clay bricks offer two advantages simultaneously: • they are light-weight • they have a relatively low U-value	0.61	1,750	
4	**200mm AAC blocks** This walling system offers two advantages simultaneously: • It is light-weight • It has a relatively low U-value	0.77	1,950	
5	**115mm brick + 100mm AAC** This combination is very effective wall construction to achieve thermal comfort. However, in warm-humid conditions, to prevent condensation in the wall when using air conditioners, bitumastic paint is applied.	1.1	2,000	
6	**230mm flyash brick** Flyash has a lower U-Value than burnt brick and is therefore preferable. It has the additional advantage of recycling industrial waste fly ash from thermal (coal based) electricity generating plants	1.93	1,700	

5 Cost calculation is done on the basis of CPWD DSR, 2019

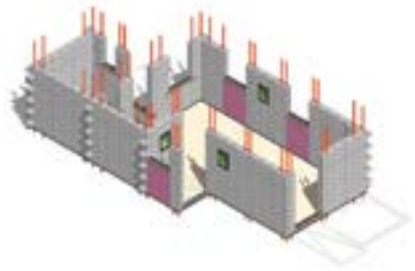
5.1.3 Constrained Masonry: Hollow Core Interlocking Blocks

This new method of construction reduces the requirement for reinforcement steel down to approximately 20kgsteel/ sqm of built-up area. This provides two significant benefits, reduced cost and reduced embodied energy of construction. This qualifies for credits under ''Embodied Energy''.

This block can be easily manufactured in a batching plant at site with the help of a compressing machine. The production may be completely mechanized or semi-mechanized as required. These machines are generally capable of producing up to 4000 blocks per day.

This system is suitable for buildings up to G+3 height. The block size generally comes in 150x300x100mm or 180x360x100mm

Table 2 Construction Process with Hollow Core Blockwork Masonry

 The typical row house design with hollow core interlocking blocks, showing vertical reinforcement in red.	
No shuttering is required for raising vertical structure in this structural system.	
A lintel band runs along the entire wall, which helps bind the masonry together.	

5.1.4 Fenestrations (Non-Opaque Façade)

The adequate size of openings on the facade helps in optimizing natural ventilation in the house. The design type of these windows/ventilators such as casement, sliding, top hung, bottom hung etc. determines the effectiveness of fenestrations in achieving thermal comfort.

Openable window-to-floor area ratio (WFRop) indicates the potential of using external air for ventilation. Ensuring minimum WFRop helps in ventilation, improvement in thermal comfort, and reduction in cooling energy.[6]

$$WFR_{op} = \frac{A_{openable}}{A_{carpet}}$$

The required operable window-to-floor area ratio varies according to the climate zone as shown in the following table:

Minimum Requirement of Window-to-floor Area Ratio, WFR_{op}	
Climatic zone	**Minimum WFR_{op} (%)**
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

Source: Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS

Figure 23. **Window-to-floor area ratio** Source: ECO-NIWAS SAMHITA 2018

Figure 24. **Casement window (90% operable area)**

Figure 25. **Sliding window (50% operable area)**

6 Chapter 3, ECO NIWAS SAMHITA

Default Openable Area to Opening Area Ratio	
Type of window / door/ ventilator	**Percentage**
Casement	90%
Sliding (2 panes)	50%
Sliding (3 panes)	67%

Figure 26. **Sliding window (50% operable area)**

While designing windows and ventilators one must not just look at WWR but also how these openings are distributed along the façade. The size and placement of these openings should be such that it helps in maximizing the cross-ventilation, especially in warm and humid climate. The following figure shows how having 2 smaller windows with openable ventilators is better at helping in heat exchange as compared to a single casement window of the same operable area.

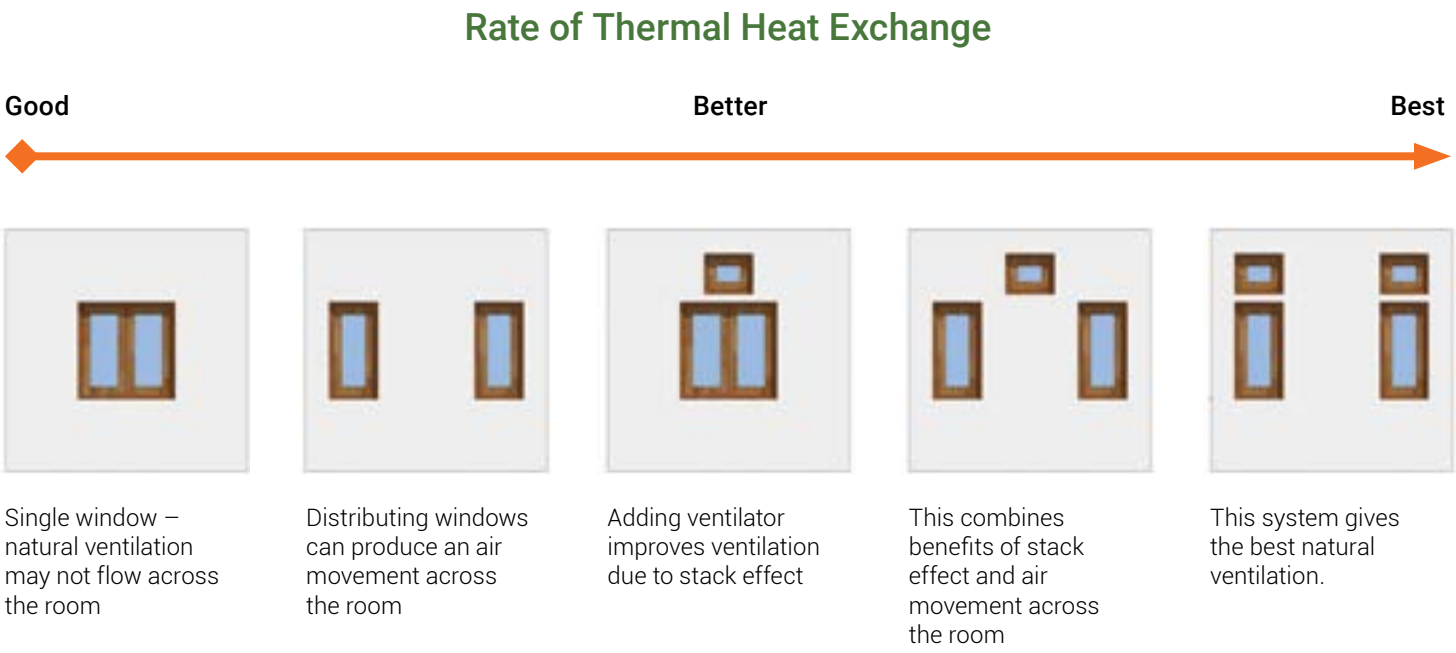


Figure 27. **Comparison of different openings on façade with same WWR for better heat exchange**

Source: Annexure 9, Eco-Niwas Samhita 2018

5.1.5 Roofing Insulation

Roof insulation plays a major role in achieving thermal comfort especially for the houses just below the terrace. The major heat gain in these houses is through conduction from the roof and thus an insulation layer within the terracing helps in reducing solar heat gains. The finishing material for terrace should be light colored and reflective such as a china mosaic tile finish or heat reflective paints.

The surface temperature of the roof surface can be brought down significantly by applying a high SRI value paint.

Figure 28. **Use reflective surface on terraces to help reduce solar heat gains**

Figure 29. **Roof with reflective finish**

Figure 30. **Roof without reflective finish**

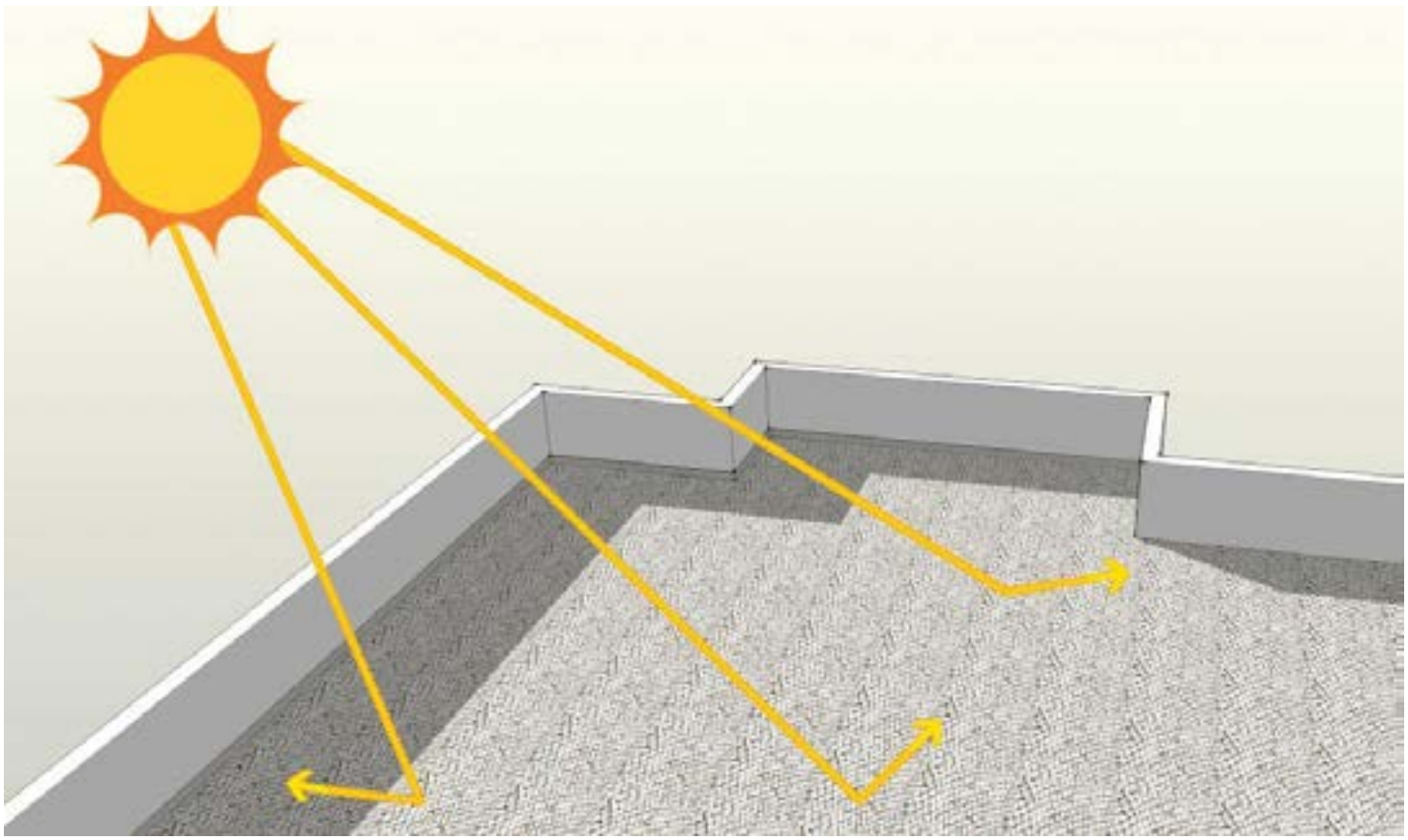
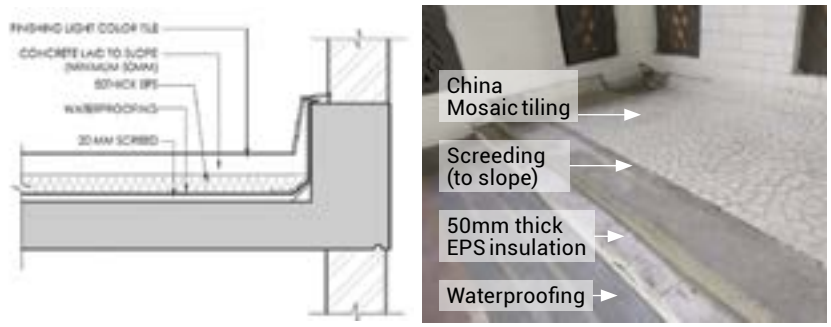
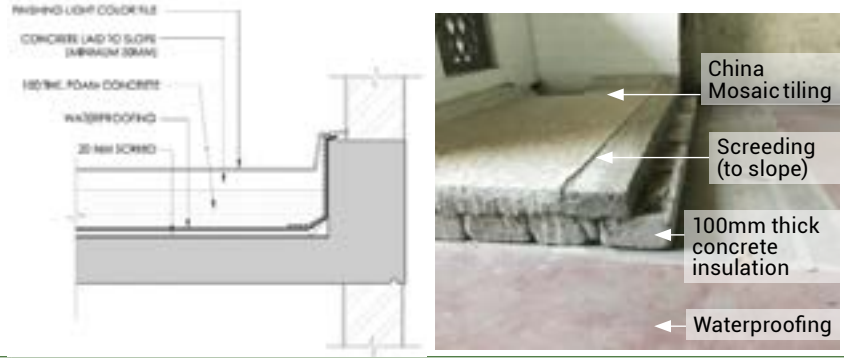


Table 3 Types of Roofing Construction with U-Value Less than 1

S.N.	Material	U-value W/m2k	Cost Rs/sqm	Visual Representation
1	Terracing with **50mm thick EPS insulation**	0.64	2,250	
2	Terracing with **100mm thick foam concrete** insulation	0.62	2,050	

5.2 Shading Device (Windows/Balconies)

The non-opaque part of the façade contributes to greater

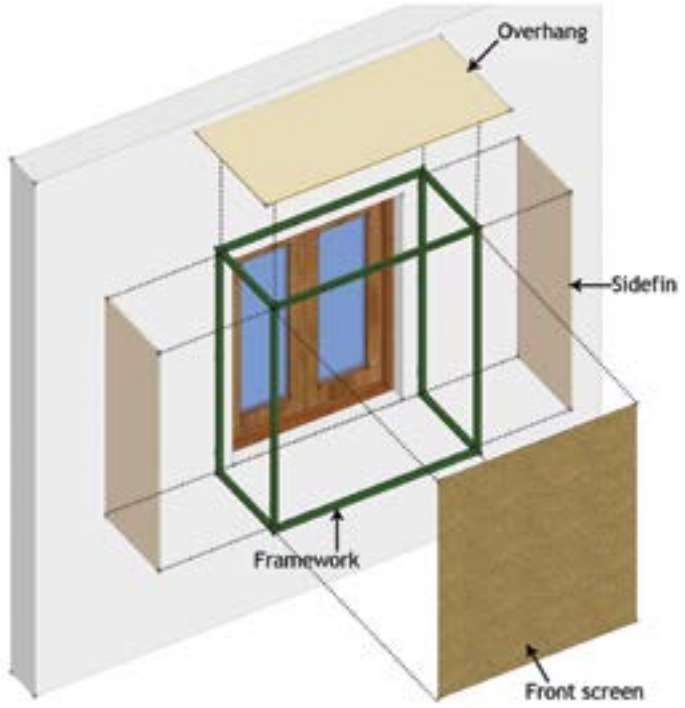


Figure 31. **Components of the shading system**

solar heat gains as compared to the opaque part. Thus, shading the windows, ventilators etc. becomes even more critical. Shading requirement for a fenestration is based on the direction it faces. Shading elements can either be horizontal (overhang) or vertical (side fin and front screen).

This may be achieved through the following ways:

a) A **hinged** or **pivoted** shutter with optimum size perforations/cut-outs/openings etc. This shutter could be made from various materials like-
   1. Punched galvanised steel louver panel
   2. Painted louver wooden panel
   3. Perforated metal/plastic screens
   4. Water-resistant/ WPC boards
   5. Treated Bamboo chiks

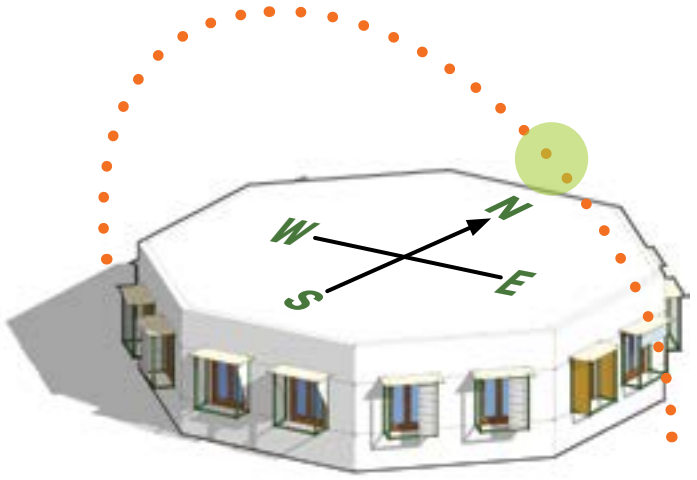


Figure 32. **Shading frame can easily adapt to various orientations**

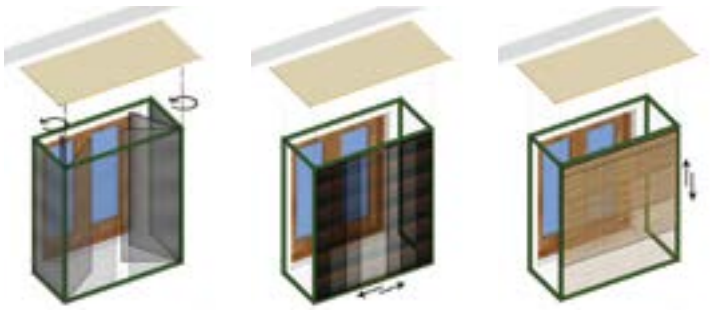
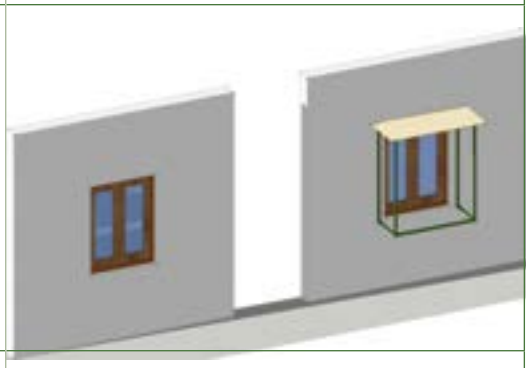
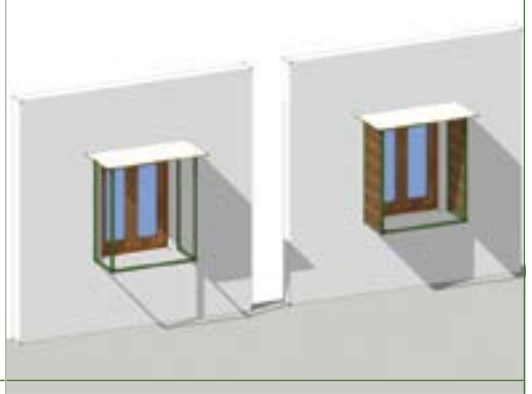
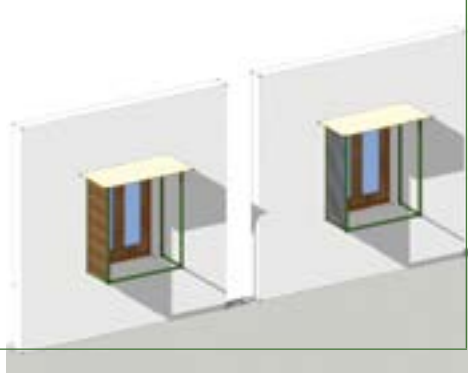


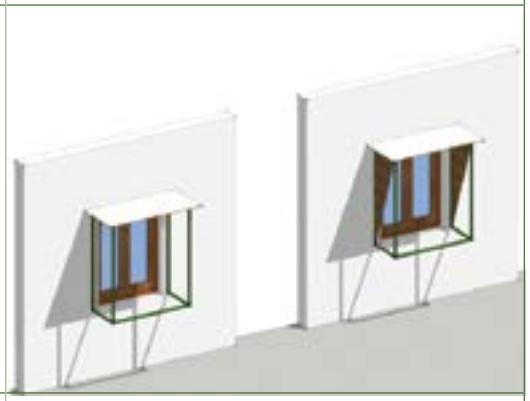
Figure 33. **Systems for shading screen assembly**

b) A **retractable** system with a breathable and translucent membrane. This system could be further classified in two categories:
   i) **Sliding-folding** (horizontal movement) - Here, stretchable, durable and abrasion resistant nylon and polyester fabrics/curtains can be slided along two rods fixed on top and bottom of the fabric.
   ii) **Roll-up roll-down** (vertical movement) - Here, materials like bamboo chiks, foldable fabrics (Ferrari), cloth etc. could be used.

Table 4 **Shading Device Components with Respect to Orientation**

The table below summarizes the design for window shading devices for various orientations.

	Orientation	Overhang	Side Fins	Front Screen	Illustrations
1	**North Façade** (above tropic of cancer)	✓			
	The Northern facade in **northern latitudes** of India receives direct solar radiation only in the extreme summer months, during early morning and late afternoon. The horizontal overhang of 50cm to 60cm depth, usually provided to protect the window from rain, provides shade against the high altitude sun and has an additional benefit of reducing the diffused radiation from the sky impinging on the window.				
2	**North Façade** (below tropic of cancer)	✓	✓		
	The Northern facade in **southern latitudes** of India, however, is exposed to direct solar radiation during the morning and evening hours for a much longer period of the year compared to the exposure in Northern latitudes. Also, the angle of incidence of the sun's rays on the façade is less oblique and more impactful. Hence, it is necessary to provide vertical fins on the Eastern and Western sides of the window in addition to the horizontal overhang above the window.				
3	**North-Eastern/North-Western Façade**	✓	✓		
	The North-East and North-West facades face the rising and the setting sun respectively during the hottest part of the year. This is most critical for the North-Western façade. This can be dealt with by putting fixed screens/shutter across the face of the window. The screen can have slits or perforations on 15-20% of the surface area. This would allow for better ventilation, while blocking 80% of direct solar radiation.				

	Orientation	Overhang	Side Fins	Front Screen	Illustrations
4	**Eastern/Western Façade**	✓		✓	
	The East and West facades are exposed directly to the strong radiation of the sun for the entire morning on the East face and for the entire afternoon on the West face. The East facing window needs protection from the sun during the morning. The West facing window needs to be protected during the afternoon. A screen or shutter is necessary across the face of the window. Since this is necessary for only half of the day, a good solution is to have a movable shading system across the face of the window.				
5	**Southern Façade**	✓	✓		
	The openings on **south façade** generally face lesser direct solar radiation as the sun altitude is higher. Here, the major role is played by overhangs. However, some amount of sun does get in from east and west as the sun ascends and descends. Thus, an overhang and fixed sidefins are sufficient.				
6	**South-Eastern/South-Western Façade**	✓	✓	✓	
	The south east and south west facades are exposed to both the lower altitude sun and the overhead sun and gets solar radiation from both side and front. So, it is neccessary to provide shading provision on sides and front as well. This can be achieved by having fixed sidefins and a movable front screen. Movable shading screens can operate in the following ways: a) Hinged/pivoted system b) Retractable system i) Sliding/folding screen ii) Roll-up roll-down				

6. Water Efficiency

In order to achieve water security for a given development, an integrated approach to manage the water is essential.

6.1 Water Management Strategy

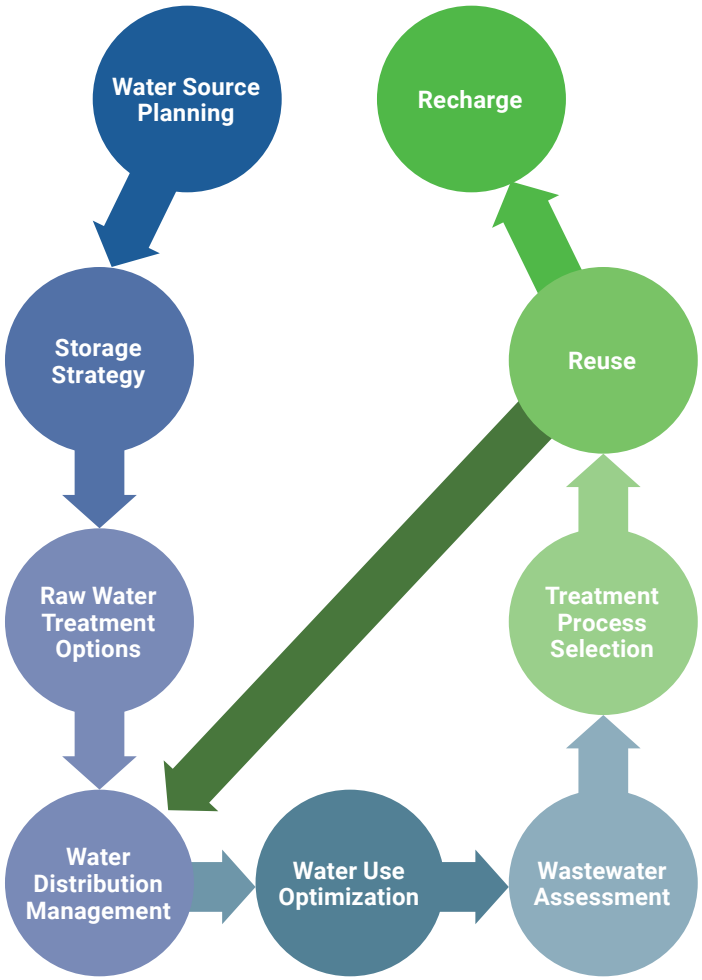


Figure 34. **Flowchart for efficient water management**

6.1.1 Water Resource Planning

6.1.1.1 Groundwater Management System

For residential housing schemes that depend on underground water for its domestic supply, it is pertinent to understand the hydrogeology of the site. Hydrogeological features such as depth of water table, geological profile, drawdown curve, hydraulic gradient, transmissivity, storativity of the aquifer is required to be understood.

Based on the depth of groundwater table, dynamic hydraulic head and pump discharge capacity, the annualized cost of extraction for a population of 1,000 persons with average

Water Efficiency

The cost of water in today's world is far lesser than the price of water. Due to lack of adequate management of existing water resources and increased levels of water pollution, access to fresh water continues to be a source of worry in many areas of the world (including India). Water efficiency strategies in green building practices have become paramount to both new and existing construction efforts. Considering water efficiency in Green Buildings, today several technologies are being used including rainwater harvesting, recycling and reuse of grey water, low-flow fixtures, sensors etc. Water efficiency measures in residential and commercial buildings can greatly reduce water waste, yielding lower sewage volumes, reduced energy use, and bring in financial benefits too.

per capita demand of 100 L, ranges from ₹4 to ₹10 per Kilo Litres per day (KLD).

A detailed pump cost analysis can be found in Annexure 7

Table 5 Cost Comparison of Varying Depth to Groundwater

Depth to GW	Pump Capacity	Discharge Range	Pump Cost	Borewell Cost	Annualized Cost/ KLD
500 feet	5 HP	60 – 120 LPM	₹ 30,000	₹ 60,000	₹ 4
1000 feet	9 HP	150 – 240 LPM	₹ 45,000	₹ 1,00,000	₹ 6
1500 feet	15 HP	~200 LPM	₹ 90,000	₹ 1,35,000	₹ 10

6.1.1.2 Municipal Water Supply

For residential schemes with municipal water supply, two cases are applicable

Figure 35. **Steps to determine volume of municipal supply**

Case 1 – Household Supply

1. Measure average daily hours of supply – hours
2. Measure the average discharge of supply (use bucket method) – Litres per hour
3. Compute Total volume of supply = Daily water supply (hours) * Discharge (litres per hour) = Litres/Kilo Litres (A)

Case 2 – Tanker Supply

1. Determine frequency of tankers – everyday/once in two days/ twice per week
2. Measure the volume of water each tanker supply – litres
3. No of tankers per day; average tanker capacity (litres) – Litres/Kilo Litres (B)

$$\text{Compute \% demand catered by municipal supply} = \frac{(A)+(B)}{\text{Total daily demand (population x litres per person per day)}}$$

For sizing of underground storage tank, please refer section on storage strategy.

6.1.1.3 Rainwater Harvesting Management

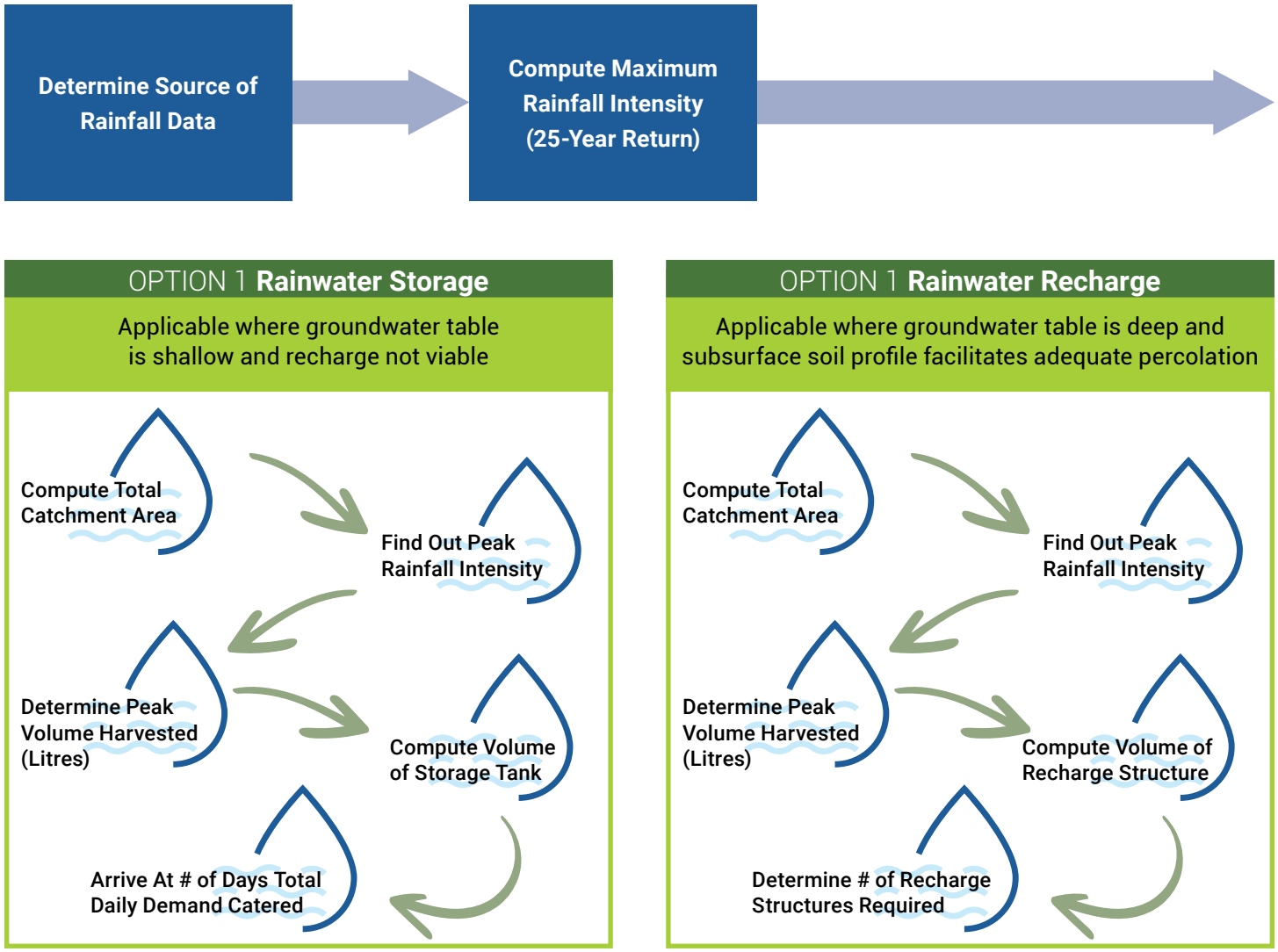


Figure 36. **Flow diagram for calculation of RWH storage tank and recharge well sizes.**

Table 6 Case Examples Showing Volumetric and Cost Estimation of RWH Storage Tank

Parameter	Unit	Case 1 Gujarat	Case 2 Madhya Pradesh/ Chhattisgarh	Case 3 Karnataka
Annual rainfall	mm	500	800	1,200
Total saleable area	sqft	1,50,500	1,50,500	1,50,500
Peak rainfall intensity	mm/hr	20	25	30
Roof-top area	sqm	3,600	3,600	3,600
Runoff coefficient		0.85	0.85	0.85
Paved surface	sqm	1,000	1,000	1,000
Runoff coefficient		0.75	0.75	0.75
Green area	sqm	1,500	1,500	1,500
Runoff coefficient		0.5	0.5	0.5
Annual rainwater harvested	litre	22,80,000	36,48,000	54,72,000
Peak volume of water harvested	litre	91,200	1,14,000	1,36,800
Option 1 - Size of storage tank required	cum	91	114	137
Cost of storage tank	Rs/sqft	11	14	16

Computation of peak rainfall intensity is a complex exercise (refer list of vendors at the end of the section)
For source of rainfall data, refer to imd.gov.in/pages/services_hydromet.php

Example: For a peak rainfall of **20 mm/hour (annual rainfall 500 mm)**

Catchment distribution (Plot area 10,000 sqm)

a. Roof-top area: 3,600 sqm runoff coefficient: 0.85
b. Paved surface: 1,000 sqm runoff coefficient: 0.75
c. Green cover: 1,500 sqm runoff coefficient: 0.5

Table 7 Case Example Showing Cost Comparison Between Recharge and Storage Structures

Percentage Rainwater Captured	Annual Rainwater Captured (Litre)	No of Days Water Demand Met Per Year	Volume of Storage Tank Required (M^3)	Storage Cost (₹/sqft)	Number of Recharge Wells Required	Recharge Cost (₹/sqft)
100%	22,80,000	24 days	91	₹ 12	23	₹ 8
75%	17,10,000	18 days	68	₹ 9	17	₹ 6
50%	11,40,000	12 days	46	₹ 6	11	₹ 4
25%	5,70,00	6 days	23	₹ 3	6	₹ 3

1. **Total annual rainfall captured (litres) = Total catchment x Annual rainfall x Runoff coefficient**

2. No of days water demand met = $\frac{\text{Total annual rainfall captured (litres)}}{\text{Daily total water demand (litres per day)}}$

3. Volume of storage tank required (cubic meters) = $\frac{\text{Total catchment area (sqm) x Peak rainfall intensity (mm per hour) x Runoff coefficient}}{1000}$

4. Storage cost (₹/square feet) = $\frac{\text{Volume of storage tank (cubic meter) x Cost per cubic meter}}{\text{Total saleable area (square feet)}}$

5. Number of recharge wells = $\frac{\text{Total catchment x Runoff coefficient x Peak rainfall intensity}}{\text{Average capacity of 1 recharge well (litres))}}$

6. Recharge cost (₹/square feet) = $\frac{\text{Total number of recharge wells x Cost per recharge well}}{\text{Total saleable area (square feet)}}$

The design of storage tank depends upon peak rainfall intensity (25-year return period). Depending upon the climate zone and daily peak rainfall, the size of tanks or number of recharge wells should be determined.

It can be seen from the table above that cost of rainwater storage tank is almost double the cost of recharge wells.

6.1.1.3.1 Recharge Well

Capture Rainwater From Catchments → **Prefiltration Chamber (Sand, Gravel, Aggregates)** → **Recharge Well (Unlined Bottom)**

Average size of recharge well: Diameter 3'/4'/5' feet, Depth 10'/15'/20' feet, Storage volume ~2,000 – 10,000 Litres

Design of down-take pipes from roof depends upon peak discharge. Usually 3" or 4" PVC pipes are used

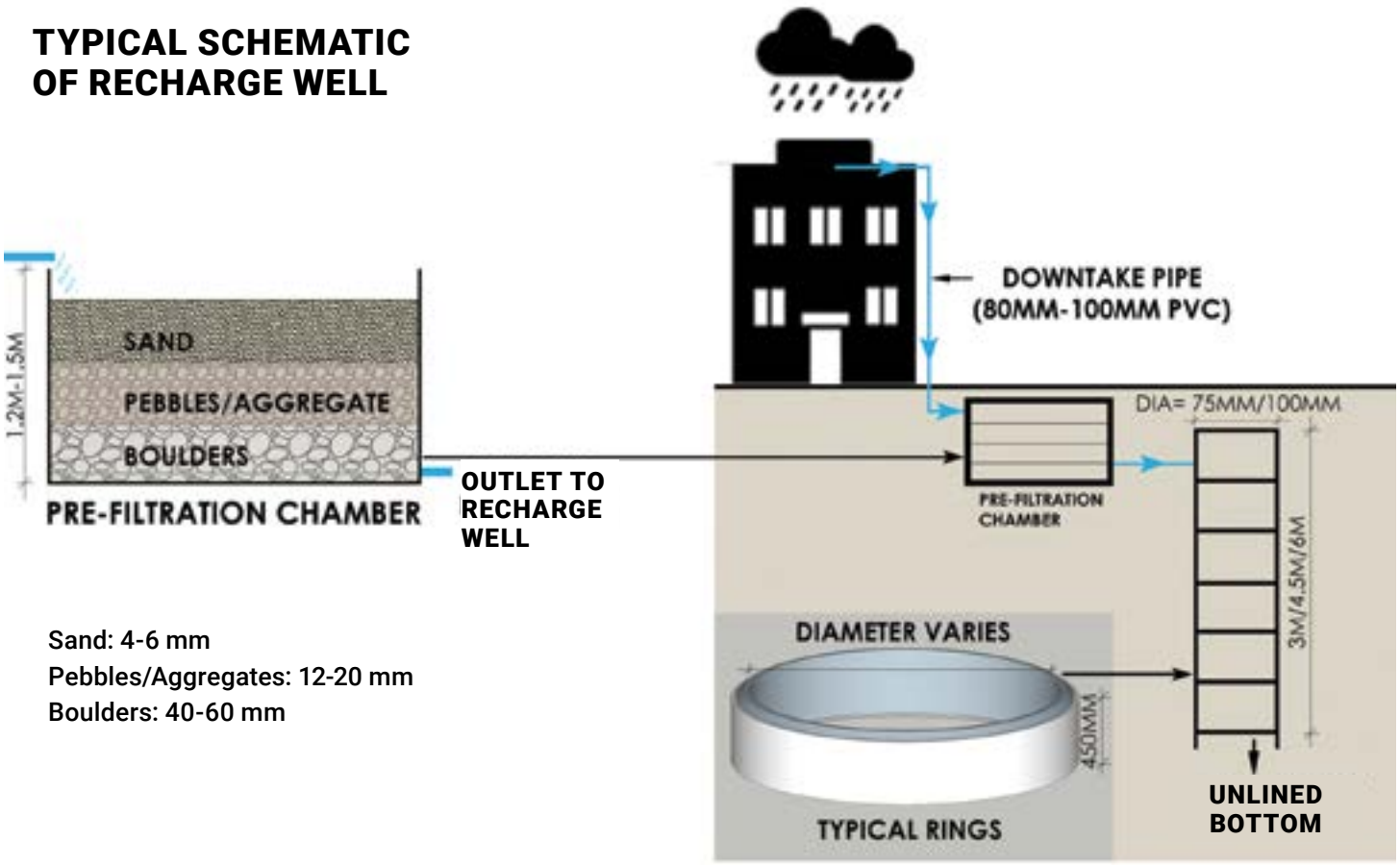


Figure 37. **Stages of rainwater harvesting with recharge well system**

Percolation Rate: For recharge wells, the percolation rate is an important criteria to assess the size of well.

Table 8 Strategic Recommendations for RWH in Various Cases

Case	Recommendation
Shallow groundwater table (4-6 feet below ground)	Store the captured rainwater
Rocky strata below ground	Store the captured rainwater to avoid excess cost on excavation
Moderate – deep groundwater table	Recharge well
Presence of onsite bore well/hand pump	Connect rainwater pipe to existing bore well/hand pump

Table 9 List of Advisory Institutions for RWH

List of Advisory Institutions	Website	Contact Details
BIOME Environmental Solutions	biome-solutions.com	+91 80 4167 2790
Mr. A R Shiva Kumar **Karnataka State Council for Science & Technology, IISC Bangalore**	www.kscst.org.in	ars@kscst.iisc.ernet.in
CDD Society	cddindia.org	+91 80 2848 6700

6.1.2 Strategy for Storage Tank Sizing

Storage tank is required:

- To store potable water from multiple source for consumptive use except flushing
- To store treated water for flushing

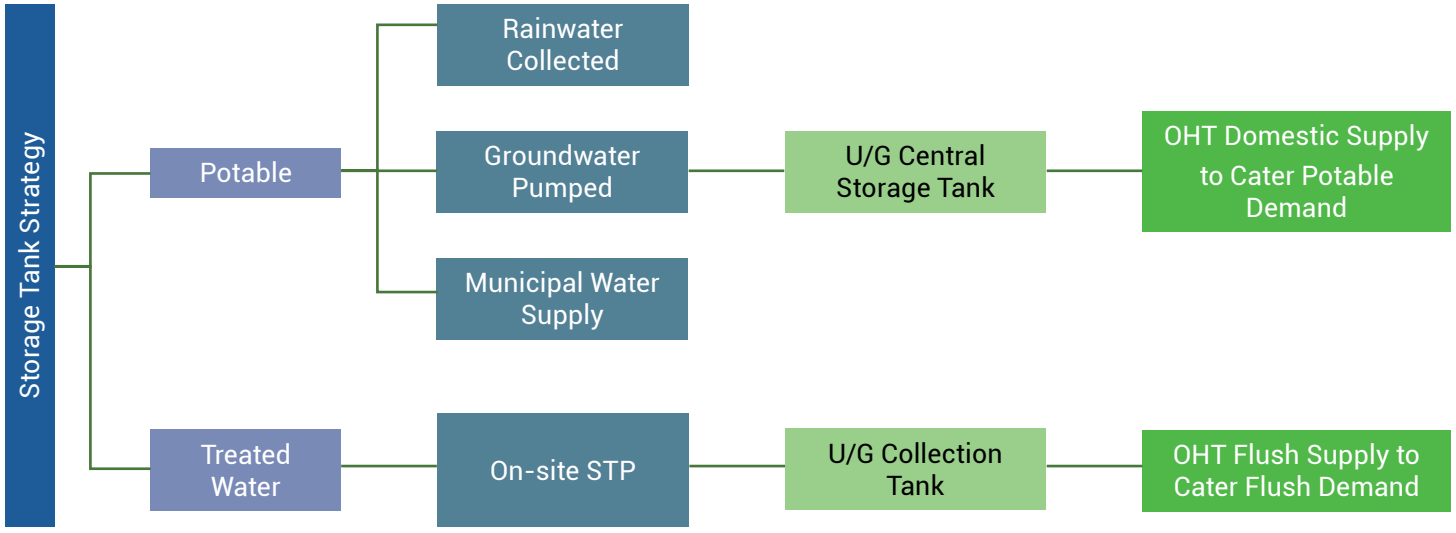


Figure 38. **Flow diagram of potable and treated water**

Size of centralized underground storage tank:

Highest of

- Total peak rainfall harvested through storage (m^3) = from earlier section = 91 m^3
- Total water demand at 95 LPCD for 1.5 days (m^3) = 142 m^3
- Average daily municipal water supply (m^3) = ~ 50 m^3

Treated water

- Total volume of greywater treated (A)= 4.6 m^3/day
- Total flush water demand (~30 litres per person per day * no of persons per block) = 80 * 25 = 2000 L or 2 m^3/day(B)
- Excess treated water for recharge/landscape = (A) – (B) = 2.6 m^3/day

Table 10 Sizing of Potable and Treated Water Storage Tanks

U/G Storage Tank — Centralised	Quantity	Units
Rainwater harvested captured	91	M^3
Water demand 1.5 days	142	M^3
Avg. daily municipal water supply	50	M^3
Recommended size of tank	142	M^3
Treated O/H Storage Tank — One for Each Block		
Daily greywater treated	4.6	M^3
Daily flush water demand	2.0	M^3
Recommended size of tank	2.0	M^3
Water for landscape/recharge	2.6	M^3

Table 11 Strategic Recommendations for Storage Tank Sizing for Various Cases

Case	Recommendation
Shallow groundwater table (4 – 6 feet below ground)	Increase U/G tank surface area by fixing depth
Deep groundwater table (beyond 20 feet)	Flexibility to increase depth of U/G tank with optimal area (this reduces the overall footprint of tank)
Rocky strata (4 – 5 feet below ground)	Construct semi-underground tank + increase its surface area to reduce cost of blasting/excavation

6.1.3 Raw Water Treatment Systems

If the quality of raw water does not meet the prescribed standards of IS 10500:2012, additional treatment is required. There is no need to treat the raw water to match drinkable quality. A centralized water softener can be installed to the non-potable requirement of the households. Whereas, at household level, individual Reverse Osmosis (RO) systems can be installed for potable use (drinking and cooking). For the sake of affordability, it is recommended to install water softener when Groundwater is the primary source of water supply. Generally, Municipal water supply does not require additional water softening.

Below matrix showcases best suited technologies for water softening.

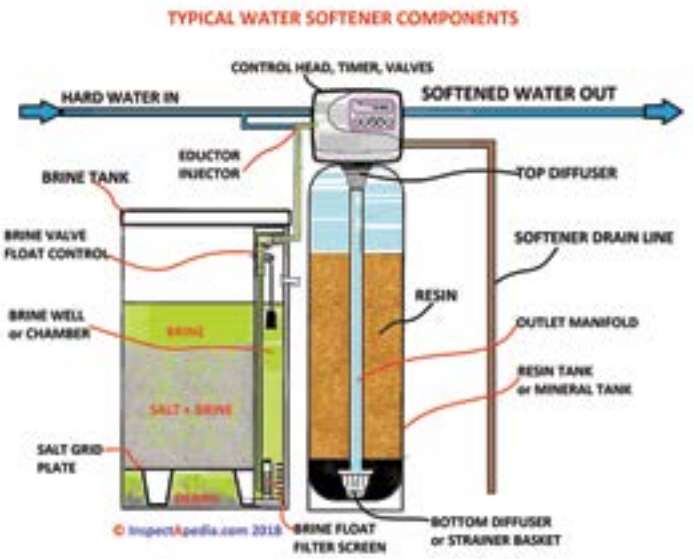


Figure 39. **Process of raw water treatment**

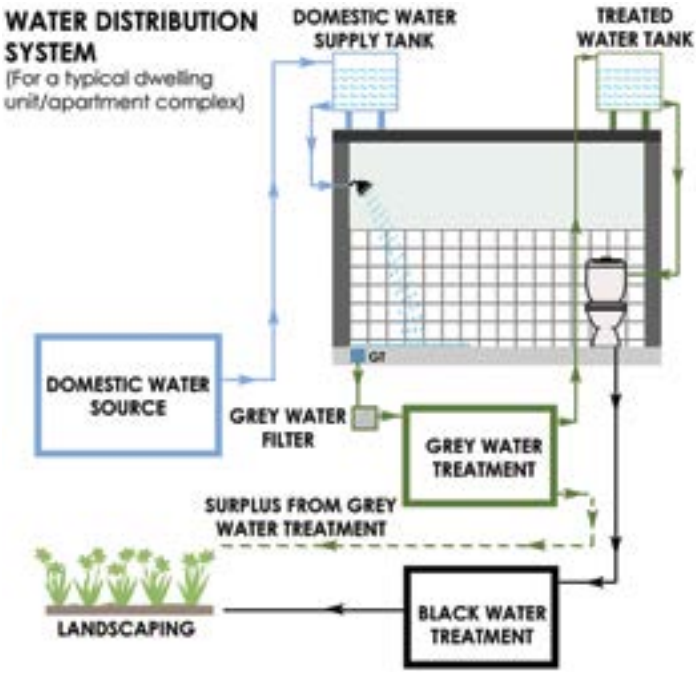
Table 12 Comparative Matrix of Raw Water Treatment Systems

Treatment Technology	Characteristics	CAPEX*	OPEX*	Suitability
Water Conditioner	• Easy installation & cost-effective • No replacement, no electricity • Prevents scale & also breaks down existing scale – without salts, chemicals or electricity • Provides an endless supply of 'softened' water without further cost or maintenance	₹1,50,000 for 80-150 Liter Per Minute (LPM)	₹6,000 per Year	• For individual/group households • Suitable for green rating • Lower O&M costs • Medium – high TDS
Ion-Exchange Technology (Salt Based)	• Works for up to 1200 ppm hardness level • Corrosion free • Works on ion exchange process • Salt replacement every three days • Availability of local service providers • Low-medium skilled operator	₹3,85,000 for 200 LPM	₹18,000 per year	• Less than 800 – 1200 PPM hardness • Medium O&M
Auto Water Softener	• Automatic regeneration technology • Time based regeneration • Enhanced quality of water • LCD Panel for Control	₹59,000 for 5,500 Liter Per Day (LPD)	₹18,000 per year	• Smaller capacities • Sensitive operations • Salt exchange for three days

6.1.4 Water Distribution Management

The water can be conveyed through two types of piping mechanisms;

- Single stack piping
- Dual stack piping



As per recent guidelines of Ministry of Housing and Urban Affairs[7], Government of India:

"In all new government buildings/Group Housing Societies, public buildings, whenever building plan is approved, it should be ensured that there should be dual piping as has been provided in City/State/UT BBLs"

As per the above statement, it is now mandatory to install dual piping mechanism in new developments across India. The water can be supplied through two technologies; Gravity and Hydro-pneumatic system. A summarized comparison is shown as follows:

7 http://mohua.gov.in/upload/whatsnew/5d1c7709d059eGuidelinesUWC_JSA03072019.pdf

Overall, the gravity-based distribution system is more apt for low-income housing. Despite having high capital cost compared to hydro-pneumatics system, the O&M cost is low and therefore generates savings.

Table 13 Comparative Matrix of Water Distribution Systems

Technology	Advantages	Disadvantage
Gravity	• Low O&M cost (no skilled operator required) • Easy to maintain • No continuous requirement of power	• Additional piping in form of risers • Additional number of tanks
Hydro-pneumatic	• Robust and long-lasting • Usability of roof top • Reduce number of tanks	• Skilled operator required • Installation of additional DG set and its operation expenses high • Complicated system

6.1.5 Water Use Optimization

Installation of water meters to identify and reduce leakages and monitor consumption

Installation guide:

1. At UG Tank outlet – to measure the quantum of domestic water supply (₹1,500 – ₹5,000 per meter)

2. At inlet of each dwelling unit – to measure quantum of water consumed per household (₹750 – ₹1000 per HH).

Household Inlet ⊗ **Household Uses**

3. At outlet of sewage treatment plant – to measure the quantum of water (black and grey) treated together or separately (₹2,500 – 5,000 per meter).

STP Outlet ⊗ **Landscape/Reuse/ Recycle**

6.1.5.1 Low Flow Fixtures

Low flow fixtures are now available at economical prices in India. Using these fixtures for faucets, showerheads and WC/cisterns cuts down water consumption by about 20% compared to conventional fixtures. This enables one to earn the credits for water conservation.

Figure 40 **Faucets/taps with aerators**

Figure 41 **Low flow showerheads**

Figure 42. **Dual flush cistern**

Low-flow Showerheads

Low-flow showerheads are designed for flow rate of less than 7 lpm.

Low-flow Toilets

Low-flow toilets and ultra-low-flow toilets have been designed to use half the amount of water of traditional toilets. Low flow toilets will have flushing with less than 7 lpm or 7 lpf.

Typically, the cistern size for Low-flow toilets would be 5-7 ltrs. The cistern will have two flushing options- short flush and long flush.

Faucets/Taps

All faucets whether for kitchen sinks or wash basins or bathing should have a flow rate of less than 7 lpm.

An aerator or flow restrictor can be added to almost any faucet, providing for an easy and cheap modification of standard fitting.

The table below shows the maximum flow rates of the fixtures at a water supply pressure of 3.16 kg-f/sq.cm. or 3.1 bar:

Table 14 **Maximum Flow Rates of the Fixtures**

Fixture	lpm/lpf
WCs (solid/liquid)	7/7
Kitchen faucets	7
Lavatory faucets	7
Urinals	3
Showers	7

6.1.6 Planning and Design of Wastewater Treatment System

Figure 43. **Wastewater management system**

In the above schematic the black water generated from a household is treated and used for gardening/ landscaping purposes. On the right, greywater generated from the house is being treated and used for toilet flushing, car washing etc. It is a sustainable approach to separate wastewater at source to optimize the treatment cost and area.

Arriving at STP capacity is important to avoid over designing or under designing the system. The following schematic provides an approach to arriving at STP capacity.

Sources — Identify sources of wastewater from the campus i.e. household, canteen, offices, training centers, etc.

Capacity — Once the source type is identified, calculate wastewater generation from each source and arrive at the wastewater treatment capacity, refer Annexure 1 for detailed examples

Choose Technology — Once the capacity is identified, choose the technology suitable for context using table 6.2.2

Contact Service Provider — Once the technology is chosen, contact the service provider for implementing WWTP.

6.1.6.1 Planning for Wastewater Systems

Sewage Treatment Plants (STP) are site specific, innovative and can be designed on the basis of techno-socio-economic feasibility for an integrated solution. For example, the grey water and black water separation would optimize the capital cost of the treatment infrastructure as the **grey water doesn't require secondary treatment and needs a less sophisticated disinfection module**. It is seen that the capital cost for treatment reduces **to nearly 25% by separating grey and black water**. Any consequent increase in conveyance cost can be reduced by locating the treatment plant close to the source.

Type	Pro's	Con's
Combined	• Low plumbing cost	• High treatment cost
Separated	• Low treatment cost • Better water quality	• Increase in plumbing cost

Type	Area	Cost
Combined	1.5-5 m^2 / KLD	50,000 ₹/KLD
Separated	1.5-5 m^2 / KLD	37,000 ₹/KLD

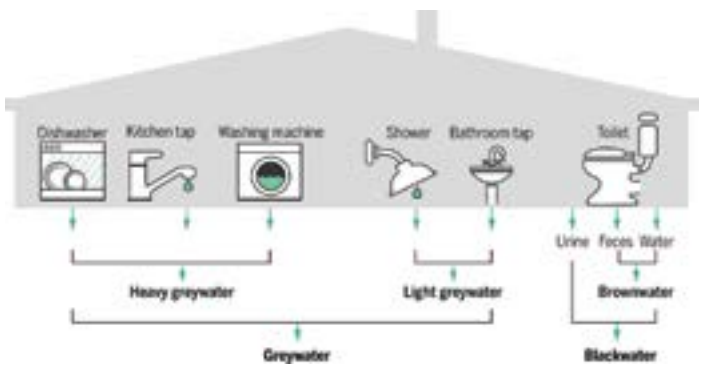


Figure 44. **Sources of domestic waste water**

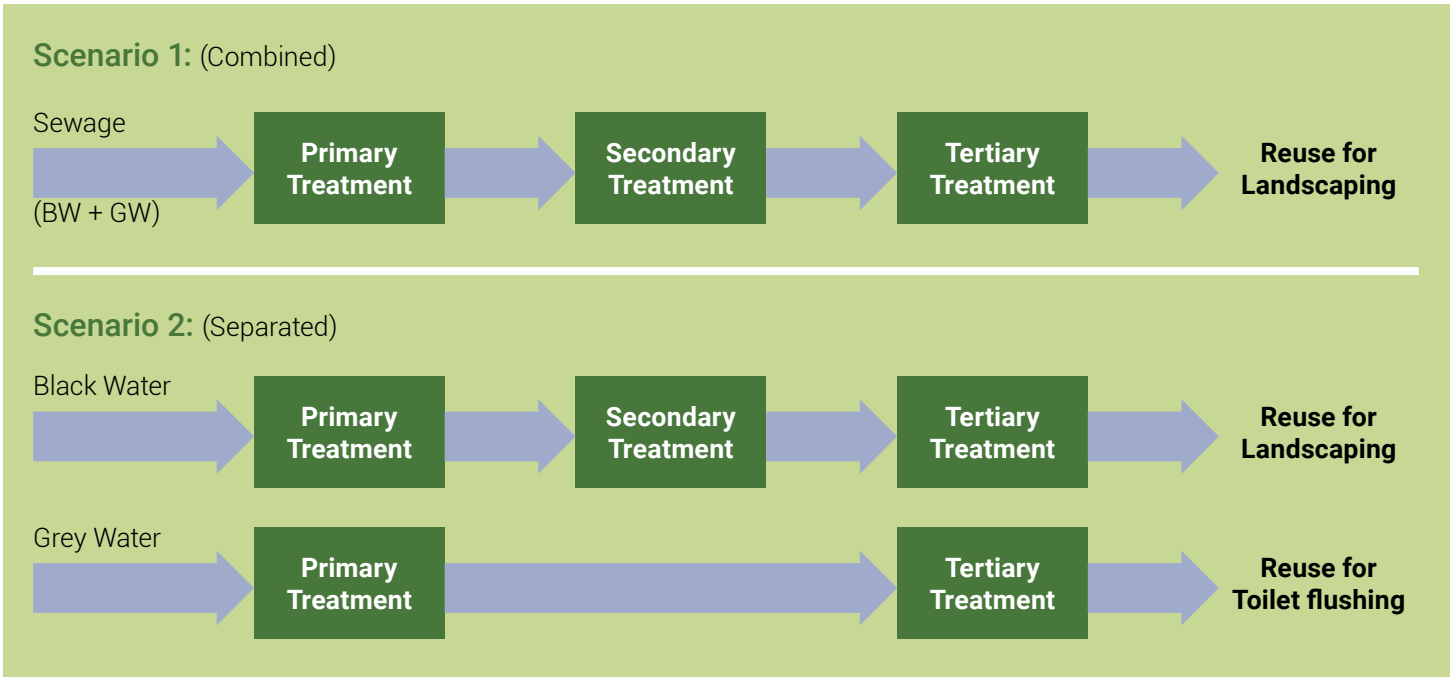
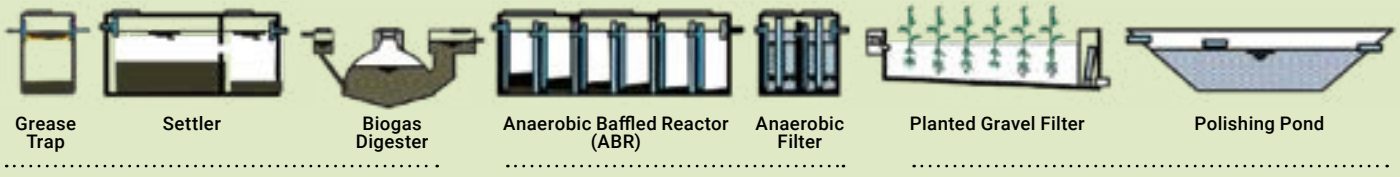


Figure 45. **Wastewater treatment systems**

6.1.6.2 Schematics for Wastewater Systems



Stage	Primary Treatment	Secondary Treatment	Tertiary Treatment
Efficiency	40-50%	75-90%	95-97%
Maintenance	Monthly inspection Desludging every 2-5yrs	Monthly inspection Desludging every 2-5yrs	Monthly garden trimming And check/ adjust filter

Figure 46. **Wastewater treatment process in DEWATS™**

A. DEWATS™

DEWATS™ recommends a decentralized approach - building many smaller systems to treat wastewater close to the point of generation, enabling water to be effectively reused for toilet flushing and gardening. Simply designed using natural bacteria, plants and gravity instead of electricity and chemicals, it is ideal for India where electricity is not reliably available and skilled manpower is hard to come by. It is also very easy to integrate aesthetically into built environments and is adaptable to a variety of wastewater characteristics.

Key Features of DEWATS™

1. 80% Lower O&M costs than comparable technologies
2. No electricity required

3. No chemicals added
4. Minimal maintenance
5. Integrated with landscaping
6. Produces biogas and nutrient-rich water that are re-usable
7. Capacity 1,000 — 1 Million liters per day (1-1,000 KLPD)

B. Phytorid Wastewater Treatment Technology

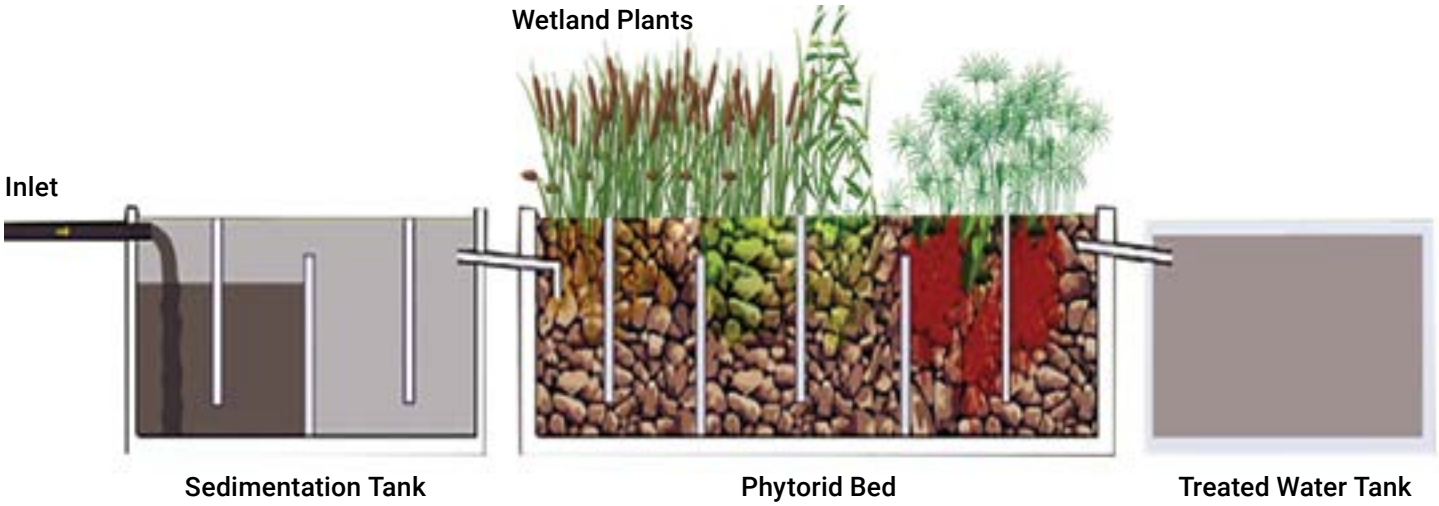


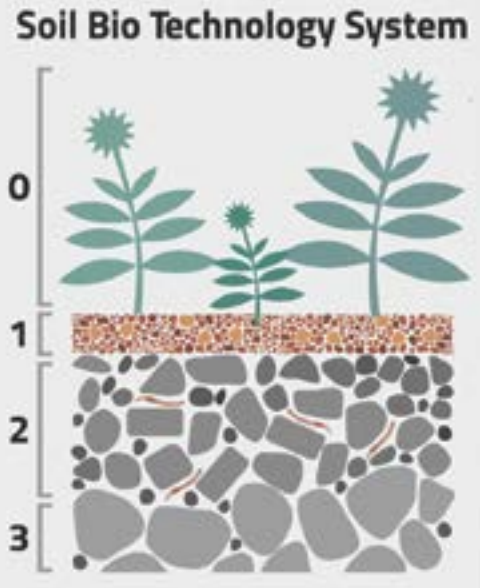
Figure 47. **Wastewater treatment process in Phytorid System**

1. CSIR-NEERI's technology involves a constructed wetland exclusively designed for the treatment of municipal, urban, agricultural and industrial wastewater.
2. The system is based on the specific plants, such as Elephant grass (Pennisetumpurpurem), Cattails (Typha sp.), Reeds (Phragmitessp.), Cannas pp. and Yellow flag iris (Iris pseudocorus), normally found in natural wetlands with filtration and treatment capabilities. Some ornamental as well as flowering plants species such as Golden Dhuranda, Bamboo, Nerium, Colosia, etc. can also be used for treatment as well as landscaping purposes.
3. The phytorid technology can be constructed in series and parallel modules / cells depending on the land availability and quantity of wastewater to be treated.
4. The phytorid technology treatment is a subsurface flow type in which wastewater is applied to cell / system filled with porous media such as crushed bricks, gravel and stones. The hydraulics is maintained in such a manner that wastewater does not rise to the surface retaining a free board at the top of the filled media.
5. The system consists of the following three zones: (i) inlet zone comprising of crushed bricks and different sizes of stones, (ii) treatment zone consisting of the same media as in inlet zone with plant species, and (iii) outlet zone.
6. The reduction in the treated effluent for the total suspended solids (TSS) varied from 70% to 80%, BOD from 78% to 84%, nitrogen from 70% to 75%, phosphorus from 52% to 64% and fecal coliform from 90 % to 97%.
7. The treated effluent is useful for municipal gardens, fountains and irrigation.
8. The total area required for the system is approximately 35 sq.m. for 20 m^3/day.
9. This technology has been transferred to General Techno Services, Techno green Environmental Solutions, Pune, BIOUMA, Goa and Devi Agencies, Aurangabad, and implemented to save water and cater the local people.

C. Soil Biotechnology (SBT)

1. Very low energy use intensity due to high natural oxygen transfer in process. (0.06 kWh/kL sewage).
2. Very low space intensity of 0.8-1.0 sqm/kL per day sewage.
3. An engineered evergreen natural process with no moving parts except for pumps.
4. No sludge due to ecology at work.
5. Very high bacteria, BOD, COD, suspended solids, colour, odour, ammonia removal.
6. Practically maintenance free.

Figure 49. **Soil biotechnology plant** | Image source Prof H.S.Shankar, IIT Bombay



Depth of the Layer	Composition	Function
LAYER 0	Green Plant	Bioindication of the health of the system
LAYER 1	Gravel	Prevents soil erosion Traps grease
LAYER 2	Crushed laterite rock Soil Clay brick Earthworms Active bacterial culture	Biodegradation of organic matter in wastewater Aeration Filtration Increase of retention period for treatment
LAYER 3	Boulders	Facilitates the drainage of treated water

Figure 48. **Wastewater treatment process in soil biotechnology system** | Image source Sugam.in

D. Sequencing Batch Reactor (SBR): Process Description:

SBRs are based on the activated-sludge treatment process. SBRs use a batch approach in which secondary sewage treatment occurs in a single tank. In the first stage of SBR treatment, influent is added to the batch-reactor tank and aerated. Following aeration, the wastewater is allowed to settle. Finally, the treated wastewater is removed from the top of the tank using a decanter valve, pump, or airlift tube. At smaller scales in India, SBR tanks were found to be constructed of reinforced concrete or mild steel.

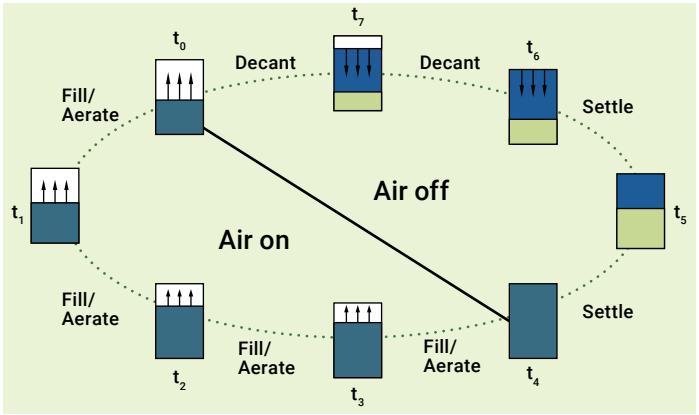


Figure 50. **SBR technology process** | Image source Ethics Infinity Pvt. Ltd.

Advantages:

1. Allows for react, settle, and decant phases to occur within the same tank
2. Does not require secondary clarifiers or return-activated-sludge (RAS) lines
3. Generally has lower capital costs than MBR-based systems
4. Is an automated process
5. Requires a relatively small footprint

Disadvantages:

1. Can face issues with high peak flows—unless already factored into design
2. Requires higher skill level for maintenance, due to more complex system setup (automation/instrumentation)
3. Generally offers a lower level of wastewater treatment than MBR-based systems

E. Moving Bed Bioreactor (MBBR)

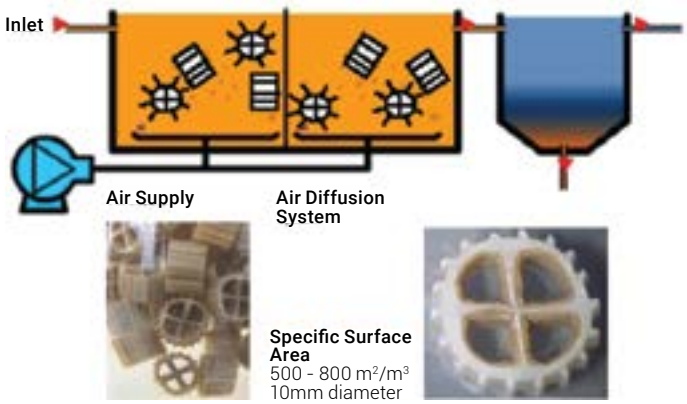


Figure 51. **Treatment process in MBBR** | Source: Makes India Clean (http://www.makesindiaclean.com/mbbr/)

MBBRs biologically treat wastewater by circulating moving media in aerobic, activated-sludge environments. The moving media is typically a floating plastic substrate colonized by a community of bacteria. These bacteria form a biofilm on the plastic surface. Increased levels of biofilm enhance the biological treatment process by introducing a more robust microbial community. In addition to the biofilm attached to the plastic carriers, biomass in the system also exists in the form of suspended flocks. At smaller scales in India, MBBR tanks were found to be constructed of reinforced concrete or mild steel. Some suppliers also offer fiber reinforced polymer (FRP) tanks.

Advantages:

- Can operate at high organic loads
- Is less prone to hydraulic overloading than other STP types
- Generally, has lower capital costs than MBR-based systems
- Requires a relatively small footprint
- Eliminates issues with media becoming clogged (compared to fixed film systems)

Disadvantages:

- Is a manually operated process
- Generally, offers a lower level of wastewater treatment than MBR-based system

6.1.6.3 Technology Matrix

Table 15 **Wastewater Treatment Technology Matrix**

Treatment Technology	CAPEX Per KLD	OPEX Per KLD/Year	Area m^2/ KLD	Advantages	Disadvantages
DEWATS™	35,000 – 70,000	1,000 – 2,000	1.5 - 5	• Eligible for green rating • Lower O&M costs • Integrates aesthetically • No electricity required • No chemicals added • Minimal maintenance	• Medium to high capital costs • High to low area required
SBT	10,000 – 15,000	1,000 – 1,500	0.8-1.0	• Natural process • No mechanical aeration involved • No sludge generation and smell or odour • Minimal energy consumption • No skilled labour required	• Filter media flooding • Clogging of feeding pipes
Phytorid	14,000 – 35,000	1,000 – 2,000	1-2	• Natural process • No sludge generation or odour / smell • Flexibility in design • No energy consumption • No skilled labor required for O&M	• Medium O&M cost • Medium to low capital cost
MBBR	21,000 – 1,19,000[8]	12,000 – 36,000[9]	1.2-3	• Can operate at high organic loads • Lower capital • Requires a relatively small footprint • Eliminates issues with media becoming clogged	• High operation and maintenance costs • Requires skilled operators • Requires regular sludge disposal • Not preferred for green rating
SBR	35,000 – 750,000[9]	3,600 – 46,800[9]	1-2	• Smaller footprint • Biological nutrient (N&P) removal • Ability to withstand hydraulic and organic shock loads • Does not require secondary clarifiers • Is an automated process	• High O&M cost • Medium to low capital cost • Not preferred for green rating • Requires regular sludge disposal

8 An assessment of small-scale STP technologies: India, Examples, performance, and cost for three common STP types- STEP, May 2017
9 Case studies of implementation on different scale – community, institutional and individual building- CSE, JNNURM

6.1.6.4 O&M Requirements of Wastewater Systems

Table 16 O&M Requirements of Wastewater Systems

Technology	Key O&M activities
DEWATS™	• Weeding, removal of dead leaf litter and other litter, once in three months • Desludging of the settler, anaerobic baffled reactor, once a year • Cleaning of filter materials at Anaerobic Filter, Planted Gravel Filter once in three years
SBT	• Cleaning of pipes • Scarping of the top surface to remove the settled suspended particles • Microbial culture is tested and recommended to be changed every 8-10 years
Phytorid	• Plants need to be harvested periodically • Upper layer of media in the inlet zone requires scrapping or replacement periodically
SBR	• Operating valves and switches for pumps • Regular desludging of solids and monitoring recirculation to maintain MLSS • Disposing sludge regularly • Maintaining pumps/motors
MBBR	• Requires membrane replacement approximately every 3 years • Requires higher skill level for maintenance, due to more complex system setup

6.2 Typical Water Balance Chart

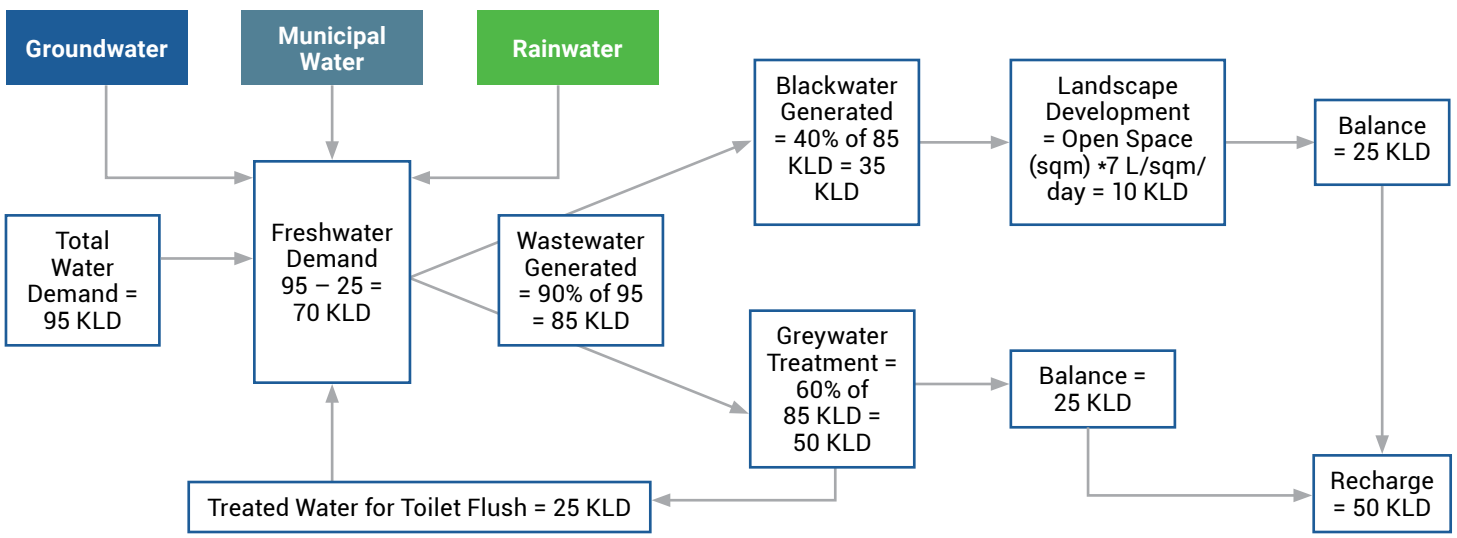


Figure 52. **Typical water balance chart**

7. Waste Management and Disposal

7.1 Waste Management During Construction

- Waste management and monitoring during construction is a critical factor to stop environmental degradation.
- Often, the construction waste, rubble etc. ends up in a landfill. It is better to reuse the waste on-site and ensure proper monitoring and hygiene.

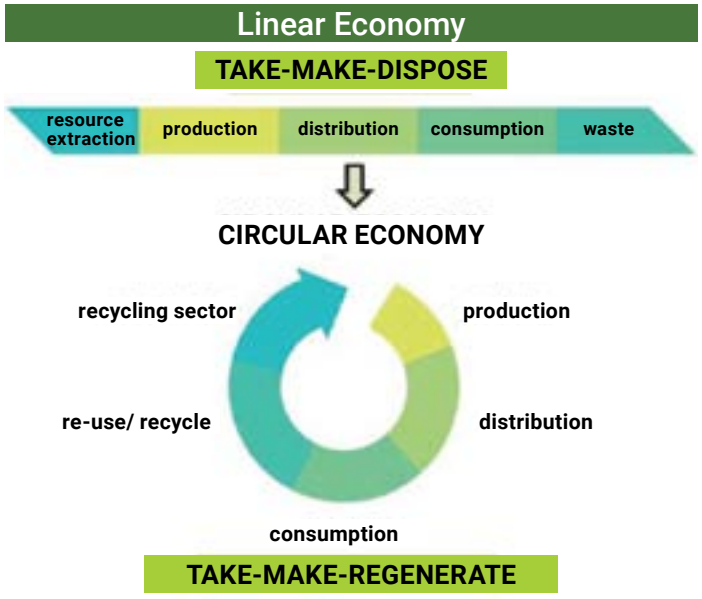


Figure 53. **Circular economy of waste** | Source:ECOFIRST

Wastewater Management

Wastewater is any water that requires cleaning after its most recent use. This includes water that has been used by humans for household and industrial purposes as well as rainwater that may have accumulated pollutants on its way to the rivers and oceans. Wastewater treatment is the process of cleaning and protecting water and to convert it into an effluent that can be reused or returned to the water cycle with minimal environmental issues.

Solid Waste Management

Solid-waste management refers to the process of collecting, treating, and disposing of solid material that has been discarded by people. Improper disposal of municipal solid waste can create unsanitary conditions, and may lead to pollution and outbreaks of vector-borne disease. The task of modern solid-waste management is to not only manage proper disposal mechanisms but to introduce interventions and behaviour changes that reduce the waste itself through recycling and reuse. Solid waste management pose complex technical challenges as well as a variety of administrative, economic, and social problems that must be managed and solved.

7.2 Reusability/Recyclable Materials

The main idea is to first reduce waste and to think of waste as a resource. By reducing waste of construction materials and reusing waste materials in some useful way we reduce the quantity of raw materials being extracted from their natural source. This is a very effective way of conserving our natural resources. Generally, all the metal scraps from railings, reinforcements etc. is resold or re-used at site. Other materials which cannot be resold/reused should be dumped at a designated/approved landfill site, such as construction of a new road. Contractors must arrange organized stacking of waste materials, keeping a record of the quantities sold or re-used on the project or at another location.

The table below illustrates a possible way of tracking the wastage of materials and the cost recovered from its reuse

Table 17 Waste Material Audit

S.N.	Item	Date Checked	Quantity Remaining	Reusing Strategy	Quantity reused /Sold	Cost Recovered /Saved
1	AAC blocks	30.09.18	150	Use in terrace insulation	150	850
		15.02.19	120		120	700
		25.05.19	680		0	
2	Shuttering board					

7.3 Segregation of Waste and On-Site Consumption of Recycled Organic Waste

A system of waste management should also be in place when a project is occupied by residents. The developer should plan and provide arrangements at the unit level, block level and site level for the segregation of waste and its reuse. Separate dustbins for organic/ biodegradable and inorganic/non-biodegradable materials need to be provided. The system should be maintained by the O&M staff. A treatment system for converting organic/ bio-degradable waste into compost needs to be provided at a suitable location on the project site. It is assumed that most residents at their homes will not do composting.

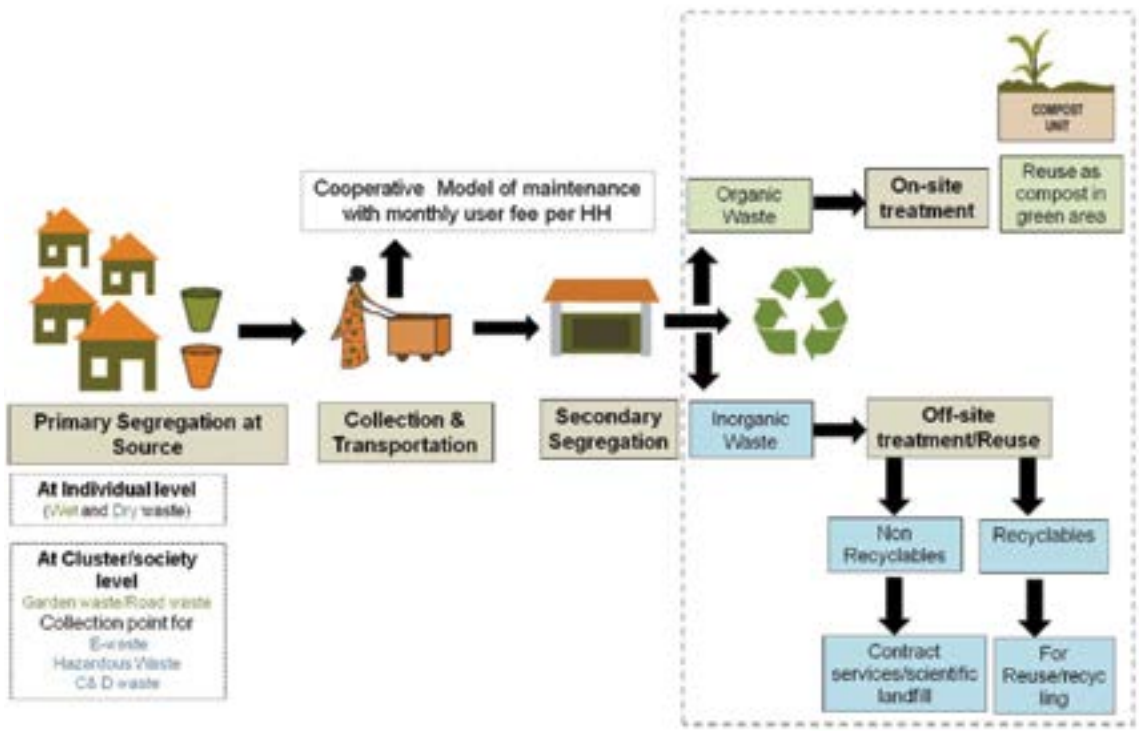


Figure 54. **Waste segregation** | Source ECOFIRS

The developer would need to establish this system during the period of maintenance under its charge, before handing over to the RWA. See Figure 53.

The chart below gives useful tips for selecting the appropriate method of organic waste composting

Table 18 **Various Systems of Waste Management** | Source ECOFIRST

	Decentralized			Centralised		
Decision metrics	**Leave-in-pots**		**Manthan/Tumblrs**		**Vermi-composting**	**Bio - Gas**
	Gambla, Khamba	Aga		**Batch Type OWC**		
Illustration/Photo						
Process description	An aerobic composting process where microbes (bacteria and fungi) in the presence of free oxygen convert bio-degradable waste to compost.			Continuous decomposition of waste in the OWC with the aid of culture / saw and temperature control	Natural composting process aided worms and by culture addition	Anaerobic digestion and decomposition of organic material by micro organisms
Applicable at:	Per household	At Building Level	At building or cluster level	At cluster level	At building or cluster level	At Cluster level
Waste- manure conversion duration	45 days	First Cycle -4 weeks and then every 2 weeks	First batch 2 months, next batches one month	45 days	15 days	Daily generation of bio-gas
Area required*	High **Area required: For 802 HH – 1200 sqm approx**	High **Area required: For 600 kg – 1200 sqm approx**	High **Area required: For 600 kg – 200 sqm approx**	Low **Area required for 600 kg:30-40 sq.m**	High **Area required for 600 kg:200-300 sq.m**	Medium **Area required for 600 kg:70-80 sq.m**
Labour requirement	High	Medium	Medium	Low	High	Medium
Volume of Output vs input	30-40% of input		15-20 %	10-15% of input	50% of input	80 – 140 cubic metre of bio – gas & 80 kg manure per ton of waste
Direct energy requirement	No	No	No	Yes	No	Yes
Capital cost*	**Rs. 16,04,000**	**Rs. 18,00,000**	**Rs.22,50,000**	**Rs. 10,50,000**	**Rs. 10,00,000**	**Rs. 17,00,000**
Operation cost *	**Rs. 2,40,600**	**Rs. 7,50,000**	**Rs. 1,00,000**	**Rs. 2,56,000**	**Rs. 3,83,250**	**Rs. 1,97,0500**
RECOMMENDATIONS	Not recommended. As the responsibility lies on the residents and the society has no control.	Not recommended. Area required is more.	Can be explored as the quality of compost is good as it the most natural way of composting. But Area required is more.	Preferred as Low space requirement* and less labor requirement.	Not Recommended as the worms are very sensitive to the type of waste and need trained maintenance and supervision.	Can be Explored. Equitable and immediate distribution of bio-gas is necessary. Should be located near large canteens/common community spaces. Or can be reused as electricity

8. Creating a Sustainable Ecosystem for Green Affordable Housing

From being relatively unknown at the turn of the century, the term 'green building' has today become synonymous with lower overhead costs, better productivity and greater overall efficiency in construction.

According to a 2015 report by the European Commission, at the global level, energy efficient methods could save an estimated 280 to 410 billion Euros in energy spending alone. At the building level, developers report that green buildings, both new and renovated, command a 7% increase in value over traditional buildings, according to Dodge Data & Analytics, 2016. Green construction methods offer a deluge of benefits with virtually no drawbacks.

However, even when a new technology or method is as logical and compelling as the Green Building concepts, it is often necessary to evolve an enabling environment to accelerate its adoption and consequent benefits. With the race that we are running against climate change, the need for such an enabling environment couldn't have been more acute. Vital aspects such as sound rating mechanisms, preferential financing for green affordable housing, support from development banks, prudent governance and widespread advocacy and communication can potentially become key prime movers and must be pursued with priority.

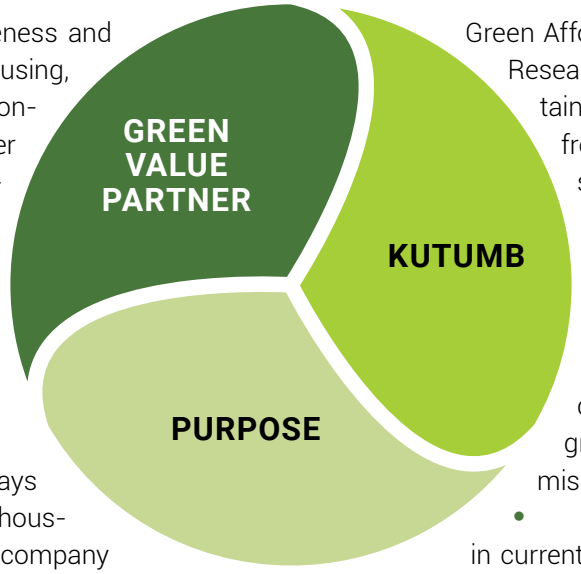
India is making steady and promising progress in the development of an enabling ecosystem, and some noteworthy developments are enumerated below:

8.1 IIFL Home Finance Ltd.: Championing Green Sustainable Affordable Housing

IIFL HFL, a wholly owned subsidiary of IIFL Group, has made it its mission to be an enabler for an inclusive and sustainable future that can be cherished by all. Starting operations in 2009, it has become one of India's fastest-growing leaders in the housing finance space with a focus on the economically weaker sections, such as the lower-middle class and middle class sections, helping them realize their dream of owning a home. Its primary customers are those looking for home loans up to ₹35 lacs, and 80% of its disbursed loans fall under priority sector lending. IIFL HFL has worked with over 7,000 approved housing projects and over 35,000 households that have benefited greatly through credit linked subsidy under the Pradhan Mantri Awas Yojana. Over 47,500 loans have been disbursed to women owners or co-owners, and more than 86,500 to first time home buyers. IIFL HFL has also provided more than 22,800 loans to the informal income segment.

IIFL HFL believes in nurturing the environment through sustainable practices and makes effort to impart positive impact on the environment while seeking its financial bottom-line. As the Company works towards its own growth, it has integrated the principles of environmentally, socially and governmentally sustainable development.

The company aims to spread awareness and adoption of the concept of Green Housing, which refers to methods that make construction more eco-friendly with lower utility costs and improved health outcomes. This makes affordable green housing substantially more beneficial to low-income households, and hence a logical step towards reducing long-term costs and improving stability.



IIFL HFL has constantly looked for ways to incentivise the adoption of green housing in the country. To that end, the company has initiated actions and devised strategies and programs including the Kutumb, PURPOSE and Green Value Partner initiatives:

8.1.1 The Kutumb Initiative

One of the primary ways that IIFL Home Finance Limited incentivizes the adoption of Green Housing is through 'Kutumb', a platform designed to bring together industry experts and housing developers to create sustainable infrastructure and a dependable model for Green Buildings in the affordable housing segment. The benefits of Green Buildings are not just limited to the environment, but permeate through to economic and social aspects as well. They include everything from a reduced carbon footprint, the conservation and restoration of natural resources, improved air and water quality and reduction in waste, to enhanced occupier productivity, optimisation of lifecycle performance and improved health and comfort for residents. For its work in spreading the concept of Green Housing, Kutumb has been given the 'Best Green Initiative in Affordable Housing Segment' at the ET Now Green Future Leadership Awards, 2019.

8.1.2 PURPOSE

The objective of constitution of PURPOSE (Platform for Green Affordable HoUsing & Finance, Through Research, Policy & TechnOlogy, for Sustainable Eco-System) is to bring experts from varied domains of building construction, finance and sustainability, creating an advisory council to influence policies at all levels of implementation pertaining to green affordable housing. PURPOSE is a strategic and directional initiative to contribute and develop ecosystem for green affordable housing in India. The mission of PURPOSE is:

- To identify gaps and shortcomings in current policy structure, and promoting the evolution of green affordable housing and its certification in India
- To promote construction of innovative green building materials, which are cost efficient and have sustainable impact, and identify new innovative and cost-effective technologies; developing strategy to spread awareness and market transformation
- To develop strategies so as to create various innovative financial structure encouraging the innovation in affordable housing sector
- To create an eco-system for sustainable and affordable development, with key functions of monitoring and accountability

8.1.3 Green Value Partner Initiative

This initiative by IIFL HFL seeks to provide end-to-end assistance (hand holding) to the developer. Green Value Partners work along with the developer throughout a project's lifecycle, from concept to completion, to ensure successful realization of the intended project's vision and efficiencies. GVPs also ensure that all criteria are understood in depth and met in order to successfully achieve a Green Building Certification.

IIFL HFL further supports the process with a Monitoring

and Audit mechanism that ensures the developer is well supported throughout the project life-cycle. The process begins from identification of suitable projects/developers and initiating dedicated efforts for knowledge sharing and aligning the project's vision with green building objectives. Thereafter, a designated GVP for the project in association with the project team undertakes preparation of multiple submissions at various project stages like Feasibility Study/ Due Diligence, Environment Social Governance (ESG) Compliance Report, Project Monitoring Checklist, etc.

To complete the entire process, IIFL HFL onboarded a set of competent technical experts with construction and green building experience. The goal of the entire mechanism is to ensure appropriate compliance.

Kutumb, GVP and Purpose have become the three key pillars of IIFL HFL's concerted effort to ensure accelerated adoption of Green building concepts in India, in step with the nation's vision of creating affordable housing at an unprecedented scale in the coming years. IIFL HFL is proud to be one of the building blocks of the evolving green building ecosystem in the country, offering all services required for its nurture. Although IIFL HFL has provided a base for building this sustainable ecosystem, ground realities must be considered to understand what the future holds for India. In the subsequent sections, we examine these developments.

8.2 Rating Mechanisms

Certification goes a long way in assuring prospective buyers and investors that a building is truly sustainable. Good and reliable rating mechanisms are a building block for the development of a favourable ecosystem for green buildings as they provide both a standard as well as a measure of progress of the concept. In the year 2000, the U.S. Green Building Council (USGBC) launched its rigorous Leadership in Energy and Environmental Design (LEED) rating program. According to four Industry studies that surveyed more than 150 green buildings across the USA, it costs only about 0.8% more to achieve basic LEED certification than to construct a standard building. India too has some bankable rating mechanisms in place that are recognized by investors and governments, such as IGBC Green Affordable Housing, GRIHA for Affordable Housing and Excellence in Design for Greater Efficiencies (EDGE). As discussed elsewhere in this book in detail, the rating mechanisms have evolved both in expanse and depth over the years in India and have significantly aided the green building movement.

8.3 Financing Options

The Indian Government has rightfully put infrastructure development into top gear, with a firm belief that good infra-

structure will stimulate job creation and higher economic activity. By 2040, the country will require nearly $4.5 trillion worth of infrastructure funding, of which nearly $200 billion will be required for renewable energy, $7.7 billion for intra-city metro rail networks, $667 billion for the electric vehicles programme and a full $1 trillion for affordable green housing.

Traditional sources of financing will not be able to meet the Investments required to achieve these ambitious targets. Innovative approaches towards finance are key to the successful execution of large scale green projects in India; green financing strategies such as green bonds, catalytic and transformational financing and impact investing can provide solutions for a country like ours.

Green bonds help developers access funding from specialized funds focused on climate change. As of today, 120 institutional investors from nine countries have come together to form the Institutional Investors' Group on Climate Change. Furthermore, over 1,500 institutions are on-board as signatories to the United Nations' Principles for Responsible Investments. Sovereign funds like GIC, Abu Dhabi Investment Authority, and multilateral agencies such as International Monetary Fund, International Finance Corp and Asian Development Bank, among others, are also proactively channeling funds to invest in green sustainable projects.

In India, banks and non-banking financial institutions have traditionally been the primary sources for funding green infrastructure. But they have a limited threshold for long-term debt due to mismatch in asset and liability. Also, current regulatory restrictions allow insurance companies and pension funds to invest only in AAA-rated bonds, which acts as a serious limiter, and for green bond issuances to increase, this regulatory framework must change. The government needs to actively consider making green bonds tax-free to deepen the market in India.

India's first green bonds were issued as recently as 2015; the country's green bonds market is still nascent. So far, India has raised over $6 billion via green bonds, with one-third of this figure issued in 2017. In the $120 billion global market for green bonds, China was the top issuer in 2017 with a 22% share, followed by the US at 13%. Green bond issuances in Asia are set to cross $600 billion in the next five years, and it is in India's interest to develop a strong green financing ecosystem as demand for green financing from international investors continues to surge.

Over the next decade, the millennial investors' cohort will become a critical influencer on mutual funds, pension funds, banks and corporates. It will demand better administration from an environmental standpoint and will pressure companies to follow better environment, social and governance standards. A conducive and transparent regulatory environment could, for India, unlock the full potential of green financial strategies, supporting the country in achieving its Paris Climate Accord targets.
However, in any developmental initiatives of national importance, such as green affordable housing, often the first steps are taken by specialised development banks, agencies and the government. In India too, the development banks and the government have taken the intiative to support green affordable housing.

8.4 Development Bank Support

India's apex housing finance institution, the National Housing Bank (NHB), together with the Agence Française de Développement (AFD) and the European Union, committed to expand their allocation of resources to promote green and affordable housing projects through the SUNREF India Housing Programme.

Under this programme, housing finance companies, banks and home purchasers will have access to competitive funding opportunities to finance green and affordable housing projects. Training opportunities on various technical aspects, such as norms, planning and project design regarding green and affordable components, will also be provided to stakeholders through this initiative.

The programme includes a line of credit worth 100 million Euros granted by AFD so that stakeholders can have access to adequately priced resources in the form of loans. This includes an investment incentive worth 9 million Euros that will go towards reducing the loan cost for final borrowers, out of which up to 1 million Euros will be used to support the cost incurred on green label certifications for housing projects, according to a statement by the bank.

The SUNREF India programme not only encourages green housing through concessional funding, but also supports the upgradation of technical knowledge and practices. With nearly 70 percent of India's housing development set to be implemented in the next decade, it is vital that the impact of construction on the environmental is reduced. The 100 million Euro credit line will go towards supporting NHB's refinancing operations to housing finance companies, banks and home buyers carrying eligible green building projects certified by local certification programs (IGBC and GRIHA). In doing so, it will strongly incentivize the adherence of housing projects to green norms, making NHB's programme a major achievement for the Indian housing sector. By 2025, 12,000 households will have benefitted from the SUNREF Housing Programme in India, of which at least half will be from economically weaker sections.

8.5 Institutional Support

To promote green buildings in India, many state governments and local bodies have provided incentives to developers who get their buildings green-certified. For instance, the Ministry of Environment, Forest and Climate Change (MoEFCC), offers fast-track environmental clearance for green building projects which are pre-certified or provisionally Certified by IGBC. All IGBC rated green building projects in the MSME sector have become eligible for financial assistance at concessional rates from Small Industries Development Bank of India (SIDBI). Some states are also taking steps that encourage Green buildings, with some providing additional Floor-to-area ratio (FAR) for green buildings.

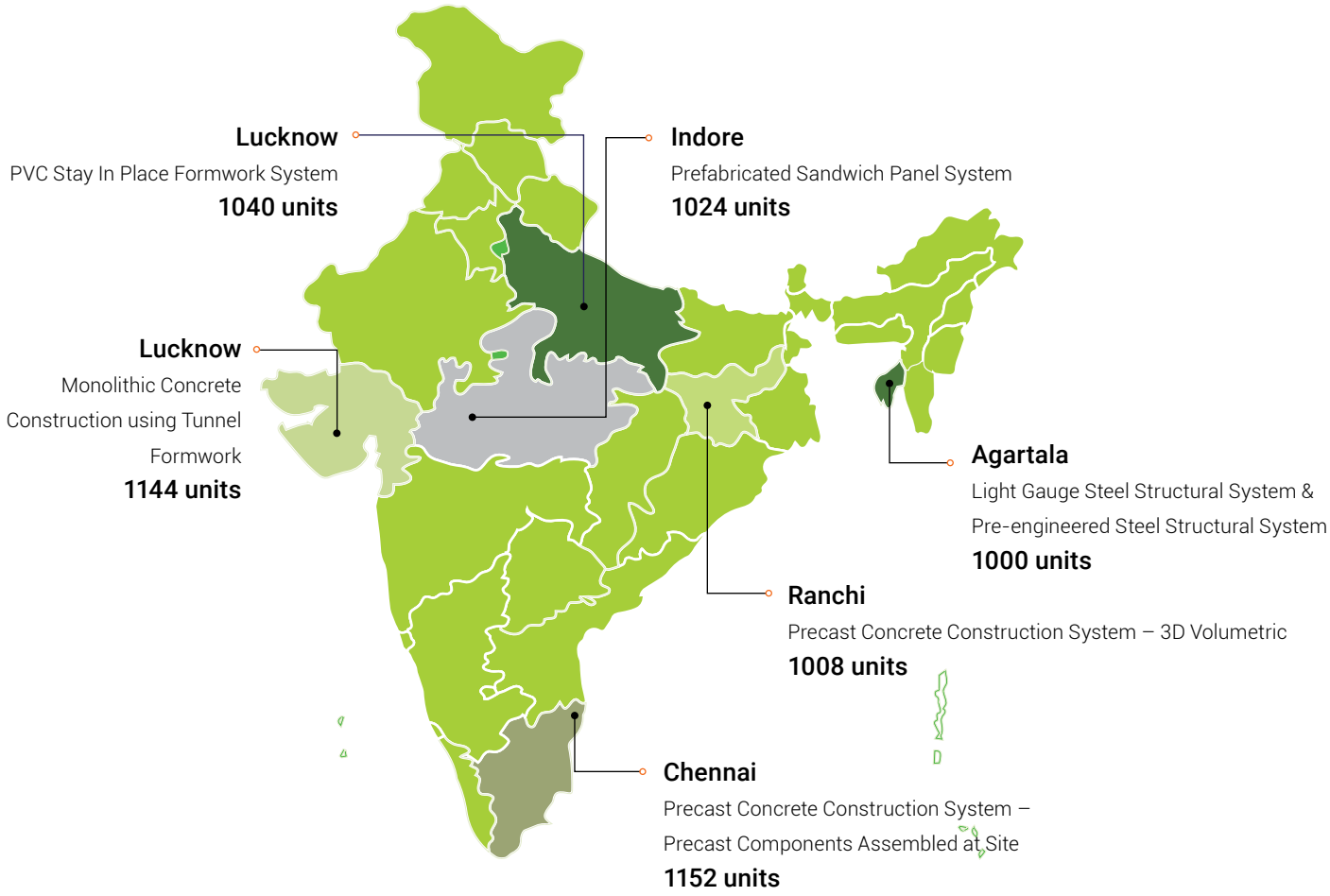
Sustainable construction concepts are now an integral part of architectural curriculums too. Architecture students are being taught about green methods, materials, policies and best practices even before they have had a chance to become accustomed to prevalent unsustainable practices, ensuring that the coming generations of builders and developers will be progressively more geared towards sustainable building.

Just two decades ago, green buildings were regarded as interesting experiments but unfeasible in the real business world. Since then, we have seen a major shift in thinking. Green construction has evolved from being one of the options to rapidly becoming the way to go. Corporations, housing builders, retailers, health care institutions and governments, amongst others, are invested in pushing the concept of green building fully into the mainstream. In India, green construction concepts have been accepted with heartening welcome, but a country the size of ours has the potential to make major positive or negative impact on the climatic situation and sustainable development in general. It is therefore imperative that green construction progresses from being a popular option to the standard of construction in this country. And, if the four most important stakeholders; the developer, the consumer, the financier and the regulator, work towards this cause with an informed and educated perspective, the progress that is needed will come about naturally.

8.6 Light House Projects

Light House Projects (LHPs) are model housing projects with houses built with shortlisted alternate technology suitable to the geo-climatic and hazard conditions of the region. These will demonstrate and deliver ready to live houses with speed, economy and with better quality of construction in a sustainable manner.

Six Technology providers have been selected through rigorous online bidding process for construction of LHPs at six differnet locations in six states. This selection was based on Green Housing Technology Challenge India (GHTC), initiated by Ministry of Housing and Urban Affairs (MoHUA), to identify and mainstream globally best available proven construction technologies that are sustainable, green and disaster resilient, to enable a paradigm shift in affordable housing.



https://ghtc-india.gov.in/Content/LHP.html

8.7 The Green Building Revolution

HOW

The trigger comes from the fact that buildings are responsible for huge amounts of carbon emission, excess of waste, water & energy consumption.
They are the consumers of non-renewable & natural resources.

WHY

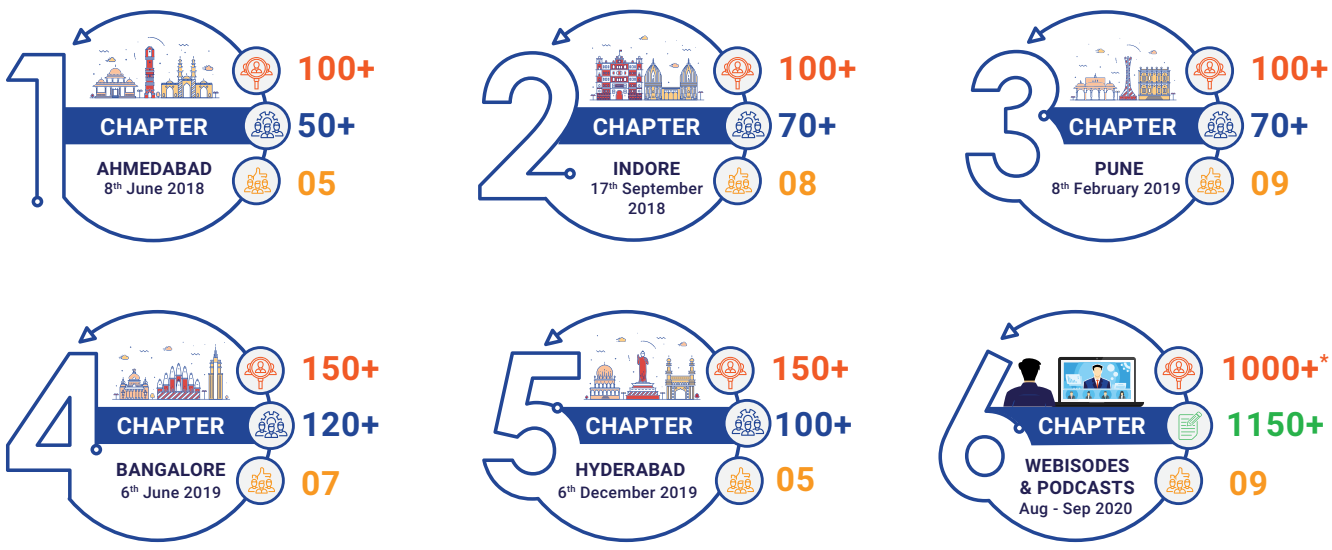
Agenda is to the blend benefits of green home within affordable housing segment in India, ultimately strengthening our belief in Honourable Prime Minister's vision and mission of Pradhan Mantri Awas Yojana - Housing for All by 2022 **[PMAY - HFA (U)]**

WITH

Kutumb is an initiative to build awareness about the need for green affordable housing amongst its stakeholders and provide a common platform to transform this idea into reality

कुटुम्ब

Snapshot



Participants (incl. Developers) **Developers** **Experts** **Registrations**

8.8 Green Value Partnership

WE HELP YOU GET STARTED

- Preliminary Techno-financial assessment of the Green aspects
- Assist in selection of Green Rating system and project registration
- Offer list of empaneled professional agencies

READILY AVAILABLE DESIGN SOLUTIONS

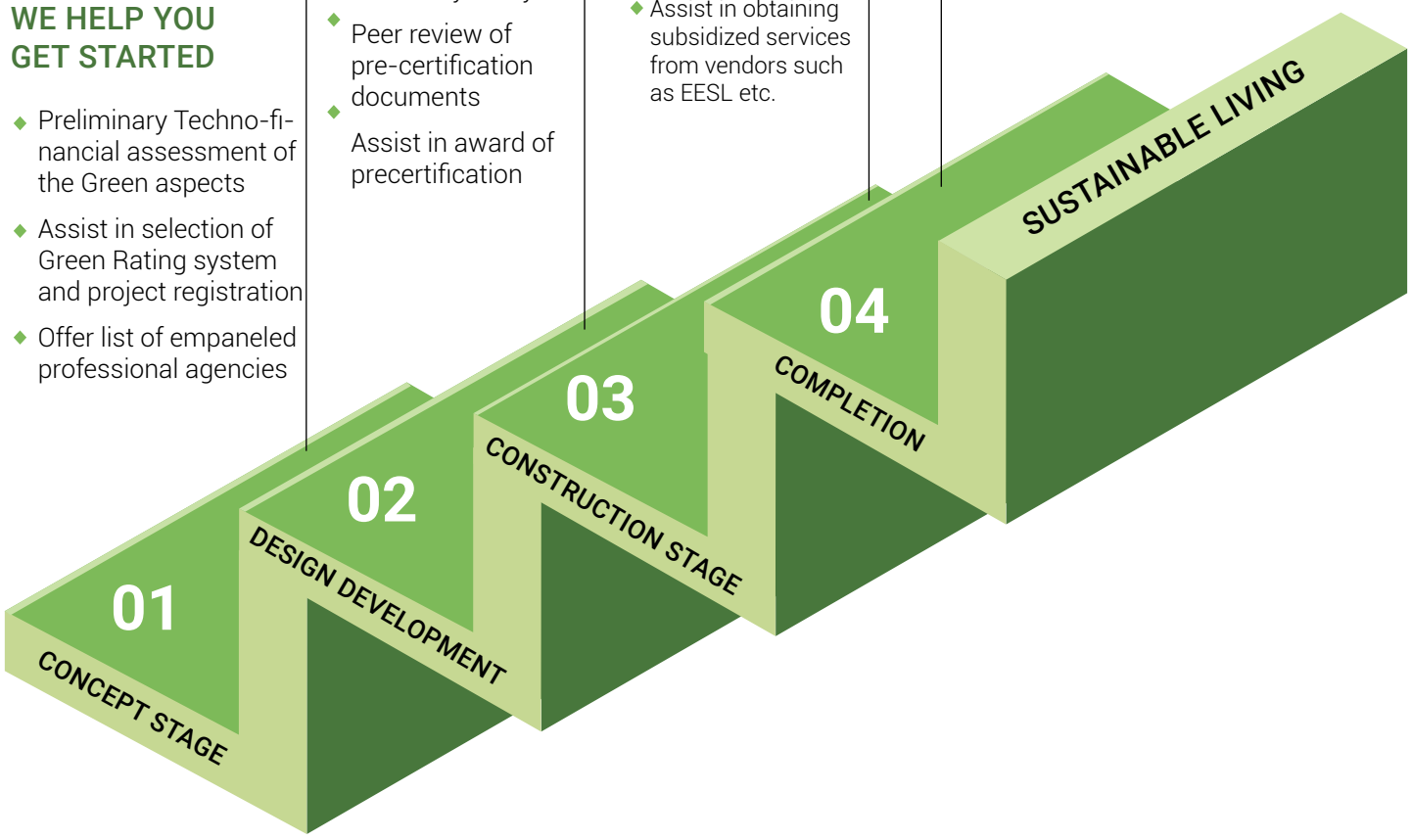
- Feasibility study
- Peer review of pre-certification documents
- Assist in award of precertification

CONTINUED SUPPORT PRECAUTIONARY AND CORRECTIVE MEASURES

- Technical compliance review at multiple stages of construction and provide compliance recommendations
- Assist in obtaining subsidized services from vendors such as EESL etc.

WE HELP YOU FINISH WHAT WE STARTED

- Review of compliance at substantial completion stage
- Peer review of Final certification documentation
- Assist in obtaining Final certification



PRO- BONO SUPPORT BY IIFL HFL TOWARDS A SUSTAINABLE LIVING

8.9 IIFL HFLs DNA

Complete Profitability

AN ESG INITIATIVE

- Learning & Development
- Growth
- Gender Diversity
- Right Values

- Financial, Ethical & Sustainable Growth
- Constant Innovation

- Financial Inclusion
- Financial Literacy
- Women Empowerment
- Housing For All

- Environmental & Health Impact
- Environmental, Social & Governance
- Sustainable Development
- Responsible Investment

Annexure 1

GRIHA Rating System with Cost Impact and Handbook References

GRIHA FOR AFFORDABLE HOUSING								
S.N.	**Criterion Name**	**Criterion Number**	**Intent**	**Requirement**	**Available Points**	**Design Intervention Required**	**Cost Impact**	**Handbook Reference**
Section 1 - Site Planning								
1	Low Impact Design	1	To adopt passive architectural design strategies in the building design and incorporate natural site features (topographical/ microclimatic) to create climate sensitive design with reduced energy consumption while maintaining occupant comfort	Demonstrate reduction in environmental impact through design by adoption of various passive design and low-impact site planning strategies.	4	This requires attention at an early design stage in working out the site layout and building designs. Passive design strategies of building orientation, ventilation, shading and design for open space, plantation according to the natural features of the land can be incorporated in the design.	Low	Section 4.1 Section 5.1 Section 5.2
				Demonstrate use of active, low-energy cooling/ heating systems in the building	2	Applicable only in high end projects.	High	
2	Design to Mitigate UHIE	2	To ensure incorporation of site design strategies which assist in reduction of hard paving on site to mitigate Urban Heat Island Effect (UHIE).	More than 25% of the site surfaces visible to sky are either soft paved/covered with high SRI coating (SRI > 0.5)/shaded by trees/ shaded by vegetated pergolas/shaded by solar panels or any combination of these strategies.	3	For paved area use open grid pavements and/or plant trees to ensure that the exposed hard paved area is either shaded or are light colour to reflect the sun's heat is required. Minimmising hard paved areas is the cost-effective strategy for meeting this requirement.	Low	Section 4.1.2
				More than 50% of the site surfaces visible to sky are either soft paved/covered with high SRI coating (SRI > 0.5)/shaded by trees/ shaded by vegetated pergolas/shaded by solar panels or any combination of these strategies.			Low	

S.N.	Criterion Name	Criterion Number	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
3	Preservation and Protection of Landscape During Construction	3	To ensure preservation of mature trees and fertile top soil on site, thereby minimizing the impact of construction activities on existing landscape.	Ensure that no existing mature tree is cut on site. OR Transplant mature trees within the site and ensure their survival. OR Plant 3 trees of native/ naturalised species for every 1 tree cut. OR Any combination of these for all existing mature trees on site.	Mandatory	The conditions comprise statutory requirements. No major design intervention or cost escalation envisaged.	No impact	
				Increase total number of trees on site by 25% above the pre-construction phase. OR Plant 4 trees of native/ naturalised species for every 1 tree cut.	1	Planning of the site keeping existing mature trees is ideal. Additional planting can be planned in the site plan.	Low	
				Preserve top soil during construction; maintain its fertility (during construction phase) and use for landscape post-construction	2	Planning to separate and preserve top soil requires planning of site operations and may incur additional cost. The feasibility depends on the size of the site and excavated area.	Low	
4	Stormwater Management	4	To ensure that storm water runoff from the project site, prior to and post construction, remains the same to avoid urban flooding.	Ensure that the excess runoff generated above the pre-construction run off is managed within the site.	1	Requires design for storm water absorption at site by providing soft ground, grass pavers, rain water harvesting pits. This is a statutory requirement.	No impact	Section 6.1.1 Section 6.1.2
				Ensure that 100% post construction storm water runoff quantity is managed within project premises.	1	May require additional rainwater harvesting pits, holding pond.	Low	
5	Reduction in Air and Soil Pollution During Construction	5	To minimize air and soil pollution during construction on site.	Adopt at least 3 measures on site to curb air pollution during construction	Mandatory	Construction logistics planning required.	No impact	
				Develop and implement a spill prevention plan (to control effects of spill from hazardous materials like bitumen, diesel etc.) on site.	1	Construction logistics planning required	No impact	
				Adopt staging during construction on site, and strategies to prevent/ reduce movement of soil (not top soil) outside the site through adoption of various strategies (like soil erosion channels, sedimentation control etc.)	1	Construction logistics planning required.	Low	
Section Total					**16**			

S.N.	Criterion Name	Criterion Number	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
Section 2 - Energy and Occupant Comfort								
1	Envelope Thermal Performance	6	To ensure thermal comfort by minimizing the overall heat gain from the envelope through suitable construction materials and optimal fenestration design.	Ensure peak heat gain through building envelope meets the thresholds of Building Envelope Peak Heat Gain Factor.	2	Refer to the appropriate suggestions from handbook and design intervention requirement. Daylight perfomance calculation to be done by expert.Quote NBC 2016 Part 3 Clause 20.	Low	Section 5.1
				Demonstrate reduction in peak cooling load (percentage) over the base case.	6		Low	
2	Occupant Visual Comfort (Daylight)	7	To harness the available daylight and provide adequate, equally distributed and diffused day light for better visual comfort.	Ensure that a minimum percentage of total built up area meets the UDI requirement for 90% of the potential day light time as per the below mentioned thresholds	5		Low	Section 5.1.4
3	Efficient Lighting	8	To promote use of energy efficient lighting in outdoor spaces and indoor common areas.	All lighting fixtures installed in outdoor spaces and indoor common areas shall have a minimum luminous effeciency of 75 lumen/watt.	2	LED lighting fixtures to be incorporated in the design phase. Minimal cost impact due to effecient options available in the market, eg. LED lights.	Low	
				Automatic controls must be provided for 100% of outdoor lights	Mandatory	Procurement to be undertaken accordingly.	Medium	
4	Energy Efficient Equipment	9	To promote use of energy efficient equipment.	All the following equipment falling under the scope of the developer must be at least BEE 3-star rated/ labelled: • Motors • Transformer(s)	2	The procurement process has to include high efficiency equipment from the very conceptual phase, as these equipment have a long lead time and major cost escalation.	High	
5	Renewable Energy	10	The intent of this criterion is to promote the use of renewable energy technologies and enable energy generation on site*.	Rated capacity of the renewable energy system (Solar PV/Solar hot water system/ Biomass/ Geothermal/Wind turbine) installed on site conforms to installation @1kWp per500 sq.m of total built-up area thresholds as established	6	To be included in the Project design. Easier to incorporate on the roofs of low rise buildings to achieve the maximum points.	High	
6	Energy Metering	11	To promote energy consumption monitoring through metering	Install a dedicated energy meter for each dwelling unit.	Mandatory	Inherent part of design.	No impact	
				Install dedicated energy meters, each for outdoor spaces and indoor common area lighting.	1	Electrical distribution system to incorporate sub meters for internal lighting and external lighting	Medium	
				Install energy meter on renewable energy system to measure the energy generated (if installed).	1	Sub meters to be installed	Low	
Section Total					**25**			

S.N.	Criterion Name	Criterion Number	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
Section 3 - Water Savings								
1	Efficient Use of Water During Construction	12	To minimize the requirement of potable water during construction by deploying effective construction management practices on site.	Adopt strategies (at least 2 from the list) to reduce the consumption of potable water during construction	1	Construction methodologies to be planned. Requires water saving methods for curing cement based construction, reducing use of water for cleaning and washing. Saves cost if managed systematically.	Low	
				Use of treated waste water/captured rain water in construction activities.	1	To be incoroporated in the Construction logistics plan.	Low	Section 6.1.1
2	Optimization of building and landscape Water Demand	13	To reduce the overall water demand of the building through system optimization, which includes installation of water efficient systems such as low flush toilets equipped with dual flush functionality and water faucets with aerators. Additionally, this criterion emphasizes on reducing the landscape water demand through use of regionally appropriate, xerophyte (low water using native species of flora) plant species and efficient irrigation systems.	Reduce the total water requirement in the building by the following thresholds over the base case.	5	Please refer to the appropriate suggestions from handbook and design intervention requirement.	No impact	Section 6.1.5
				Reduce the total landscape water requirement by the following thresholds over the base case.	4	Selection of plant species that require less water and minimising of lawns to be incorporated in landscape design.	No impact	
3	Water Reuse	14	To ensure the availability of appropriate facilities for tertiary- level treatment of wastewater generated, artificial groundwater recharge and rainwater storage; and maximum utilization of treated and harvested water within the project site to reduce the overall dependence on fresh water supply from concerned authorities.	Sewage treatment plant (STP) should be provided to treat 100% of the sewage water (grey water and black water combined)1 generated on site.	2	The requirement is as per the EIA requirement and most of the municipalities also mandates the installation of STP. Thereby, no additional design intervention is required, though choice of STP may vary based on the size of the project and technology to be installed.	Medium	Section 6.1.1 Section 6.1.2 Section 6.1.6
				Re-use of treated water (from STP) and rainwater (from storage tanks) to meet the water requirement of the project as per the thresholds mentioned	5	To be incorpoated during the Project's Services design development. This will require additional plumbing arrangements for water storage and water distribution.	Medium	Section 6.1.1

S.N.	Criterion Name	Criterion Number	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
4	Water Metering	15	To ensure that a monitoring mechanism is in place for supply of fresh water from concerned authority and at STP outlet line.	Installation of water meters at the following locations: ● Fresh water inlet : municipal supply/bore well ● STP outlet (If installed)	Mandatory	Installation of meters to have minimal cost implications.	No impact	Section 6.1.5
				Installation of sub water meters at each dwelling unit within the project site	1	Requires planning of wet service areas of dwelling units to minimise piping length and installation of meters.	Low	
Section Total					**19**			
Section 4 - Waste Management								
1	Construction Waste Management	16	To ensure segregation, safe storage, recycle, reuse and disposal of construction waste during construction.	Develop and implement a construction waste management plan in compliance with the norms laid under Construction and Demolition Waste Management Rules, 2016.	1	Regulatory requirement.	No impact	Section 7.1
2	Post Construction Waste Management	17	To adopt and implement sustainable solid waste management strategies and provide appropriate infrastructure on site for collection, segregation, storage and disposal of solid waste during the operation phase; and to promote & provide infrastructure facilities for treatment of segregated organic/ biodegradable waste on site.	Adopt solid waste management plan in compliance with norms elaborated under Solid Waste Management Rules, 2016. And Provide infrastructure for primary collection (door to door/chute system) & segregation (multi-colored bins) of solid waste. And Provide designated secondary waste management areas within the project site for safe and hygienic storage of collected solid waste	3	Locations of waste bins and storage, seggregation, treatment of solid waste to be incorporated during the design development. Refer strategies enlisted in the subsequent sections.	No impact	Section 7.2 Section 7.3
				Provide contractual tie-ups with CPCB (Central Pollution Control Board) authorized waste recyclers for safe recycling of recyclable wastes like metal, paper, plastic, glass, etc	1	The practice can be undertaken with minimal cost implication.	Low	
				Provide infrastructure facilities for treating all the organic waste/ biodegradable solid waste on site and converting it to resources such as manure, bio gas etc.	2	The associated cost implication varies based on the technology adopted and sizing of the same based on the Project size.	High	
Section Total					**7**			

S.N.	Criterion Name	Criterion Number	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
Section 5 - Sustainable Building Materials								
1	Reduction in Environmental Impact of Construction	18	To reduce the environmental impact of construction by utilizing environment friendly construction materials or technologies that use waste material or have recycled content or have low embodied energy.	Minimum 15% replacement of sand, aggregate or Ordinary Portland Cement (OPC) with any BIS recommended waste by weight of sand, aggregate or OPC respectively used in structural concrete. Or Utilization of minimum 2.5% recycled content in structural framework. Or Demonstrate reduction in combined embodied energy of structure and walls by at least 10% below the base case.	6	Construction materials specifications can be formulated accordingly with no cost implication. This also enables lower heat of hydration and has nil to minimum cost implication. Documentation to be done by the Green Building Consultant.	Low	Section 5.1.2 Section 5.1.3
				More than 25% replacement of sand, aggregate or Ordinary Portland Cement (OPC) with any BIS recommended waste by weight of sand, aggregates or OPC respectively used in structural concrete. Or Utilization of more than 5% recycled content in structural framework. Or Demonstrate reduction in combined embodied energy of structure and walls by at least 20% below the base case.			Low	
				Minimum 40% composition of building blocks / bricks by any BIS recommended waste by volume, for 100% load bearing and non-load bearing masonry walls. Or Utilization of minimum 40% recycled content in infill panels. Or Demonstrate reduction in combined embodied energy of structure and walls by at least 30% below the base case.		Construction materials specifications can be formulated accordingly with no cost implication. Documentation to be done by the Green Building Consultant.	Low	

S.N.	Criterion Name	Criterion Number	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
2	Use of Low-Environmental Impact Materials in Buildings Interior	19	To promote installation of low environmental impact materials in the building interiors and reduce the usage of virgin material.	Demonstrate that at least 25% of all materials used for building interiors meet the GRIHA requirement of low-impact material	5	Construction materials specifications can be formulated accordingly with no cost implication. Documentation to be done by the Green Building Consultant.	Low	Section 5.1.2
				Demonstrate that at least 50% of all materials used for building interiors meet the GRIHA requirement of low-impact material			Low	
				Demonstrate that at least 70% of all materials used for building interiors meet the GRIHA requirement of low-impact material			Low	
3	Use of Recycled Content in Roads and Pavements	20	To substitute raw materials in infrastructure construction with wastes, in order to reduce the pressure on mining for virgin materials as well as landfills required for their disposal by utilizing them in the construction of bituminous roads and pavements.	Utilization of minimum 8% recycled waste (as per CRRI/IRC recommendations) in road construction by volume of materials for 100% of the bituminous roads on site.	2	Construction materials specifications can be formulated accordingly with no to minimal cost implication. Documentation to be done by the Green Building Consultant. Utilise construction waste materials.	Low	
				Utilization of minimum 10% recycled waste in construction of pavements by volume of materials for 100% of all material used in the pavements on site.	2		Low	
4	Low VOC Paints, Adhesives, Sealants and Composite Wood Product	21	To promote use of low-VOC and lead-free interior paints; low-VOC adhesives and sealants; composite wood product without urea-formaldehyde in order to maintain good indoor air quality for the occupants.	Ensure that all interior paints are low-VOC and lead-free, all adhesives and sealants used are low-VOC and such interior composite wood products are used which do not have urea-formaldehyde as a bonding resin.	2	Construction materials specifications can be formulated accordingly.	Low	
5	Zero ODP Materials	22	To lower the greenhouse effect and ensure use of low ozone depleting potential (ODP) materials in building insulation, HVAC & refrigeration equipment and fire fighting systems.	Ensure that all the insulation used in the building should be CFCs and HCFCs free.	Mandatory	Applicable only in high end projects/buildings.	No impact	
				Ensure that the fire suppression systems and fire extinguishers installed in the building should be Halon free.	Mandatory	CO2 based fire extinguishers can be used.	No impact	
				Ensure that all refrigerants used in HVAC system to be free from CFC and HCFC	Mandatory	Applicable only in high end projects/buildings.	No impact	
Section Total					**17**			

S.N.	Criterion Name	Criterion Number	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
Section 6 - Social Aspects								
1	Facilities for Construction Workers	23	To ensure safe, healthy and hygienic working and living conditions for construction workers of the project.	Ensure compliance with NBC (2016) safety norms for providing the necessary safety equipment and measures for construction workers.	Mandatory	Comprises of statutory compliances under the BOCW Act. Documentation to be done by the Green Building Consultant.	No impact	
				Ensure provisions for drinking water, hygienic working & living conditions and sanitation facilities for the workers.	Mandatory		No impact	
				Provide a crèche facility for children of construction workers.	1		No impact	
2	Universal Accessibility	24	To promote adoption of measures in the project to make it universally accessible.	Compliance with Harmonised Guidelines and Space standards for Barrier Free Built Environment for Persons with Disability and Elderly persons.	2	As per the new Rights of Person with Disability (RPWD) Act 2016, the accessibility measures to be implemented in project have become mandatory.	No impact	
3	Proximity to Transport and Basic Services	25	To reduce the carbon footprint of building occupants.	The walking distance of transportation facilities (formal & informal) shall be less than 500 m from the main entrance of the project. – 1 Point Formal – Bus stand, MRTS, ISBT, Railway stations; Informal – Auto stands, rickshaw stands, e-vehicle stands	10	Documentation to be done by the Green Building Consultant.	No impact	
				The average distance of basic services from the main entrance of the project shall be lesser than the following thresholds.			No impact	
4	Environmental Awareness	26	To create awareness about sustainability and environment amongst building occupants and visitors.	Adopt measures to create environmental awareness amongst the building occupants and visitors.	2	Can be prepared as part of the Environement Management Plan. No cost implication envisaged.	No impact	
5	Tobacco Smoke Control	27	To facilitate effective implementation of tobacco control laws and to put in place strategies such as prohibiting smoking in the common areas for better occupant health.	Adopt measures to ensure zero exposure of non-smoking occupants to tobacco smoke.	Mandatory	Administrative Credit, no design intervention is required.	No impact	

S.N.	Criterion Name	Criterion Number	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
6	Water Quality	28	To ensure that the quality of water available for use during operational phase of the building meets the relevant national standards.	To ensure quality of water from all sources (ground water and municipal water) conforms to IS 10500 – 1991	Mandatory	Comprises of Statutory requirement.	No impact	Section 6.1.1 Section 6.1.3
7	Provision of Access to Clean Sources of Cooking Fuel	29	To promote the usage of clean sources of cooking fuel advocated by Pradhan Mantri Ujjwala Yojana (PMUY) by facilitating provision of infrastructure for PNG or LPG connections.	To ensure provision of necessary infrastructure for safe access to clean sources of cooking fuel (PNG, LPG, etc.).	1		No impact	
8	Bonus Points	Additional Criterion	To reward additional measures adopted by the project which have not been covered in the previous 29 criteria.	Adopt strategies, independent of the previous 29 criteria, to make the project more sustainable.	4	Refer Innovative strategies described in the subsequent sections of the handbook.	Low	
Section Total					**20**			
GRIHA Affordable Housing Criterion Total					**104**			

Annexure 2

IGBC Rating System with Cost Impact and Handbook References

IGBC GREEN AFFORDABLE HOUSING RATING SYSTEM								
S.N.	**Credit Number**	**Credit Name**	**Intent**	**Requirement**	**Available Points**	**Design Intervention Required**	**Cost Impact**	**Handbook Reference**
Site Measures								
1	Mandatory Requirement	Local Building Regulations	Ensure that the building(s) complies with necessary statutory regulatory codes thereby regulating the growth of the built environment.	Approval of building plan (or) site plan	Mandatory	Administrative Credit, no design intervention is required.	No Impact	
				Fit-for-occupancy certificate			No Impact	
2	Mandatory Requirement	Site Selection	Avoid the development on inappropriate sites thereby reducing the environmental impacts caused due to the location of a building on a site	Avoid development of buildings, hardscapes, roads or parking areas on portions of sites that meet any of the mentioned criteria	Mandatory	Administrative Credit, no design intervention is required.	No Impact	
3	1	Proximity to Public Transport	Encourage use of public transport, so as to reduce negative impacts caused from automobile use	Locate the building within 1 km walking distance from an intra-city railway station (or) a bus-stop (or) other modes of public transport.	1	Documentation to be done by the Green Building Consultant	No Impact	
				The project can operate or have a contract in place for shuttle services (from / to the nearest intra-city railway station or bus-stop), for atleast 25% of the building occupants.		Administrative call from the developer, if required such facility may be arranged, the critical aspect is to document the facility appropriately.	No Impact	
4	2	Top Soil Preservation	Preserve excavated top soil and reuse later for landscaping applications thereby, reducing negative impacts to the site and surroundings	Preserve top 150 - 200 mm soil from excavation & reuse the soil for landscaping purposes within the same site and plant vegetation to prevent soil erosion	2	Planning to separate and preserve top soil may incur additional investment and management. The additional cost may vary as per the size of the site and excavated area.	Low	

S.N.	Credit Number	Credit Name	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
5	3	Access to Social Infrastructures	Provide access to basic amenities, so as to reduce negative impacts caused from automobile use.	Crèche / School / Anganwadi, provisional store, clinic, pharmacy, primary health center /dispensary, ATM, entertainment zones, milk booth, saloon, parks, restaurant	1	Documentation to be done by the Green Building Consultant	No Impact	Section 4.1.2
				Seating facility and toilets in the common area for service staff & visitors (minimum one toilet for every 200 dwelling units) Tot-lot for children	1	Part of the housing development, no additional cost involved for project. Documentation and design intent is required.	Low	
6	4	Green Cover on Site	Minimise disturbances or restore the site so as to reduce long-term negative environmental impacts, thereby promoting habitat and biodiversity	Avoid disturbance to the site by retaining natural topography or vegetation and/ or design vegetated spaces for atleast 15% of the site area.	2	To be incorporated in the initial stages of site planning.	No Impact	
				For this credit, vegetation on the ground only shall be considered and vegetation over built structures such as roofs, basement, podiums, etc., cannot be considered.		The vegetation on ground will be an additional benefit for the project saleability and micro-climate performance.	No Impact	
7	5	Heat Island Effect, Non-roof	Minimise heat island effect (Non-Roof)so as to reduce negative impacts on micro-climate, human and bio-diversity	For atleast 25% of exposed non-roof impervious areas (such as footpaths, pathways, roads, uncovered surface parking and other impervious areas) within the project site, provide atleast one or combination of the following: 1. Shade from tree cover within 5 years. 2. Open grid pavers, including grass pavers.	2	For paved area use open grid pavements and/or plant trees to ensure that the exposed hard paved area is either shaded or are light colour to reflect the sun's heat is required. Minimising hard paved areas is the cost-effective strategy for meeting this requirement.	Low	Section 4.1.2 Section 4.1.3
8	6	Heat Island Effect, Roof	Minimise heat island effect (Roof) so as to reduce negative impact on micro-climate, human and bio-diversity	Use material with high solar reflectance and thermal emittance (such as, white / light coloured china mosaic tiles or white cement tiles or high reflective coatings or other high reflective materials/ surfaces) to cover atleast 50% of the exposed roof areas	2	A decision to use light / reflective material for roofing finish is needed. No additional cost is incurred.	Low	Section 5.1.5

S. No	Credit Number	Credit Name	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
9	7	Parking Facilities for Tenaments	Provide adequate parking within the site to minimise disturbance caused due to parking on public roads, thereby, enhancing the quality of civic life	Provide parking for residents, to meet or exceed local bye-law requirement.	1	As part of the mandatory requirement as per building by-laws, no additional design intervention is required.	No Impact	Section 4.1.3
				For visitors, provide parking spaces as per local bye-law. Or In places where local bye-law for visitor parking does not exist, provide parking for visitors equivalent to 10% of the parking area / spaces required for residents as per local bye-law.		If required by local by-laws, then no additional design intervention is required. Where bye-laws do not ask for visitors parking, additional visitor parking needs to be planned.	No Impact	
10	8	Design for Differently Abled	Ensure that the building/ campus design caters to differently abled people.	Design the building / campus to provide the following, as applicable, for differently abled people in accordance with the guidelines of National Building Code (NBC) of India 2016.	2	As per the new Rights of Persons with Disability (RPWD) Act 2016, the accessibility measures to be implmented in project have become mandatory. Thereby, in case the project has not considered the necessary measures, then it is imperative to use them to meet the RPWD Act.	No Impact	
11	9	Basic Facilities for Construction Workforce	Promote welfare of construction workforce by providing safe and healthy work conditions.	Design the basic facilities for construction workforce in accordance with the guidelines of 'The Building and other Construction Workers Act, 1996 & Rules, 1998'.	2	Part of the Environmental Impact Assessment and its potential to audit the project based on the same. It is imperetive to implement the measures as mentioned in BOCW Act.	No Impact	
Section Total					**16**			

S.N.	Credit Number	Credit Name	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
Water Conservation								
12	1	Availability of Potable Water	Ensure that households are provided with piped water supply to meet water requirements, so as to ensure that the community is habitable	Provide piped fresh water supply and storage system, considering per capita consumption of 90 litres fresh water per person per day.	1	The minimum potable requirement is prescribed in Part 9 of NBC 2016 which ensures that the credit requirement is met.	No Impact	Section 6.1.1 Section 6.1.2
13	2	Rainwater Harvesting. Roof & Non Roof	Implement Rainwater management systems to enhance ground water table and thereby reducing dependence on potable water	Provide rainwater harvesting system to capture atleast 50% of run-off volumes from roof and non-roof areas. The harvesting system designed should cater to atleast 1 day of normal rainfall occurred in the last 5 years.	3	Provision of rainwater harvesting pits on site is a mandatory requirement of most local authorities. Calculation for rainwater harvesting pits and their documentation needs to be submitted.	No Impact	Section 6.1.1
14	3	Water Efficienct Plumbing Fixtures	Enhance efficiency of plumbing fixtures, thereby minimising potable water use	Install all water taps with aerators and water closets with dual flush cistern 1. Aerators fitted for taps (in dwelling units) 2. Water closets with dual flush (in dwelling units) 3. Water efficient fixtures in common area toilets	3	The requirement as per NBC 2016 will exceed the requirement proposed. design intervention may be required, though, few small precautions may be required to ensure the performance of fixtures.	Low	Section 6.1.5
15	4	Waste Water Treatment	Reduce consumption of potable water and waste water generation to minimise the burden on municipal water supply	Waste Water Treatment: Provide an on-site treatment system to treat 50% of waste water generated in the building/campus, to the quality standards suitable for reuse as prescribed by Central (or) State Pollution Control Board, as applicable.	3	The requirement is as per the EIA requirement and most of the municipalities also mandates the installation of STP. Thereby, no additional design intervention is required, though choice of STP may vary based on the size of the project and technology to be installed.	Low	Section 6.1.5 Section 6.2
16	5	Treated Waste Water Reuse	Encourage use of treated waste water to reduce dependence on potable water	Waste Water Reuse: Reuse treated waste water or captured rain water for landscaping, flushing water and vehicle wash/other appropriate applications.	2	Reuse of treated water will require additional interventions in terms of plumbing requirement.	Low	Section 6.1.6 Section 6.2
17	6	Management of Irrigation Systems	Reduce water demand for irrigation through water efficient management systems and techniques.	Provide or install highly efficient irrigation systems incorporating the features.	2	The installation of pressuring device, shutoff valve etc is required.	Low	Section 6.2

S.N.	Credit Number	Credit Name	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
18	7	Water Metering for dwelling units	Encourage water sub-metering to improve the water performance in the project, and thereby save potable water	Provide water meters as applicable: (minimum three water meters)	1	The identification of respective water meter is critical, no additional design intervention may be required for this credit.	Low	Section 6.1.5
Section Total					**15**			
Energy Conservation								
19	1	Energy Efficient Building Envelope	Improve energy efficiency of the building(s) and system(s) to reduce environmental impacts from excessive energy use	Wall: The project must ensure that the overall U-value of the wall assembly shall meet the baseline criteria based on climatic zones of India as mentioned	1	Please refer to the appropriate suggestions from handbook and design intervention reuirement.	Low	Section 5.1.2 Section 5.1.3
				Roof: The project must ensure that the U-value of the overall Roof assembly shall meet the baseline criteria based on climatic zones of India as mentioned	1	Please refer to the appropriate suggestions from handbook and design intervention reuirement.	Low	Section 5.1.5
				Glazing: The project must ensure that the U-value of the Glazing of all windows shall meet the baseline criteria based on climatic zones of India as mentioned	1	Please refer to the appropriate suggestions from handbook and design intervention reuirement.	Low	Section 5.1.4
				Solar Heat Gain Coefficient (SHGC) of Glazing: The project must ensure that the SHGC of the Glazing of all windows shall meet the baseline criteria based on the window to wall ratio & climatic zones of India as mentioned	1	Please refer to the appropriate suggestions from handbook and design intervention reuirement.	Low	Section 5.1.4
20	2	Shading Elements for Building Openings	Implement shading devices over external openings and optimise Window to Wall ratio.	At least 80% of the exterior openings (fenestration) shall have sun shades/ chajjas with a projection factor of 0.5 or more.	1	Please refer to the appropriate suggestions from handbook and design intervention reuirement.	Low	Section 5.2
				Climate responsive concepts and design features as applicable	1	Please refer to the appropriate suggestions from handbook and design intervention reuirement.	No Impact	Section 5.2 Section 5.1.1 Section 5.1.4

S.N.	Credit Number	Credit Name	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
21	3	Efficient Lighting	Enhance energy efficiency of the building(s) and system(s) to reduce environmental impacts from excessive energy use	Use energy efficient lighting fixtures to reduce the lighting power densities (LPD) in all interior, exterior, common and parking areas	2	Please refer to the appropriate suggestions from handbook and design intervention reuirement.	No Impact	
22	4	On-Site Renewable Energy and Solar Water Heater Systems	Promote self-sufficiency in energy through renewable technologies for on-site power generation and use within the project.	Install renewable energy systems for atleast 50 % of annual energy consumption for common area lighting (AND/OR) for Solar Water Heating, whichever is applicable	2	Though this feature has been mandated by few local municipal and state authorities, this measure is expensive and will increase the cost of construction.	High	
23	5	Energy Saving Measures in Appliances & other Equipment	Conserve energy in the use of appliances and other equipment, thereby reducing environmental impacts.	Pumps: BEE 4-Star rated pumps or Minimum 60% efficiency for pumps for capacity greater than 3HP and ISI certified pumps for others	1	The procurement process has to include high efficiency equipment from the very conceptual phase, as these equipment have a long lead time and major cost escalation.	Low	
				Motors: BEE 4-star rated motors (or) Minimum 75% efficiency for motors of capacity greater than 3 HP and ISI certified motors for others	1	The procurement process has to include high efficiency equipment from the very conceptual phase, as these equipment have a long lead time and major cost escalation.	Medium	
Section Total					**12**			
Material Conservation								
24	Mandatory Requirement	Separation of Household Waste	Facilitate segregation of house-hold waste at source so as to prevent such waste being sent to land-fills	Provide separate bins to collect dry waste (paper, plastic, metals, glass, etc.,) and wet waste (organic).	Mandatory	Please refer to the various provisions explained in the handbook.	No Impact	Section 7.3
				Additionally provide separate bins in a centralised/ common facility to collect waste such as e-waste, medical and paper waste.		Please refer to the design intervention suggested in handbook.	No Impact	
25	1	Organic Waste Management	Ensure effective organic waste management, post-occupancy, so as to prevent waste being sent to landfills	Install on-site waste treatment systems Viz. dump-pits, organic waste converter or Vermi-Composting, etc., to treat atleast 50% of the organic waste generated and reuse them for landscaping needs.	2	The equipment need to be procured upfront and use of the OWC has to be communicated to the users. The OWC may increase the cost of construction, for more detail please refer to the handbook.	HIgh	Section 7.3

S. No	Credit Number	Credit Name	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
26	2	Handling of Construction Waste Materials	Encourage practices to manage construction waste, thereby, avoiding waste being sent to land-fills.	Avoid atleast 50% of the waste generated (by either weight or volume) during construction from being sent to land-fills.	2	Documentation to be done by the Green Building Consultant.	No Impact	Section 7.1
27	3	Use of Local Materials	Encourage use of building materials available locally thereby minimising the associated environmental impacts resulting from transportation	Source atleast 50% materials which are extracted and manufactured, locally within a distance of 400 kms	3	Documentation to be done by the Green Building Consultant.	No Impact	
				Survey and identify building materials which are in the specified distance, in early stages of project design.		Documentation to be done by the Green Building Consultant.	No Impact	
28	4	Materials with Recycled Contents	Encourage use of materials which contain recycled content to reduce environmental impacts associated with the use of virgin materials	Use materials with recycled content such that the total recycled content constitutes atleast 10% of the total cost of the materials used in the building(s)	3	Documentation to be done by the Green Building Consultant.	No Impact	Section 7.2
29	5	Appropriate Technologies	Encourage use of appropriate and alternative construction technologies to conserve natural resources and thereby reduce environmental impacts	At least 50% (by cost) of the structure should be constructed using appropriate and cost effective technologies without compromising on strength, durability & functional performance and encourage use of alternative technologies.	4	Please refer to innovative technologies proposed in Handbook.	No Impact	Section 5.1.3
30	6	Alternative Construction Materials	Encourage use of alternative construction materials to conserve natural resources and thereby reduce environmental impacts	Atleast 25% of the alternative materials should be used in the building construction.	2	Please refer to innovative technologies proposed in Handbook.	Low	Section 5.1.3
Section Total					**16**			

S.N.	Credit Number	Credit Name	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
Indoor Environment Quality								
31	Mandatory Requirement	Tobacco Smoke Control	Minimise exposure of non-smokers to the adverse health impacts arising due to passive smoking, post occupancy.	Smoking should be prohibited in all the common areas of the building.	Mandatory	Administrative Credit, no design intervention is required.	No Impact	
32	1	Day Lighting	Ensure connectivity between the interior and the exterior environment, by providing adequate daylighting	Achieve minimum glazing factors as listed below in atleast 50% of the regularly occupied spaces in each dwelling unit.	2	This design aspect can be checked and reviewed by the architect himself, the IIFL GVP will support in analysing this credit. Though, in case the project team has already hired a green bnuilding consultant, then a GBC can confirm the compliance of the respective credit.	No Impact	Section 5.1.4
				Demonstrate through computer simulation that 50% of the regularly occupied spaces in the building achieve daylight illuminance levels for a minimum of 110 Lux in a clear sky condition on 21st September at 12 noon, at 2 feet 6 inches height.			Low	
33	2	Fresh Air Ventilation	Avoid indoor pollutants by providing adequate outdoor air ventilation, thereby enhancing the indoor environment quality	Provide openable windows or doors and ventilators to the exteriors in all regularly occupied spaces of each dwelling unit such that the openable area is designed as outlined	2	Documentation to be done by the Architect. The GVP from IIFL will support the team to manage the documentation for the respective credit.	No Impact	Section 5.1.4
34	3	Cross Ventilation	Encourage adequate cross ventilation in the design thereby, providing a healthy environment.	Provide openable doors / windows / ventilators to the exteriors in all regularly occupied spaces of each dwelling unit in atleast two of the orientations.	2	Documentation to be done by the Architect. The GVP from IIFL will support the team to manage the documentation for the respective credit.	No Impact	Section 5.1.4
35	4	Exhaust System	Ensure that bathrooms and kitchen are adequately ventilated, so as to improve the quality of the indoor environment.	Design exhausts systems in bathrooms as per the requirements provided	2	Documentation to be done by the Architect. The GVP from IIFL will support the team to manage the documentation for the respective credit.	No Impact	
36	5	Low VOC Materials, Paints and Adhesives.	Encourage use of materials with low emissions so as to reduce adverse health impacts on building occupants	Use low VOC paints, sealants and adhesives to reduce adverse health impacts on building occupants.	2	Documentation to be done by the Architect. The GVP from IIFL will support the team to manage the documentation for the respective credit.	Low	

S.N.	Credit Number	Credit Name	Intent	Requirement	Available Points	Design Intervention Required	Cost Impact	Handbook Reference
37	6	Occupant Well Being Facilities	Provide occupant well-being facilities, so as to enhance physical, emotional and spiritual well-being of building occupants.	Demonstrate that the project has community well-being facilities of appropriate size (such as yoga/ meditation room/ reading room or any gathering space and common seating spaces).	1	Documentation to be done by the Architect. The GVP from IIFL will support the team to manage the documentation for the respective credit.	No Impact	
Section Total					**11**			
Innovation and Design Process								
38	1	Innovative Practices	Provide design teams and projects an opportunity to attempt for innovative performance in green building categories not specifically addressed by the IGBC Green Affordable Housing Rating System.	The projects can also identify the innovation strategies those are not addressed by any existing credits in the rating system. Identify the intent of the proposed innovation credit, to achieve significant, measurable environmental performance requirements for compliance of the credit.	4	The innovation can be identified in discussion with the design team and developers. The innovation may come with additional cost to the project.	Low	
39	2	IGBC Accredited Professional	Support and encourage involvement of IGBC Accredited Professional in green affordable housing projects, so as to integrate appropriate design measures and streamline certification process	Atleast one principal participant of the project team shall be an IGBC Accredited Professional.	1	The accredited professional may get involved from architect side, developer side, green building or may include professionals from IIFL GVP program as well.	No Impact	
Section Total					**5**			
IGBC Green Affordable Housing Rating Total					**75**			

Annexure 3

EDGE Rating System with Cost Impact and Handbook References

EDGE for Homes							
S. N.	**Criteria Number**	**Criterion Name**	**Intent**	**Requirement**	**Design Intervention Required**	**Cost Impact**	**Handbook Reference**
Energy Effeciency Measures							
1	HME 01	Reduced Window to Wall Ratio	Finding the correct balance between the transparent (glass) and the opaque surfaces in the external façades helps to maximize daylight while minimizing unwanted heat transfer, resulting in reduced energy consumption.	Window Wall Ratio (WWR) should be selected and the WWR value entered into the software in all cases, irrespective of the value.	Optimum WWR to be incoporporated during the Design development stage.	No impact	Section 5.1.4
2	HME 02	Reflective Paint/ Tiles for Roof- Solar Refelectivity	Specifying a reflective finish for the roof can reduce the cooling load in air-conditioned spaces and improve thermal comfort in non-air conditioned spaces.	This measure can be claimed if the solar reflectivity (albedo) of the roof is greater than the local base case as set out in the Key Assumptions for the Base Case in the Design section	Roofing finish specifications to be formulated accordingly. Choice of suitable option can lead to minimal cost implication.	Low	Section 5.1.5
3	HME 03	Reflective Paint for External Walls - Solar Reflectivity	Specifying a reflective finish for the walls can reduce the cooling load in air-conditioned spaces and improve thermal comfort in un-cooled spaces.	This measure can be claimed if the solar reflectivity (albedo) of the external wall finish is greater than the local base case as set out in the Key Assumptions for the Base Case in the Design section.	Wall finish specifications to be formulated accordingly. Choice of suitable option can lead to minimal cost implication.	Low	Section 5.1.5
4	HME 04	External Shading Devices	External shading devices are designed on the building façade in order to protect the glazing elements (windows) from direct solar radiation	EDGE uses a shading factor equivalent to that of a shading device that is 1/3 of the height of the window and 1/3 of the width of the window on all windows of the building.	Design of shading devices to be undertaken accordingly. Refer subsequent sections for effective shading options.	Low	Section 5.2
5	HME 05	Insulation of Roof	Insulation is used to prevent heat transmission from the external environment to the internal space (for warm climates) and from the internal space to the external environment (for cold climates). Insulation aids in the reduction of heat transmission by conduction, so more insulation implies a lower U Value and better performance. A well-insulated building has lower cooling and/or heating energy requirements.	This measure refers to the U Value or thermal conductivity of materials as the indicator of performance, in which the use of insulation improves the U Value. The measure can be claimed if the U Value of the roof is lower than the base case.	Refer subsequent sections for suitable assembly alternatives with required U-values. Cost implication varies based on the assembly alternative.	Medium	Section 5.1.5

S. No.	Criteria Number	Criterion Name	Intent	Requirement	Design Intervention Required	Cost Impact	Handbook Reference
6	HME 06	Insulation of External walls	Insulation is used to prevent heat transmission from the external environment to the internal space (for warm climates) and from the internal space to the external environment (for cold climates). Insulation aids in the reduction of heat transmission by conduction, so more insulation implies a lower U Value and better performance. A well-insulated building has lower cooling and/or heating energy requirements.	This measure refers to U Value as the indicator of performance, in which the use of insulation improves the U Value. The measure can be claimed if the U Value of the external walls is lower than the base case		High	Section 5.1.2 Section 5.1.5
7	HME 07	Low E-coated glass	The purpose of adding a Low-E coating to glazing is that it reduces the transference of heat from one side to the other by reflecting thermal energy. In warm climates the intention is to reduce heat gain and in cold climates the intention is to reflect heat indoors.	This measure can be claimed if Low Emissivity (Low-E) coated glazing is used.	Specifications to be formulated accordingly. Cost implication depends on the glazing area.	Low	
8	HME 08	Higher Performance Glass	By selecting double or triple glazing, which has an improved thermal performance as well as a coating (tinted glass or Low-E) the heat transfer is reduced further than in HME07 and an even lower SHGC can be achieved	This measure can be claimed if the glazing is multi-paned (double or triple) and has a superior thermal performance.		High	
9	HME 09	Natural Ventilation	A well-designed natural ventilation strategy can improve occupant comfort by providing both access to fresh air as well as reducing the temperature. This results in a reduction of the cooling load, which lowers initial capital and maintenance costs.	This measure can be claimed when two conditions are met. The first one is the room depth to ceiling height ratio and the proportion of openings required for a certain floor area. Both conditions should be calculated room by room in order to ensure adequate natural ventilation for the whole home.	Design intervention required. Natural ventilation provisions to be incorporated during the Design phase. Refer subsequent sections of the handbook for relevant startegies. NBC guidelines may be referred.	No Impact	Section 5.1.4
10	HME 10	Ceiling fans in all Habitable Rooms	Ceiling fans are used to increase air movement that aids human comfort by promoting the evaporation of perspiration (evaporative cooling).	This measure can be awarded where ceiling fans have been specified in all habitable rooms. In countries where ceiling fans are standard (such as India) energy-efficient ceiling fans must be installed for this measure to be claimed.	Inherent part of Housing design in India.	No Impact	

S. No.	Criteria Number	Criterion Name	Intent	Requirement	Design Intervention Required	Cost Impact	Handbook Reference
11	HME 11	Air Conditioning systems (COP of 3.5)	In many cases cooling will not be fitted as part of the original build, which increases the risk that future occupants will deal with any overheating with an amateur installation of inefficient and poorly sized air conditioning units. By designing the installation of an efficient cooling system, the energy needed to deliver the required cooling will be reduced.	If the project includes a cooling system, the actual COP of system should be entered into software (even if COP is lower than 3.5). Savings can be achieved if the air conditioning system provides a Coefficient of Performance (COP) greater than 3.5 under ARI condition.	Design intervention required for high end projects. Specify high COP cooling system. Marginal cost increase in high end projects.	Not Applicable	
12	HME 12	High Efficiency Boiler for Heating space	The specification of a highly efficient boiler for space heating reduces the energy required to satisfy the heating load for the building.	This measure can be claimed if the boiler used for delivering space heating has an annual fuel utilization efficiency that is greater than the base case.	Applicable only for cold climate regions. Design intervention required. Cost implication depends on the system adopted and Project areas.	Not Applicable	
13	HME 13	High Efficiency Boiler for Hot Water	The specification of a highly efficient boiler for water heating reduces the energy required to satisfy the hot water demand for the building.	This measure can be claimed if the boiler used for delivering hot water heating has annual fuel utilization efficiency greater than the base case	Design intervention required where hot water is provided from a central heating unit. Cost implication depends on the system adopted and Project areas.	Not Applicable	
14	HME 14	Heat Pump for Hot Water Generation	To provide hot water with high efficiency by recovering heat from outgoing stale air and transferring it to domestic hot water. Heat pumps for hot water use electricity to move heat from one place to another instead of generating heat directly. To clarify the concept, heat pumps for hot water take the heat from surrounding air and transfer it to water in an enclosed tank	This measure can be claimed if the waste heat from electric heat pumps is used for delivering hot water and has an efficiency greater than the base case. The coefficient of performance (COP) is used in this measure to establish the efficiency.		Not Applicable	
15	HME 15	Energy Efficient Refrigerators and Clothes Washing Machines	Minimize the energy consumed by refrigerators and clothes washing machines installed in a home.	This measure can be claimed if the refrigerators and clothes washing machines installed are energy efficient. This can be demonstrated by purchasing refrigerators and clothes washing machines that achieve recognized appliance ratings.	Provision of these appliances are generally not under the scope of the developer.	Not Applicable	
16	HME 16	Energy Saving Light Bulbs- Internal Spaces	The specification of CFL, LED, or T5 lamps reduces the building's energy use for lighting. Due to the improved energy efficiency, heat gains are lowered, which in turn reduces cooling requirements. As the service life of these types of bulbs is generally higher than that of incandescent bulbs, maintenance costs are also reduced.	This measure can be claimed if at least 90% of the light bulbs in all habitable spaces (including living rooms, dining rooms, kitchens, bathrooms, and corridors) are either compact fluorescent (CFL), LED, or T5 type.	Specifications to be formulated accordingly. The alternatives provided in the credit comprises of most of the technologies currently available in the market, therefore, no major design intervention would be required.	Low	

S. No.	Criteria Number	Criterion Name	Intent	Requirement	Design Intervention Required	Cost Impact	Handbook Reference
17	HME 17	Energy Saving Light Bulbs- External Spaces	The specification of CFL, LED, or T5 lamps reduces the building's energy use for lighting. As the service life of these types of bulbs is generally higher than that of incandescent bulbs, maintenance costs are also reduced.	This measure can be claimed if the type of light bulbs in all common area and outdoor spaces is compact fluorescent (CFL), LED, or T5.		Low	
18	HME 18	Lighting Controls for Corridors & Outdoors	By installing automatic controls in public, shared, and outdoor spaces, the possibility of lights being left on when not required is reduced and less energy is consumed.	All lighting in shared corridors, common areas, staircases, and outdoor areas must be controlled by photoelectric switching or dimming, occupancy sensors, or timer controls.	Design intervention required. Cost implication depends on the Project area and technology adopted.	Low	
19	HME 19	Solar Hot Water Collectors	The installation of solar water heating will reduce the grid electricity (fossil fuels) used by the building for water heating.	This measure can be claimed where solar thermal water heating is specified.	Design intervention required. Cost implication depends on the total demand of hot water.	High	
20	HME 20	Solar Photovoltaics	Installing solar photovoltaic panels reduces the amount of electricity required from the grid.	This measure can be claimed if solar photovoltaic panels are installed on the building. Because the specific proportion of electricity is replaced by renewable energy, the PV panels are considered an energy efficiency measure.	Design intervention required. Cost implication depends on the proportion of electricity demand intended to be offset by solar PV.	High	
21	HME 21	Smart Meters	Reduce energy demand through increased awareness of energy consumption, in this way the end-users appreciate, understand, and contribute to responsible use of energy in the building	This measure can be claimed when smart meters are installed in each unit of the building, by subscribing to an online monitoring system or installation of a Home Electricity Management System (HEMS), which requires little additional equipment installation. Note that this measure cannot be claimed when 'prepaid meters' are installed as they are not considered smart meters under EDGE.	Design intervention required. Cost implication depends on the total number of meters required to be installed.	High	
Water Effecient Measures							
22	HMW 01	Low Flow Showerheads	By specifying low-flow showerheads, water use is reduced without adversely affecting the functionality.	Savings can be achieved if all showerheads have a flow rate of less than the base case. The base case assumes a flow rate of 10 liters per minute.	Specifications to be formulated accordingly.	Medium	Section 6.1.5
23	HMW 02	Low Flow Faucets for Kitchen Sinks	By specifying low-flow faucets for kitchen sinks, water use is reduced without adversely affecting the functionality.	Savings can be achieved if the flow rate of the faucets specified for the kitchen sinks is less than the base case.		Low	

S. No.	Criteria Number	Criterion Name	Intent	Requirement	Design Intervention Required	Cost Impact	Handbook Reference
24	HMW 03	Low Flow Faucets for Washbasins	By specifying low-flow faucets for washbasins, water use is reduced without adversely affecting the functionality.	Savings are achieved if the flow rate of the faucets specified for the washbasins is less than the base case of 8 liters per minute.		Low	
25	HMW 04	Dual Flush for Water Closets	Fitting dual flush water closets helps to reduce the water used for flushing by providing a reduced flush option when a full flush is not required.	This measure can be selected when water closets have dual flush systems.		Low	
26	HMW 05	Single Flush for Water Closets	Fitting low-flush water closets reduces the water used for flushing.	Savings will be claimed when water closets have a flush volume which is lower than the base case.		High	
27	HMW 06	Rainwater Harvesting System	Rain water in a climatic zone with excessive rainfall can reduce the use of fresh water from the municipal supply.	This measure can be claimed if the rainwater collection system provides the water supply for use within the building (for example; for toilet flushing).	This is a mandatory requirement as per local by-laws. Refer sections of the Handbook for design alternatives.	No Impact	Section 6.1.1 Section 6.1.2
28	HMW 07	Recycled Grey-water for Flushing	By recycling the grey water, the use of fresh water from the municipal supply can be reduced.	This measure can be claimed if there is a grey water recycling system that reuses waste water from kitchens and bathrooms for the purpose of flushing toilets within the building.	Design intervention required. Refer subsequent sections of the Handbook for design alternatives. Cost implication depends on the Project requirements and technology adopted.	Medium	Section 6.1.6 Section 6.1.4
29	HMW 08	Recycled Black Water for Flushing	To reduce the use of water from the municipal supply and reduction of load on the local water and sewage infrastructure, a black water recycling system should be used.	This measure can be claimed if there is a black water recycling system that reuses wastewater from all internal uses.		Medium	Section 6.1.6
Material Effeciency Measures							
30	HMM 01	Floor Slabs	To select a floor slab specification with a lower embodied energy than the typical specification. The floor slab specification matching the actual building design should be entered into the software	The design team should select the specification that most closely resembles the floor slab specified, and enter the thickness. Where there are multiple specifications the predominant specification should be selected. The specification for the floor slab should be that of the intermediary floor and not the ground floor.	Specifications to be formulated accordingly.	No Impact	

S. No.	Criteria Number	Criterion Name	Intent	Requirement	Design Intervention Required	Cost Impact	Handbook Reference
31	HMM 02	Roof Construction	To select a roof specification with a lower embodied energy than the typical specification. The roof slab specification matching the actual building design should be entered into the software	The design team should select the specification that most closely resembles the roof specified, and enter the thickness. Where there are multiple specifications, the predominant specification should be selected.		No Impact	Section 5.1.5
32	HMM 03	External Walls	To select an external wall specification with a lower embodied energy than the typical specification. The external walls specification matching the actual building design should be entered into the software	The design team should select the specification that most closely resembles the external walls specified, and enter the thickness. Where there are multiple specifications, the predominant specification should be selected. The external walls of the building are those directly exposed to the outdoor environment	Specifications to be formulated accordingly. Refer subsequent sections of the Handbook for design alternatives of wall assembly.	No Impact	Section 5.1.2 Section 5.1.3
33	HMM 04	Internal Walls	To select an internal wall specification with a lower embodied energy than the typical specification. The internal wall specifications matching the actual building design should be entered into the software	The design team should select the specification from the drop down list that most closely resembles the internal walls specified, and enter the thickness. Where there are multiple specifications the predominant specification should be selected.		No Impact	
34	HMM 05	Flooring	To select a flooring specification with a lower embodied energy than the typical specification. The floor type specification matching the actual building design should be entered into the software	The design team should select the specification that most closely resembles the floor finish specified. Where there are multiple specifications the predominant specification should be selected.	Specifications to be formulated accordingly.	Low	
35	HMM 06	Window Frames	To select a window frame specification with a lower embodied energy than the typical specification. The window frame specifications matching the actual building design should be entered into the software	The design team should select the specification that most closely resembles the windows specified. Where there are multiple specifications the predominant specification should be selected.		Medium	
36	HMM 07 & 08	Insulation	To select insulation with a low embodied energy. If the building has insulation on the walls and the roof, then the insulation type matching the actual building specifications should be entered into the software	The design team should select the specification that most closely resembles the insulation specified. Where there are multiple specifications the predominant specification should be selected. The base case assumes that no insulation is specified.	Specifications to be formulated accordingly. Refer subsequent sections of the Handbook for insulation alternatives.	High	Section 5.1.2 Section 5.1.5

Annexure 4

Cost Optimization and Affordability

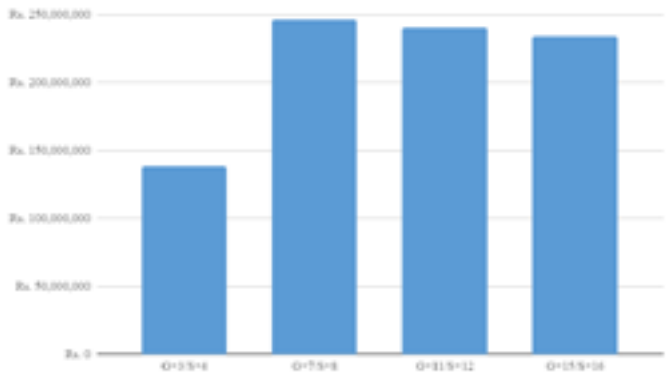
It is well-understood that sustainability quotient cannot be expected to adversely impact a project's financial profitability. Therefore, a preliminary analysis has been undertaken to establish the optimum project attributes that can maximize the profitability of an affordable housing project. Astoundingly, our discovery of the most profitable affordable housing model is aligned with the factors that have been promoted as sustainable features in this handbook.

The following assumptions have been considered in the aforementioned financial profitability analysis-

1. Land cost- ₹ 15,000 per sq.m. (₹15 Cr. per Ha)
2. Land area- 1 Ha (10,000 sq.m.)
3. Built up area of each unit — 70 sq.m. (super BU area) with approx. 45 sq.m. carpet area
4. Construction cost

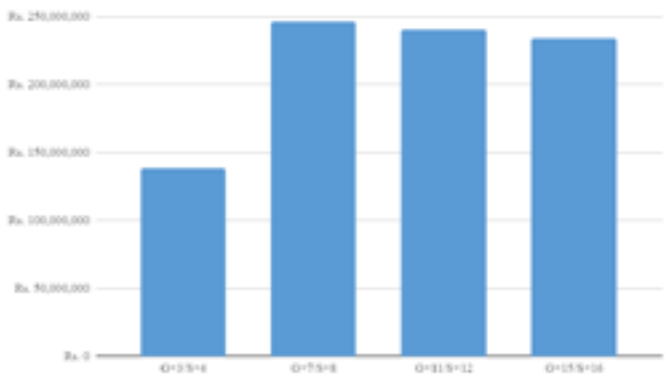
	S + 4	S + 7	S + 11	S + 16
Cost per sq.m.	**₹12,000**	**₹15,000**	**₹17,000**	**₹18,000**
Justification	Gradual increase due to increase in Structural cost			

Based on the above inputs, the following results were generated for the Project's profitability:



Base case — **Project's Total Profitability**

Although the Project's total profitability for alternatives of G+7/S+8 and further high-rise appears similar, the stark difference in a Project's actual profitability is demonstrated by the 'profitability per unit' graph below. This aspect is further enhanced by the reduced burden of selling larger number of units in high-rise alternatives and a quantitative decrease in marketing overheads and- burden of unsold inventory.



Base case — **Profitability per Unit**

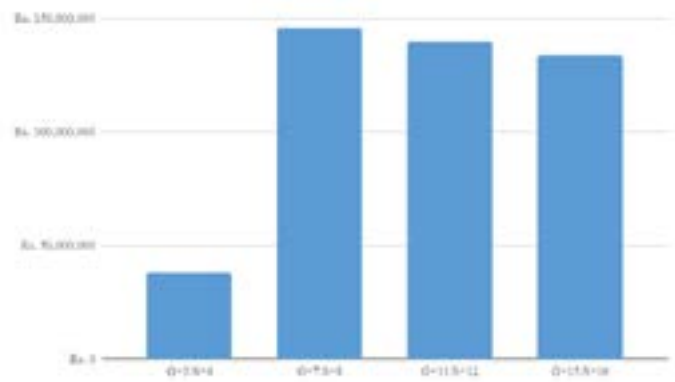
The above graph clearly establishes G+7/ S+8 as the most profitable alternative. This is further enhanced by the fact that building multiple towers of S+8 height allows for easier phasing (demand based if needed) as compared to further high-rise options. This ensures minimized trapping of capex in unsold inventory and faster completion of towers enabling early occupancy by buyers and in turn enhancing the cash flows (by virtue of payment milestones) for developers.

With increasing land prices in the urban centers and rising demand for affordable housing near them due to migratory patterns, the project's total cost is largely driven by the cost of land. Therefore, a sensitivity analysis has been undertaken to establish the pattern and verify the applicability of S+8 as the most financially profitable scenario.

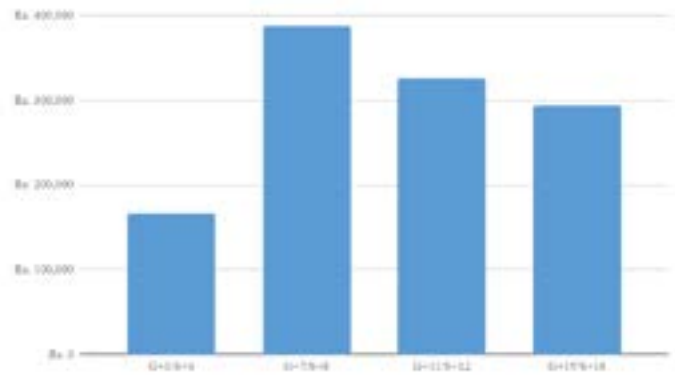
Case 1

Land cost — ₹ 25,000 per sq.m. (₹ 25 Cr. per Ha)

Case 1 — **Project's Total Profitability**



Case 1 — **Profitability per Unit**



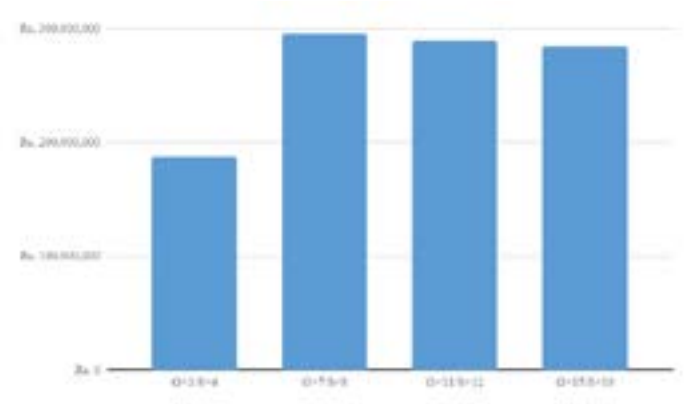
As noted, the trend in this case is similar to the one explained in the base case above.

Case 2

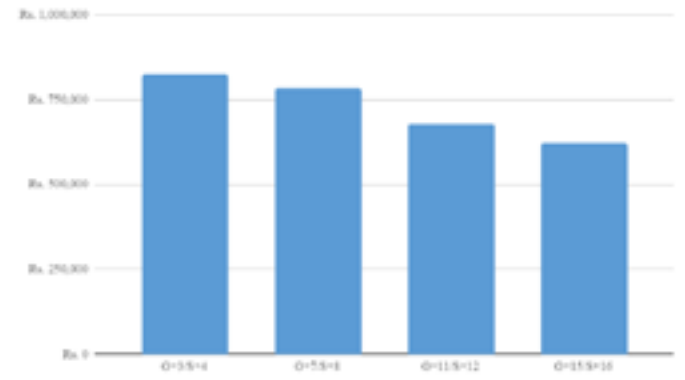
Land cost — ₹10,000 per sq.m. (₹10 Cr. per Ha)

This case is generally applicable for projects in the outskirts of urban centers and newly developing Tier 2 & Tier 3 cities.

Case 2 — Project's Total Profitability



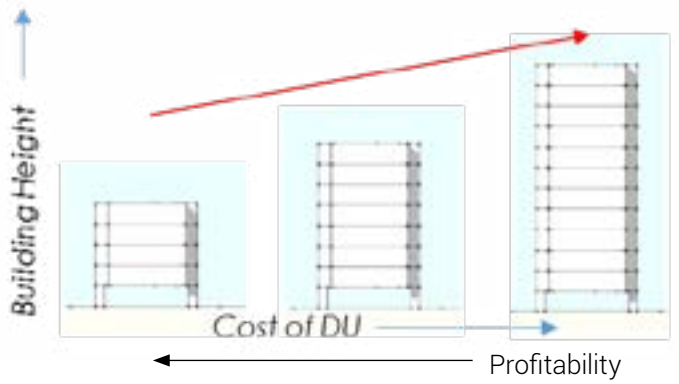
Case 2 — Profitability per Unit



In case 2, the overall Project profitability follows the same trend as Base Case and Case 1, whereas the profitability per unit is higher for low-rise development alternative.

CONCLUSION

As observed in the above cases, G+7/S+8 is fairly the most profitable alternative as compared to the high-rise development options. It is also considered a more sustainable alternative to achieve environmental and social sustainability. Therefore, we would urge the developers to undertake an in-depth analysis of a project's alternatives utilizing the services of experts such as IIFL's GVP team to ensure optimum implementation of green building aspects and maximize profitability for the projects.



Annexure 5

Calculations for STP Capacity

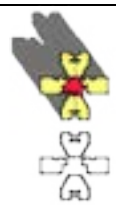
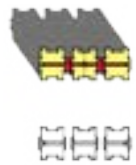
S.No	Description	Units	Value
1	Number of households (Z)	Number	
2	Number of people per household (Y)	Number	
3	Water supply per person per day (W), Refer table below	LPCD	
4	Water return coefficient (V), assume 0.85 ie. 85%	—	0.85
5	STP capacity for combined system (U = (Z x Y x W x V)/1000	KLD	
	STP capacity for separate system		
6	Total Blackwater generated = U x 0.7	KLD	
7	Total Greywater generated = U x 0.3	KLD	

Table for Finding Water Supply per Person per Day*	
Communities with Population	**LPCD**
<20,000 with water supply through stand post	40 (Minimum)
<20,000 with water supply through house connection	70 – 100
20,000 to 100,000 with full flushing system	100 – 135
>100,000 with full flushing system	150 – 200

* as per NBC 2016

Annexure 6

Comparison of Envelope Area/Floor Area for Building Types

S.No.	House type	Block Perimeter	Exposed Perimeter	Floor area	BP/A	EP/A	Typical floor height	No. of floors	Exposed envelope area	Exposed envelope area/Floor	Comparison to Row house
1		342.28	304.32	809.68	0.42	0.38	3	4	3651.8	4.51	2.28
2		375.68	277.44	816.86	0.46	0.34	3	4	3329.3	4.08	2.06
3		192.82	170.84	428.61	0.45	0.4	3	4	2050.1	4.78	2.42
4		201.16	171.52	349.04	0.58	0.49	3	4	2058.2	5.90	2.98
5		235.09	109.1	459.45	0.51	0.24	3	4	1309.2	2.85	1.44
6		143.28	93.6	567.42	0.25	0.16	3	4	1123.2	1.98	1.00

Annexure 7

Comparative Statement for Pump Requirements

Groundwater Pump Analysis	Case 1	Case 2	Case 3	Unit
Depth of GW Table	500	1,000	1,200	Feet
Water Demand	95,000	95,000	95,000	L/day
Total Dynamic Head	525	1,050	1,260	Feet
Water Horsepower	TDH*Q*SG/3960	TDH*Q*SG/3960	TDH*Q*SG/3960	
Discharge Required	100	120	120	Liter/min
	22	27	27	Gallon/min
Water Horsepower	3	7	8	HP
Design Pump Capacity	5	11	13	HP
Pump Discharge	6,000	7,200	7,200	LPH
Running Hours per Day	16	13	13	Hours/day
Energy Consumed	54	109	130	kWh/day
Electricity Rate	7	7	7	₹/kWh
Total Electricity Cost	380	760	911	₹/day
Bore Well Cost	50,000	1,00,000	1,20,000	₹
Capital Cost Including Pump Control Switchboard	40,000	75,000	90,000	₹
Annual Depreciation	10%	10%	10%	
Depreciation Amount	25	49	58	₹/day
Annualised Cost	4.26	8.51	10.21	₹/KLD

Water Horsepower — Power Required to Move Water

TDH — Total Dynamic Head, Feet

Q — Pump Discharge, Gallon/Minute (1 Gallon = 4.54 Liters)

SG — Specific Gravity of Water, 1 Kg/M^3, 3960 is the Formula Constant Derived Empirically

Input Values Required:

1. Depth to GroundwaterTable
2. Average drawdown of water table
3. Assumed Discharge of Pump
4. Total Daily Water Demand
5. Electricity Rate (₹/unit)
6. Cost of Bore Well (₹/feet)

Annexure 8

Government Incentives Pertaining to Green Building Projects

The Central Government as well as various state governments across the country offer various incentives including fast track environmental clearance for green building projects that are pre-certified or provisionally certified by approved rating agencies such as GRIHA, IGBC or LEED etc. In addition to faster clearances, several authorities offer incentives such as additional floor area ratios, concessional financing and subsidies to encourage construction of green building. A few states have also mandated that any renovation of older buildings should adhere to the new green building norms. Various authorities keep updating these inentives from time to time. Interested parties should check these schemes while planning their projects and make the best use of the incentives. IIFL HFL's Green Value Partner initiative tracks these schemes on real-time basis and is pleased to provide consolidated information and guidance to interested projects across the country.

Alongside is a geographical representation of the states where schemes are being provided as on date.

REFERENCES

- Eco- Niwas Samhita 2018(Energy Conservation Code for Residential buildings), Part-1: Building Envelope, Bureau of Energy Efficiency (BEE)
- Position paper on Low-Carbon Resource-efficient Affordable Housing, Case: Rajkot. Ashok B. Lall Architects, GKSPL.
- National Building Code 2016
- SP41, Handbook on functional requirements of buildings (other than industrial buildings)
- Design guidelines for energy-efficient multi-storey residential buildings | Warm and Humid Climates, Bureau of energy efficiency programme (BEEP)
- Design guidelines for energy-efficient multi-storey residential buildings | Hot and dry Climates, Bureau of energy efficiency programme (BEEP)

Climate Change Issue is a Collective Responsibility

V Suresh
Chairman,
CII-IGBC

Rapid urbanization is happening across the globe and India, in particular. People would migrate to seek better employment, standard of living and quality of life. As India aims to become a 5 Trillion USD economy, the pace of urbanisation would further enhance in the coming years. In light of this, the need of the hour is to bring in various facets of resource conservation, energy and environmental management into the centre stage of design of buildings and other forms of built environment.

Building on this imperative, CII's Indian Green Building Council (IGBC) — formed in 2001 with the support of all the stakeholders — has facilitated introduction of green building concepts to the country. In a span of about 20 years, IGBC has launched 25 green building rating systems which are designed to address various building typologies and national priorities.

As on February 2020, over 5,700 green building projects have adopted IGBC's green building rating system, amounting to over 7.09 billion sq.ft of registered green building footprint in the country. This has led to market transformation by bringing in more than 1,100 certified green products and technologies for building construction industry. Today, India is one of the top 3 countries in the world in terms of embracing green and aspires to facilitate 10 billion sq.ft of footprint by 2022.

Addressing the specific needs of residential sector, IGBC has launched Green Homes in year 2008 and is under constant upgradation with the latest version 3.0 launched in year 2019. To cater green features in existing residential developments, Green Residential Societies rating was launched in 2015. Green Affordable housing rating system was developed in the year 2017, to provide better quality of living, optimise resource consumption and reduce operation and maintenance costs ultimately reducing the carbon footprint. Over 2 billion sq.ft. of residential building footprint with 14 lakh dwelling units are going green across the country. These projects address key sustainable aspects viz., integrated water management, energy efficiency, zero waste management, use of passive & active design strategies with cost effective & innovative building technologies and GreenPro certified products.

Given this context, the 'Sustainable Housing Book', an initiative of IIFL Home Finance is being launched at the right time. This handbook can be a comprehensive guide on policies, green building concepts, technologies, and innovative practices. I am glad to note, this handbook addresses the socio-economic benefits of embracing green and larger issues of pollution in construction industry, which will help in enhancing quality of life.

Addressing climate change issue is a collective responsibility. We need to act now and take significant steps in that direction.

An Investors Perspective on Sustainable Housing

Mark Eckstein
Environment Social and Governance Director
CDC Group

There is growing recognition that India's real estate sector needs to adopt more sustainable design and construction practices at scale and at speed. It is estimated that the sector generates approximately 24% of the country's annual CO2 emissions, is responsible for 30% of raw material use and is also significant user of water both during construction and operations. There are also significant labour and safety concerns associated with the sector, including widespread labour abuse and fatalities during construction.

With nearly 70% of India's housing development planned for the coming decade, it is imperative that we accelerate efforts to ensure the rapid adoption of "Green" and sustainable practices across the sector. This needs to happen at all scales and types of real estate construction – but especially in the affordable housing space where the benefits of "Green" real estate are more impactful for residents through the delivery of housing with lower utility and maintenance costs, and which have been designed to address public transport and air quality needs through the provision of green space.

The urgency of this transition is clear given India's rapid urbanization – and the attendant challenges this brings in terms of congestion, air quality in particular. The Eco-Cities India program has estimated that if 20% of new homes in India were designed to green building standards it would generate an estimated energy saving of 198 million kWh per year and 108 billion liters in water savings. These are significant and important benefits not only for residents and construction companies, but in aggregate will make a real difference in India's commitments to address climate change and the pressing need to ensure water use is optimized in India.

Fortunately, there is now growing progress in addressing many of the environmental and social challenges in the sector, and IIFL Home Finance Ltd. has increasingly taken a leadership role in promoting better design and construction practice. For example, through its Kutumb program and through the active engagement it has shown with developers, architects and planners to scale the delivery of a greener housing offer, and to share experiences and benefits with the wider developer and investor community.

As an investor in IIFL, and as an institution which has a mandate to support and enable more responsible private sector practices which deliver larger social and environmental dividends this is very welcome news and something that CDC fully supports and encourages. When CDC invests directly in real estate we work with developers to implement international green building standards such as IFC EDGE and we know this has multiple business benefits including cheaper maintenance and operational costs, higher re-sale values, access to new dedicated capital and bond markets that aim to address climate change and other Sustainable Development Goals. CDC also recognizes that important progress is being made in driving down the costs of "Green" real estate through technology, economies of scale as the message spreads, and the work of government and state agencies in promoting policies that support greener real estate. And of course as the benefits become more obvious demand from home owners and investors will help to drive the momentum further.

This Handbook is therefore both timely and an important source of guidance to a wide range of developers, investors and policy makers, as it can and should shape the ambitions of the sector.

Sustainable Housing Should be Integrated to the Planning Process

Jayram Santosh
Partner & Head, Climate Change — Sustainability and CSR Advisory, KPMG

According to the United Nations' World Urbanization Prospects 2018, India has the second-highest urban population in the world, with 416 million urban residents; this is further expected to grow by 416 million people by 2050.[10] While we work on "Housing for All", we also need to consider the sustainability aspects around the housing. Whether it is handling the waste (improved health and avoiding epidemics) or using sustainable materials and techniques (reduced impact on environment), these should be integrated to the planning process to make a sustainable progress.

The initiatives such as **Kutumb**, are carving the roadmap for the development of Green Affordable Housing by educating the developers about ways and means to reach this goal.

10 https://population.un.org/wup/Publications/Files/WUP2018-Highlights.pdf

Enhancing Success Through Right Advice

Yash Miglani
Director, Migsun Wynn

Migsun Developers had registered the Project (Migsun Wynn) for IGBC Green building certification during the project commencement period in 2017. Thereafter, due to various reasons the same was not being pursued further.

IIFL Home Finance's Green Value Partners (GVP) team met the Developer and the technical team in 2019 and re-initiated Developer's proposal for Green building certification by elaborating the benefits of such undertaking including environmental benefits, marketing benefits, FAR benefits etc. The GVP team also guided the Developer's technical team regarding the process of pre-certification and certification.

The GVP team participated in multiple technical discussions with the Developer's team and subject consultants, wherein they recommended changes in certain specifications including change of glass from Green glass to transparent glass, which not only resulted in additional Green credits, but also resulted in substantial cost savings for the Developer. The team diligently reviewed the Green building documentation being prepared by the Developer's consultant, thereby enabling achievement of Gold level pre-certification for the project by scoring 74 credit points, without losing a single point during review by IGBC.

The aforementioned efforts by the Developer and the GVP team, not only resulted in construction of additional built up area thereby enhancing the financial profitability; but also achieved a huge environmental impact in terms of embodied energy by usage of more than 80% locally available materials, efficient solid waste management; and operational savings in terms of 20% energy savings, 40% water savings, treatment of 100% waste water, harvesting of more than 90% of rainfall etc.

Such impact over a project consisting of 1,710 Units would not only enable an enhanced living for the 1,710 families which would be residing in the facility, but also the immediate community; and has the potential for catapulting the adoption of Green buildings by Developers in the Indian Housing domain.

Accelerating Adoption Through Binding Regulations

Smita Singh
Delegation of the European Union to India

India is developing at a fast pace and understands the need to be a global responsible economy ensuring sustainable consumption and production practices in order to address the threats related to climate change and environment degradation. The infrastructure needs of the country are enormous and there is a lot of pressure on the Government as well as the private sector to adopt and promote environment friendly solutions. The concepts of green housing, net zero or nearly zero energy buildings, eco-houses have been popular terminologies over the past decade; however, the uptake of such technologies has been slow worldwide. This is mainly because transforming our buildings to have a lower carbon impact requires significant changes at the policy level as well as innovative technology solutions. While a number of Government regulations and policies have addressed the need for promoting sustainable housing in India, it is now time to impose these regulations as binding regulations — for all types of construction — commercial as well as residential. Focus on the housing sector should not exclude the lower income households and hence need for affordable green housing should be made popular. Recognizing the cost sensitivities of adopting energy efficient/ climate friendly technologies and sustainable construction raw materials, there is still limited conviction that green housing is a necessity today rather than a mere conscious option for certain consumers. The European Union is working progressively towards making its economy sustainable and aims to be carbon neutral by 2050. European Union's Green Deal roadmap boosts the efficient use of resources by moving to a clean, circular economy; investing in environment friendly technologies; supporting industry to innovate; ensuring buildings are more efficient. In India, the European Union is supporting the National Housing Bank to promote affordable green housing in India in partnership with AFD.

I hope that with better awareness on the advantages of shifting to sustainable housing solutions, the sector will be driven by the customers thereby attracting the private sector players to offer innovative solutions at reasonable costs!

Addressing Housing Deficit in a Sustainable Manner

Susan Olsen
Unit Head-
Private Sector
Financial
Institutions
South Asia, ADB

The size of the housing deficit in India is large and concentrated in the affordable housing segment. According to the Government of India, the housing deficit is estimated at 18.7 million units in urban areas and 43.7 million units in rural areas, with the greatest need being in the economically weaker and low-income groups. Given the priority placed by the Pradhan Mantri Awas Yojana (PMAY) Initiative on incentivizing the construction of 20 million affordable homes for the urban poor by 2022, private developers are actively participating in the construction of lower cost housing units. ADB is also playing an active role in financing projects that contribute to reducing the housing deficit in India. ADB also supports addressing the housing deficit in an environmentally sustainable manner. Private developers in the affordable housing space play a key role in this effort. The climate consequences of significantly increasing the supply of affordable housing units without regard for resource utilization are severe, given already rising pollutions levels and the shortage of water in many cities across India. We commend IIFL for taking a pioneering role in promoting awareness and technical support for key stakeholders in the affordable housing ecosystem, and for increasing their commitment to finance green certified residential buildings. The green building methods supported by IIFL, and described in this handbook, play a vital role in ensuring that environmentally friendly processes are respected through the entire construction lifecycle, from design and construction, through to operation and maintenance. While India is one of the leading countries on green building initiatives, the number of green buildings - as measured by number of projects and square meters of green certified construction—remains very low, given the vastness of the market. We hope this handbook helps stakeholders and developers to increase their commitment to sustainable construction and overcome some of the technical barriers to more green and affordable housing in urban areas across India.

GREEN BUILDING CASE STUDY

Supra Builders Hyderabad

Supra Builders, who built India's first solar-powered apartment building, didn't start their first sustainable project with the intention of constructing a green building. "In fact, we didn't even know about green building concepts and had to learn about them on Google", says Chaitanya Rayapudi, Chairman & M.D, Supra Builders Pvt. Ltd..

After the land for the construction site had been bought, it was found that groundwater levels in that region were very low and inadequate for construction. Thus began the research on construction methods that use little or no water. The study showed that this was entirely possible by selecting the right materials for construction. Through a combination of R&D, green materials and common sense, Supra Builders successfully built an optimal green building with solar power as the primary source of electricity, which incidentally became India's first solar-powered apartment building. This is now the company's forte and operating USP. From thereon, they have only been involved with top-of-the line green and solar-powered projects.

The Challenges

The biggest challenge Supra Builders faced was a lack of know-how. They were new in this space, and it was their constant research on alternate building materials and green solutions that made it possible to correctly execute this project.

While design and architecture did contribute to the successful implementation of green solutions, it was majorly about selecting the appropriate materials for construction. When the project was initiated, availability of alternate building materials was quite scarce compared to the current market. There are much better options and choices available now.

Supra didn't make use of concessional funding and don't even now; "it has never been part of our marketing or sales campaigns. We believe in educating the customer about our product, about

the need for going green and how it will help them in their lives after construction, and this has always proven successful. Our overall experience has been quite overwhelming and our buyers have supported us from the beginning. It is very encouraging and reassuring to know that green buildings are saleable and people are ready to buy into the concept", says Rayapudi.

The Blueprint

According to Supra, green buildings can be judged primarily on three aspects: water, wood and energy. The way these elements are used during the construction of a building, and the life of a building after construction with respect to these elements, defines how eco-friendly the building is.

Supra-constructed buildings generally use 45-50% less water during the construction phase, and rainwater re-usage systems and injection-based groundwater harvesting pits are put in place to ensure water conservation in life after construction. Several energy-efficient elements are also used in their projects. Eco-friendly material is used for all internal doors, and steel doors are used for main doors; zero trees are cut for doors and windows. The company also uses AAC bricks instead of country bricks. Jointing is done with an eco-friendly chemical contrary to the usual cement-mortar mix, and gypsum is used for internal plastering instead of cement-mortar plaster. To save power, LED lights are installed in place of conventional lights and power-saving fans instead of regular fans. Supra buildings don't need inverters or diesel generators as solar power is the primary source of electricity. Even geyzers are not required as solar hot-water systems do the

needful, along with solar fencing for security. Finally, water-based paints are used instead of chemical paints.

The Benefits

All of these measures result in both immediate and long-term benefits. Homes in Supra buildings are cooler than those in conventional buildings. There are no power cuts, and power bills are as low as ₹25-50 per month for 10 months a year. Even in the peak of summer, AC runtime is 25-35% shorter than regular buildings. The dependency on local infrastructure is about 30% lower than regular apartments, and waste is 25-30% less than regular buildings, with most of the discarded scrap being recyclable. Alternate green materials are also easy to maintain, and the general quality and comfort of life is better in Supra buildings.

Going green is the need of the hour, but most people don't really know how to do so. Once they do, people will organically move towards adopting a greener lifestyle. Green concepts are a true way of giving back to nature, and when one invests in the planet, the returns are abundant.

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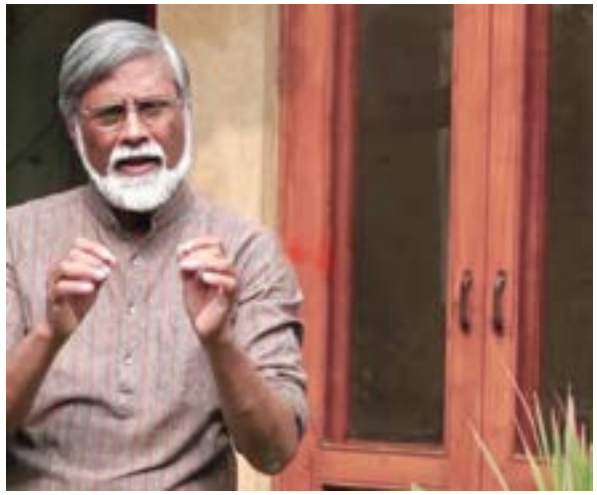
LIST OF ABBREVIATIONS

AAC	Autoclaved Aerated Concrete
AC	Air Condition
AFD	Agence Française de Développement
AH	Affordable Housing
AUM	Assets Under Management
BEE	The Bureau of Energy Efficiency
BHK	Bedroom-Hall–Kitchen
BOD	Biological Oxygen Demand
BREEAM	Building Research Establishment Environmental Assessment Method
BW	Black Water
CLC	Cellular Light Weight Concrete
COD	Chemical Oxygen Demand
DLC	Doubly Loaded Corridor
EC	Energy Conservation
EDGE	Excellence in Design for Greater Efficiencies
EPS	Environmentally Productive Space
EPS	Expanded Polystyrene
FAR	Floor Area Ratio
FRP	Fibre Reinforced Polymer
FSI	Floor Space Index
GRIHA	Green Rating for Integrated Habitat Assessment
GVP	Green Value Partner
GW	Greywater
GW	Groundwater
HA	Hectare
IGBC	Indian Green Building Council
IIFL HFL	IIFL Home Finance Limited
KLD	Kilo Litres per Day
LEED	Leadership in Energy and Environmental Design
LHP	Light House Projects
LPCD	Litre Per Capita per Day
LPD	Liter Per Day
LPM	Litres per Minute
MBBR	Moving Bed Bioreactor
NBC	National Building Code
O&M	Operation and Management
PMAY	Pradhan Mantri Awas Yojana
PURPOSE	Platform for Green Affordable HoUsing & Finance, Through Research, Policy & TechnOlogy, for Sustainable Eco-System
RAS	Return Activated Sludge
RCC	Reinforced Cement Concrete
RH	Row House
RK	Room Kitchen
RO	Reverse Osmosis
SBR	Sequencing Batch Reactor
SDGs	Sustainable Development Goals
SRI	Solar Reflectance Index
STP	Sewage Treatment Plant
TERI	The Energy and Resources Institute
TSS	Total Suspended Solids
UG	Underground
UHI	Urban Heat Island
WC	Water Closet
WFRop	Openable Window to Floor Area Ratio
WPC	Wood-Plastic Composites
WWR	Window to Wall Ratio
WWTP	Waste Water Treatment Plant

ABOUT THE AUTHORS

Ashok B. Lall

Principal at Ashok B Lall Architects (established in 1981), which is committed to an architectural practice based on the principles of environmental sustainability and social responsibility.



Mr. Ashok Lall received his Architectural Association Diploma from the University of Cambridge, U.K. in Architecture and Fine Arts in 1970. His architectural firm, ASHOK B LALL ARCHITECTS was established in 1981.

The firm has won numerous awards and its work has been widely published, having put out several articles and papers on environmentally sustainable design. The firm has also been an active member of institutions and groups promoting awareness and building competence in the sustainable design of buildings. Since 1990, Mr Lall has been engaged in education and has developed curricula and pedagogy on environmental issues from an architectural perspective. He has presented his work on sustainable design at various forums in India and abroad.

'As Professionals we have a dual responsibility. We must serve in the best possible way the legitimate need of our client. Equally, we must see that the means and ends of the building design solutions we propose also serve a larger beneficial purpose. We believe that creative practice of architecture would seek to converge this duality into a unity.' This is the philosophy by which Mr Lall and his team operate.

Mr. Lall believes that architecture is a mindful practice of an art built upon ethical foundations. This belief evokes his interest in developing strategies for sustainable urban development in the face of rapid urbanization. Over the last five years, he has designed affordable housing projects in various parts of the country and invested in the research of resource and energy efficiency in the context of affordable housing. This research culminated into a Position Paper that explains the core ideals of sustainable housing for the vast urban population of the country. He believes a correction in town planning norms and building regulations is necessary to secure a sustainable urbanized future for India.

Mr. Lall and his firm do not espouse any style or aesthetic and take each design as a process of discovery to find appropriate solutions to the needs of the project at hand. The process is driven by three guiding principles: inclusion of the client and user groups at all stages of the project, a search for simplicity and economy of means and prioritizing design strategies and technologies that emphasise sustainability and energy conservation. He believes while the primary responsibility for

Affordable Housing at Palghar, Maharashtra

driving sustainable construction rests with industry professionals, the market for Green Housing also requires an aware consumer to make demands of the designer and developer. To propagate awareness on Green Housing, he has made a popular series of videos called "New Vaastu" in collaboration with the Centre for Science and Environment, India.

In his mission to spread the message of sustainable design for affordable housing, Mr. Lall has found a partner in IIFL. IIFL's KUTUMB platform provides Mr. Lall a large and new audience to share his experience as it aides small- and medium-sized companies across the country in their shift to eco-friendly construction. This guidebook aims to be a print manifestation of the same. It showcases how building sustainable, green structures is both affordable and economical when Green Housing methods are integrated at the early stages of design. In his view, sustainable homes make a sustainable city, and Mr. Lall is committed to this cause, driven by his lifelong perception that the beauty and joy of the inhabited place are but meditations on the aesthetics of intelligent, efficient means.

Affordable Housing at Avadi, Chennai

CDD Society

An India based organisation engaged in finding solutions for conservation and reuse of water resources and management of sanitation facilities.

CDD Society is a not-for-profit organization, registered in 2005, that innovates, demonstrates and disseminates decentralized nature-based solutions for the conservation, collection, treatment and reuse of water resources and management of sanitation facilities. CDD works in the fields of wastewater treatment, faecal sludge management, waterbody rejuvenation and solid waste management. Their services include technical solutions, capacity building, applied research, knowledge publications and research.

Foreword to Chapter 6: Water Efficiency

There is little doubt that India is one of the more acutely water stressed countries in the world, housing more than 19% of the world's people who do not have access to clean water supply. Our water resources are being continuously exploited and we face a severe water management crisis; more than half of India's districts are threatened by groundwater depletion and contamination due to human use whereas surface water resources face widespread pollution due to inadequate sanitation and indiscriminate disposal of industrial effluent. There are severe health implications of the pollution and mismanagement of water resources – 4% of all deaths and ~6% of all diseases/ ill-health are caused due to poor quality of drinking water, lack of sanitation and hygiene practices. Poor water and environmental resources impact everyone but the poor more so, as they tend to live closer to dumping grounds and polluted waterbodies, infected with mosquitoes, and do not have sufficient means to protect themselves.

To tackle these challenges, there is a strong need in countries like India to manage water and other environmental resources in an integrated manner to enable healthier and hence happier living among communities, across the social and economic strata.

CDD Society believes that one of the key ingredients required to address the challenge of better management of environment resources at scale is the availability of affordable and sustainable water and sanitation solutions that can be accepted and adopted by communities on-the-ground. Such solutions should be built on naturally available local resources in order to keep both the short-term and long-term costs of setup and maintenance low; with community ownership and people's participation playing a key role in driving the implementation as well as maintenance of the solution. Further, these solutions should adopt a systems lens, and be contextualized taking into account the many social, economic, political and environmental aspects affecting them; thus, also closing the loop for all water and sanitation related issues at smaller scales.

At CDD, we term such solutions "nature-based solutions". Our mission is to innovate, demonstrate and disseminate integrated and decentralized nature-based solutions for the growing water and sanitation management issues in communities, thus leading to better health and happiness in these communities.

We have been propagating the "nature-based" approach primarily through decentralised wastewater treatment systems (DEWATS). The approach emphasizes on building many small-scale systems in place of a centralised large system to treat wastewater close to the point of generation, enabling treated water to be effectively reused for gardening and toilet flushing. We believe that this is a more robust, sustainable and affordable solution. (Though, we do acknowledge that at times i.e .for certain contexts, hybrid solutions that integrate natural systems and modern technologies, may be more appropriate).

Through "Water Efficiency" (Chapter 6), we have provided a guide (incorporating this approach) that upcoming developments can use in order to achieve water security. These recommendations come from 15 years of delivering water and sanitation solutions, on-the-ground.

Scan to Download the Book

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