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Shashwat

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Let Nature Be

"TOWARDS NET POSITIVE HABITATS"

A **GRIHA Council** Publication

THANKS TO OUR VALUED PARTNERS

ORGANIZED BY

GRIHA

teri The Energy and Resources Institute
Creating Innovative Solutions for a Sustainable Future

GOVERNMENT PARTNERS

LIC भारतीय जीवन बीमा निगम LIFE INSURANCE CORPORATION OF INDIA

NIUA National Institute of Urban Affairs

ca वास्तुकला परिषद् Council of Architecture

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In AWE towards green

WINDOW & FACADE MAGAZINE

MGS Modern Green Structures & Architecture

energetica INDIA

NBM&CW Infra Development & Const. Equipment Magazine

LANDSCAPE

MESSAGE FROM THE PRESIDENT, GRIHA COUNCIL

The concept of sustainability is evolving. From recycling to upcycling, Net Zero to Net Positive, we are now looking beyond sustainability to a thriving future scenario focused on restoration of biodiversity and regenerative capitalism. Today environment, climate, economy and society must be viewed as inseparable parts of the same entity to achieve long-term sustainability. Leading up the COP27, deliberations are being held across the world calling for more ambitious climate action, drastic cuts in greenhouse gas emissions, enhanced resilience to adapt to the effects of climate change and financial support for developing countries. The conversation has progressed towards charting a low carbon future and with stricter policies in places, action is sure to follow.

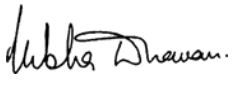
An already low-emitter, India's new commitments to fight climate change enlist bolder emission-reduction pathways of increasing renewable energy capacity to 500 gigawatt (GW) to meet 50% of energy requirements with the same by 2030, cutting total carbon emissions by one billion tonnes from date till 2030 and reducing the carbon intensity of its economy by less than 45 per cent, as a means to achieve Net Zero emissions by 2070 and eventually carbon positivity.

In this context, I am pleased to note the theme of this year GRIHA Council's Shashwat Magazine is "Towards Net Positive Habitats" which resonates deeply with the current global requirements and our international commitments. The building and construction sector is the third highest contributor to greenhouse gas emissions. India, a developing country needs to meet the requirements of its population, while reducing its carbon footprint simultaneously, a mammoth challenge. Towards fulfilment of the same, at this year's World Urban Forum platform, GRIHA Council launched the "Decarbonizing Habitat Programme (DHP)". With this programme, GRIHA initiated a drive towards a zero-carbon mission by facilitating organizations to assess their carbon footprint and adopt cost effective strategies to reduce the same. Consequent to the DHP, the theme "Towards Net Positive Habitats" which prioritizes the environment and the society by economically giving back more than what's been taken, can launch conversations to journey beyond sustainability and towards a carbon positive future.

GRIHA Council has been considered by many as a global frontrunner in ensuring sustainable development. The GRIHA rating system takes a holistic approach towards sustainability action intended to mitigate climate change and a significant aspect of that is a reduction in GHG emissions from the construction and operation of the building stock in India. As India's only indigenous rating system, GRIHA criteria have been designed specifically to cater to the climate and prevalent construction practices of the subcontinent. The Government of India in response to the Conference of the Parties (COP) decisions 1/CP.19 and 1/CP.20 recognized Green Rating for Integrated Habitat Assessment (GRIHA) as a national tool, to evaluate GHG reduction from habitats.

Fostering partnerships is a key requisite for attainment of a sustainable future and I take this opportunity to thank all our partners, our supporters and our well-wishers for your steadfast endorsement and contributions for the furtherance of the GRIHA rating system and global sustainable development. As always, we are counting on the entire GRIHA community to go the extra mile, as we navigate pathways towards net positivity.

Wishing everyone the best for the forthcoming year, 2023!



Dr Vibha Dhawan
President GRIHA Council
and Director General, TERI

GRIHA TIMELINE

2000-2010

2005-TERI GRIHA released as an indigenous green building rating in India

2007-MNRE adopts GRIHA as a National Rating System for Green Buildings

2008-National Mission on Sustainable Habitat launched

Committee of secretaries: 3-star GRIHA rating mandatory for all government buildings

CPWD embraces GRIHA

Acknowledged as an innovative region-specific green building assessment tool by the UN

❍ Evaluators' and Trainers' Programme

2011

■ CREDAI

❖ PCMC announces discounts on premium charges to developers and property tax rebate for buyers for GRIHA-rated projects

2012

❍ SVAGRIHA rating, GRIHA Product Catalogue

❖ SIDBI announces concessional rate of interest for GRIHA projects

2013

❍ GRIHA LD rating

❍ GRIHA app

✸ GRIHA projects in Noida, Greater Noida, and Punjab

❖ PCMC announces premium discounts to developers and property tax rebate for buyers for SVAGRIHA rated projects

2014

✸ GRIHA projects in Rajasthan, Pune, AUDA, and Uttar Pradesh

✸ GRIHA projects in the Government of West Bengal, Department of Municipal Affairs

✸ A 25% subsidy on FSI for GRIHA-rated industrial projects in Andhra Pradesh

❍ GRIHA v.2015 rating and GRIHA LD rating

2015

■ PWD, Maharashtra

■ Orange County

■ Extended with NASA, India

❍ Paryawaran Rakshak Programme for RWA

GRIHA Council felicitated with Green Excellence Award, 2018

20

❍ GRIHA for Day Schools rating

✸ GRIHA projects in MoUD, Delhi Division, Government of India

Sikkim mandates GRIHA

❍ GRIHA Help Centre, institute membership programme ACE, Students Membership Programme CATALYST

✸ GRIHA projects in Haryana

■ MPPH (Madhya Pradesh Police Housing) & IDC (Infrastructure Development Corporation), IICCI (Indo-Italian Chamber of Commerce and Industry)

❖ PMC announces discount in premium charges for GRIHA/SVAGRIHA projects

Developed by

teri | The Energy and Resources Institute
Creating Innovative Solutions for a Sustainable Future

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GRIHA recognized as India's own green building rating system in **INDIA's INDC** submitted to the **UNFCCC**

- ❍ Launch
- ■ Memorandum of understanding (MoU)
- ✸ Floor area ratio (FAR) incentive
- ❖ Green Building Incentive

2016

2017

- ❍ GRIHA EB rating, GRIHA for AH rating
- ❍ Revamped evaluators module and exam
- ■ MPPH & IDC, PMC, BESTECH, IREO, Vatika, CONSCIENT, ADANI Realty, Vilas Javdekar Developers and Godrej Properties
- ■ EESL (Energy Efficiency Services Limited), NHB (National Housing Bank), ISHRAE (Indian Society of Heating, Refrigerating and Air Conditioning Engineers)
- ■ Extended with NASA, India

Circular issued to all the State Police Housing Corporations for the incorporation of GRIHA in the ongoing and future projects by the BPRD SPARSH installed at the UN office on UN Day 2017

2018

- ❍ GRIHA v 2019 (Abridged Manual)
- ❍ GRIHA for Existing Day-Schools rating

2019

- ■ IIFL HFL
- ■ Council of Architecture (renewal)
- ❖ Upto 15% FAR benefits in Jammu and Kashmir for GRIHA certified projects
- ❖ Exemption from EC for GRIHA projects in Jammu and Kashmir

Government of Maharashtra makes it mandatory to achieve a minimum of 3 star rating for construction projects under GRIHA for all buildings belonging to Government, Semi-Government, local bodies and public sector undertakings for propagating sustainable habitat development in the state.

2020

- ❍ GRIHA Product Catalogue Brochure
- ■ First Construction Council, IIA (Indian Institute of Architects), Northern Chapter
- ✸ GRIHA projects in Himachal Pradesh
- ❖ Govt. of Gujarat (Industries Commissionerate) offers assistance of up to 50% of consulting charges or INR 2.5 lakh, whichever is less, for industrial buildings of more than 2,000 sq.m built up area which obtain green rating from GRIHA Council
- ❖ GRIHA, and GRIHA AH-certified (4- and 5- star projects) would be provided financial incentives under SUNREF India programme
- ❍ GRIHA v .2019 (User Manual)
- ❍ Release of policy brief on Sustain the Sustainable change
- ❍ 30 stories Beyond Buildings
- ✸ Extra FAR for GRIHA projects in Rajasthan
- ■ EMC, CIMSME, KIIFB

2021

- ❍ NHB manual
- ❍ SVA GRIHA Version 3
- ❍ JAN GRIHA
- ❍ Decarbonizing Habitat programme
- ❍ GRIHA Water Positive certification
- ❖ Kerala government incentives on one time building tax, stamp duties and property taxes for green building in the state
- ■ Planning Insights, GEV, ICA, USG Knauff, Bhopal smart city, NIUA, Sheffield Halam University

2022

हरदीप एस पुरी
HARDEEP S PURI

सत्यमेव जयते

आजादी का अमृत महोत्सव

आवासन और शहरी कार्य मंत्री
पेट्रोलियम एवं प्राकृतिक गैस मंत्री
भारत सरकार
Minister of
Housing and Urban Affairs; and
Petroleum and Natural Gas
Government of India

Message

I am delighted to learn that the Green Rating for Integrated Habitat Assessment (GRIHA) Council is releasing its annual magazine "Shashwat" with the theme 'Towards Net Positive Habitats'.

Climate Change is one of humanity's biggest challenges and cities are at the forefront of this global crisis. It is, therefore, vital that cities play an active role in mitigating emissions and leading the transition towards a resilient and sustainable future. As India charts out an ambitious plan to become a net-zero emissions country by 2070, the decarbonisation of the construction industry becomes crucial.

It is imperative that the construction industry balances climate concerns and development goals by adopting state-of-the-art technologies thereby supporting the vision of the Hon'ble Prime Minister in ensuring a greener and healthier India.

Under the Pradhan Mantri Awas Yojana–Urban, more than 16 lakh houses are being constructed using green and innovative technologies. Similarly, the Smart Cities Mission is another initiative under the Ministry of Housing and Urban Affairs which is paving the way for energy-efficient and eco-friendly solutions.

I am happy to note that the GRIHA team has launched the 'Decarbonizing Habitat Programme,' which has been designed to assess the net GHG emissions of operational buildings, and the 'Water Positive Certification,' which has been designed to reduce the water footprint of a project. Both of these newly launched programmes and other rating systems developed by the GRIHA Council are in line with the Government of India's policies and commitments towards building a cleaner nation.

I wish GRIHA Council all success in its future endeavours.

(Hardeep S Puri)

New Delhi
13 December, 2022

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Department

Date

2 November 2022

Ambassador of Royal Danish Embassy to India

The alarming rate of growing concerns over global warming and energy security have placed renewable energy & CO2 emissions reduction high on the Danish political agenda. Denmark has sought to increase its energy self-sufficiency since the global energy crisis in 1973 and has been long involved in developing and using renewable energy sources.

67% of the country's electricity supply is derived from renewable energy. Energy savings are being pursued for environmental as well as commercial purposes, as they contribute to growth and business development while increasing security of energy supply. The Danish Parliament passed the Climate Act in 2020, which set a target to reduce Denmark's greenhouse gas emissions by 70 percent in 2030 (from 1990 baseline) and achieve climate neutrality by 2050.

The Green Strategic Partnership, established during the Virtual Summit between the two Prime Ministers in September, 2020, has become a catalyst for enhanced cooperation between India and Denmark. Both countries have set ambitious goals within the climate agenda. By partnering, India and Denmark can demonstrate to the world that delivering on ambitious climate and sustainable energy goals is possible. Both Prime Ministers are delighted at the substantial progress of work under the Green Strategic Partnership. The convergence of interest on the importance of climate action, green growth and energy diversification are the pillars of the partnership.

Both the countries are constantly working to strengthen their cooperation within the renewable energy sector and have embarked on a comprehensive Energy Policy Dialogue. Strengthening cooperation on cross-sectoral energy planning, by promoting joint research & development on green fuels including green hydrogen, integration of renewable energy, energy storage and decarbonisation were agreed during the Joint Science and Technology Committee meeting held in January 2022.

I am delighted to learn of the 14th annual GRIHA Summit that is being scheduled on 15th & 16th December, 2022, with the theme Towards Net Positive Habitats. I congratulate GRIHA Council on the launch of the "Decarbonizing Habitat Programme", which has been designed to assess the net GHG emissions of operational buildings.

I convey my best wishes to the entire team of GRIHA Council for a successful event and may this lead to productive deliberation sessions and open up more possibilities to work towards a greener planet.

Freddy Svane
Ambassador

ROYAL NORWEGIAN EMBASSY

The Ambassador

It gives me immense pleasure to learn that GRIHA Council is soon to launch the 2022 edition of their eminent magazine 'Shashwat – Let Nature Be' with the theme "Towards Net Positive Habitats".

The theme is in synergy with the targets set by both our countries in COP26. Norway and India have steadily tapped bilateral economic and technical complementarities; this in my opinion strengthens cooperation between the two countries.

Norway takes a pioneering role towards environment and climate and strives to motivate other countries to come forward. Norway has submitted an enhanced climate target to the UN, ahead of the UN COP27 in Egypt. Norway's new target is to reduce GHG emissions by at least 55% by 2030, from 1990 levels. The Government has recently presented a climate status report and action plan describing how Norway intends to achieve its emission reduction target, in cooperation with the EU.

Blue economy, clean energy, green transitions, Hydrogen, Circular economy are some of the areas where Norway is focussing its attention, currently. These are the areas of interest for India also; thus, there is a lot of scope of working together to address some of these challenges. Norway emphasizes on investing in technological development and innovations to support green transitions.

I am impressed by the work that GRIHA is doing towards ensuring efficiency of design, construction and operation of buildings. I congratulate GRIHA Council on the launch of the "Decarbonizing Habitat Programme" - designed to assess the net GHG emissions of operational buildings.

I commend them for their continued commitment and dedication towards achieving future-ready and sustainable habitat.

Hans Jacob Frydenlund

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AJAY MATHUR, Ph.D
DIRECTOR GENERAL

Message

I am delighted to learn that GRIHA Council is hosting the fourteenth edition of its annual summit themed, 'Towards Net Positive Habitats'. I am pleased and honoured to pen this note of congratulations and felicitations for their yearly publication on this occasion.

Indigenously grown, GRIHA**:** Green Rating for Integrated Habitat Assessment, adopted in 2007 as the national rating system for green buildings by the Indian government, is among the stellar achievements of The Energy and Resources Institute, which has contributed handsomely to carbon mitigation in the realm of built habitat. The contributions of the GRIHA Council have been and will be crucial in reaching targets set by India to achieve net zero carbon emissions by 2070.

Globally, solar energy is increasingly becoming the preferred source of renewable energy. This is evident from the fact that solar PV capacity addition during 2021 has been higher than the capacity addition from all other forms of renewable energy. The International Solar Alliance is committed to establishing solar as a shared solution addressing multiple priorities across its 110 Member and Signatory Countries while convening a variety of stakeholders on the same platform.

There is synergy between the ISA programmes and interventions of the GRIHA Council. It is hoped that in the coming years, we can synergise our strengths and expertise to deliver effectively and efficiently to the energy transition agendas of our Member Countries.

I compliment members of the GRIHA Council for all their efforts and wish them all the success for the summit and future endeavours.

Ajay Mathur

Gurugram
25 November 2022

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लीना नन्दन
LEENA NANDAN

सचिव
भारत सरकार
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

MESSAGE

I am happy to learn that GRIHA Council is hosting its 14th Annual Summit in December, 2022 with the theme "Towards Net Positive Habitats". The theme is most appropriate, as all sectors must necessarily come up with plans for mitigating the adverse impacts of climate change.

India has been at the forefront in terms of proactive steps for addressing the challenge of climate change. We are promoting low-carbon policies and programmes that synchronize development with environmental sustainability. The updated Nationally Determined Contribution (NDC) with enhanced commitments, reaffirm India's resolve to move along a low-emissions development pathway, while simultaneously endeavouring to achieve sustainable development goals. India's vision and futuristic approach has been articulated in the Long-Term Low Emission Development Strategy (LT-LEDS) that has recently been submitted to UNFCCC.

Mission LiFE, which reinforces the traditional Indian concept of mindful utilization of resources and aims to steer demand towards Pro-Planet choices was launched by the Hon'ble PM in October this year. The objective of Mission LiFE is to promote responsible lifestyles at a global level.

Sustainable habitat is a key aspect in achieving balance between the social and economic development of human habitats together with protection of the environment. "Net Positive Habitats" are habitats that give back more resources than they consume.

I am certain that this year's GRIHA Summit will give a boost to sustainable habitat development, and I wish the team all success.

(Leena Nandan)

New Delhi, November 25, 2022

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मनोज जोशी
सचिव
Manoj Joshi
Secretary

भारत सरकार
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निर्माण भवन, नई दिल्ली–110011
Government of India
Ministry of Housing and Urban Affairs
Nirman Bhawan, New Delhi-110011

MESSAGE

I warmly appreciate the launch of 9th edition of GRIHA's annual magazine SHASHWAT centred around the theme of "Towards Net Positive Habitats".

The theme is very apt to the current scenario, since the world is witnessing the largest wave of urbanization. More than 50 percent of the world's population is now living in the cities. This ratio is expected to rise to 70 percent by 2050. In India, urban areas are currently home to over 31 percent of population and projected to house more than 40 percent of its population by the year 2030. The people migrating from rural to urban areas have dreams and aspirations to improve their quality of life with better facilities for living and livelihood that includes physical, social, institutional and economic infrastructure. The 2030 development agenda of the United Nations has emphasized the role of sustainable cities by incorporating Sustainable Development Goal (SDG) i.e. Sustainable Cities and Communities for making cities and human settlements inclusive, safe, resilient and sustainable.

National Mission on Sustainable Habitat (NMSH) administered by Ministry of Housing and Urban Affairs with the objective to make habitat sustainable. It's vision is to address climate change impacts and minimise the risks through various mitigation and adaptation strategies. The Mission will bring efficiency in service delivery, protect & conserve national resources, reduce environmental degradation & mitigating their effects to improve ability of habitats by building disaster- resilient urban infrastructure. It will also synergize inter and intra departmental coordination, handholding & capacity building and strengthening institutional capacities of the city & State Departments. The aim is to ensure appropriate integration of climate change adaptation measures through relevant policies, plans and associated processes to cater to the local needs through various rules/regulations.

It is heartening to note that GRIHA Council is consistently raising the bar for sustainable architecture and construction in India.

My best wishes to the entire GRIHA team for a successful launch of this publication.

Manoj Joshi

(Manoj Joshi)

New Delhi
10 November, 2022

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भूपिन्दर सिंह भल्ला, भा.प्रा.से.
सचिव

Bhupinder S. Bhalla, IAS
Secretary

भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

Message

I am glad to know that GRIHA Council is hosting its 14th Annual GRIHA Summit on 15th - 16th December, 2022 on the theme "Towards Net Positive Habitats".

The theme is aptly relevant to the current times, wherein it has become obligatory to take stringent actions to mitigate climate change for the survival of the current generation and also to protect our future generations.

Along with the pledge of becoming a "Net Zero" carbon emitter by 2070 in COP26, Honourable Prime Minister has also announced enhanced targets for renewable energy deployment and reduction in carbon emission. The Ministry of New and Renewable Energy, Government of India is working in complete synergy to fulfill these pledges.

The installed renewable energy capacity (including large hydro) has increased from 76.37 GW in March, 2014 to 165.94 GW in October, 2022. These advancements along with improved energy efficiency would help India to meet the overarching aim of achieving sustainable development.

I am also delighted to learn that GRIHA Council has launched the "De-carbonizing Habitat Programme". This would help organizations and industries to estimate its current carbon footprint and adopt cost effective strategies that will help in reducing the footprint in the future.

My best wishes to the GRIHA Council for the success of their 14th GRIHA Summit 2022. The GRIHA Summit will be an interesting and innovative platform for stakeholders to deliberate in the sphere of going carbon neutral.

(Bhupinder S. Bhalla)

अटल अक्षय ऊर्जा भवन, गेट नं २ के सामने, सी.जी.ओ. काम्प्लैक्स, लोदी रोड, नई दिल्ली–110003
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सौरभ गर्ग
मुख्य कार्यकारी अधिकारी
Saurabh Garg
Chief Executive Officer

सत्यमेव जयते

भारत सरकार
Government of India
भारतीय विशिष्ट पहचान प्राधिकरण
Unique Identification Authority of India (UIDAI)
आधार मुख्यालय, नौवीं मंजिल, बंगला साहिब रोड,
काली मंदिर के पीछे, गोल मार्किट, नई दिल्ली–110 001
Aadhaar Headquarters, 9th Floor, Bangla Sahib Road,
Behind Kali Mandir, Gole Market, New Delhi-110001

Message for "Shashwat- Let Nature Be," GRIHA's Annual Magazine

I heartily congratulate GRIHA Council on the launch of the 9th edition of their annual magazine 'SHASHWAT' with the theme being 'Towards Net Positive Habitats'. The theme aligns with the need of the hour and the vision of our country.

In accordance with the country's vision, we at the Unique Identification Authority of India (UIDAI) aspired to have its headquarters building in New Delhi as an example of an energy-efficient and sustainable building landmark.

To achieve this pursuit of being an environment-friendly building, UIDAI has been closely associated with GRIHA Council along with a team of highly skilled architects, project managers, contractors and other building service consultants.

I am proud that the UIDAI-Headquarters Building is now certified as a fully Green Habitat state of art-5-Star (Final) GRIHA rated project which releases negligible harmful green house gases into the environment, while

1. Recharging an average of 1995 KL annually into the ground water through the rain water harvesting system;
2. Producing about 10% of its total electricity consumption through its-in-house solar power plant;
3. Having a nil discharge STP which provides 25 to 30% of recycled water of its total consumption, along with a fully operational in-house compost plant with 53% less energy consumption with EPI of 82.04kwh/sqm/annum.
4. Negligible diesel use for energy production further promotes the highest eco-friendly performance.

We have registered other UIDAI projects under the GRIHA variant and aspire to achieve 5-Star ratings in all our projects.

I look forward to strengthening our relationship with GRIHA Council and wish them good luck in all their future endeavors.

Saurabh Garg

(Dr. Saurabh Garg)

4/11/22

Dr. K.M. Abraham CFA
Former Chief Secretary to
Government of Kerala &
Former Whole Time Member, Securities
and Exchange Board of India (SEBI)

CHIEF EXECUTIVE OFFICER
Ex-Officio Secretary to Government
Finance (Infrastructure)

September 29, 2022

Sustainable living and construction practices have been an imperative part of the culture of Kerala. So itself, the effort of Kerala Infrastructure Investment Fund Board (KIIFB) from its inception has been to inculcate these cultural traits into the infrastructure development of the State of Kerala.

KIIFB has been able to successfully raise funds from various agencies across the world as we have been able to convince them about the robustness of the system KIIFB has developed as a funding agency which stemmed from the confidence that the projects implemented with these funds will be sustainable. The MoU signed between KIIFB and GRIHA Council last year was to enhance cooperation between the two organizations and to ensure that the building footprint funded by KIIBF would be sustainable. As an initial step KIIFB has adopted the GRIHA rating for a handful projects and is looking forward for a continuous association with GRIHA Council in implementing its concepts in the upcoming projects too.

I am delighted to learn that GRIHA Council will be hosting their annual flagship event "14th GRIHA Summit" with the theme "Towards Net Positive Habitat" in New Delhi on 15th and 16th December 2022. The theme selected for the event assumes importance as the construction industry is getting back on track after the havoc brought about by the pandemic. Congratulations to the Council for their efforts in bringing together such an event.

I take this opportunity to thank GRIHA Council for developing an indigenous green building rating system that is best suited for Indian condition and wish them success in all their future endeavours.

Dr K M Abraham

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MESSAGE

I heartily congratulate GRIHA Council on the launch of the 9th edition of their annual magazine 'SHASHWAT' with the theme 'Towards Net Positive Habitats'. The theme aligns with the vision of our country and our commitment to reverse climate change and become an environment conscious community.

I am pleased to inform that Airports Authority of India (AAI) has recovered remarkably well after the pandemic with air traffic levels reaching pre-pandemic levels. We are also looking at an infrastructural growth with the upgradation of more than 40 airports, construction of new terminal buildings and expansion or strengthening of runways.

However, AAI acknowledges that there are environmental and social impacts as an outcome of our core business, which is to build and operationalize airports. The organization aims to consolidate and strengthen good corporate governance including socially and environmentally responsible business practices.

AAI airports are consistently implementing best practices in carbon management and power generation from non-renewable source of energy. Similarly, a dedicated Corporate Social Responsibility (CSR) AAI project has been undertaken to specifically cater to the communities located close to the airports and their requirements with the focus on environment conservation, health, education and community development.

GRIHA Council has been enabling AAI to achieve our vision by providing the right framework to practice sustainability. It is a well-known fact that AAI has obtained GRIHA rating for several of the New Airport Projects under the UDAN scheme and will continue to do so in the future.

I wish GRIHA Council success in all their future endeavors and look forward to our continued collaboration.

(Sanjeev Kumar)

Shailendra Sharma
Director General

सत्यमेव जयते

भारत सरकार
Government of India

CPWD

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MESSAGE

It gives me immense pleasure to learn that the GRIHA Council is hosting its annual flagship event the "**14th GRIHA Summit**" in New Delhi on 15th and 16th December, 2022.

The theme "**Towards Net Positive Habitats**" assumes much importance considering the anticipated growth in construction industry with rapidly increasing urbanization in the next decade.

CPWD envisages a leading role for itself in execution, maintenance and standardization of the built environment in India, while continuing to play the role of a government department in facilitating implementation of policies for sustainable development and transparency in governance along with assimilation of knowledge and experience. CPWD is dedicated to educate its clients to adopt more and more green building practices and has been simultaneously adopting GRIHA rating for its projects as well.

I am also informed of the launch of 'Water Positive Certification' and 'Decarbonising Habitat Programme' by the GRIHA team. Both these initiatives are important for sustainable development and establishing parameters for measuring actual progress towards development of net positive human habitat.

I wish GRIHA Council the very best in all future endeavors.

(Shailendra Sharma)

VICE PRESIDENT & CHIEF EXECUTIVE OFFICER, GRIHA COUNCIL

Dear Friends & Colleagues,

We are faced with humanity's greatest and most urgent challenge—Climate Change. As per the latest IPCC report 2022, the world would breach the critical 1.5 °C level in just two decades and only the most drastic cuts in carbon emissions from now can prevent an environmental disaster. With the built habitat being one of the largest contributors to global warming, it is vital to reform conventional building construction, design & usage, to ensure that sustainable and ecological approaches become the norm.

With global warming threating every form of life and significant impacts becoming unavoidable such as food insecurity and natural disasters; it is of utmost importance that we reanalyse our mitigation and adaptation approaches. The world must rapidly decarbonize.

In keeping with the current scenario that we face, I am pleased to announce that the theme for this year's GRIHA Summit and annual magazine SHASHWAT is "Towards Net Positive Habitats". With sessions planned to address decarbonization, carbon sequestration, net positive waste-water-energy, we aim to inspire conversations and actions to reduce emissions, build community resilience & increase financing mechanisms for adaptation and converse biodiversity & ecosystems. We require immediate and ambitious responses to ensure a sustainable future for all.

India has pledged to be a Net Zero Emission nation by the year 2070 in COP 26. In commitment to this vision of our Hon'ble Prime Minister of India, GRIHA Council has initiated a drive towards a zero-carbon mission with the launch of its "Decarbonizing Habitat Programme" at this year's World Urban Forum in Poland. The "Decarbonizing Habitat Programme" will aid organizations in assessing their total emissions including components of Energy – Water – Waste – Transport – Social – Lifestyle and intends for the quantification to encourage them to curtail their operational carbon emissions.

As a prelude to the 14th GRIHA Summit scheduled on 15th - 16th December, 2022 at India Habitat Centre, Lodhi Road, New Delhi on the theme 'Towards Net Positive Habitats'; we conducted a session at World Urban Forum which discussed strategies for carbon reduction and offsetting, methods for carbon sequestration and taking definitive strides to ensure a net positive habitat. This session garnered much interest especially from the 2000-Watt Smart Cities Association with whom GRIHA Council is discussing opportunities for collaboration to ensure carbon neutrality.

GRIHA has steadfastly established its green footprint in the country and has over 3280 nos. registered projects across India exceeding 722 million square feet in built up area. This is an indicator of the awareness and subsequent uptake of green development in the nation. We as an organization are setting and working to deliver bigger and more aggressive sustainable development goals. We have aligned our latest GRIHA variants to movements of circular economy, carbon counting & net positivity, while retaining focus on awareness and engagement for most efficacious outcomes.

I am also pleased to share that GRIHA continues to expand its impact across the globe and has signed a Memorandum of Understanding (MoU) in June 2022 with Sheffield Hallam University, United Kingdom for co-operation, discussions and joint activities between GRIHA Council and SHU's Lab4Living to promote sustainability in the built environment.

An MoU was signed between Govardhan Ecovillage and GRIHA Council that focuses on the promotion of green buildings worldwide along with the co-development of training and capacity building programmes for the youth globally.

Another recent development was the Memorandum of Understanding (MoU) signed between GRIHA Council and Bhopal Smart City Development Corporation Limited (BSCDCL) with an objective to rate Bhopal Smart City in accordance with the GRIHA for CITIES rating and all planned buildings within its purview as per the applicable GRIHA variant. This MoU also focusses on training of local officials and project teams. We look forward to further advance such comprehensive partnerships for strategic engagements, ratings and research in the upcoming years.

In the year 2019, GRIHA rated 300 existing government buildings of PWD Maharashtra as per our GRIHA for Existing Buildings (EB) Rating variant. Following the successful implementation of this landmark initiative, this year we signed a MoU with Public Works Department (PWD) Nanded region, Government of Maharashtra intended to review and rate all existing government buildings in Nanded district in accordance with the GRIHA for Existing Building (EB) rating and as well as encourage all upcoming government projects to be developed and rated as green buildings in accordance with applicable GRIHA rating variants. In accordance with the ambit of the MoU, 60 existing government projects have commenced renovations aligned with GRIHA EB requirements. We look forward to mainstreaming green building practices in the existing building stock and encouraging further sustainable development.

I thank my team for their hard work and dedication to making every critical project a great success. I take this opportunity to thank our clients and associates from across industries with whom we share profound partnerships based upon shared principles, values, vision and goals. As we move into the New Year 2023, we look forward to strengthening these networks for the betterment of the environment. Let us reaffirm our commitment to remold the planet into a healthy and holistically sustainable one through innovations, resilience and adaptability.

Season's greetings to all and my very best wishes for a happy and healthy New Year!

Sanjay Seth
Vice President and
Chief Executive Officer
GRIHA Council

CONTENTS

Company Insights

WIPRO

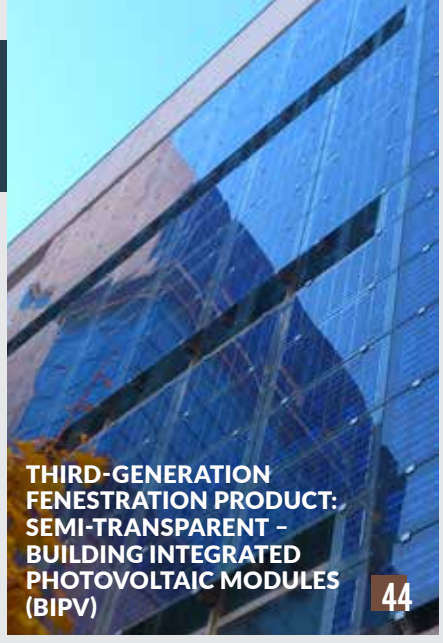
97

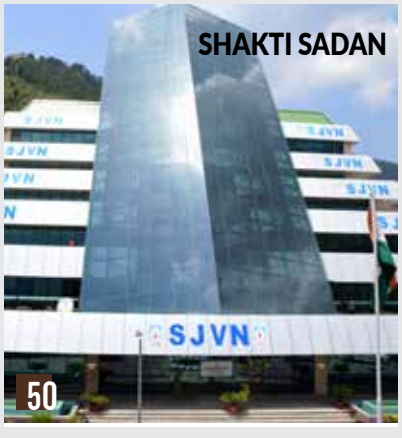
IN- FOCUS

BLOG

TESTIMONIAL

FEATURES





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Potential of AI/ML in Harnessing Energy Efficiency

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Srishti Sharma is an energy efficiency professional with 4+ years of experience in advocating for energy efficiency and sustainable development of the ecosystem. She holds her post-graduate degree: M.Sc. in Resource Management and Design Application with specialization in Environment Management and Sustainable Development from University of Delhi.

The growing economies and increase in purchasing power of the middle-income group have led to rapid urbanization and industrialization—which has accelerated the energy demand at an exponential rate. Since the gross domestic product (GDP) and energy demand are intrinsically intertwined, this has led to an increase in greenhouse gas (GHG) emissions. The major economies of the world like the USA, China, and India are still heavily reliant on fossil fuels and will take some time to transition towards cleaner fuels.

Energy efficiency can provide a way forward for these countries before shifting towards the non-conventional route to mitigate the ever-increasing rise in GHG emissions. Advancement in technology such as artificial intelligence (AI) has opened the doors for introducing innovative and advanced technologies that can work in tandem with energy efficiency to mainstream sustainable living by efficient use of our resources.

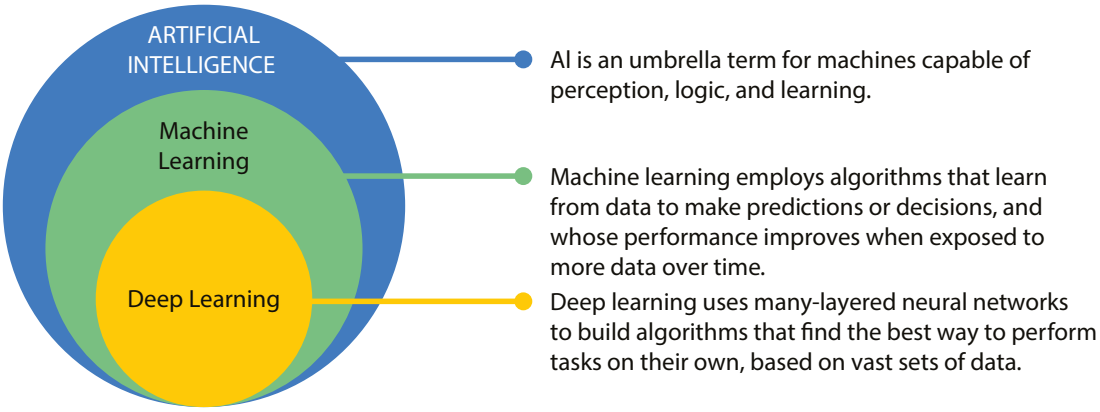

Figure 1: Components of artificial intelligence
Source Verma

Energy Efficiency and AI/ML

Energy efficiency on its own is not a new concept, and it has been in practice since the advancement of the Industrial Revolution. The ongoing energy efficiency practices are going obsolete due to rapidly changing technologies and lack of analytical optimization. Recent advancement in computational technology has led to the development of machine learning (ML) and AI. AI/ML uses complex algorithms that constantly iterate over large data sets, analyzing the patterns in data and facilitating machines to respond to different situations in which they have not been explicitly programmed. Since energy efficiency optimization requires working over large data sets to analyze and improve the system's key performance indicators (KPI) (Makala and Bakovic), AI/ML's inherent capability can be harnessed for executing this task.

AI/ML in Energy Efficiency

AI has the potential to reduce energy waste, lower energy costs, and facilitate and accelerate the use of clean, renewable energy sources in power grids, worldwide.

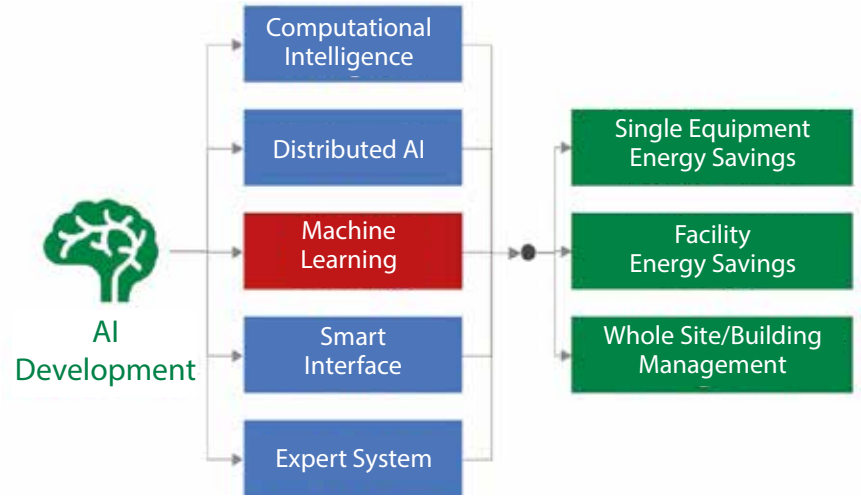

Figure 2: AI development for energy efficiency
Source Kwon, Lee, and Kim (2022)

AI can also improve the planning, operation, and control of power systems. Thus, AI technologies are closely tied to the ability to provide clean and cheap energy that is essential to development. Some of the uses of AI are shown graphically in Figure 3.

Challenges in Harnessing the Power of AI/ML

Implementation of AI/ML is still an enormous task to achieve. There are a few challenges which are required to be addressed before going opting for AI/ML, as mentioned below:

- **Lack of infrastructure:** Network and data penetration is still a big issue for most of the developing nations all around the world. AI inherently requires constant data communication, and a lack of these infrastructures poses a substantial challenge for the uptake of AI/ML.
- **Huge investment:** Up-taking AI/ML requires significant infrastructure changes such as the rollout of smart meters, smart sensors, connected devices, etc, which pose huge investment along with ground-level challenges.
- **Enabling database ecosystems:** There is a need to educate the AI industry on the aspects of the energy sector. Lack of enabling database ecosystems, limited availability of manpower, and no mechanism to maintain high-quality data are some of the factors that hinder AI implementation.
- **Lack of standardization on the data sets:** Same data from different sources will come in a different format. It will be difficult for the AI/ML systems to directly integrate themselves with the raw data and require additional computational and manpower resources to make these data sets usable.
- **Security risk:** AI/ML prediction algorithms are inherently complicated; there is a possibility that the whole system is managed by a few individuals of the organization who may not fully understand this complex system. This constitutes a security risk as even a single error can cause widespread blackouts. Provided that existing models are far from perfect, it is necessary to have safeguards in place when incorporating them into energy systems.
- **Sensor installation issues:** One of the practical challenges in the rollout of AI/ML is in convincing

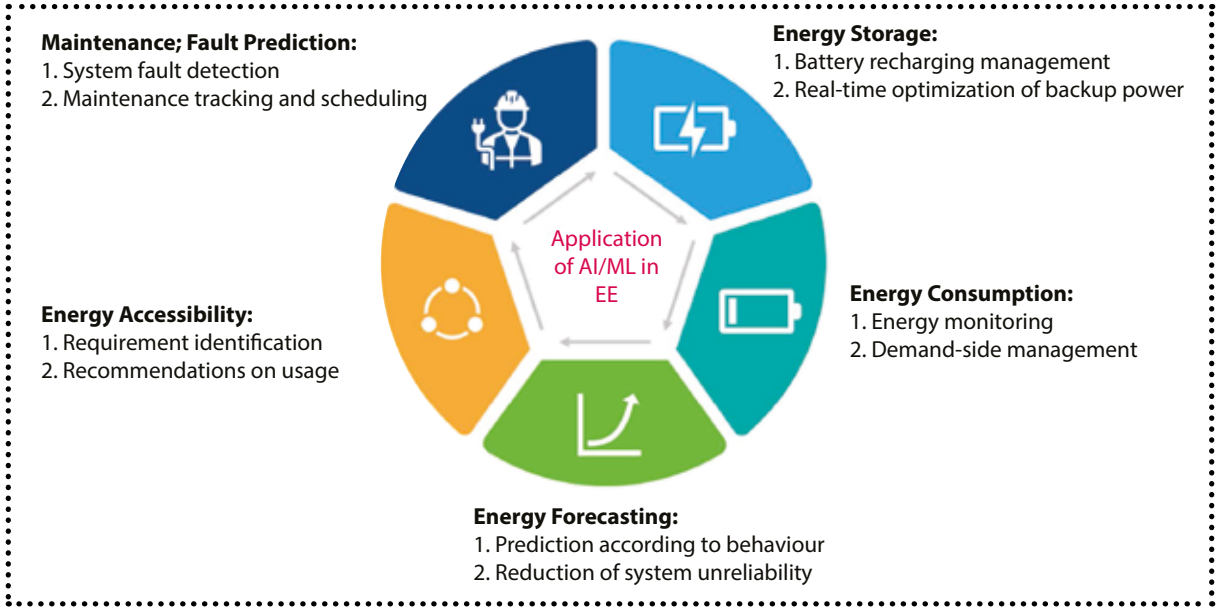

Figure 3: Application of AI/ML in energy efficiency
Source Kwon, Lee, and Kim (2022)

the stakeholders to install smart sensors and devices. There are already privacy concerns looming among the users of the smart meters that their data can be studied to activate a theft at their homes; so, implementing data protection laws, technology and convincing the users is a challenging task.

Intended Outcome and Suggestive Approach for Harnessing the Power of AI/ML

Implementation of AI/ML can be a significant stress buster for multiple government agencies which are facing huge monetary losses due to (AT&C) aggregate technical and commercial losses losses and billing inefficiencies, for example, according to EESL, "India is losing INR100,000 crore in unbilled electricity; the solution is smart meters" (Kumar). If INR100,000 crore can be saved by the implementation of smart meters, imagine the impact AI/ML can produce post it's full-scale implementation.

Implementations of AI/ML require intricate planning and step-wise execution of the plan. Below is the suggestive approach for effectively and efficiently rolling out a robust AI/ML system:

- **Awareness generation:** Awareness generation is the first and foremost important step in the rollout of AI/ML. Educating the stakeholders such as distribution companies (DISCOMs), industrialists, commercial businesses, private individuals, ESCOs, etc., about the benefits AI/ML can bring to their respective sectors and support in the removal of the misconceptions related to the technology and safety concerns.
- **Infrastructure creation:** The AI/ML rollout depends upon the installation of various smaller components such as advanced metering infrastructure, smart sensors, internet connectivity, and the development of various software/tools. The government should allocate a separate budget and prepare a proper roadmap for the implementation of the AI/ML.
- **Standardization:** AI/ML includes various equipment that will be provided by multiple suppliers, for example, smart meters will be manufactured and provided by various suppliers. To remove the incompatibility issues and ease of repairability government needs to make Indian standards.
- **Stricter data privacy laws:** By implementation of AI/ML, the data we will be dealing with will be very sensitive in nature. So, there is a need to revise and strengthen the existing data protection laws.

Way Forward

As we advance, AI/ML can pave the path for implementing energy efficiency across different sectors. Government should work on capacity building and conducting awareness programmes to apprise the key stakeholders such as policymakers, end users, consultants, and industry experts about the potential of AI/ML in the energy sector. Further, ministries whose scope of work includes commercial building, industry, and power sector should develop a bouquet of guidelines that could foster wide-scale adoption of AI/ML along with mitigating the cyber security risk. Hence, the need is to facilitate the use of AI/ML and make the masses aware of the potential of AI/ML technology.

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START-UP STORY

Journey of Buyofuel

India, the third largest energy consumer in the world, is taking concrete measures to reduce its reliance on fossil fuels to ensure energy security and sustainable long-term development. By 2030, the Indian government is aiming to reduce its carbon footprint by 30%–35%. This has created an opportunity for India's biofuel industry to play a crucial role in the country's transition to clean energy and a Coimbatore-based start-up— Buyofuel— is gaining significant traction across all sectors.

Buyofuel, a one-stop destination for all biofuel needs was founded in May 2020 by Kishan Karunakaran, Venkateswaran Selvan, Prasad P Nair, and Sumanth Kumar. This B2B marketplace has a network of raw material aggregators, manufacturers, consumers, and waste generators which makes it easier to build connections within the biofuel community.

As a step towards a sustainable future, Buyofuel has developed an efficient online marketplace for trading biofuel-based commodities in a quick, accessible, affordable and secured manner, removing the existing barriers on a single platform. The team is committed to bringing sustainability into effect by ensuring access to renewable fuels and promoting a circular economy and an emission-free environment.

Buyofuel made its first sale in August 2020 and has a team of 25+ members located across Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Telangana, Gujarat, Maharashtra, and Goa. It has the largest buyer and seller base for biofuels and wastes in India with a monthly buying capacity of about 600,000 MT and a selling capacity of 200,000 MT, respectively.

Initially started in Tamil Nadu and Kerala, Buyofuel now has 1,000+ users, and sold nearly 35,000+ tonnes of biofuel. Almost 80% are first-time digital users, while the remaining 20% are corporates such as Ramco Cements, Welspun, UltraTech Cement, ITC, and Saint-Gobain.

In the past, the companies that were hesitating to choose biofuels as an energy source will now get connected to a marketplace with complete transparency right from sending an enquiry to placing an order to execution of the order to doorstep delivery. The online platform brings all-important role players under one roof to ensure quality, consistency, and transparency with credit assistance for a seamless user experience.

Kishan Karunakaran,
CEO, Buyofuel

"It is essential that industries need support in smoothly transitioning from fossil fuels to biofuels in order to create a pollution-free environment and a sustainable future. A technology-powered online marketplace will not only accelerate India's transition to biofuels but will also boost the nation's progress towards net-zero emissions. Moreover, India's commitment to the UN Sustainable Development Goals of providing affordable, clean energy for all will be strengthened through the rapid adoption of biofuel consumption," said Kishan Karunakaran, CEO, Buyofuel.

In June 2022, it recorded its highest sales of 14,000 tonnes, helping large fuel consumers switch from coal to renewable alternatives manufactured within India. As part of its mission, Buyofuel promotes biofuel consumption not just to benefit the environment, but also to benefit thousands of Indian farmers.

As a decentralised alternative fuel marketplace, Buyofuel has emerged as one of the most viable options to mitigate significant concerns of global warming caused by burning fossil fuels.

Advancing from Housing for All to Thermal Comfort for All: Integrating Thermal Comfort in Residential Projects

Urbanization is accompanied by housing development which is further associated with energy demand. Substantial increase in energy demand puts a sizeable pressure on the natural resources, resultantly, fast depletion of natural resources that significantly contributes to emission of GHGs, well-known causative factors for global warming and climate change. This calls for inclusion of sustainability, energy efficiency, and climate resilience in the new construction. These are the topics of relevance that have suitably dealt within this article by **Abdullah Nisar Siddiqui**, **Anurag Verma**, and **Divya Bansal Talwar**.

Abdullah Nisar Siddiqui is currently associated with Climate Smart Buildings Programme of Indo–German Energy Programme (IGEN-CSB) at GIZ India. The primary objective of the Programme is to support MoHUA to enhance thermal comfort in Affordable Housing through development of Thermal Comfort Standards and National Action Plan on Thermal Comfort for All.

Anurag Verma, trained as a civil and architectural engineer with a focus on sustainable building design, building performance simulations and BIM. He has worked as Senior Researcher at Centre for Science and Environment besides working on thermal comfort in affordable housing, benchmarking of environmental performance of educational institutes, and C&D waste. He is currently engaged with Climate Smart Buildings Programme, as Junior Energy Advisor, in partnership with MoHUA, and is developing thermal comfort standards and resources for capacity building.

Divya Bansal Talwar is associated with GIZ's Climate Smart Buildings Project as Junior Energy Advisor. She is an Architect and Urban Designer, working in the affordable housing domain with a focus on cost-effective design solutions and strategies. She has been working extensively on a variety of research, policy development, and housing projects in both public and private sectors, relating to sustainable affordable housing in India at city and project levels.

With rapid urbanization, the demand for housing is increasing exponentially. Nearly 95% of the housing deficit in India is in the lower income categories. The Pradhan Mantri Awas Yojana–Urban (PMAY–U), Government of India's flagship programme for affordable housing for all is expected to suitably address this void by adding 1.2 crore new housing. The massive housing developments of today are bound to put sizeable pressure on the energy demand in the future. Projections have confirmed that electricity consumption in residential buildings alone is expected to increase seven-fold during 2012–32 period (BEE 2014). These establishments are not only going to have a bearing on the energy demand but will also require substantial quantities of building materials, putting tremendous pressure on our natural reserves.

Land is a costly resource, especially in the urban areas, multi-family apartments are an efficient way of providing high-density affordable housing. Cost and timely delivery are critical factors for these housing projects. The houses that are constructed today will last at least for 50–60 years in the future. Thus, implementing energy efficiency in buildings that are constructed in the span of next 10 years, highlights a singular opportunity to reduce the locked-in energy, alter future consumption patterns and enhance cost savings for the several decades. As we prepare ourselves to face the challenges of climate change, it becomes pertinent to ensure that the housing provides thermal comfort, one of the primary functions of housing, by utilizing passive design and sustainable building materials. This will ensure sustainability, energy efficiency, and climate resilience in the new construction. Today is the high time to address energy efficiency through development of compatible designs, as when these homes get occupied and once the standard of living of the occupants improves, the dependance on active modes of cooling and air conditioning will rise. This will lead to a vicious cycle of greenhouse gas (GHG) emissions. Consequently, ambient temperatures will rise that will require refrigerant-based cooling.

The objective of government's aspirational Housing for All mission is not just to provide mass housing but to improve the quality of life of the masses. Thermal comfort is an essential requirement for achieving improved standard of living, and this need not come with added cost of construction or operation in a building. There are various efficient practices that can be adopted such as optimum building orientation, optimizing fenestration sizes, shading elements, efficient walling materials, insulation, and structured passive design techniques along with local innovative sustainable building material. Capacity building and awareness programmes for technology providers, private builders, public housing providers and homeowners are needed to amplify the necessity of thermal comfort and to break the notion of being expensive and hence need not be adopted for developing affordable housing projects.

Along with the design, selection of appropriate material for the building envelope plays a key role in enhancing thermal comfort within the dwelling unit and reducing the operational costs during the life of the building. At present, speed of construction is a primary factor in selection of construction technology in mass housing projects. Setting up a regulatory framework to ensure minimum standards of thermal comfort is achieved in all housing is essential in order to ensure that thermal performance of the material is considered while deciding on the construction specifications.

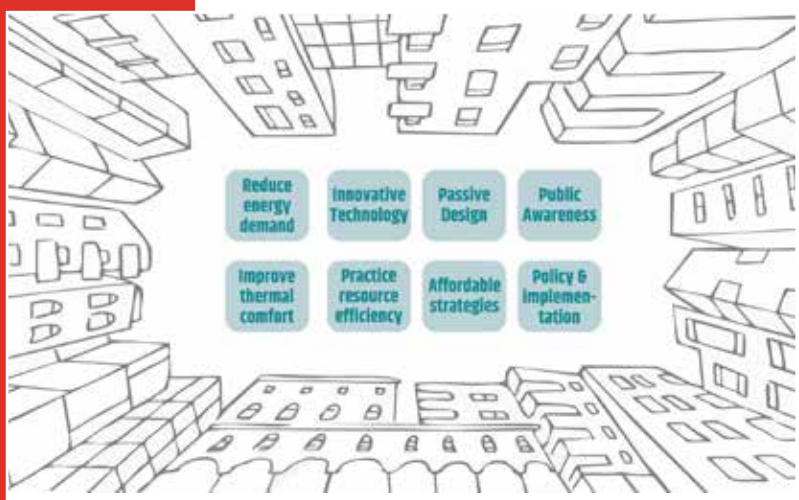

Figure 1: Actions needed in the construction sector to combat climate change

Figure 2: Factors influencing occupant's thermal comfort

This will ensure that the selected materials respond to the climate and context and give an impetus to the local construction and manufacturing industry. Research in this domain is bringing up a lot of innovative construction materials and technologies that work with local, agro-based or bio-based raw materials engineered to deliver high performance, robust building materials and technologies.

Several new-age building materials and walling assemblies are now available which provide better insulation (lower U-values) and can help in maintaining acceptable thermal comfort levels throughout the year besides performing well on other criteria such as strength, resistance to fire, water resistance, stability, etc. The Building Materials and Technology Promotion Council (BMTPC) has recognized some of these walling assemblies and technologies which have demonstrated acceptable structural and functional performance (BMTPC 2020). These materials and technologies are currently being utilized in various light house projects (LHP) and demonstrations housing projects (DHP) being executed in different states of India, to showcase their performance and demonstrate innovative construction methodologies.

Material selection for affordable and sustainable housing is not just limited to energy efficiency and thermal comfort. Their impact is multifaceted and affects embodied energies and associated environmental impact due to extraction, production, and transportation. Therefore, these considerations along with their reusability and recyclability must also become deciding factors for evaluating the performance of building materials and innovative technologies, on the principles of circular economy. Currently, Construction and Demolition (C&D) Waste Management Rules, 2016 mandate utilization of recycled C&D waste in public projects, however the assessment of such products in terms of energy efficiency and thermal comfort is still in the nascent stage.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is implementing the Indo–German Energy Programme (IGEN) on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Government of India. Work in building energy efficiency has been partially addressed through IGEN initiatives such as Eco-Niwas Samhita, 2018 and 2021, which is the energy conservation code for residential buildings, labelling mechanism for residential buildings, Energy Efficient Building Material Directory, catalogue of replicable designs for energy efficient residential buildings and the Smart Home programme. However, to achieve the desired level of thermal comfort, enhance ease of understanding of wider citizens of the country, and develop the capacity of stakeholders, further efforts are required.

Lowering of energy and emissions' intensity of the building sector and implementing focused strategies on materials to reduce life-cycle carbon emissions is recognized to be the most cost-effective way of combating climate change. IGEN's programme—Climate Smart Buildings (CSB)—extends technical assistance and cooperation to enhance climate resilience and thermal comfort in buildings by adopting innovative passive measures, local sustainable and low embodied energy material, coupled with best available technologies in construction (GIZ 2022). The Climate Smart Buildings (CSB) programme is supporting the Ministry of Housing and Urban Affairs (MoHUA) in development of National Actional Plan on Thermal Comfort for All. The Action Plan would be a vision document for ensuring thermal comfort

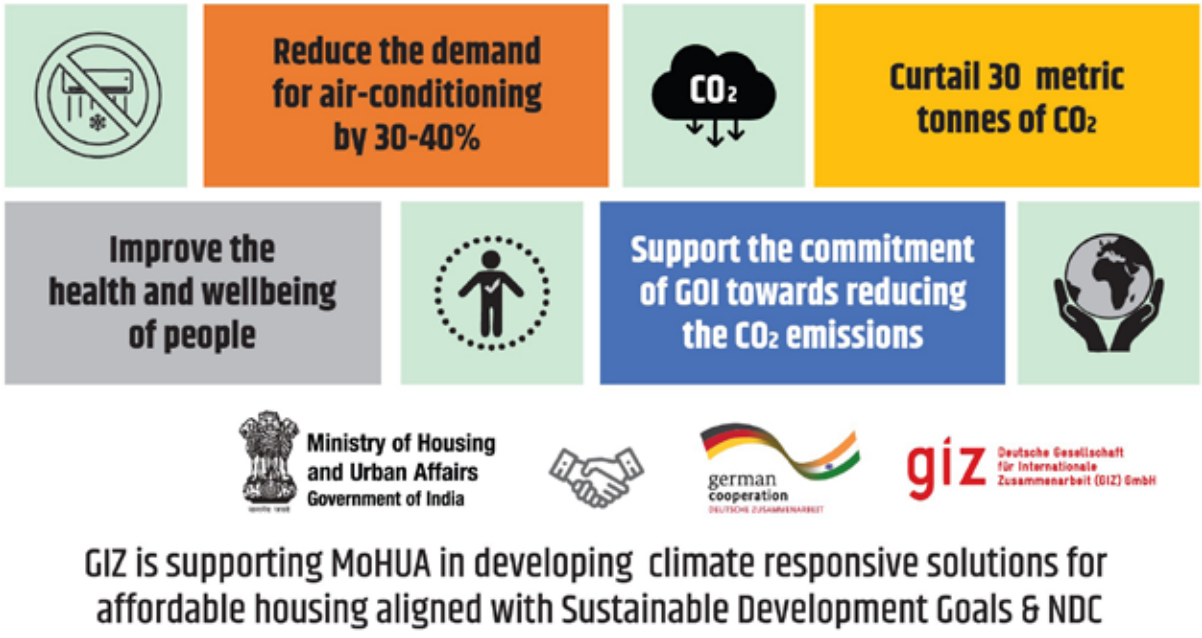

Figure 3: Climate Smart Buildings, Indo–German Energy Programme (IGEN-CSB)

to all by 2047, and it would be supplemented by a thermal performance standard for enhancing thermal comfort by at least 35% in upcoming affordable housing. Considering that training and capacity development is the essential backbone to ensure effective implementation and enforcement of any policy, the CSB programme is developing an e-learning platform, hosting training and gamification modules to enhance the awareness on thermal comfort and provide professionals and government officers with necessary knowledge for framing thermal comfort policy and integration processes at national and state levels.

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इस पॉलिसी में, निवेश पोर्टफोलियो में निवेश जोखिम पॉलिसीधारक द्वारा वहन किया जाता है।

पेश है

आज का **स्मार्ट** निवेश, कल के सुरक्षित भविष्य के लिए.

एलआईसी का न्यू पेंशन प्लस

Plan No.: 867 UIN: 512L347V01

एक युनिट–लिंक्ड़, असहभागी, वैयक्तिक पेन्शन योजना)

ऑनलाइन भी उपलब्ध

एलआईसी के न्यू पेंशन प्लस के साथ अपनी पेंशन का प्लान बनाइए

- आयु की पात्रता : 25–75 वर्ष
- सुविधाजनक प्रीमियम भुगतान
- गारंटीड अभिवृद्धियाँ
- आस्थगित वार्षिकी
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हर पल आपके साथ

नकली फोन कॉल्स और झूठे/धोखाधड़ी पूर्ण ऑफ़र्स से सावधान रहें. आईआरडीएआई जीवन बीमा पॉलिसियों की बिक्री, बोनस घोषित करने या प्रीमियमों के निवेश जैसी गतिविधियों में संलग्न नहीं है. ऐसे फोन कॉल प्राप्त करने वाले व्यक्तियों से अनुरोध है कि वे पुलिस में इसकी शिकायत दर्ज करवाएँ. **बिक्री समापन से पूर्व अधिक जानकारी या जोखिम घटकों, नियम और शर्तों के लिए बिक्री पुस्तिका को** ध्यानपूर्वक पढ़े.

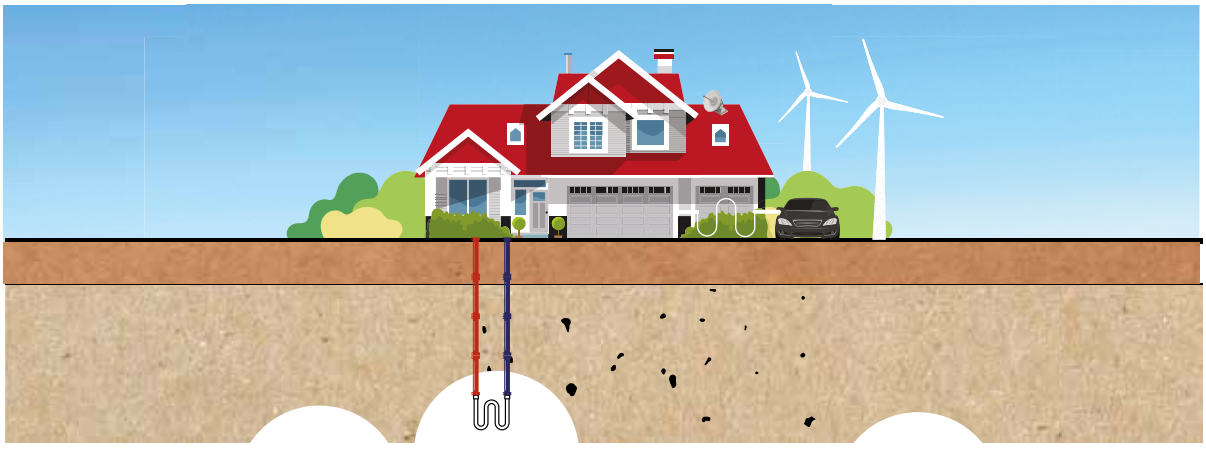
Geothermal Heating and Cooling: Free Energy Beneath Your Feet!

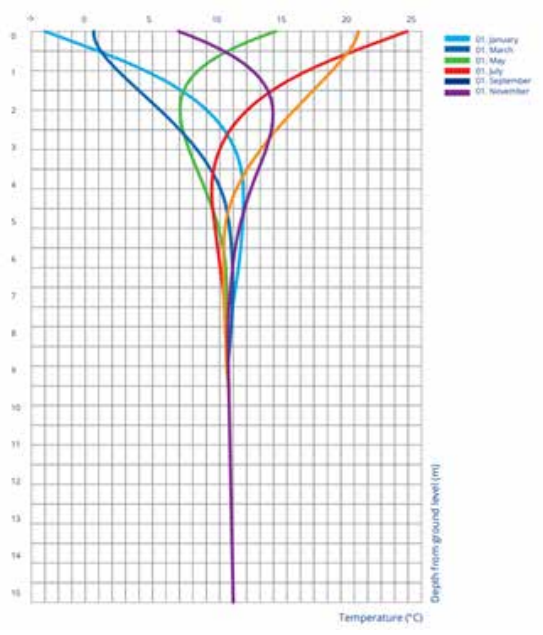
Human progress is proportional to depletion of the earth's natural resources. This, in turn, has a number of environmental repercussions including but not limited to climate change and global warming. Under the light of this fact, it can be established, renewable energy sources such as solar, wind, and geothermal energy are gaining prominence. Article by **Yash Sen** dwells into the efficient utilization of geothermal energy as a non-polluting, abundant source of energy.

Yash Sen as mechanical engineer has 8 years of experience to his credit. His areas of expertise include HVAC design, project execution, project management, cost analysis, and quality check. He has also handled projects of international repute, major fields include geothermal heating and cooling systems, radiant heating, mechanical heat recovery ventilation (MVHR), aerothermal systems, solar PV, chillers, and VRF systems. Energy conservation measures incorporated to building physics, renewable hybridization, and a net-zero approach are also amongst his major accomplishments. Besides, his career is backed by experience in implementation of operations and marketing plans, aimed towards business generation. He is a diligent member of technical societies like ISHRAE and ASHRAE. Currently, he is associated as Deputy Manager with Design 2 Occupancy, Jaipur. He can be approached via: yashsen@design2occupancy.com.

Geothermal Energy: The Energy Source for Future Generations

Fossil fuels such as coal, oil or natural gas are the finite resources that have been created by natural processes in our earth over millions of years. Once exploited, they cannot be replaced. Over the last hundred years our society has become substantially dependent on these types of energy resources. Pollution and exploitation of our planet has become aligned with the progress we are making, this in turn, gives rise to many environmental repercussions such as climate change and global warming. This underlines the need for renewable and environmentally friendly energy sources. Owing to this fact, renewable energy sources such as solar, wind, and geothermal energy are gaining prominence.





What is Geothermal Energy?

The geothermal energy originates from the heat retained within the earth from radioactive decay of minerals, and from solar energy absorbed at the surface. Ground energy is thermal energy stored within the top approximately 400 m of the earth's surface. The closer to the surface, the more the earth temperature is influenced by the outside weather conditions, majorly by the amount of solar radiation. Despite the fact that weather conditions vary significantly during the different seasons of the year, the temperature in a few metres of depth remains relatively constant. In order to extract the energy from the ground, a pipe system must be installed. Generally, there are two main systems—closed loop system and open loop system. Closed loops usually contain a mixture of water and anti-freeze (propylene or ethylene glycol) to transport the energy extracted or dumped from/into the ground to the heat pump. Open loops pump natural water from a well or body of water such as lake, and river into a heat exchanger inside the heat pump and then return the water back to the water source. The supply and return lines must be placed far enough apart to ensure thermal recharge of the source.

Functionality of a Geothermal System

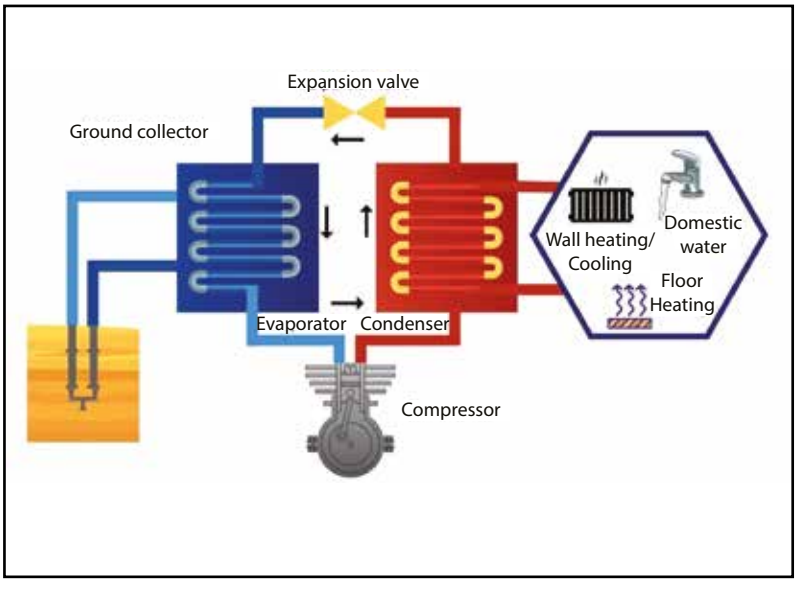
Geothermal systems usually consist of a collector loop which is horizontally or vertically buried in the ground, a heat pump (GSHP) which transforms the earth extracted energy into usable energy for heating or cooling and a low temperature heating or cooling system. The collector loop is filled with an anti-freezing liquid that warms up (or cools down) when travelling through the buried piping system, adapting to the earth's temperature. In the heat pump a vapour compression cycle works which is exchanging heat in the ground according to the need of the season.

Types of Loops

Generally, two types of loops are used in a geothermal system which majorly depends on the application, site location, and feasibility of the system. These loops are known as closed loops and open loops systems.

Closed loop

- **Horizontal loops**: They consist of horizontally buried pipes, in approximately 1.5 m of depth.



Because of its closeness to the surface, the performance of horizontal collectors differs with seasonality. Although the investment is relatively low, as quite a large space, depending on the required output and soil conditions, approximately 30m^2 collector space is needed per kilowatt of heat load of the building might be needed, installation of horizontal loops might not be possible everywhere.

- **Vertical loops:** Vertical collectors consist of one or more return and supply pipes that are installed vertically into the ground, approximately 100 m, however, greater depths are also possible, which depends on the design parameters. Vertical collectors can be utilized in nearly all types of ground or landscape and soil conditions.

Open loop

- **Well open loops:** Open loops pump natural water from a well or body of water (lake, river) into a heat exchanger inside the heat pump and then return the water back to the water source. The supply and return lines must be placed far enough apart to ensure thermal recharge of the source.

Benefits of a Geothermal System

Utilization of geothermal system is accompanied by a multitude of benefits, some of the chief benefits are enumerated below:

- Environmentally friendly: no pollution in the environment.
- Renewable: geothermal energy is constantly available on 24/7/365 basis.
- Multi-purpose: heating, cooling, and domestic hot water simultaneously.
- Ideal energy source for the modern trend of surface radiant systems, chilled beams, etc.
- The system is economical due to low-operating costs and maintenance costs; savings of up to 70% is possible.
- Versatile: can be used for small family houses, big office buildings, or industrial complexes.
- Various systems are available depending on given local conditions and regulations.
- Easily hybridized with solar PV plant and optimize the energy efficiency of the whole system.

Scenario in India

In India, utilization of geothermal energy is emerging for space cooling and many projects are executed with efficient working. The tropical climate in India makes it susceptible to a heavy load of energy that ultimately affects the environment which can be mitigated by employing geothermal heating/cooling system. Geothermal heating and cooling is the new advancement in the field of heating, ventilation, and air-conditioning (HVAC). The analysis of geothermal ground source heat pump (GSHP) shows that 51% of electricity can be saved with the help of these pumps. More efficient GSHPs are available in the market, this optimizes the energy balance between heating, cooling, and domestic hot water needs. India, in particular, a geothermal closed vertical ground loop is a relatively grey area to design an efficient cooling system for hot climates around the year without exploiting much of the conventional resources. Researchers have tried different systems and found that some systems can offer an energy-efficient performance along with occupant comfort. To decrease energy consumption and minimize the adverse impact on the environment, the correct combination of building physics, geothermal and solar energy to decarbonize the HVAC solution has to be deployed. India has a noteworthy potential for geothermal heating and cooling system which is in line with the goal of becoming a net-zero carbon country by 2070.

MoU with International Copper Association

An MoU was signed between GRIHA Council and International Copper Association India in a common pursuit of promoting Sustainable Habitat in India through GRIHA Rating and its variants, research, technical development, and capacity building.

One Day Training programme at University Institute of Architecture, Chandigarh University

An online GRIHA awareness programme was organized by the University Institute of Architecture, Chandigarh University in association with GRIHA Council on 5th May, 2022 for familiarizing the students with the GRIHA rating system.

Orientation Workshop for PWD officials, Nanded

A half-day GRIHA orientation workshop was organized by GRIHA Council with support from the Public Works Department (PWD), Nanded Region, Government of Maharashtra on 23rd February, 2022 at Conference Hall, PWD Rest House, Nanded.

4th GRIHA Consultant meet

GRIHA Council conducted its fourth GRIHA Consultant meet on 22nd April, 2022 at India Habitat Centre, New Delhi.

Online Training on "GRIHA Product Catalogue"

GRIHA Council conducted an online training on "GRIHA PRODUCT CATALOGUE" on 3rd June, 2022 as 10 years of GRIHA Product Catalogue were completed.

One-Day Student Training Programme at Sri Ramakrishna Engineering College, Coimbatore

Sri Ramakrishna Engineering College, Coimbatore is registered with GRIHA as a Gold member under the GRIHA CATALYST membership.

Half-day Awareness Programme at Ranganathan Architecture College, Coimbatore

An online half day awareness programme was conducted for Ranganathan Architecture College, Coimbatore, under the ambt of its Gold GRIHA CATALYST membership.

GRIHA Learning Centre

Our own team of professionals is hosting the course on GRIHA v.2019 and is sharing their first-hand experiences while disseminating the knowledge on complex concepts of sustainability.

GRIHA

GRIHA LEARNING CENTRE

An e-learning platform for GRIHA trainings and examinations

Training Programme & MoUs

Building Fitness Indicator (BFI)

BFI launched by GRIHA Council is developed as a checklist to assess the measures adopted by building proprietors and managers to ensure hygiene and ventilation in workplaces. The resulting analysis appears as readings on a meter, indicating whether the organization is prepared to combat the highly contagious disease.

MoU with Sheffield Halam

Through the MoU, both the organizations will work together on outreach and joint funding applications that enable research and development pertaining to environment, sustainable products and services.

MoU with Bhopal Smart City

Both the organizations will work together in achieving GRIHA ratings for upcoming developments in the city of Bhopal.

Indian Institute of Technology Bhilai

Prof. Rajiv Prakash,
Director, IIT Bhilai

Indian Institute of Technology Bhilai was established in 2016, in the state of Chhattisgarh. Once fully developed, its campus is high likely to be a model case study for the country. The campus is planned to be developed in various phases and is expected to cater to 12,000 students. This campus is designed to be functional on 24×7 basis, for all 365 days of the year. It is therefore designed to be a smart eco-campus that will utilize principles of sustainability and environmental sensitivity at all levels.

The campus of IIT Bhilai is designed with a vision that the generations of its students will experience, appreciate, and implement the value of nature, because of the core adoption of the sustainability. This will enable them to realize the joy of living in harmony with the nature. The master plan and green buildings are designed in such a manner that they keep intact the natural features of the allotted space, also retaining most of the existing trees and water bodies. The aim is to develop a campus which blends into the existing environment.

The campus master plan has followed the necessary guidelines, ensuring appropriate orientation of buildings such that natural wind flow is not hampered. This would be advantageous in keeping the buildings cool in an otherwise very hot region of Central India. The natural light (and not the heat) is channelled through the buildings so that they remain lighted during the day, all through the year. The buildings are well heat insulated, this will largely keep the infrastructure cool naturally, also reducing the reliance on air-conditioning systems, even in the peak summer.

From a sustainability viewpoint, water management, wastewater management, sewerage and storm water management are exceptionally designed with zero-water discharge with diminutive water demand from external sources. The electricity requirements are minimized by utilizing most effective mechanisms such as 100% use of LED lights, scheduling and management using Campus Management System. The campus is planned to be pedestrian friendly with minimal use of vehicles by its residents.

GRIHA has a responsible part in realizing IIT Bhilai's aim of developing a sustainable campus, with inclusion of various green building features using environmental friendly and better sustainable materials so as to achieve better functionality, reduced maintenance and running costs.

The campus has received several exemplary performance awards for its passive architecture design, energy management, and integrated water management. IIT Bhilai recently became the recipient of **GRIHA 5-star Rating** for large development of its master plan.

An Affordable Self-build Biomass-cum Solar Dryer for Small and Marginal Farmers to Reduce Agri-produce Waste

Food conservation is an energy- and cost-intensive process and hence becomes a matter of affordability for marginalized farmers in India. Article by **Abhiram Rachamadugu** discusses development of a low-cost, low-energy solar dryer for conserving food.

Abhiram Rachamadugu is a Std 12 student from Mallya Aditi School in Bengaluru. He has worked closely with Aarti Home, an NGO that works for women empowerment and gender equality in rural communities. He has worked with Vera Tatva Consultants LLP, Designbuilder Software Ltd, and Studio Aangan to develop a low-cost solar dryer.
He can be contacted at abhiramra@gmail.com

Introduction

A drive through rural India during the harvest season is amazingly beautiful—fields laden with fruits and vegetables, people harvesting fresh produce and vegetable markets full of fresh multi-coloured fares. At the same time, it is unimaginably heart breaking—stories of farmers unable to find the right price for their produce, crops getting wasted or even unharvested and farmers sinking deeper into debts. According to the Food and Agricultural Organization (FAO), nearly 40% of the food produced is wasted every year in India (IFCO Systems 2020). Contributory causes are many, for instance, inefficient supply chains, varying prices of produce, unpredictable weather patterns, insufficient food-processing infrastructure. The situation is more alarming in India, where nearly 45% of children are malnourished, wasting so much food is truly a waste.

This need not be a continuing storyline in India! We have the benchmarks set by Australia and New Zealand, where food wastage has been reduced to just 5%–6% of their produce. There are viable solutions to the problem. The one we are exploring is to give farmers, especially small and marginal farmers, the training and ability to preserve their produce. We can also prevent wastage of food by developing easy to preserve products that cater to the eclectic food preferences of the urban India.

Finding the Best Way to Preserve Produce

Food preservation methods have been around for millennia and humans have developed these methods for many reasons, such as saving food for off-season when it is not available in plenty, increasing value for trading or imbuing new flavours in the food, etc. The preservation methods can be categorized into salting, pickling, and drying (Gragg and Brashears 2014). Pickling and salting not only require extra resources but also significantly change the nature of the produce, limiting the options for further product development (Barrett 2003). Additionally, the extra costs associated with these processes would be difficult for marginal farmers to afford (Ohshima 2014). Hence, drying is considered a safe and low-cost preservation option (Berk 2013).

There are several methods to dry food. As lot of farms in India don't have a stable electricity supply, electricity-based methods will be impossible to implement. Open air drying under direct sun, while being energy free, comes with its own issues of hygiene and loss of colour (Belessiotis and Delyannis 2011) and nutrients due to ultraviolet (UV) exposure (Gruijl, Henk, and Kranen 2001).

Low-cost Prototype Design

Energy-free drying needs a mix of heated air, low humidity, and high airflow (Gupta, Bhawalker, and Sootha 1982). Several effective options of solar dryers are available in the market. However, a detailed market survey has confirmed that the products are relatively expensive and difficult to maintain for small and marginal farmers.

Model Name	Capacity	Price
Generic Aluminium Dryer	100kg/load	INR181,000
Rulux Dryer	25kg/load	INR59,000
Generic Commercial Dryer	150kg/load	INR600,000
Custom Low-cost Dryer	**25kg/load**	**INR15,000**

To overcome the associated issues, a solar-cum biomass dryer that can be built *in-situ*, using local materials, by local artisans or the farmers themselves and is easy to repair and maintain, was conceived. Several options of solar dryers were explored before finalizing the design that consisted of a collector and a drying chamber. The collector also has an option to be heated with biomass so that it could be used even during cloudy days (which coincides with high vegetable produce season). The collector and chamber were sized based on hand calculations and a prototype was built in Kadapa, Andhra Pradesh. It was constructed out of local materials using the black

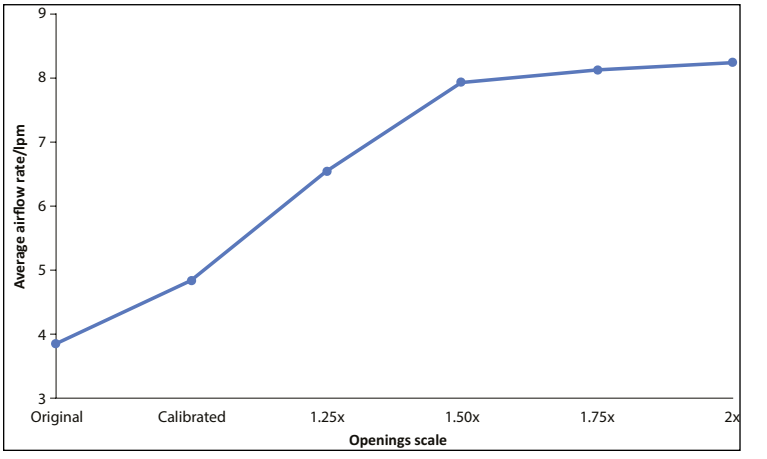
Kadapa stone as a base for the collector topped with a single pane of glass. Brick and cement were used to construct the chamber. The connections and outlets were created using locally available cement pipes. A GI metal door with thermocol insulation was fabricated to access the

chamber. This prototype was used throughout the summer to test its efficiency.

Improving the Prototype

As the primary prototype was designed based on hand calculations of heat and mass transfer, it was noted that further improvement was possible to make the solar dryer more efficient. In order to do so, the first step was to get the data from the primary prototype and use it to calibrate a digital thermal model. For this, an array of sensors was used to collect a variety of data. Ambient WS-2902C weather station was installed to measure the external weather conditions, and temperature and humidity loggers (WS-31P/E) were used to measure the internal temperatures and humidity in the collector and the chamber. Furthermore, Onset HOBO U12-012 logger was used with a TMC20-HD temperature probe to collect the data in the collector.

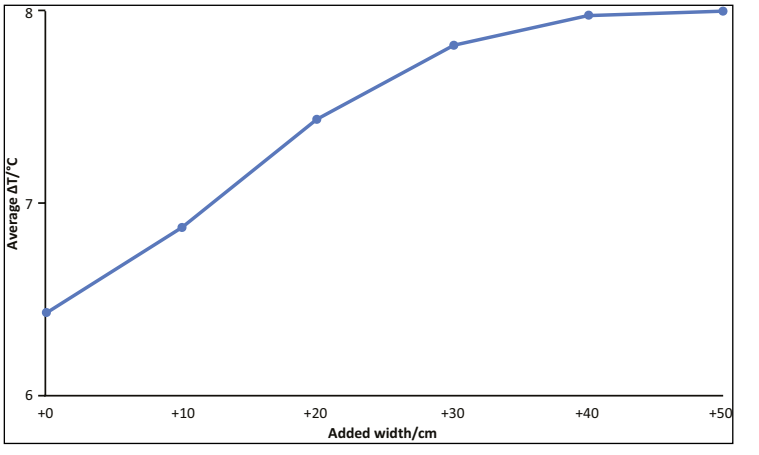
The prototype was modelled in DesignBuilder software, Version 7.0.0.116 which was provided by DesignBuilder under their Student Licence category. Several material-based assumptions had to be made for calibrating the model, for example, the thermal properties for Kadapa black limestone were not available and so they had to be inferred from regular limestone. The calibration studies resulted in introducing a concrete base near the entry of the collector to model the heat picked up from the surrounding ground, reducing the thermal mass (4'' brick wall to 2.5'' thick brick wall) to account for the irregularity of construction, and increasing the emissivity of the Kadapa slab to 0.9 to account for the temperature increase in the collector.



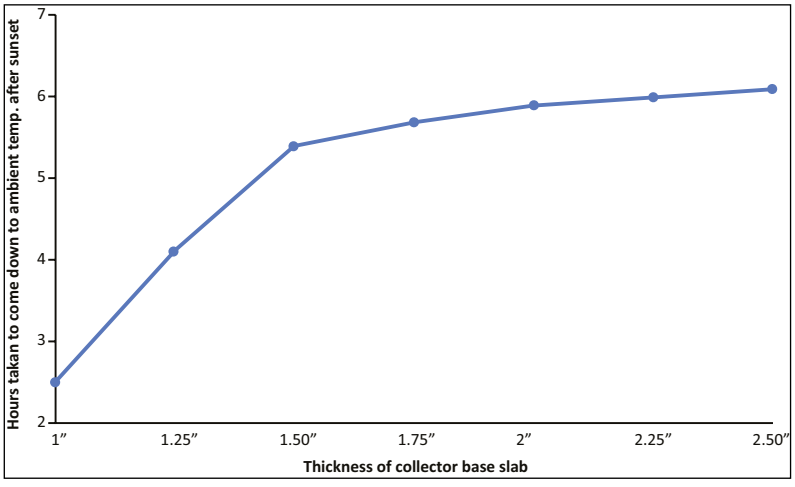
Average airflow rate/lpm

The calibration was further checked for accepted accuracy based on the CV Root Mean Square method, which is often used to verify the validity of a simulated model. The variation between the measured and simulated values using this method came to 3.4 (the accepted limit has to be <5).

The calibration study showed that there were three main variables that tended to affect the speed



Average temperature with respect to dimensions



Time take in vs base slab thickness

and quality of drying – quantity of airflow, heating of air in the collector and the heat retention capacity in the chamber.

Sensitivity studies were undertaken for all three parameters independent of each other. The first study was the heating of air or ΔT. ΔT was mainly affected by the width of the collar collector, so increasing the width in 10 cm had the greatest effect in finding the optimal dryer dimensions. The results showed that an increase of 40 cm, resulting in a final width of 1.40 m, is optimal. The next study was to find optimal airflow. To stabilize airflow, the openings were all adjusted to have equal surface area. After this, the opening sizes were adjusted in 0.25× increments each time. The results were in favour of openings that were 1.5× the size of the original. The final study was in heat retention, for which the thickness of walls and stone slabs were investigated. The results showed that a stone slab 1½" thick (1.5× the original) is optimal. Anything more, shows negligible increases but will result in an increase in the cost, making the dryer less cost efficient. Slabs any thicker will also be very difficult to move and install.

The final process resulted in the dryer being approximately 37% more efficient than the preliminary prototype. The cost of the dryer to the farmer would be INR18,000, and once the mason gets used to building it, the cost is likely to go down even further. The next steps to developing this improved dryer would be to build this model and test the performance in real life post the monsoons in India. After that, local farmers will be trained in building and operating the dryer, by Aarti Home, an NGO working closely with rural communities in Andhra Pradesh under their women's empowerment programme which they run in collaboration with Women's Education Programme (WEP), a US-based non-profit. Aarti Home will also be providing a marketing platform for the dried/dehydrated products developed by the farmers. After sufficient prototyping and testing, the design will made open source, so that anyone around the world can benefit from this design.

The design development, data collection, and simulations were also done by Abhiram Rachamadugu, with the support of Vera Tatva Consultants LLP, DesignBuilder, and Studio Aangan.

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BEYOND SUSTAINABILITY

The Seabin was created by two surfers who wanted to clean up the world's oceans.

The Seabin can filter out plastic, detergents, and oil, allowing clean water to flow back out. Inside the bin is a catch bag, which traps any floating pollutants.

A submersible water pump sucks water through the bin, passing it out again once it has been cleaned. It only needs to be emptied once a month and could make a big impact on water pollution in ports and harbors worldwide.

To know more scan the QR code:

Solar glass could change the way we create homes and commercial buildings.

Researchers are developing solar glass, a sustainable engineering project that has generated a lot of buzz in recent years. Just as the name implies, the solar glass would be able to capture and store solar energy.

According to the research team, 5 to 7 billion square metres of usable window space exists, enough to power a full 40% of US energy needs using solar glass.

To know more scan the QR code:

The "Veganbottle" is made from an all-natural bioplastic that could replace plastic bottles forever.

Everything in the Veganbottle, from the cap to the wrapper, is made from 100% biodegradable materials. The bottle is made from sugar cane extracts. Sugar cane requires far less water than other crops, and the manufacturing of the bottle itself uses less energy than conventional manufacturing.

To know more scan the QR code:

Third-generation Fenestration Product: Semi-Transparent – Building Integrated Photovoltaic Modules (BIPV)

Ankit Bhalla and **Amar Nath** discuss the significance of BIPV in new establishments, especially in the urban settings as the BIPV not only solves the purpose of electricity but also enhances aesthetic view of a building. Authors' findings also establish the BIPV technology to be future-ready and promising because of being sustainable.

Ankit Bhalla specializes in the field of Energy Efficiency and Sustainability and is currently working as a Manager-Technical in GRIHA Council, TERI, New Delhi. Presently he is heading the technical department and GRIHA Product Catalogue, a process for actively engaging with green building industry, in addition to the technical development responsibilities of GRIHA AH, GRIHA for Existing Day Schools, GRIHA, SVA GRIHA & GRIHA LD rating, he is also involved in project and product evaluation, business development, site audits and training of building professionals.

Amar Nath is currently associated as Managing Partner with Scube Solutions, located in Faridabad, Haryana. He is a mechanical engineer with a master's in energy systems from IIT Bombay, having 12 years of experience in the fields of energy efficiency, green buildings, and solar PV. He is a BEE-certified ECBC Master Trainer, GRIHA Representative, and IGBC AP and is an expert in providing consultancy services for rating systems like IGBC, LEED, and GRIHA. His core expertise includes energy simulation, solar and daylighting simulations, and CFD simulations. He was also a team member in the development of the GRIHA V 2015 rating system.

Think about a fenestration that lowers the building's air-conditioning load and at the same time generates power to cater the building's energy demand.

The next series of questions that will be rising in your mind will be:

Are there such fenestration systems? How do they work?

The answer is yes, it is possible with the use of BIPV as a fenestration feature. BIPV stands for building integrated photovoltaic system. Now days, they are used to replace conventional building materials like fenestration, roof, wall etc. and plays an important role in making a building more green and sustainable. One of the most common use of BIPV is as a fenestration, which enhances the aesthetic view of the building and at the same time provides electricity for building use.

Glazing is one of the common features in commercial and residential buildings, as it allows daylight to penetrate in the building and caters visual comfort to the inhabitants. Since early 80's in the last century, enormous efforts have been paid by the architects and engineers to deliver building façades with an extensive glazed area to fulfill the visual necessities of the people who view from both inside and outside of the building.

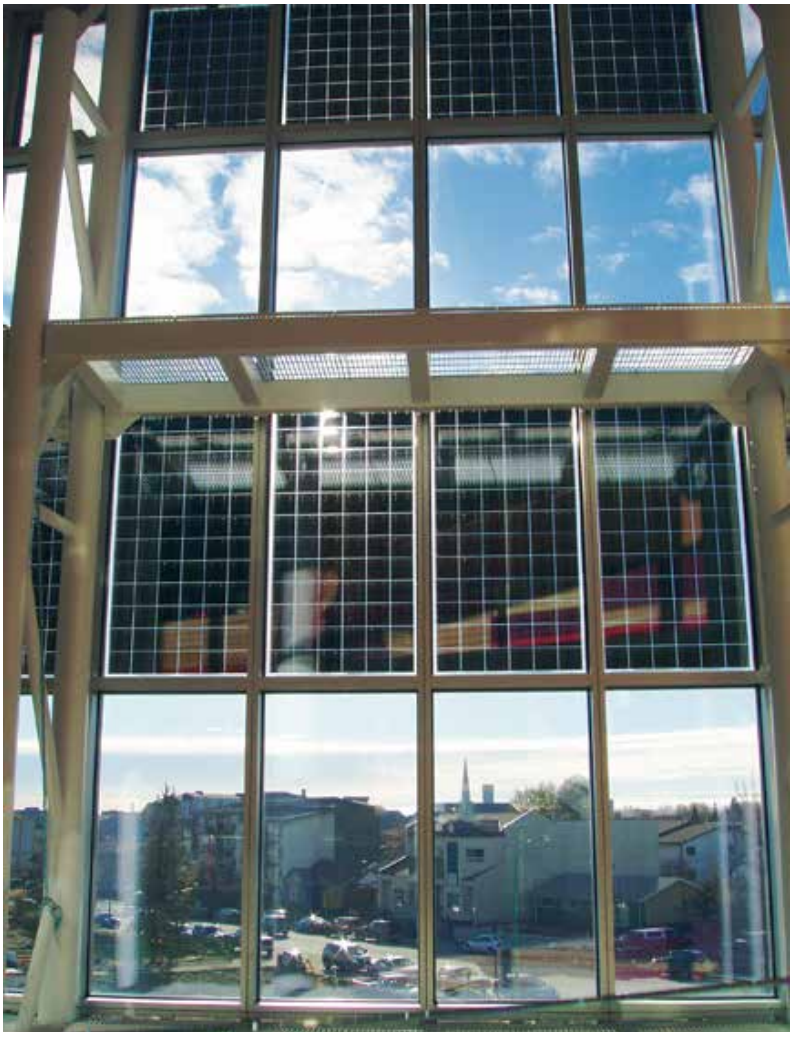
Fenestration is an architectural term which refers to the proportion and design of window, skylight and door systems in a building as described by ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers), 2009; fenestration serve as a physical and visual connection to the outside environment, providing a means to admit solar radiation for daylighting and also acts as an agent of heat gain into a space. Now these solar radiations bring in a lot of heat radiation with it, causing visual discomfort (glare) to the person working in the close perimeter of the fenestration, also it increases the indoor temperature of the space leading to high cooling demand and energy consumption. In order to reduce the energy consumption, it is essential to induce energy efficiency devices or systems in the buildings.

Performance of a glass window is measured in terms of U-value, solar heat gain coefficient (SHGC) and visual light transmission (VLT). U-value and SHGC are responsible for heat gain inside the building and determine the cooling load of the building. VLT plays an important role in determining the space area to be day lighted. When compared to a conventional glass, BIPV has better U-value and solar factor, and hence play an important role in reducing cooling load of the building. Similarly, design integration of BIPV at conception level of building also helps in achieving increased daylight area by replacing the conventional wall, thus gaining benefit of both, better daylight area and reduction of load on grid.

Use of semi-transparent BIPV as a system of on-site renewable

energy generation in energy efficient sustainable buildings is increasing day by day. The acceptance of this technology is due to its contribution towards a net positive energy building. Semi-transparent BIPV has been described as the term for design and combination of photovoltaic in the building envelope, which can replace conventional building materials. This integration can occurs in vertical fenestrations substituting window glass, or other facade modules in the building envelope. In urban areas where there are generally more tall buildings, increased façade area and relatively little roof space, support the adoption of photovoltaic for windows. These photovoltaic modules integrated into the building façade decreases the overall cost of the building by forming a part of the façade and replacing traditional building elements. In these kinds of systems, PV modules act as a part of exterior skin of the building. The PV modules used in the systems can be either transparent or semi-transparent.

BIPV comes in two main forms: partially opaque/light transmitting; and transparent. As executed these days, light transmitting BIPV consists of solar cells made from thick crystalline silicon either as single or poly-crystalline wafers. These deliver about 90 to 100 Watts per m² of PV array (under full sun). Whereas transparent BIPV systems are thin-film products that typically incorporate very thin layers of PV active material placed on a glass surface or a metal substrate using vacuum-deposition manufacturing techniques similar to those employed in the coating



of architectural glass. Presently commercial thin-film materials deliver about 45 to 50 watts per m² of PV array area (under full sun).

A semi-transparent BIPV module consists of three layers: Series of opaque solar cells sandwiched between two translucent glass panes with transparent resin encapsulation that settles in the space between each solar cell. With regard to its structure, part of the module area is covered with opaque solar cells (mono- or poly- crystalline silicon) while the rest is transparent. In the area covered by solar cells (henceforth referred to as the “solar cell part”), solar radiation is absorbed by the solar cell after passing through the laminated glass on the front. A certain amount of heat is also absorbed by the glass layers. The absorbed heat is then released gradually toward both the indoor and outdoor sides. In the area without solar cells (henceforth referred to as the “transparent part”), most of the solar radiation enters the interior environment directly through the glass, while a part of the solar radiation is absorbed by the glass and released gradually

after a period of time. On both surfaces of the modules, absorbed heat is then exchanged with the ambient environment by means of convection and radiation.

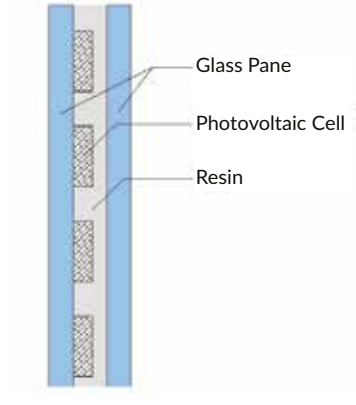


Figure 1: Cross-section of a semi-transparent BIPV module

Basically, the modes of heat transfer through a piece of glass include: (a) reflection, absorption and transmission of direct and diffuse solar radiation; (b) convection and radiation of absorbed solar radiation; (c) conduction and convection due to indoor-outdoor temperature difference. The first two components are affected by the amount of solar radiation, and they can be represented by the term solar heat gain coefficient (SHGC), which combines the transmitted solar radiation and the inward-flowing fraction of the absorbed solar radiation as follows,

$$SHGC = \tau + N_i \alpha$$

Where τ and α are the solar transmittance and solar absorptance of the glass respectively. N_i is the inward-flowing fraction of the absorbed radiation, which can be affected by many parameters such as inside and outside convective coefficient, glass overall heat transfer coefficient, zone geometry and zone radiation properties. However, for simplification, Ni can be expressed in terms of inside (h_i) and outside (h_o) convective coefficient for simple glass as follows,

$$N_i = \frac{h_i}{h_i + h_o}$$

Third part relates with the thermal conductivity. Thermal conductivity is property of a material which defines the rate of heat flow. U-value (also known as U-factor) takes the effect of thermal conductivity of the material and determines the heat transfer caused by indoor and outdoor temperature difference and is used to measure the thermal transmittance. It characterizes the heat transfer rate through a window and defines the quantity of energy transferred. The U-value can either represent the glazing itself or the entire window, including the frame and spacer material. Lower the U-value, better the performance of the glass. The U-value for single glass is:

$$U = \frac{1}{\frac{1}{h_o} + \frac{1}{h_i} + \frac{L}{K}}$$

Where,

h_o = outdoor glass surface heat transfer coefficients, W/(m^2.K)

h_i = indoor glass surface heat transfer coefficients, W/(m^2.K)

L = glass thickness, m

K = thermal conductivity, W/(m^2.K)

Another important property of windows is the visible light transmittance, which is in a range of 0 to 1. Along with fenestration area, visible transmission is directly related to daylighting and characterizes the solar radiation transmitted through the fenestration with respect to the response of human eye. In solar spectrum, there are three major categories of light energy: ultraviolet (UV), visible, and infrared (IR). The transmittance (T), reflectance (R) and absorptance (A) of a layer are formally defined as the fractions of incident flux that transmit, reflect and are absorbed by the layer, respectively.

$T_{vis} + R_{vis} + A_{vis} = 1$

The sizing of BIPV as window element is a challenging task for engineers and architects. The lack of technical knowledge reduces the confidence of architects and engineers in adopting BIPV systems in the early stages of building design. If it is incorporated in early stages of building design then building may get benefited in terms of reduction in dead load, less dependency on grid, better day-lighted area, reduction in cooling load, reduction in walling material, reduction in use of fossil fuels and reduction in emission of ozone depleting gases. Hence, it becomes crucial to consider it in early stage of design. The parameters which governs the sizing of BIPV are mainly the following:

- Peak demand of the building
- Daylight requirement of the building
- Aesthetic view of the building

- Orientation of façade
- Energy requirement of the building

Energy generation from BIPV depends on its orientation, efficiency and solar availability of the location. The electricity generated is direct current (DC) which can be utilized in the building directly or it can be first converted into alternating current (AC) with the help of inverters for general use in the building. The energy generated can also be stored in batteries for later use. Energy generated can also be transferred to the grid when in surplus and can be taken back when required. Sizing of inverters and batteries is also a crucial part of the designing and needs detailed engineering.

Hong Kong Science Park is one of the examples, where BIPV modules have been installed in the façade. There are 224 pcs of 1575 x 1450 mm and 28 pcs of 2075 x 1575 mm, 10 mm clear low iron tempered glass/ 2 mm cell circuit with resin/ 10 mm clear heat strengthened glass. Each laminate has 160 SBBM1 cell and is rated at 227Wp +/-10%. These PV laminates are puntiform mounted by “spider” brackets covering a façade area of 553 m². The total PV rating for façade is 57.2KWp.

BIPV (Building Integrated Photo Voltaic panels) module has been employed for another building in Hong kong that is One Peking. In this building a double laminated 8 + 8 mm heat-strengthen glass with 100 x 100 mm silver colour polycrystalline silicon cell fixed on the surface, with a total of 144 modules over an area of 200 m² have been employed. The BIPV panels are connected with the grid electricity and are used to absorb

the solar energy. The solar energy is then converted into electricity and supply to the building.

Cost of PV installation and the energy efficiency are expected to improve in future. With rapid development of BIPV technology and design, the growing potential of BIPV is favorable. By studying the potential of BIPV applications in terms of cost consideration, availability of solar radiation and area, it is found that India is technically favorable for BIPV applications. If more administrative support can be provided by the Government and power companies, the development of BIPV in India will be faster for a more sustainable environment.

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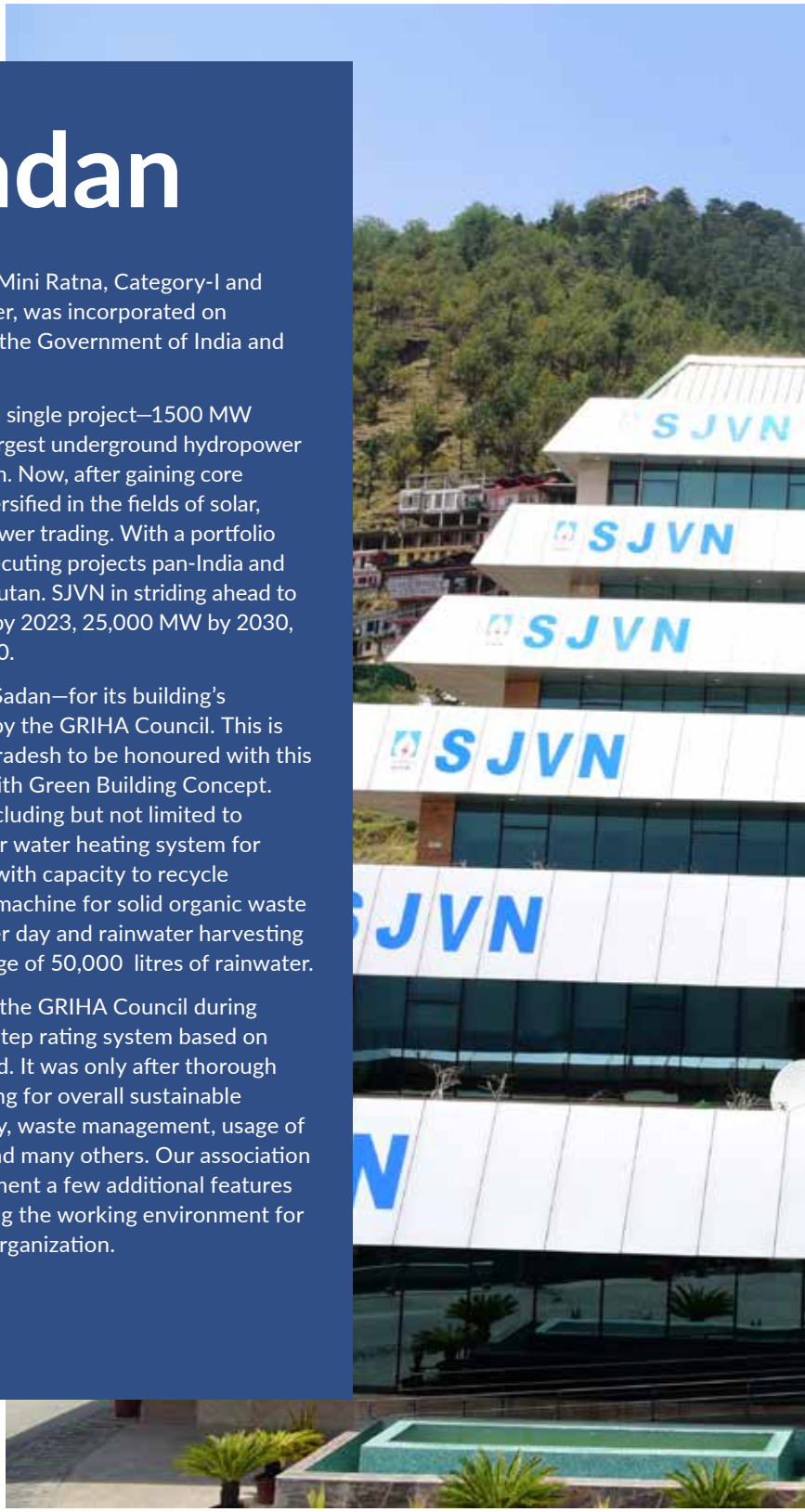
Shakti Sadan

SJVN (Satluj Jal Vidyut Nigam) Limited, a Mini Ratna, Category-I and Schedule 'A' CPSE under Ministry of Power, was incorporated on 24 May 1988, as a joint venture between the Government of India and the Government of Himachal Pradesh.

The journey of the company started with a single project—1500 MW Nathpa Jhakri Hydro Power Station, the largest underground hydropower station of the country, in Himachal Pradesh. Now, after gaining core competency in hydropower, SJVN has diversified in the fields of solar, wind, thermal, power transmission, and power trading. With a portfolio of around 40,700 MW, the company is executing projects pan-India and in neighbouring countries of Nepal and Bhutan. SJVN in striding ahead to achieve its vision of achieving 5,000 MW by 2023, 25,000 MW by 2030, and 50,000 MW installed capacity by 2040.

SJVN's Corporate Headquarters—Shakti Sadan—for its building's performance—has received 4-star rating by the GRIHA Council. This is the first of its kind building in Himachal Pradesh to be honoured with this rating. Shakti Sadan has been designed with Green Building Concept. The building has many unique features including but not limited to 120 kW solar energy system, 40 kW solar water heating system for energy needs, sewerage treatment plant with capacity to recycle 90,000 litres of wastewater, composting machine for solid organic waste management with a capacity of 250 kg per day and rainwater harvesting system for water conservation with storage of 50,000 litres of rainwater.

SJVN had a rich learning experience with the GRIHA Council during different stages of evaluation. The multi-step rating system based on various criterions was very well structured. It was only after thorough evaluation, SJVN achieved the 4-star rating for overall sustainable building features such as energy efficiency, waste management, usage of renewable energy, water conservation, and many others. Our association with GRIHA has also inspired us to implement a few additional features that have considerably helped in improving the working environment for our employees and to be a future-ready organization.



Nand Lal Sharma, Chairman and Managing Director, SJVN

Heeta Lakhani is the Founder & Director of the ClimAct Foundation. She has a Master's of Science degree in Environmental Studies and Resource Management from TERI University, India. She is a firm believer in the power of youth participation in grassroots and international processes and strives to create change-makers who combat the climate crisis with knowledge-based action. Heeta was introduced to the world of the United Nations Climate Change process at COP21 in 2015 and was the Global Focal Point for YOUNGO for 2020–21. She also co-founded the Youth Negotiators Academy, which focuses on training youth to be effective negotiators in the UN intergovernmental processes.

Heeta Lakhani

In this conversation with GRIHA Council, **Heeta Lakhani** discusses her work on climate education at ClimAct Foundation, the different kinds of challenges she faces in her work and the inspiration behind her commitment to work for the betterment of our planet's health.

GRIHA: Can you tell us about your work at ClimAct Foundation and its programmes across India?

The ClimAct Foundation focuses on climate education, holistically, it looks at an intersectional approach towards climate education. The Green Warriors Program focuses on children and young people, and Mind the Gap Program is for communities and organizations. In 2017, I started working on climate education, which is now called The ClimAct Foundation. In short, it helps to bridge the gap between what is happening internationally and within India. Since there is quite a bit of gap in climate education, which we want to try and fill, this is how the ClimAct Foundation was eventually first conceptualized.

GRIHA: What inspired you to take actions on environmental issues?

Ever since I was young, I wanted to be somebody who works for nature. I didn't know what it was but ever since I learned the term environmentalist, I wanted to be that. Eventually, I did a Master's in Environmental Studies. When I went to Paris for the COP (Conference of the Parties to the UNFCCC) and came back, there were of course a few trigger moments. It made me want to get back in the field of climate and a few months later, I decided to quit my day job and I started volunteering. I volunteered for about a year and then slowly started doing a few part-time activities/jobs alongside the volunteer work. So, I have always done more than one thing at a time which made me realize that I have always spent a lot of time volunteering, learning about the youth space, trying to figure out where I fit best and trying to see what the gaps and challenges are. Eventually, this led me to my path.

GRIHA: What kind of sustainability initiatives do you organize for the youth?

With the ClimAct Foundation so far we've been doing more of these educational programs. We've been doing this over the past couple of years, of course, virtually because of COVID-19 pandemic. But before that, we've done quite a few sessions, for example, in Mumbai, we were a part of the colour-coded Arts Festival—where we did sessions for children. We've conducted workshops at the Children's Museum, on days like World Environment Day aiming at the younger kids to understand about climate and the environment.

Currently, we are focusing more on collaboration with other entities in a similar way. We have done workshops and learning sessions with tribal kids in Manipur in a semi-virtual format, session with partners in Bengaluru, a year-long engagement with a corporate in Mumbai, trying to make their space a little bit greener, and so on.

GRIHA: What is the value of youth advocacy in the climate movement? What unique perspective do you bring?

I was first introduced to the youth club at International Space in 2015 wherein a lot of young people were a part of it. Since the access to information was limited initially, youth was not involved into initiatives, which were organized for climate change. However, now, with an access to a lot of information, school strikes, etc., the youth movement has definitely picked up, which helped the youth to learn about the international process. And, they realize that this is something that is happening in a space where they really need to be part of it or at least try and understand what's happening around them. Also, the pressure that even the national governments, at least at The International Space, recognize that firstly, the voices of young people are important to take into consideration. Secondly, there are generations to come who are facing the impacts of the consequences of those decisions that they are taking at such negotiations. There are a lot more young people who are now aware, who are now wanting to be part of the solution rather than just sitting on the sidelines.

GRIHA: What element of uniqueness do you bring in climate education?

I think there are a couple of two big things that we bring into the picture: One is really bringing in

an intersectional approach as we are not looking at education in terms of just classroom learning, education just in the terms of Science or, at it as only from the point of climate, but, really from the point of bridging the different sectoral perspectives and making our content for the audience. The content is created such that it can be accessed by every young person in whichever part of the country he/she is, eventually, making it audience specific.

GRIHA: Throughout your journey, what was the biggest challenge that you had to face and how did you overcome it?

One of the major challenges we face is outreach and the second one is funding. Our organization is very recently founded, which is why it is not so recognized. Although the work was going on since 2017, the organization has been formalized not too long ago. Additionally, one of the major challenges also includes having a dedicated team as presently the entire team is working on voluntary capacity.

GRIHA: How can students from schools that are not so well versed with environmental risks approach you?

Actually, there are a few different approaches. We are essentially now planning that from 2023 onwards a series of virtual sessions will be organized where we can reach out to people across the country and talk about different topics. The only barrier that we might face is the internet connectivity.

But, of course, adapting it to a more mature version with a team of volunteers who are partner organizations on the ground where we can train the facilitators to do these sessions in person so that depending on the type of audience and the kind of limitations, we could work with people on the ground. So, we're building up both these models. We are trying to find a virtual version where we can do sessions and also facilitators on ground (sort of partners) who can do such kind of sessions.

GRIHA: What are the ways in which "school climate strikes" can make a difference in the climate change dialogue?

I think one is just the sheer number of young people that are part of this dialogue. So, the more young people (who are aware about it) get involved, there is a stronger voice that adds up to the discussion. Therefore, whether it is just at the school level or whether it is more assertive foreign policy, advocacy level, there is power in a collective.

From these climates strikes, they have gone beyond to question a few things to understand such as, ways of working—whether it is their own sort of lifestyle, the zero-waste lifestyle or getting into proper work areas which is more focused on different topics such as waste, carbon emissions, water, etc. The good thing that I have seen is that this has brought a community or generation of young people together and this has also just been the launching pad for them to go off into literally creating a way of life out of this for themselves. So, it has gone beyond just a movement on the streets to something that people have now picked up in their day-to-day lives.

GRIHA: Could you please share your perspective on the youth engagement activities, and also the need to co-found the Youth Negotiators Academy?

Youth Negotiators Academy is a constituency within the United Nations Framework Convention on Climate Change (UNFCCC) for engagement of children and young people. So, that is where I spend most of my time within the UN space that is really helping the launching pad—whether for understanding the negotiation process or whether for meeting other young people. Since 2016, the set of learning curve has been really incredible.

There is still a need for young people to be part of the national delegations because at the end of the day, if you want to make change, it is an inter-governmental process and very few governments have young people who are part of the process. So, this was one of the biggest set of triggers for why

we felt the need to co-found the Youth Negotiators Academy. So really, being a young person at the UN is very different than being a youth.

They need to be trained, to come at least as far as some of their colleagues to be able to sit at the same table as the senior colleagues and understand responsibility and leadership transfer. So, this is exactly what we are doing. It is a program which has four pillars; training is the first one, second one is creating a community. Training focuses on the UN process and creating a community is a global program where community is key. The third pillar is of course advocacy which is slowly changing that focus on bringing young people not just as observers or support staff. Giving them the leadership position, authority to trust them, to be able to do something is vital. And finally, the fourth pillar is one of the most challenging that we felt is travel and subsistence grants for most of the countries that we are working with like some of the global South countries.

GRIHA: How can we as individuals, or how bigger organizations or for that matter governments can contribute to this whole movement?

I think in a utopian world, we probably would not need young people to go out and strike or we would not need young people to go out and advocate. So, the vision would actually just be that we are proactively participating whether it is businesses, governments, organizations or individuals. Well, climate education is not something that they have to do in addition to everything else. It is a part of that functioning, working and way of life. So, there are always going to be different kinds of pulls and pushes from different sectors and elements, but in a world, we're dealing it with the level of urgency, over the level of action that is required.

GRIHA: Is there any specific person whose work you admire and what is the source of your inspiration?

There are quite a few people whom I admire. A few of them at the international level, for example, executive secretary of the UNFCCC, the executive secretary, deputy secretary-general of the United Nations, and a lot more. I think they have been fantastic and it is really good to see women leaders who have come from different parts of the world, different realities and coming from Global South countries. They have overcome challenges in their own lives and have risen to the leadership positions. And also talking about people from India, there are so many distinguished individuals from Dr R K Pachauri to Mr Bittu Sahgal and a lot more, who have been my mentors.

Despite all kinds of odds and challenges all these people have proven that there is hope for the planet. And fortunately, I have been able to work with most of them already. And then, not to forget, most of my colleagues, teammates, co-founders and a lot of young people also inspire me. This is exactly what brings me open inspiration every single day.

GRIHA: What is your message to our readers struggling to find balance between sustainable living and intergenerational justice?

I think there is not too much of a conflict between either of the two. Sustainable living can go at different levels right from my own life to what I am doing as my personal choices. What I wear to what I use or I eat or maybe travel. There's no one particular way of living sustainably. Each one of us needs to figure out and there is a very basic question that you need to ask yourself—"what you need and what you want". It is really like working together across generations; working together to ensure that it is not the job or not the responsibility of one generation or the other but a collective responsibility of all the generations together.

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Behaviour Change for Climate Change

Mallika Dev is an Architect & Urban Planner. She has done PG Diploma in Urban Environmental Management & Law from National Law University. She is an IGBC Accredited Professional. Currently Working as an Assistant Professor in University School of Architecture & Planning, GGSIPU, New Delhi. She has keen interest in finding the linkages of urban lifestyle & climate change.
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Figure 1: The Consumer Culture

Humans stand for a finite part of living beings on earth, but are highly, negatively influential in terms of disturbing the ecosystem of this life-supporting planet. Anthropogenic activities are largely governed by our behaviour and consumerism forms a significant part of this approach. The article by **Mallika Dev** aptly accentuates how humans' desire for accumulating the materialistic world has resulted in producing irreparable damages to the earth's ecosystem. In the long term, the repercussions are many and unarguably lethal.

We are fortunate enough that we are a part of an era of abundance, often addressed by many as 'Anthropocene'. We signify a miniscule fraction by weight of all living beings on the planet Earth, ironically we have a disproportionately significant impact on our environment. Human species weighs only 0.06 Gt whereas the total weight of living beings on planet is 550 Gt. If we continue with the same lifestyle and behaviour, the future of humanity will be at stake. Our biosphere is changing rapidly in response to lifestyle of materialism and overconsumption. Do we have the right to do so? What is the fine line between consumption and overconsumption? Can shifting to a sustainable behaviour be the key?

Consumerism denies its consequences

The fast-paced lifestyle in our cities makes us feel that some material objects will ease our life. Many a times we accumulate things which we don't require. We buy things to satisfy desires but material desire has no end. The psychology behind this behaviour of overconsumption is the search of happiness that buying that 'one thing' will give us the happines, just after buying that 'one thing' is trailed by another 'one thing' and the list continues endlessly.

For every purchase, there is a sizeable amount of consumption of natural resources and in the manufacturing lies a lot of pollution to the natural systems. For example it is estimated that the carbon footprint of a typical pair of running shoes made of synthetic materials is 14 $kgCO_2$ eq. and that of a pure cotton shirt over it's lifetime, is 15$kgCO_2$ eq. while a polyester jacket from cradle to grave will use 18 kg CO_2 eq. We need to think before any purchase and ask: "Do I Really Need it?"

Figure 2: 'I am what I have' Psychology

The awareness action gap

In the urban settings we do spend most of our time in covered spaces and hence feel disconnected from the nature. We are unable to care and respect nature as we are not consuming the products directly from the natural resources rather the products come to us as in a packaged form after a lot of mechanical process. We all are aware of the environment friendly behaviour like not using single-use plastics, carrying our own cloth/jute bag, segregating the waste, composting , switching of the electric appliances when not in use, opening the curtains for daylight, plant rich diets, reduced food waste, clean cookstoves, electric vehicles, ride sharing, telepresence, rooftop solar, household water savings, etc.

However, even after possessing all the information, the question arises that how efficiently and how many of us practise this knowledge in our daily lives. We are unable to understand the consequences of our actions on the environment. Hence there is something beyond the knowledge that hinders us from practising these good habits.

Role of human behaviour

Behaviours that perpetuate global warming are arguably much more difficult to change because the climate benefits of changing behaviours are often delayed and mostly invisible. We can change our behaviour if and only if we acknowledge the fact that there is some problem associated with it and that our consumption style will lead to problems to our own children, grandchildren and this ignorance by us is leading to a problematic life to our own future families. The famous proverb, "We do not inherit the earth from our ancestors; we borrow it from our children' justifies the need to amend our behaviour.

Behaviour changes for sustainability

Our behaviour is highly governed by belief, attitude, and intentions. Many a times we don't want to change our behaviour because of the fear of not getting accepted by the community. Consciously living in a small house to reduce carbon footprint can be taken as not been able to afford a big house full of material comforts.

Figure 3: Steps for behaviour change

We have a huge opportunity to apply the insights about human behaviour and transform conservation threats into real-world solutions.

Being social we care about how it compares to the status of others in our group. Personalized normative feedback approach can be used to provide individuals with information about themselves as well as their peers. Providing homeowners with information about how their consumption of utility services, such as electricity and water differs from that of their neighbours. The feedback is designed to pressure high users to reduce their consumption and thereby greenhouse gas (GHG) emissions. Simply by changing the default settings of the printer as 'double sided', an organization can save nearly 7,391,065 sheets of paper in 6 months implementing the behavioral science concept of 'default effects' which refers to the human tendency to choose the option that is automatically selected. Based on the behaviour choice theories various model of behaviour change can be evolved and practised for pro-environment behaviour.

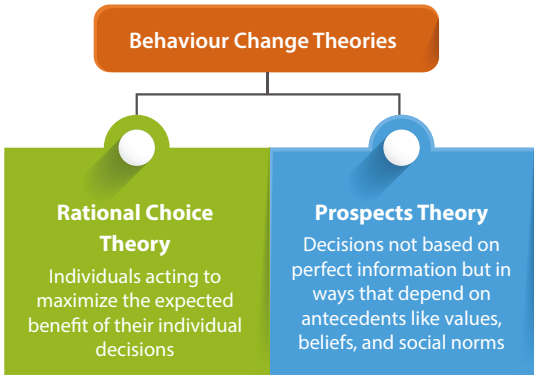

Figure 4: Behaviour change theories

Education model suggests that education will lead to awareness and attitude change, which will create behaviour change. In Extrinsic Motivation Model external motivation can be used to change the behaviour. Human behaviour can be influenced through providing incentives and/or punishments. According to Intrinsic Motivation Model, there are certain behaviours and goals that humans are inclined to do because they are enjoyable. Norm Activation Model rely on the activation of personal norms that in turn lead to personal feelings of responsibility and ultimately leading to behaviour change. Value–Belief–Norm Model proposes that personal value and belief systems crystalize into personal norms and shape behaviour due to our desire for value-consistent actions in a number of different contexts.

We are the part of nature and therefore share a strong link to nature. For our well-being and of all other species and for the nature itself, we need to make different choices and the way we interact with other species in

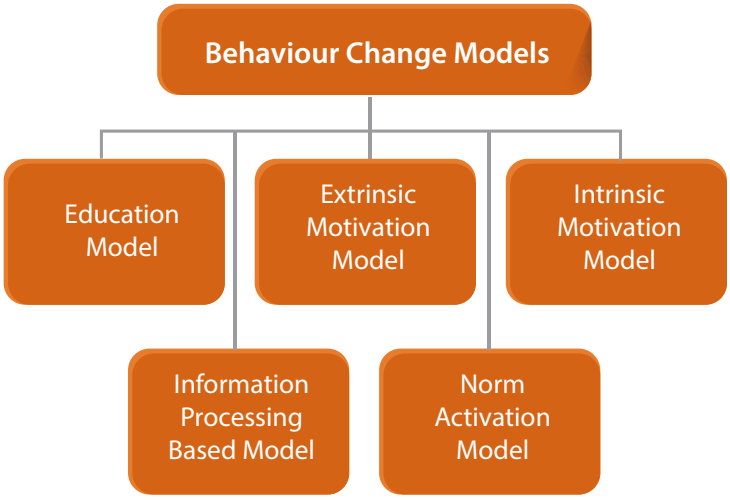

Figure 5: Behaviour Change Models

nature. We need behaviourally informed solutions for achieving sustainability. Individual behaviour changes when taken up by billions of people make a decisive difference.

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Playponics

The Playponics playground equipment has been researched and designed to help reconnect younger and older persons alike with the natural world and to highlight the connections between environmental sustainability and our health and wellbeing. Many schools attending the Paryavaran Rakshak Programme organised by TERI and the GRIHA Council, tested out the seesaws and the swing and saw how their play was used to move water around a garden to help keep crops thriving. The Playponics project has so far been funded by Sheffield Hallam University's (SHU) Global Challenges Research Fund (GCRF) and the Expanding Excellence Fund (E3). A team of researchers from the Lab4Living (L4L) at SHU is working across India in collaboration with Ativa design. Lab4Living (L4L) at Sheffield Hallam University is an interdisciplinary research group, based on a collaborative community of researchers in design, healthcare and creative practices. We work together to address real world issues that impact on health and wellbeing, developing products, services and interventions that promote dignity and enhance quality of life. Ativa is a design consultancy based in New Delhi that co-design and co-develop products and solutions to tackle social and sustainability issues faced by India as a developing nation.

Please visit our exhibit on display outside the TERI office at India Habitat Centre very generously provided to the Playponics team by the GRIHA council for a month upto the 16th of December. We are looking for schools and communities who would be interested in having a setup and also funders/ sponsors. For more information about Playponics, please see our website https://playponics.in/ and/or contact us on info@playponics.in.

THE 14 GRIHA SUMMIT 2022
"TOWARDS NET POSITIVE HABITATS"

Sheffield Hallam University

Lab 4 Living

ATIVA

SCAN ME

Dr. Vibha Dhawan, President GRIHA Council and Director General TERI, lighting at the lamp at the inauguration of the GRIHA Event 2021

Welcome address by Dr. Vibha Dhawan, President GRIHA Council and Director General TERI

Shr. Bhupendra Yadav, Hon'ble Minister of Environment, Forest and Climate Change and Ministry of Labour and Employment, addressing the audience

The GRIHA Event 2021

The signing of Memorandum of Understanding between Govardhan Eco Village and GRIHA Council

Distribution of Awards to the projects for Exem

Introductory remarks by Mr. Sanjay Seth, Vice president, & CEO GRIHA Council

Group photo of the delegates and the GRIHA Council team

H.E. Mr. Hans Jacob Frydenlund, Ambassador, Royal Norwegian Embassy in India, addressing the audience

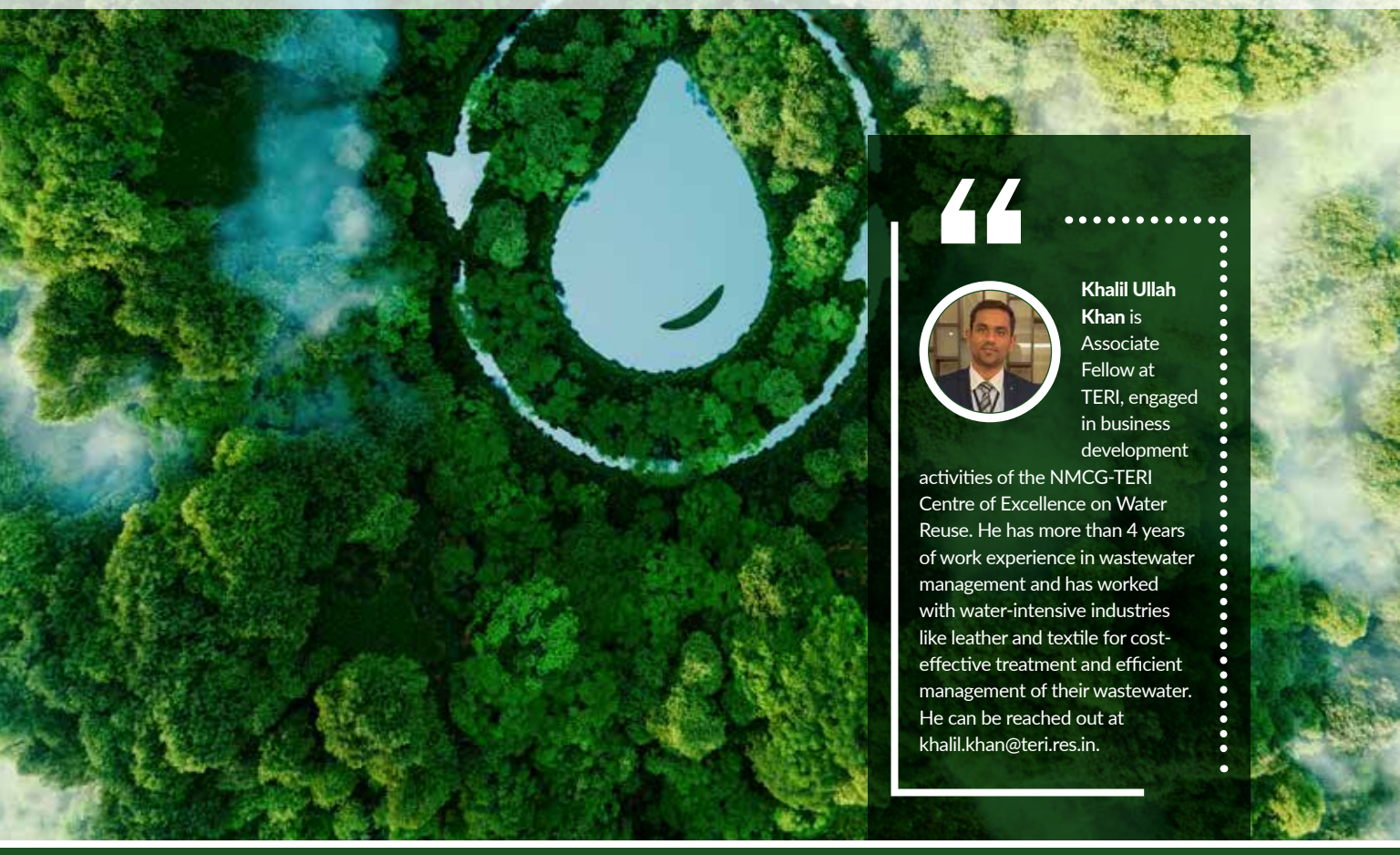
Special remarks by H.E. Mr. Freddy Svane, Ambassador, Royal Danish Embassy in India

Launch of SVA GRIHA Rating at the Inaugural session at the GRIHA Event. L-R - Mr. Sanjay Seth, Ms. Divya Dutta, H.E. Hans Jacob Frydenlund, Sh. Bhupendra Yadav, H.E. Freddy Svane, Anand Santhanam, Dr. Vibha Dhawan

mplary performance

Award for the sustainability contest held on social media

Wastewater Reuse: Linear Economy to Circular Economy



Khalil Ullah Khan is Associate Fellow at TERI, engaged in business development activities of the NMCG-TERI Centre of Excellence on Water Reuse. He has more than 4 years of work experience in wastewater management and has worked with water-intensive industries like leather and textile for cost-effective treatment and efficient management of their wastewater. He can be reached out at khalil.khan@teri.res.in.

Water is a common ingredient of many activities in our daily life, be it drinking, domestic, industrial, or any other. The water generated once the activity is complete, is known as wastewater. In this article, **Khalil Ullah Khan**, throws light on the significance of wastewater treatment and enlightens us how circular economy in wastewater can ensure water security and generate business models. Wastewater is not an end—it is a means to end—water.

Growing Global Water Challenge

Have you ever wondered, how life would be without water. Let me give you a vivid illustration of the same. There would be no food to eat, there would be nothing to drink, the industrial production will come to a halt and the life on earth as we know will become non-existent. Increasing population, industrialization, and unplanned urbanization is incessantly increasing the stress on earth's freshwater resources when 2 billion people are already living in water-stressed areas (UN Water 2021). The World Bank estimates that the world's water demand is projected to exceed supply by 40% by 2030 (UNESCO 2021). Therefore, the growing water scarcity and related challenges need to be identified and addressed promptly in an integrated manner. It is only through careful planning and management of water resources that we can ensure water security.

Wastewater

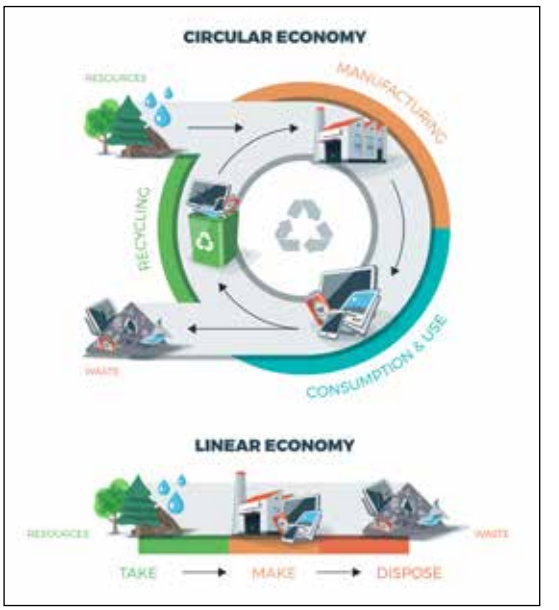
Water is used for many activities in our daily life, be it drinking, domestic, industrial or any other. The water generated once the activity is complete, is known as wastewater. Wastewater may contain energy, water, organics, phosphates, nitrogen, cellulose, rare earths, and other resources depending on the type of wastewater. These resources can be recovered for reuse if the wastewater is effectively collected and efficiently treated.

As per Central Pollution Control Board (CPCB), India generates about 29,129 million litres per day (MLD) of sewage against which the installed sewage treatment capacity is 6190 MLD, remaining 22,939 MLD (~79%) goes untreated into the environment which further creates various water-related challenges. Numerous water-borne diseases and water problem are result of untreated or inadequately treated wastewater. The data states that there is a huge need of investment in water treatment infrastructure to capture its potential fully. The size of municipal water and wastewater market in India is estimated to be US$2 billion in FY 2020 (EY–ASSOCHAM 2019).

Paradigm Shift: Linear to Circular Economy

In linear economy, the emphasis is given on simply treating the wastewater to meet regulatory norms and discharge. The linear approach of abstracting water, utilizing, collecting, treating and discharging is not sustainable.

Owing to high capital and operational cost and lack of incentives for reuse, the wastewater is considered a liability and burden by both industry and municipality in India, instead of a resource.



Wastewater can be treated to different qualities, depending on the need of the user to satisfy the demand and can be reused. Treated wastewater reuse will reduce stress on freshwater sources and can be a potential solution towards a water secure India. Therefore, it is important to include wastewater reuse in the hydrological cycle as a potential source of water.

As per Ellen McArthur Foundation, “A circular economy is an industrial system that is restorative or regenerative by intention and design. It is an economic system aimed at minimizing waste and making the most of resources.”

Wastewater is an untapped resource and incorporating principles of circular economy in wastewater management is that “maximum resource recovery and reuse of treated wastewater can change a costlier treatment system into a system which is financially sustainable and generate value for investors”. Resources recovered in the forms of energy, reusable water, biosolids, and other resources from wastewater treatment, can generate revenue for the treatment plant to cover the operation and maintenance cost of the plant partially or fully.

The circular economy approach in wastewater treatment is also essential to achieve the Sustainable Development Goals which focus on improving water-use efficiency, reducing number of individuals suffering from water scarcity, and restoring water-related ecosystems, among other relevant targets.

In India, the policies target municipal corporation for development and operations of wastewater treatment infrastructures which in most cases lack the techno-financial capability to supply services satisfactorily. Therefore, private sector involvement through various public–private partnerships is necessary to improve the treatment infrastructure of the country. Currently, the private sector is reluctant to invest in this field due to almost negligible returns and

remarkably high risk, however, the change to circular economy will open new streams of revenue, enabling business models which will promote and attract private sector investment to close the funding gaps.

As the urbanization increases and the availability and distribution of water resources is being altered by climate change, in near future it will become extremely difficult to meet the demand for water. Therefore, future development in India requires methodologies that reduce freshwater consumption, promote reuse of treated wastewater, and focus on resource recovery under principles of circular economy. Currently, there is nearly total absence of regulatory framework for water reuse and resource recovery from wastewater in India. However, Indian Governments new programme, Arth Ganga, promotes reuse of treated wastewater for irrigation, industries and revenue generation for urban local bodies (ULBs).

To achieve the goals of circular economy, wastewater initiatives, policies and regulatory frameworks need to be planned at distinct levels keeping the demand of different sectors in focus and the paradigm shifts from linear to circular economy will need to overcome numerous institutional, economic, regulatory, social, and technological challenges. One of the biggest problems which will be the most challenging to overcome, is that the water in India is highly undervalued. The reuse of water will remain a challenge till the time treated water does not become cheaper than freshwater.

Water scarcity is a global concern and cannot be neglected. It is time, we start considering wastewater a resource and wastewater treatment facilities as 'water resource recovery facilities'.

Case Study: San Luis Potosi, Mexico

A case from San Luis Potosi State of Mexico can help illustrate the significance of reusing wastewater. The State is a water-scarce region. Rapid urbanization and intensive industrialization led to rapid aquifer depletion. But the state government recognized the value of wastewater and started utilizing it rather than disposing it. The state government built seven wastewater treatment plants in the region with an objective to treat 100% of the wastewater. The treated water is provided to industries at 33% cheaper rate than the groundwater which has benefitted both industry and the plant. The intervention has also resulted in reduction of groundwater extraction by 48 million m^3 in six years, resulting in restoration of aquifer. The business model with extra stream of revenue also attracted the private sector to partially fund the capital cost of the plant under PPP agreement. (Wastewater: From waste to resource, The case of San Luis Potosi, Mexico, World Bank Group)

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START-UP STORY

Journey of Strawcture Eco

Strawcture Eco's, Founder and CEO, **Shriti Pandey** left her cushy job in New York City and headed to spend a year in rural India.

While travelling the length and breadth of the country, she discovered a myriad of possibilities to reinvent the existing practices in the construction industry and at the same time ended up witnessing stubble burning first-hand. Combining both these experiences, Strawcture Eco was born.

In India, more than 500 MMT of straw is generated annually. Out of this, 40% stubble is burnt every year. This leads to 36% increase in lung cancer cases annually and a National Economic loss of $30 billion/annually in terms of air pollution and health infrastructure cost. That is surprisingly equivalent to the GDP of countries like Zimbabwe and Sudan!

On the other hand, the construction industry has been stifled by the carbon-heavy methods of creating structures for centuries all around the world. It is the third-largest consumer of coal and the global demand for wood has gone up by eight times in the last three decades. This just cannot be met 'sustainably' any more. Any new buildings being developed between 2015 and 2050 will contribute 90% to greenhouse gases (GHGs) by its embodied footprint, which is the footprint of building materials.

Shriti Pandey, Founder CEO, Strawcture Eco

Figure 1: SG retail store, MGF Mall (Gurugram)

Figure 2: Heritage International School (Gurugram)

The waste of one industry can serve as the raw material for the other. Embracing this sacred concept of optimizing resource utilization and waste reduction, we redefine the value chain of building materials and adopt an approach which is in harmony with nature.

We, at Strawcture Eco, have come up with a disruptive innovation that can decarbonize buildings. AgriBioPanels™ are 100% carbon-negative engineered panels that are E1 Certified, fire-resistant, moisture-resistant, and termite proof. They are made of 96% straw, an annually renewable fibre. Each square metre of AgriBioPanels can sequester 30 kg of carbon dioxide in its lifetime. The AgriBioPanels™ can be used for interior applications in a building for dry walls, ceilings, doors, furniture, and mezzanine flooring.

AgriBiopanels have the lowest thermal conductivity value, lowest volatile organic compound (VOC) emissions, and above 0.7 NRC Sound Insulation value. They come in different thicknesses, sizes, and are versatile when it comes to its finishes. We are a Pro, ISI, BIS-certified brand and have all testings from NABL-certified labs.

Till date, we have sold more than 700,000 sq. ft of AgriBioPanels™, storing 2100 MT of CO_2, an impact equivalent to that created by 2100 fully grown trees! We have displayed our products application in 20+ cities in India, covering 11 states and now expanding by building a network of channel partners in all Tier 1 cities in India by 2023.

We have showcased the viability of our product during Covid times and in the last 2 years have built four Covid relief structures in Bihar, Odisha, and Nagaland with our AgriBioPanels™ being used for partitions, ceilings, hospital beds, and doors.

India has the potential to reach the forefront of sustainable building, and hence can show the world the future of biomaterials, establishing the fact that waste is only a waste, if you waste it.

Figure 3: Covid Hospital (Nagaland)

GRIHA PROJECTS' FOOTPR

Upto **15%** FAR benefits for GRIHA certified projects

Exemption from environmental clearance for GRIHA projects

5% additional FAR for 4/5 star GRIHA-rated projects

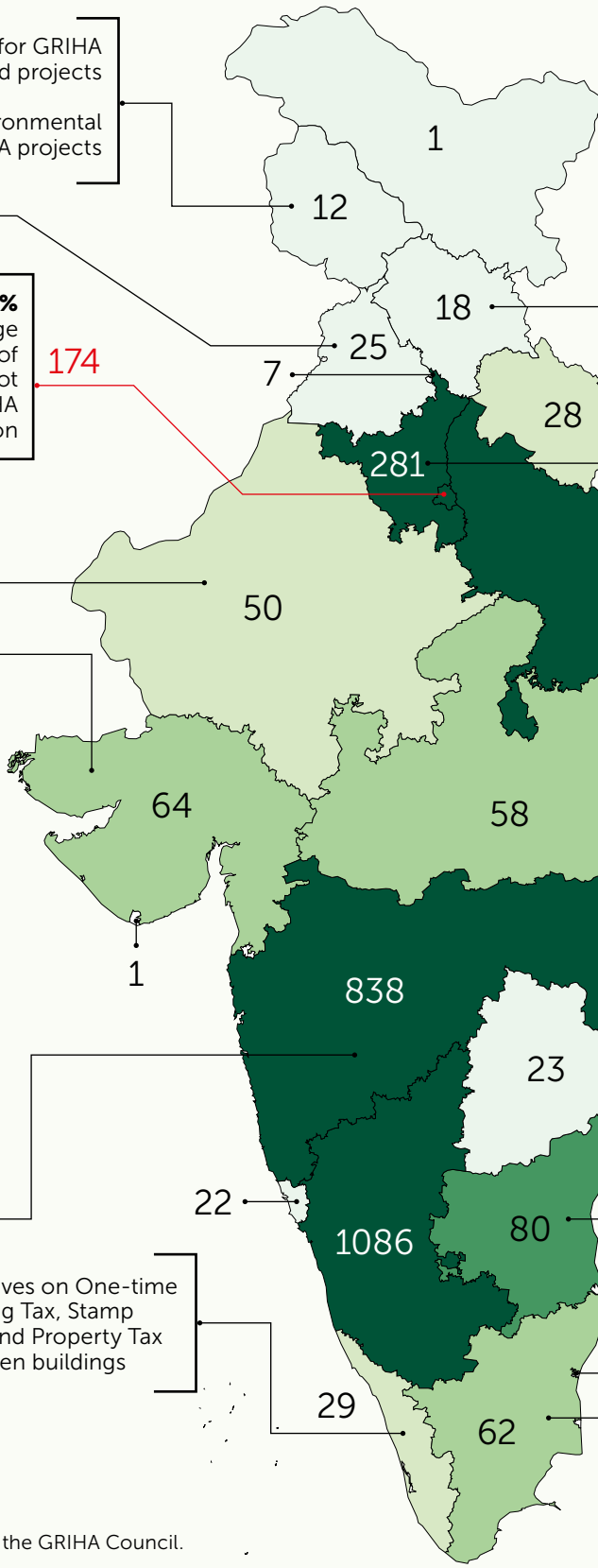
MoHUA gives **1%** to **5%** extra ground coverage and FAR for projects of more than 3,000 m^2 plot size on the basis of GRIHA evaluation

Buildings with GRIHA rating certificate will be eligible for availing additional **7.5%** to **15%** FAR free of charge

- AUDA: **5%** discount on chargeable FAR payable to the approving authority
- Assistance of up to **50%** of consulting charges or INR 2.5 lakh, whichever is less, for industrial buildings of more than 2,000 m^2 built up area which obtain green rating from GRIHA Council
- 50% (upto 10 lakh) reimbursement of GRIHA Certification fee for hotel/resort projects

- **PMC & PCMC**
  - Discount in premium charges (payable to Municipal Corporation, for both GRIHA and SVAGRIHA projects)
  - Up to **10%** discount could be availed on Property Tax for home owners for the GRIHA projects. For SVA GRIHA projects, up to **15%** discount on Property Tax for home owners
- PWD, GoM, mandates GRIHA rating for both new and existing government buildings
- **MAHARASHTRA:** Government of Maharashtra has made it mandatory to achieve a minimum of 3-star rating for construction projects under GRIHA for all buildings belonging to government, semi-government, local bodies and public sector undertakings for propagating sustainable habitat development in the state

Incentives on One-time Building Tax, Stamp Duty and Property Tax for green buildings



*The numbers indicated in the map represent registered projects for rating with the GRIHA Council.

RINT & LINKED INCENTIVES

GRIHA registered projects = 3300+
GRIHA footprint = 67 MSM (APP)

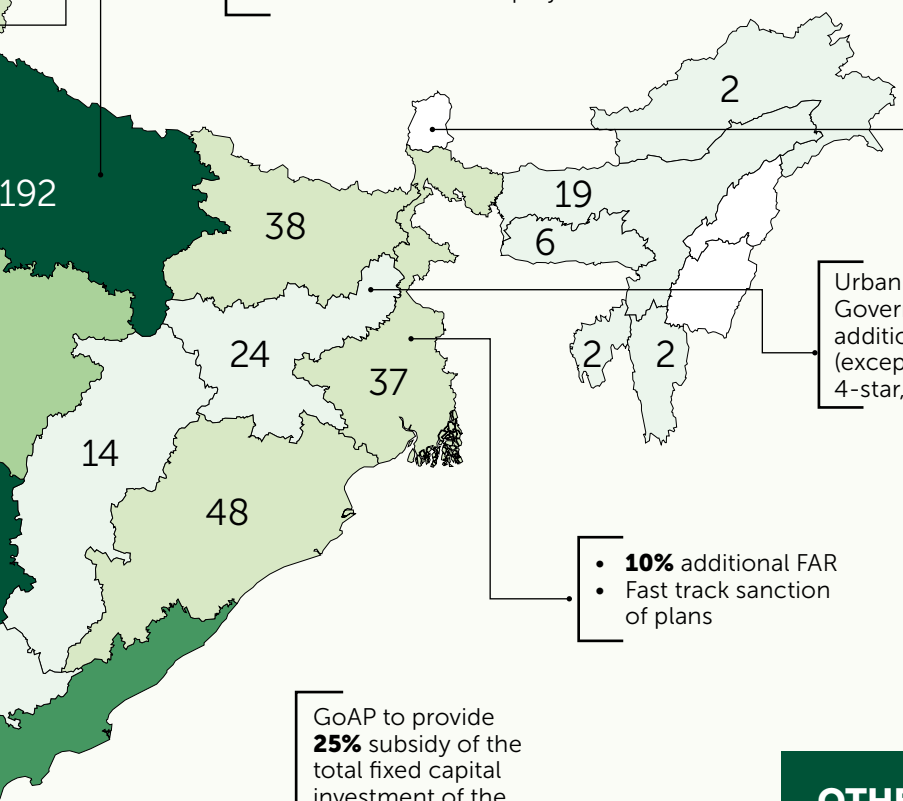
0 — 100+

10% additional FAR for GRIHA 4/5-rated projects

- Up to **15%** extra FAR for all building uses (except plotted residence) for all GRIHA variants
- All PSUs and government buildings to be constructed as per GRIHA norms

- **NOIDA & G.NOIDA: 5%** additional FAR for projects of plot area greater than 5,000 m^2
- **UTTAR PRADESH: 5%** additional FAR for 4/5 star GRIHA-rated projects

Mandatory for all government and semi-government projects to go for a minimum 3-star GRIHA rating



Urban Development and Housing Department, Government of **JHARKHAND: 3%, 5%,** and **7%** additional FAR shall be awarded to all building uses (except plotted residential) for achieving a 3-star, 4-star, or 5-star GRIHA rating, respectively

- **10%** additional FAR
- Fast track sanction of plans

www.grihaindia.org/griha-incentive

GoAP to provide **25%** subsidy of the total fixed capital investment of the project

25% subsidy for environmental protection infra for industrial projects

OTHERS

1. Fast Track Environmental Clearance by the MoEFCC for GRIHA pre-certified projects
2. GRIHA and GRIHA AH certified (4 and 5 star projects) would be provided financial incentives under SUNREF India programme
3. Ministry of Urban Development (MoUD), GoI has announced free of cost 1% to 5% extra ground coverage and FAR for GRIHA projects: MoUD has issued a notification for local authorities to incentivize and provide 1% to 5% extra ground coverage and FAR for projects of more than 3,000 m^2 plot size on the basis of GRIHA evaluation

Decentralized Wastewater Treatment Solution for Commercial and Housing Complex through TADOX® Technology

Dr Nupur Bahadur is Senior Fellow and Area Convenor, TADOX® – Technology Centre for Water Reuse and Heads NMCG-TERI Centre of Excellence on Water Reuse in Water Resources Division, TERI. She is the Inventor of TADOX® technology and holds deep passion for teaching, research, technology development and demonstration, policy intervention, consultancy, capacity building and technopreneur roles. She can be reached at nupur.bahadur@teri.res.in

Dr Nimisha Singh works in the TADOX® – Technology Centre for Water Reuse area at TERI as Research Associate. She has expertise in developing process schemes around separation technologies with focus on treatment or recovery of compounds for circular economy. She manages the platform of TADOX® technology for implementation and provides supports to industry partners for scientific and technological assessment. She can be reached at nimisha.singh@teri.res.in

High water demand is accompanied by high wastewater discharge. The wastewater when discharged untreated or with inadequate treatment has a cumulative effect in deteriorating the quality of receiving water. In the present article, **Dr Nupur Bahadur** and **Dr Nimisha Singh** discuss TADOX® technology and its potential for suitably treating wastewater. To facilitate understanding, the discussion is supplemented by a case study. The TADOX® technology possesses features that makes it far superior to the existing conventional and costlier wastewater treatment technologies.

Background

Post-pandemic era in which the world is juggling to balance work and home together in a totally different and new way as some companies offer work-from-home options for its employees but some not, the real estate market has observed a constant upswing. The development of real estate includes building and developing residential and commercial entities for government as well as for public in large. In the Indian context, this sector is expected to reach US$ 1 trillion in market size by 2030 and will contribute towards 13% country's GDP by 2025 (Real Estate Industry Project 2022). This sector not only has crucial role in increasing country's GDP but also plays an important part in realizing national missions such as Swachh Bharat Mission—one step towards cleanliness. Such missions were realized by the Government of India in order to address the rapid urbanization which confers increased water demand and subsequent release of mammoth amount of wastewater. The wastewater when discharged untreated or with inadequate treatment has a cumulative effect in deteriorating the quality of receiving water. The 2011 Census reports that only 32.7% of the total urban household is connected to piped sewer system (Singh 2018). Thus, in 2016 Ministry of Urban Development, Government of India issued Model Building Bye-Laws (MBBL) which assert for on-site sewerage treatment and wastewater reuse in large building projects (Model Building Bye-Laws 2016).

In the Indian context, norms framed by regulatory bodies such as Central Pollution Control Board (CPCB) are set in-place. Despite this, the discharge of untreated/ inadequately treated effluents from high-rise housing societies, group housing societies, commercial buildings into nearby open spaces and drains is a common phenomenon. The receiving body in-turn gets severely impacted with poor aesthetics, odour issues, having sewage with high biochemical oxygen demand (BOD) and chemical oxygen demand (COD), which ultimately leads to low dissolved oxygen (DO) levels, indicating very poor water quality, thus poses a severe environmental hazard.

Further, the major infrastructure development industry that lies in special economic zone (SEZ) which are into developing, processing, and non-processing areas such as office spaces, service apartments, residential and commercial complexes, food courts, health centres, etc. are also found to be violating the treatment, safe disposal, and discharge norms. Simply because the conventional effluent treatment plant (ETP)/sewage treatment plant (STP) working on biological treatment phenomenon, is not able to bear the shock load, especially when industries are having different functioning areas (processing and non-processing) and mixed quality of effluent is generated. Also, conventional biological treatment systems have large land requirement, takes on average 12–24 hours in treatment, leading to high demand of resource and energy-intensive process. Ultimately the treated water quality is sufficient only for dilution and horticulture use. For high end applications like the water for cooling tower, fire extinguishing, storage, flushing, etc. there is high dependence on groundwater and other sources such as the tankers from the municipal corporations, etc. Thus, the problem is prevalent for commercial and housing complexes spanning across India and there is requirement of strategic approach to deal and provide such a solution that could also go long way in accomplishing policy tool for the country in similar sectors.

Recent case

On similar ground, a case was recently found near The Energy and Resources Institute (TERI) Gurugram Campus. A problem of water logging was identified within the TERI premises. So, during reconnaissance survey of the area, it was noted that the untreated sewage from the nearby SEZ is being discharged into the storm water drainage which gets accumulated on the low-lying land near the SEZ area (refer Figure 1). Owing to heavy rain and continuous discharge of untreated sewage from the SEZ area the water overflowed from the area where it usually accumulates and flooded the nearby areas (Figure 2: 4a, 4b, 5, and 6). The untreated sewage being discharged in the storm water drains was also getting accumulated inside the TERI Campus (Figure 2: 6a and 6b). The elevation difference from point 1 to point 5 inside TERI Campus is almost 5 metres.

Figure 1: Google Earth Image of survey area showing TERI Campus (yellow), Farmhouses (pink), SEZ (green), water-clogged area (red) and water flow from SEZ towards TERI and farmhouses (Blue)

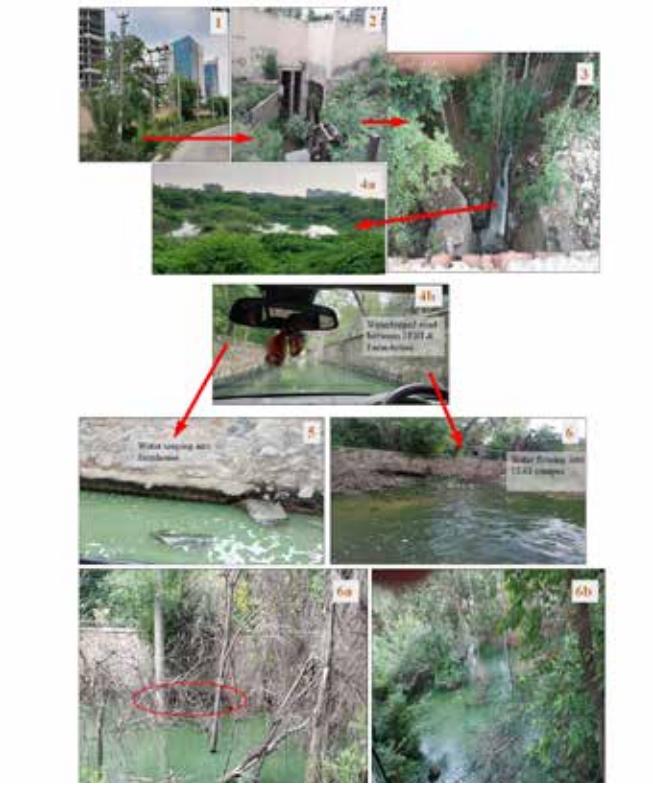


Figure 2: Photographs of overflow and water-logged area
Source: Google Earth Image

Thus, for a point source pollution abatement of such kind a decentralized wastewater treatment technology needs to be explored.

TADOX® technology

TERI's Advanced Oxidation Technology (TADOX®) involves majorly two stages of treatment. The stage 1 process involves novel primary treatment approaches with newer formulations of coagulants and flocculants. The aim of primary treatment is reduction of Toxic Shock Syndrome (TSS) by 90%, such that suspended impurities do not interfere with the UV light, to be imparted at secondary treatment stage. The secondary stage treatment, that is, stage II, involves UV-photocatalysis as an advanced oxidation process (AOP), where TiO_2 nanomaterials

(NMs) are mixed with the effluent, provided contact time and aeration and passed into a photocatalytic reactor (PCR) having suitable UV light radiation source.

TiO_2 NMs being semiconducting in nature get self-activated in the presence of UV light and *in-situ* generates hydroxyl radicals, which acts as oxidizing agents and leads to oxidative degradation and mineralization of targeted pollutants. The UV-TiO_2 photocatalytic action leads to generation of hydroxyl radicals for oxidative degradation of pollutants.

Used nanomaterials are recovered using suitable filtration systems, regenerated and reused for treatment up to a large number of cycles and even months in some cases, showing same efficiency. The treated water is colourless, odourless and adequately treated, and goes as feed to tertiary treatment, which may require RO, followed by use of evaporators, depending upon point of use application.

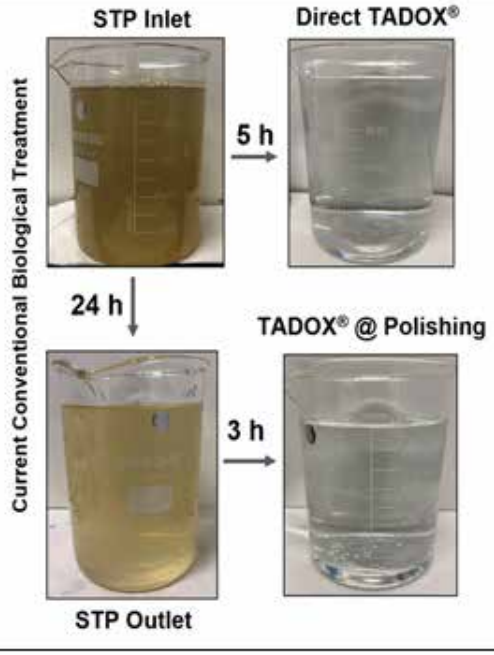
The key features of TADOX® technology that makes it far superior to the existing conventional and costlier wastewater treatment technologies are:

- Operating conditions: works at ambient temperature and pressure
- No secondary pollution: involves complete degradation/ mineralization of pollutants to innocuous carbon dioxide and water or convert them to less harmful/non-toxic compounds
- Target compounds: operative at traces of a wide variety of complex molecules
- Clean and green technology: use of nanomaterials ensures less use of chemicals
- Shorter treatment time: helps in enhancing capacities and augment capacities of existing ETP/STPs
- Modular system: retrofitted in existing treatment systems
- No stream segregation: technology can treat mixed effluents containing sewage
- Energy and resource efficient: mixed sewage can be treated directly without any pre-biological treatment
- Reduced cost of treatment: 25–30% reduction in operational expenditure (OPEX) and capital expenditure (CAPEX)

Having such features, TADOX® technology has been used to generate 25+ case studies for different industrial wastewater in different geographical areas. Some of these work has been discussed here (Bahadur and Bhargava 2022).

STP INLET	
pH	7.9
Colour, (Pt- Co) (CU)	185
COD, mg/L	650
BOD, mg/L	261
TSS, mg/L	380
Total N, mg/L	32.0
Total P, mg/L	81.2
E. coli, MPN/100 ml	1.02×10^5
Total Coliform bacteria, MPN/100 ml	6.12×10^6
Total count, CFU/100 ml	5.24×10^5

STP OUTLET	
pH	8.2
Colour, (Pt- Co) (CU)	125
COD, mg/L	400
BOD, mg/L	78
TSS, mg/L	110
Total N, mg/L	30
Total P, mg/L	13
E. coli, MPN/100 ml	1.21×10^4
Total Coliform bacteria, MPN/100 ml	1.13×10^5
Total count, CFU/100 ml	1.84×10^4



DIRECT END-TO-END TADOX®	
pH	8.0
Colour, (Pt- Co) (CU)	8
COD, mg/L	64
BOD, mg/L	7
TSS, mg/L	<5
Total N, mg/L	1.9
Total P, mg/L	<1
E. coli, MPN/100 ml	16
Total Coliform bacteria, MPN/100 ml	1.16×10^2
Total count, CFU/100 ml	28

TADOX® AT POLISHING STAGE	
pH	8.1
Colour, (Pt- Co) (CU)	5
COD, mg/L	46
BOD, mg/L	<3
TSS, mg/L	<5
Total N, mg/L	1.7
Total P, mg/L	<1
E. coli, MPN/100 ml	<8
Total Coliform bacteria, MPN/100 ml	3.13×10^2
Total count, CFU/100 ml	11

Figure 3: Municipal sewage treatment by TADOX® technology

TADOX® as decentralized wastewater treatment plant for sewage and municipal wastewater

The case study presented here includes the treatment of Delhi Jal Board's municipal wastewater to enhance water reuse. The treatment was done with two approaches: 1. directly treating the raw effluent entering the STP called **Direct TADOX** and 2. polishing of treated wastewater from STP called **TADOX @ polishing**.

The quality of water after TADOX® treatment has improved substantially with BOD and COD reduction of 97% and 90%, respectively as compared to the conventional treatment where reduction for BOD is 70% and COD is 38%. TADOX® as polishing step has reduced BOD to <3 mg/L which meets the discharge norms by CPCB. The improved water quality also meets the reuse norms for high end application. Total time of treatment is reduced to 4–5 hours as compared to average 12–24 hours. There is possibility of complete bypass of any kind of biological treatment leading to much more resource and energy efficient treatment with treated water quality available for high-end reuse.

Key takeaways

The point source pollution is quite big and prevalent across India. So, rather than defaming and imposing penalties on the infrastructure developers, an approach to involve the stakeholders' discussions that includes builder, government regulators and technology developers may address this challenge. The TADOX® technology not only has the potential to address the aforementioned challenges and produce high quality of treated water that meets the National Green Tribunal (NGT) and CPCB surface discharge norms but also is highly suitable for reuse in high end applications such as the water for cooling tower, fire-extinguishing, storage, dust suppression, floor cleaning, toilet flushing, etc. along with horticulture and landscaping.

This approach also has potential to treat wastewater at the source because of minimum land requirement, can be retrofitted with other treatment processes, augment the overall treatment capacity which would ultimately reduce the dependency on freshwater usage for non-potable application in large buildings and complexes. Thus, such a technological innovation has direct societal and environmental impact together serving the missions of national interest like the Swatch Bharat and Smart Cities Mission, etc.

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Gratitude Eco-Villa

Roma and Prabodh (owner of the project)

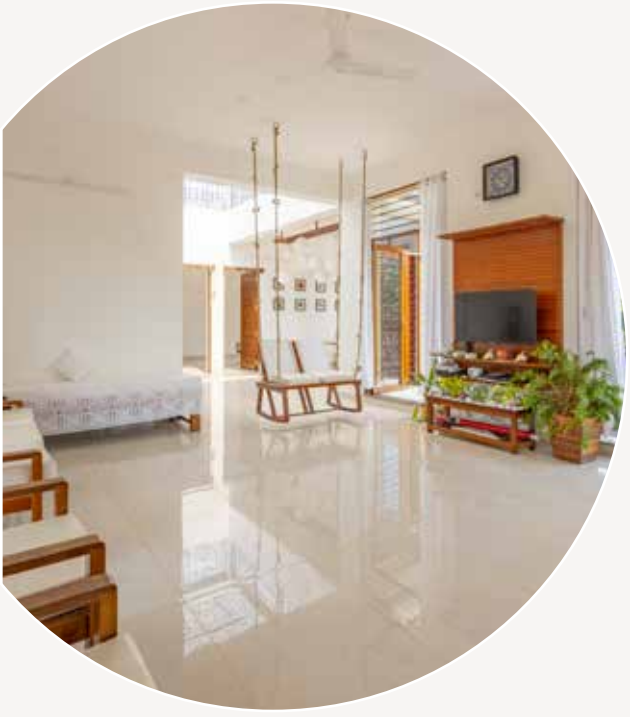
Roma and I envisaged an aesthetically functional city home that would truly embody our aspirations to be 'one with nature'. We are happy that our home—Gratitude Eco-Villa—has been awarded for its exemplary performance in Sustainable Building Materials and Technologies by GRIHA Council, India. It's a 5-star SVGRIHA rated project.

Our primary need was a living space that integrates nature and its elements to the optimum level. We wanted to build a home, not just ecologically viable in design and function but also one that gives back to the Mother Earth. Lofty and ambitious in our goal, we are immensely grateful to see its translation into Gratitude Eco-Villa.

It is the Auroma Architecture, an established architecture firm in Puducherry that gave shape to our dreams. Their Principal Architect—Trupti Doshi—is recognized amongst India's top 10 sustainable architects.

Built over an area of 306 m^2 with a built up space of 474 m^2, Gratitude Eco-Villa has become a global game changer in sustainable architecture. The Villa reduces CO_2

emissions by up to 40% which is equivalent to saving 102 tonnes of CO_2 emissions. This mitigated CO_2 would have otherwise required 600 mature trees, occupying over 40 acres of forest land over a period of one entire year for its absorption. For actual realization of this reduced embodied carbon, Gratitude Eco-Villa has received India's first 'House of Tomorrow' Award from ACC Holcim and stands as a proven foundation of how build urban cities could be developed with the ability to balance human needs, at the same time, restoring the natural world.



Auroma Architecture achieved this through a combination of design strategies, resource efficiency, green materials, and technology. The facade, designed-like the unfolding pattern of an origami fan, minimizes the direct heat and doubles as a wind-catcher that maximizes the wind flow all through the elevation. It is entirely daylit without the need of any artificial lighting during the day. The villa is very comfortable to live in. Resource efficiency processes such as rainwater harvesting, solid waste management, wastewater treatment, and solar energy have been integrated into the building thoughtfully and functionally without compromising the ease of living and without increasing the maintenance cost.

Our experience with GRIHA has been both noteworthy and appreciable. The very first touch point experience, the online registration process, was smooth and easy. We could access all relevant information with clarity. After the registration we were provided with a detailed template for self-assessment that helped us understand our eligibility criteria for the specific star category in a go. We were especially impressed with the personalized assistance and guidance we received during the documentation process for SVAGRIHA application.

Ms Prerona and Mr Akashdeep under the able leadership of Mr Sanjay Seth and Ms Shabnam Bassi from the GRIHA team were extremely helpful.

We hope more individual home owners are inspired to collaborate with GRIHA's futuristic green initiatives and take vital steps towards building a sustainable planet.

We have always believed that **"the little things make the BIG things happen"**. And along with it we should create new habits and new ways of thinking. Our little green step, our offering of gratitude towards the Mother Earth, the Gratitude Eco-Villa, along with GRIHA's initiatives, hopes to inspire all future home builders to make a significant difference!

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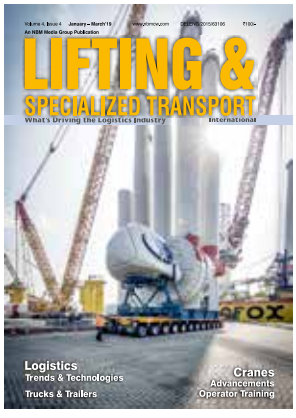

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Lignin: A Molecule to Unlock a Greener Lifestyle

Agricultural residue is primarily composed of three primary chemical components, namely cellulose, hemicellulose, and lignin. Until a few years, the residue was considered waste and often burnt. On the contrary, this waste has the potential for being raw material for many industrial applications. **Ruchi Agrawal** and **Astitva Rai** give an in-depth discussion on utilization of these components for producing products of significance.

Dr Ruchi Agrawal is Associate Fellow at TERI, Gurugram, India, and works in the area of decarbonization and sustainable bioeconomy development via green bioproducts, biopolymers, nanomaterials, and biofuels. She has been a recipient of 'Outstanding Associate Editor-2021 Award from Frontiers in Nanotechnology, Wiley Award-2017 for Top Cited Paper, Young Scientist Uttarakhand Governor Award-2016', DST-INSPIRE Fellowship (2010–12). She has been a visiting fellow at the Department of Chemical and Biomolecular Engineering, University of Tennessee, USA in 2017 and presently, she is actively working with her team which includes 3 Ph.D. students towards Sustainable Products Development vis-a-vis Waste Management via Circular Economy Approach for Environmental and Agricultural Sustainability with the financial support from SERB, DST, Government of India. Her accomplishments has been well demonstrated in >50 peer-reviewed research articles and 7 patents. She can approached via her e-mail ID: ruchi.agrawal@teri.res.in

Astitva Rai is presently pursuing his Bachelor's degree in Biotechnology from NSUT, Delhi. He is keenly drawn towards initiatives directly impacting the environment. His current stint at TERI Gram is solely focused on bio-based materials and biofuels. With this article the author wishes to play his part in the movement against climate apathy.
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Introduction

Consciousness towards perishing resources once available to us readily is on the rise. We now see more people every day prepared to alter their lifestyle as a whole so as to generate minimum waste and leave the least of carbon footprints behind. We see a massive shift towards vegetarianism, veganism, e-vehicles, sustainable architecture, eco-friendly apparel, plant-based cosmetics and all things sustainable.

This surge in demand can be addressed without burdening the first-generation biomasses and crops. Moreover, certain components of agrarian waste—which have predominantly found a use in industrial processes—can be absorbed into our daily lives in numerous other ways.

India ranks as the second largest contributor of the agriculture sector, behind only China. Cereal production in India was 69.59 million tonnes (MT) and wheat production was marked at 11 MT in the year 1961.

Fifty-seven years later in 2018, the production of cereals was a staggering figure of 260.85 MT (73.32% increase) and 99.70 MT for wheat (88.96% increase) (Ritchie, Rosado, and Max Roser 2020).

If a nation were to observe a substantial increase of production in its agriculture sector, the waste generated from these activities would imperatively see a proportionate rise. Thereon would develop the need of responsibly and sustainably processing, using or otherwise disposing it. As of 2020, the Indian Council of Agricultural Research estimates an annual generation of 350 MT of agricultural waste ((ICAR 2020). It would take roughly 23 million blue whales to weigh the same.

The winter (Kharif) harvest brings with itself a sizeable part of waste. Those from rice and wheat, namely the straw stubble, have been an area of key attention for many of us. Starting from the farmers who are in a dire need of techniques to process the residue of a harvest, to the environmentalists and biotechnologists working tirelessly for developing sustainable agrarian practices, to the policymakers for mandating these practices and finally to the citizens whose lungs bear the brunt of a gray haze which engulfs major parts of north India, starting from October of every year (Rai 2021).

To term agricultural biomasses 'waste' is a distasteful remark given how resourceful they have been to humankind and continue to be a matter of great deliberation for industrial competitiveness.

Owing to its three primary chemical components, namely cellulose, hemicellulose, and lignin, said agricultural residue has come to be known as lignocellulosic biomass. While cellulose has found great utility by portraying competitive advantages in energy, food, pharmaceutical, apparel and various other industries, lignin, the second-most abundant biopolymer, is yet to gain significant industrial traction.

Out of the estimated 300 billion tonnes (BT) of resources from which lignin is produced annually, only 2% is available to use and rest is majorly burnt as fuels for pulping industry given its inherent property of being an unstable polymer (Ryłko-Polak, Komala, Białowiec 2022). The usual extraction techniques, ergo, belly-flop.

Gray skies and smog cover shield parts of north India from sunlight for days

Image credit: Astitva Rai, 1 November 2020

Residue from pulp industries

Image credit: Everett R. Davis/Shutterstock.com

I understand, as a fellow Indian, the compulsion to disparage those who aren't the first but do not lambast my loved lignin. Patience is a virtuous trait, validated by about 200 years of dedicated insight into it.

Research pertaining to its potentiality as a resourceful plant derivative dates back to the early 19th century, where in the year 1838 its existence was first acknowledged by French chemist, Anselme Payen. Almost a century later and across the years of World War II, one of the first products from a lignin-rich substrate was obtained (Joseph and Islam 1999).

It was during these years, with the advent of sophisticated instrumentation, that lignin was being diligently characterized, identified and used for traits that today are pertinent to environment consciousness. Industrial plants catering to ethanol's surging demands during the 1940s were erected in Germany, Canada, and Sweden that made use of lignin-rich substrates. From the same substrate—which was a residue of pulp and paper industry—numerous other goods were manufactured which included vanillin, adhesives, laminating papers, food, and fodder yeast.

Today lignin is conclusively known to exhibit remarkable UV-shielding ability (Sadeghifar and Ragauskas 2020), mechanical strength (RSC Adv. 2019), antioxidant activity (Mahmood, Yameen, Jahangeer, *et al.* 2018), energy density (Cao, Dierks, Clough, *et al.* 2018) alongside its inherent ability of being susceptible to biodegradation. Such traits have prompted us towards an endless mine of sustainable and competitive industrial applications (Norgren and Edlund 2014). For instance, its incorporation into PVA films for food packaging makes use of its anti-UV ability and mechanical strength (Zhang, Haque, and Naebe 2021). Not only did the film's mechanical strength improve by the addition of lignin, the same research concluded that it made the film more biodegradable (Korbag and Saleh 2016).

About 40% of the global carbon emissions are arising out of the construction industry, owing to the processes it implements and its power demands. Adopting cleaner and more sustainable methods of housing an ever-growing population is a concern.

Mechanical strength of lignin is of great importance to those vouching for greener construction practices. Lignin in cement mortar, paints, coatings, polyurethane foams and resins proved to be greatly advantageous (Jędrzejczak, Collins, Jesionowski, *et al.* 2021).

Bioasphalt, first talked about in 1979 because of availability and pricing of conventional asphalt, emerged as a potent replacement of its petroleum-intensive counterpart. It contained lignin as a filler and till date; given its structural similarities with bitumen; lignin is being considered as the sole, most pragmatic solution for building roads and pavements as crude oil depletes and bitumen prices soar (Jędrzejczak, Collins, Jesionowski, *et al.* 2021).

As Arjen Robben's left-footed strikes and Robin van Persie's Flying Dutchman hammered Spain's golden generation out of the 2014 World Cup, the Dutch had another trick up their sleeves.

Considerable concentrations of lignin can often be found in crop shavings, husks, and stubble

Image credit: Kitraveler/Shutterstock.com

A sample of bioasphalt prepared at University of Utrecht

In 2015, a 70-metre section of bioasphalt was built under the Bioasphalt Zeeland project (at Sas van Gent in the Dutch province of Zeeland), and it became a part of a heavy traffic road. The Wageningen University and Research Campus, Netherlands, in 2017 saw a bicycle lane made entirely of bioasphalt and since 26 November 2020, the Dutch city Vlissingen has had pavement sections made entirely of bioasphalt with some of them even containing recycled asphalt (Jędrzejczak, Collins, Jesionowski, *et al.* 2021).

November of 2021 saw the bioasphalt stretch being constructed in Groningen complete six-months of regular vehicular usage by civilians. The stakeholders of this project—Avantium, Roelofs Groep, Utrecht University, Wageningen Food and Biobased Research, Asfalt Kennis Centrum, H4A Infratechniek and Stichting Biobased Delta—are massively impressed with the results (Vels 2021).

By dint of chemical structure similarities again, when mixed with phenol-formaldehyde resins (widely used in components of roofs, kitchen cabinets, furniture, wood floor, etc.), it imparted good thermal stability, excellent mechanical properties, flexibility, and resistance to fire, water and chemicals to the resin (Nejad 2017).

Lignin found a place for itself even in commercial skincare against UV rays. Research concludes that addition of lignin to sunscreens enhances UV absorbance. The sunscreen effect of sun protection factor (SPF) 15 attained that of SPF 30 and SPF 15 even outperformed SPF 50 when mixed with small concentrations of lignin. It was also found that the sunscreen performance improved with UV-radiation time (Qian, Qiub, and Zhu 2015).

Another aspect that aids our quest of sustainability comes out of an innovation. In recent years, efforts to condense lignin to nano-sized deposits have shown remarkable results. The characteristic properties of lignin seem to be heightened when it is broken down to a nano-scale, that is, when the individual size of lignin particles ranges from 1 to 100 nanometres. It is not a mystery, though, as to how because nanoparticles are widely known to possess improved properties over their parent material (Yearla and Padmasree 2016).

Therefore, it is good news for lignin enthusiasts (shout-out to the real Anselme Payen fans). An active pursuit of nano-lignin formation and incorporation in

A 250-metre-long lignin-based test section being constructed in the north of the Netherlands, N987 between Siddeburen and Wagenborgen, 2020

industrial processes is underway globally, drawing attention to the variety of biomass we produce and processing it to nano-lignin which further broadens lignin's applicability in the economy (Hussin, Appaturi, Poh, *et al.* 2022).

Given a wide array of applications and possibilities, it is becoming increasingly possible for lignin to nudge its way into our daily lives which is a stride towards a cleaner atmosphere, greener fields, and healthier humans.

We no longer stand at the cusp of a climate crisis. It has taken far more formidable shapes and forms for us to call it the cusp.

Exponentially growing energy demands have now pushed us to the brink of a power crisis where we see a decline of domestic coal production and coal stocks at an alarming rate (Karthikeyan 2022). Further, since 1970 the global average temperature has been soaring at a rate of 1.7°C per century, compared to a long-term decline over the past 7000 years at a baseline rate of 0.01°C per century (Allen, Dube, Solecki, *et al.* 2018).

Plant-based components should increasingly be pushed to the forefront. Not only are they a direct route for involving sustainable practices in our lifestyle, the conversion of waste into value-added products will help to increase industrial profitability, reduce carbon emissions and consequently contribute to the development of the circular bioeconomy.

TERI Gram, Gwal Pahari, Gurugram, one of the leading research bodies of TERI at forefront of sustainable development in the country

Image credit: Astitva Rai, July 2022

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CoLEAD

Anmol Mathur, Co-founder and Environmental Designer

Collaboration for Linking Environmental and Architectural Design (CoLEAD) is an integrated sustainable design consultancy that takes climate change seriously.

We bridge the gap between design and engineering to help building owners, architects, and engineers create greener, climate-responsive and more comfortable buildings that inspire people and connect the traditional wisdom to the future technology for a sustainably built environment.

Our 'potential to performance' design approach is deeply embedded in research, emerging from building physics, aesthetics, and human psychology to deliver the highest level of comfort, energy efficiency, and cost benefits.

Starting with the building's morphology and façade we unlock the Passive 'Potential' via an integrated design process, reducing dependence on mechanical systems yet achieving 360-degree comfort—visual, thermal, air quality, and acoustics. The true performance is achieved by optimizing building services, where we work on the right sizing of HVAC systems, alternative low-energy comfort systems and correct sequence of operation and controls.

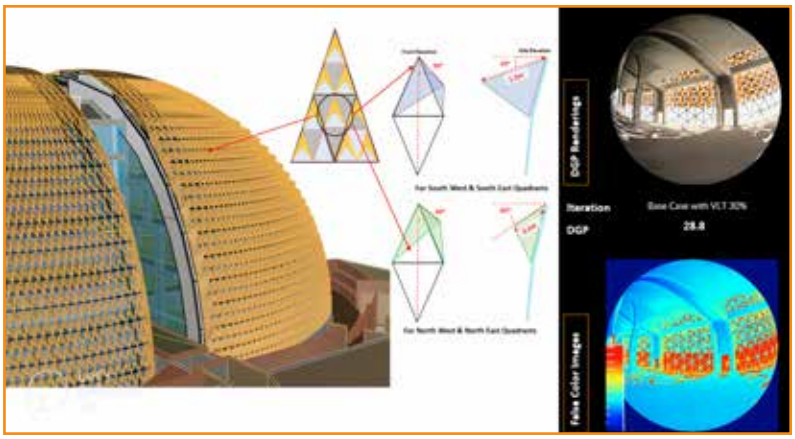
Our journey started when the pandemic had struck the world in 2020, but the seeds of this collaboration were sown and nurtured while the founders were pursuing their MTech in Building Energy Performance at CEPT University. We followed the AEC industry closely to find that currently sustainability is cornered on certifications but there is a significant potential for integrated design process to lead the industry.

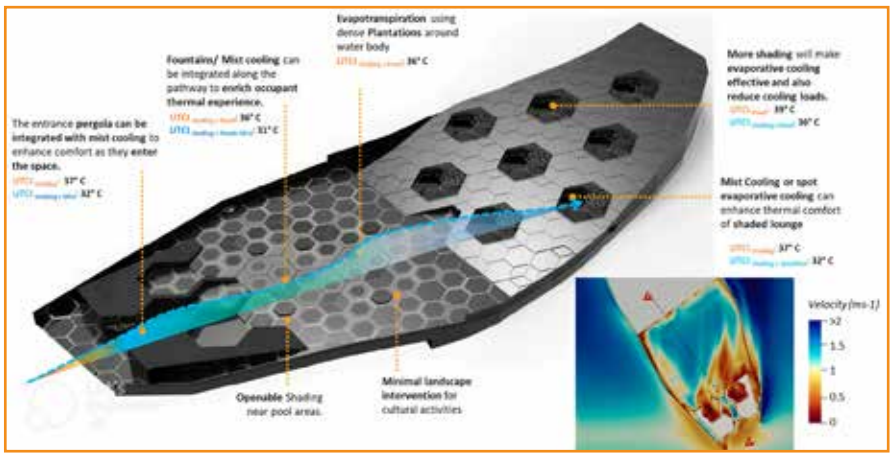
Inspired from leading international practices, we developed additional skills, pushing the boundaries of traditional green building consultancy.

The start was both exciting and anxious. Two years have gone by, and our desire to make an impact along with support from our mentors has helped us grow.

Till today we have contributed to save 7.2 million units of energy on almost 16 lack sq. ft of built-up area combined from different projects through various interventions such as:

- Façade design: We took the challenge to develop an iconic façade for the library building at Nalanda University, in collaboration with Vastu Shilpa Sangath. Shading angles through solar geometry, computational design tools, and daylight simulations were used to arrive at an interesting geometry that not only provides optimal lighting and glare-free views, but is also modular, and blends well with the diagrid structure.
- Design for outdoor thermal comfort: For the Peak, which is an award-winning resort design, developed by Studio Symbiosis, we used CFD analysis to optimize outdoor thermal comfort, placing waterbodies





and mist cooling through a wind tunnel created at the entry of the complex.

- Urban and building design for affordable housing: In Tamil Nadu we are facilitating to improve urban design of housing complex by performing outdoor microclimate assessments and increasing the access to ventilation and light to households with just the right block placement and orientation. Along with these cost-effective strategies like shading and window designs are developed to improve thermal comfort with natural ventilation.
- HVAC downsizing: In all our projects we work with MEP teams, using simulations to right size systems by eliminating redundancy and optimizing part load performance and achieving higher COP.

- Low-energy comfort systems: Working with HMX, we used simulations to assess potential of indirect evaporative cooling in commercial floor space in Indian and US climates. For industrial projects like AERO, Rohtak we designed simple fan-assisted stack ventilation to remove the internal heat gains from the shop floor. At PressureJet, Ahmedabad we optimized electrical lighting layouts and fixture selection for reduced capital and operational cost and glare fee spaces.
- Expanding from buildings to cities we are collaborating with CEPT on path-breaking work in the domain of urban energy modelling.
- Energy management: The existing building stock needs an equal attention to become efficient. Our venture is supported by Delhi Government's IP University to incubate our solution to automate auditing and calibration of building models for better energy management and retrofit recommendations.

As we grow our practice will always be inquisitive, following deep technical analysis and being creative and fearless to explore.

We are the new-age Consultants with a performance-driven design approach and are committed to creating a sustainable built environment. If you are someone who envisions making the Built environment more sustainable and liveable, join hands with us and make us a part of your journey!

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Role of Distribution Transformers in Creating a Sustainable World

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The economic growth of a nation largely relies on its power supply. India is highly likely to make noticeable growth in building infrastructure in the forthcoming years. To realize this, distribution transformers are to perform a responsible part in ensuring transfer of reliable power. The article by **Manas Kundu** and **Amol Kalsekar** talks about the utilizable technologies of distribution transformers, also taking into account the long-term sustainability.

Increasing reach and availability of reliable electrical power has been the central driver of India's growth story. From rapid urbanization to increasing mechanization—functioning of every economic activity is dependent on reliable electrical power. India is expected to take a leap of growth in building infrastructure in the years to come. Distribution transformers are the most important nodes in ensuring transfer of reliable power over the long distances and to the end users. While space, upfront costs, performance, reliability are the key concerns for transformer users; compliance to regulation / standards, safe operation, end-of-life disposal and long-service life are important from sustainability point of view. The technology of distribution transformers will play a key role in ensuring long-term sustainability.

Role of transformers in sustainability

Transformers are everywhere—as an essential link in the modern electrical grid, from the increase in voltage for efficient transfer of power across long range of distances to stepping it down at 120–240 V at the consumer end. As a result, transformers play a critical role in minimizing electrical losses, and have a significant impact on the environment concerning the grid.

The role of transformers in impacting energy efficiency and sustainability is diverse and very comprehensive. Global estimates indicate that transformers can be responsible for over 5% of the energy losses. In India, the energy losses due to transformers are estimated to be much higher. With proper choice of technology, compliance to standards, the energy losses in transformers can be reduced by up to 60%, while improving their life, thus reducing the impact on environment.

Sustainability essentials for distribution transformers

Improving the sustainability and efficiency of transformers necessitates use of technologies that enable durability and lead to lesser failures, lower maintenance while increasing the service life. In India, two main types of distribution transformers technologies are popular—liquid oil-immersed and dry-type transformers. Traditionally, liquid-filled distribution transformers have dominated the Indian market. The dry-type transformers are gaining traction as an advanced and evolved technology to address safety issue in indoor environment of buildings. However, the environment and sustainability concerns of these technologies must be understood well before their widespread adoption. The critical sustainability concerns include compliance to emerging standards, usage and disposal of different types of transformers in view of long-term environment sustainability in Indian and global markets.

The future evolution of distribution transformers has two dimensions—reliability and environment sustainability over long range of service life. Given the 25–30 years of expected life of distribution transformers, upfront cost of purchase is relatively smaller component when compared to the overall life-cycle costs. Costs of safe disposal and minimizing the impact on environment are key concerns, especially in the developed markets, with an increasing importance in developing markets.

Reducing energy losses

Transformers are the most efficient machines invented by mankind. However, when comparing the relative efficiency of different types of transformers dry-type transformers incur higher loss (that is, provide lower efficiency) as against mineral oil and ester oil-type transformers. This means over the usage period of several years, the liquid-filled transformers offer a significantly higher efficiency as compared to dry-type transformers.

Safety and space considerations

The conventional mineral oil-immersed transformers have been considered as unsafe due to use of fire-prone and non-biodegradable mineral-insulating oil. Dry-type transformers, natural and synthetic ester-oil immersed type transformer units are non-hazardous and environment friendly, and thus are gaining gradual acceptance in India.

In India, for maximizing available space on ground, the developers and builders, architects, and MEP consultants, prefer to create a space for the installation of distribution transformers in the basement. The new local regulations now permit use of sealed transformers filled with insulating liquids (ester oil) for use in basement.

Eco-friendly materials

Today, a majority of fluid-filled transformers use insulating oils. Such oils have a tendency of leakage or catching fire in case of transformer failure. Considering this risk, transformers are typically shielded with mesh and concrete. But with recent introduction of biodegradable ester oil, the risks of fire are significantly lower. Transformers using ester oil carry no risk to environment in the event of a spillage and reduce the need for accompanying guarding infrastructure.

From use of non-biodegradable resin materials to challenges in recycling of material on end-of-life, dry-type transformers are a hazard to the environment. The problem of end-of-life disposal upon completion of its useful life is particularly grave when one considers the high numbers in India. Even as the current installed base of dry-type transformers in India is low, the growth has to be marked as a critical environmental concern given the adverse impact it has in landfill challenges and carbon footprint.

In the European Union, there is growing awareness about sustainable manufacturing, useful life and end-of-life practices. And with Circular Economy Action Plan in place, emphasis is laid on both, energy efficiency and material efficiency.

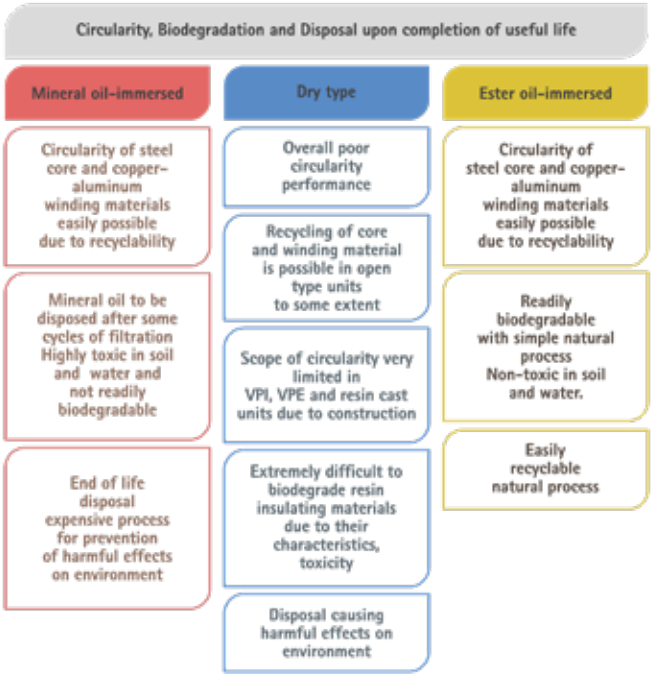

Figure 1: Environment and sustainability impact of various types of transformers

Bio-degradation of ester oil is faster than mineral oil and are therefore classified as an environment-friendly material.

In cast resin transformers, the winding is encased in tough, synthetic epoxy resin, which is extremely difficult to remove. While proper recycling is technically possible, it is often prohibitively expensive and time-consuming process. Since such recycling is a labour-intensive process, in future, India also stands at the risk of becoming a dumping ground for recycling of dry-type transformers from the developed world where labour is in short supply.

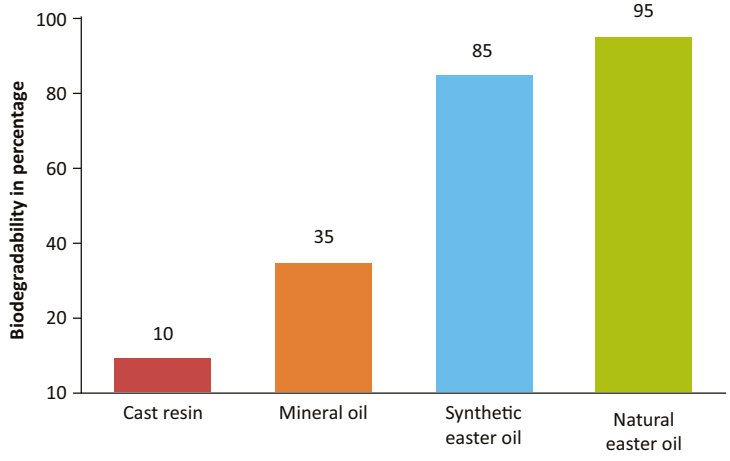

Figure 2: Performance with regard to ability to biodegrade of different types of insulating materials used in the transformers

On the other hand, natural and synthetic ester oils are easily recyclable and are biodegradable. They are non-toxic to soil and water, and contain no hazardous substances, and hence significantly minimizes environmental risk. The leak-containment systems are simple and cost a meagre amount, when compared to the mineral oil-based transformer installations. The treatment for biodegradation is a simple natural process, such as use of microbes that live in soil and groundwater, to clean up environmental spills.

Qualifying transformers for environmental performance

As per a conservative estimate by a distribution utility in United States, ester oil extends lifespan of a distribution transformer by almost 33%, compensating for increased initial capital cost compared to mineral oil transformers. From reducing energy losses, use of eco-friendly materials, reducing risks to safety, improved life and reduced noise levels, choosing ester oil- based transformers is a financially sound decision. When it comes to sustainability, ester oil-filled transformers emerge as a clear and preferred choice.

The environmental performance of transformers may have several other additional benefits in view of total cost of ownership. Usually, the cost of CO_2 emission certificates is included in the calculation of the energy price for electricity losses. The choice of sustainable technology for distribution transformer demonstrates being responsible to environment goals of reducing greenhouse gas emissions and increasing energy security.

A GRIHA Council initiative to spread environmental awareness

An innovative initiative by the GRIHA Council, **'Paryavaran Rakshak'** intends to sensitize and educate the residents of a society on minimizing resource wastage and optimizing natural resource consumption.
The programme focusses on increasing the residents' engagement on sustainability through short games on energy efficiency, water & waste management, and environmental sustainability.


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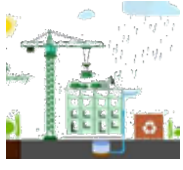

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2020

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2021

Projects won 2 awards in the categories:

1. Site Management (during construction)
2. Construction Workers Health and Safety (during construction)

Wipro—A Pioneer of Sustainability

Wipro Limited is a leading technology services and consulting company focused on building innovative solutions that address clients' most complex digital transformation needs. Wipro has been building environmental sustainability practices in its operations and value chain for some time now... in fact, much before it was considered essential in its sector. Wipro is committed to minimizing climate impacts, helping members calibrate their Net-Zero goals and strategies, and developing best practices for optimal utilization of resources. Wipro is committed to embedding climate equity postures throughout Wipro's sustainability efforts. Over the past two decades, Wipro has consistently reduced its energy, water, waste, and biodiversity impacts, and remains committed to its goal of building a more sustainable, equitable, and just society. Wipro is embarking on a programme of deep decarbonization throughout our entire value chain, aiming for Net-Zero emissions by 2040, with a mid-term target to cut our greenhouse gas (GHG) emissions by 55%, by 2030. The company has also committed to reaching Net-Zero GHG emissions by 2040.

As one of the founding members of Transition to Net Zero, Wipro has contributed in several ways, for example, as a key contributor to the publication guide on transforming climate justice in which the member companies have shared their unique experiences in beginning to incorporate the perspective of climate justice in their businesses. Wipro is committed to integrating climate justice perspectives across its sustainability initiatives.

Wipro recognizes that environmental challenges are closely inter-related with economic imperatives, and resilience is a critical dimension of its responsible corporate citizenship approach. And, therefore, whatever it does should seek to have lasting impacts towards creating a just, fair, humane, and sustainable society.

About a decade ago, Wipro created India's largest environment-education programme, Wipro 'Earthian', that has engaged schools and colleges all over India to design curriculum, programmes, and environmental education internships. The Wipro 'Earthian' Awards recognize outstanding achievement in the field of sustainable education for schools and colleges across India.

Wipro is committed to helping its customers achieve Net-Zero goals, working together and using Wipro's technologies and domain expertise across a range of climate change areas such as GHG assessments, climate-neutrality strategies, sourcing, and supply chain strategies, among others. Wipro's Net-Zero strategy is based on deep decarbonization throughout its value chain. The Net-Zero targets are based on the internationally accepted Science-Based Targets Initiative (SBTi).

Strategic control over Wipro's sustainability programmes is at the enterprise level, with the chairman, board, and group executive committee. The Board, Executive Management, and various functions are responsible for the planning, implementation, audit, promotion, and advocacy of Wipro's Sustainability Charter.

Wipro is also one of the few global companies that is majority-owned by a trust with 66% equity holding transferred irrevocably to Azim Premji Foundation. Wipro is also a member of DJSI (World), for 12 years in a row, the only company from India with such an unbroken track record.

Wipro Limited is a leading global IT, advisory, and BPO services company employing more than 160,000 people serving customers on six continents. The company has made tremendous strides in shaping and providing green IT solutions to highly carbon-intensive sectors such as energy and utilities, manufacturing, transportation, and consumer goods.

The content has been written by GRIHA Council on behalf of Wipro.

Biosyn medica: Regenerative Landscape Design in an Urban Environment

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Exposure to nature contributes to our well-being—both physical and psychological. However, access to green spaces is either inadequate or entirely absent in urban settings. The article by **Shruti Saraf Bansal, Akash Srivastava** and **Ajitesh Bansal** sheds light on Biosyn medica—a one-of-a-kind medicinal park being designed and developed in urban Hyderabad. Originally, what was a thorny shrubland is being transformed into a healthy biota, set to host over 800 species of medicinal herbs, curative shrubs, climbers, aboriginal grasses, aquatic plants, and beneficial trees.

Inhabitants' access to green spaces is a right often compromised in an urban locale. In constantly expanding cities, green spaces are a must to prevent human settlements from becoming concrete jungles and unknowing contribution to climate change. Apart from acting as 'mini lungs' to their area, green spaces also provide a supporting ground for human interactions and community building.

"Nature itself is the best physician" stated Hippocrates, the famed Greek physician (Schiff 2022). The therapeutic effects of a natural setting have been known since generations. In the present times, humans are yearning to rejuvenate and replenish themselves through age-old techniques such as quiet nature walks, yoga, and meditation in an open-air setting, forest bathing, and other natural

Figure 1: Masterplan for Biosynmedica

healing techniques. To utilize the healing powers of nature in comprehensive abundance, a 'living and self-sustaining' ecosystem, in the form of a one-of-a-kind medicinal park, named Biosyn medica, is being designed and developed in urban Hyderabad (Figure 1). As the name suggests, it stands for biodiversity synced with medicine.

The project, which was conceived in 2019, is being developed by the Telangana State Medicinal Plant Board with support from Telangana Ministry of Health. Hyderabad-based architecture and landscaping firm, Anjuna Architects, has been appointed as landscape consultants for this innovative public space. The park is envisaged as a healing haven with diverse species of flora and fauna. It is spread across an area of 24 acres, located adjoining the Himayat Sagar Lake, which is a temporary abode for many migratory birds. Originally, it was a thorny shrubland which was home to around 56 tree species. Presently, it is being converted into a healthy biota, set to host over 800 species of medicinal herbs, curative shrubs, climbers, aboriginal grasses, aquatic plants, and beneficial trees. The central walkway or 'spine' of this urban recreational park is divided into 7 sections, representing the 7 chakras, governing a human body. It is complete with walking avenues, 2 acres of manicured turf, lagoons and most importantly, copious green spaces which grow in their natural settings to replicate the aura of an organic forest. Efforts have been put into utilizing the site's innate potential without upsetting the contours and natural rock formations.

Although, most of the recently planted flora are native to the area, a certain variety of non-native species have also been sown. However, non-native species are the ones which have naturalized over the years and adapted to the local soil and environmental conditions which is why they stand a better chance of growth and that too a swift one. This combination of thoughtful plantation has been coupled with the 'Miyawaki technique' to develop India's largest medicinal Miyawaki clusters which cover around 6 acres.

This micro forest adopts the technique of Japanese botanist, Dr Akira Miyawaki, who advocated planting of young native plant species in tight groves to restore degraded lands. Saplings planted close together grow rapidly as they compete for light. By planting a native tree assortment, replicating the vegetation layers found in a mature forest, Miyawaki engineered and fast-forwarded the stages of ecological succession by which a degraded plot turns naturally into a forest (Eapen 2022). With this method of plantation, an urban forest can grow within a short span of 20–30 years while a conventional forest takes around 200–300 years to grow naturally (Tyagi 2020). Alongside the regular Miyawaki plantations (Figure 2), Biosynmedica features a food forest clusterconsisting of fruit-bearing and seed-bearing trees.

A Miyawaki plantation has the capacity to absorb 6 tonnes of CO_2 per 100 m^2 (Urban forests 2020). The Miyawaki clusters (Figure 3) of Biosyn medica, have been projected to absorb about

Figure 2: Miyawaki plantation at Biosyn medica (August 2019)

Figure 3: Growing Miyawaki cluster 1.5 years post plantation (January 2021)

1450 tonnes of CO_2 per year. Moreover, upon completion, the entire park has the projected capability of absorbing 5107 tonnes of CO_2/year (projected by Environment Protection Training and Research Institute, Telangana).

Carbon emitted vs absorbed

Conservative CO_2 sequestration per tree is 30 kg per year, 5000 trees planted on 18 acres of land in Biosyn medica, will absorb 150,000 kg of CO_2 per year. Along with that, 119,229 trees in Miyawaki are to absorb 3,576,870 kg of CO_2 per year. Therefore, upon completion, total carbon absorption would be 3,726,870 kg of CO_2 per year (internal calculation and analysis by Ar. Akash Srivastava, landscape architect for Biosyn medica). It is to be noted that as trees mature, they capture more carbon. For example, *Azadirachta indica* (Neem tree) CO_2 sequestration is 2013.5 kg per year when it is completely mature (Pandey and Bobda 2013). This herbal garden has the potential to act as a major carbon sink for Hyderabad.

The park, which was initially covered with a glut of invasive species and prickly thickets, has seen a substantial increase

Table 1: Total carbon emission from different materials used in the park

Material	Quantity	CO_2 per unit (kg)	Unit	CO_2 per unit (kg)
Soil	10,783	55	m^3	593,065
Sand	809.6	12	m^3	9,715.2
Aggregate	120	12	m^3	1,440
Cement	545.75	1997.4	m^3	1,090,081.05
Stone	1,607.5	134	m^2	215,405
Total emissions				**1,909,706.25 kg**

in native shrubs and trees. An increase in soil microbial activity has also been recorded through soil testing (official study conducted by State Agricultural University, Telangana). Owing to a plethora of fresh plantations, the nutritive topsoil is retained and the ambient air is naturally purified. Concomitantly, the soil's water retention capacity has amplified, which benefits the groundwater aquifers. Substantial recovery of surrounding microclimate has been recorded, more so near the Miyawaki clusters. These point towards an augmented and healthy soil.

The planting throughout the park has been designed in such a way that different layers of vegetation attract multiple species of fauna. Initial studies show that 37 bird species were identified in the area. It is now teeming with over 65 different types of birds, insects, and animals (studies conducted by Deccan Birders Society, Hyderabad).

The landscaped park is laden with various significant spaces which enhance its impact as a regenerative urban habitat. The ethnobotany garden displays indigenous and culturally significant species of Telangana. Along the central walkway is a conservatory featuring rare medicinal plants of the Indian subcontinent. Moreover, a 'herbarium' is being developed to cultivate rare medicinal herbs in an appropriate environment. The park is envisioned to act as an ideal ground for researchers and health enthusiasts as it will encourage research and development in a 'living' habitat.

The natural slopes of the site, which are towards Southwest and Northeast, have been utilized for rainwater storage and groundwater recharging. The installation of photovoltaic panels ensures renewable energy generation for the on-site buildings. Bamboo, the most sustainable and eco-friendly construction material, has been chosen for pergola construction. Besides these, to maintain and protect the nocturnal environment on campus, no artificial lights have been installed except on identified security spots.

The conceptualization and design of Biosyn medica is a long-lasting step to encourage and inspire built environment professionals to design harmoniously with nature and reap its multifold benefits. As per initial calculations, the park will potentially be a net carbon positive habitat in about 6 months post completion. It is set to create an incredible social impact as well as nurture ecological balance. A collaborative approach between decision-makers and landscape designers is essential to spearhead such public projects. Combined with knowledge of local ecology, skills, and socio-cultural aspects, it provides a promising pathway towards environmental sustainability and climate justice.

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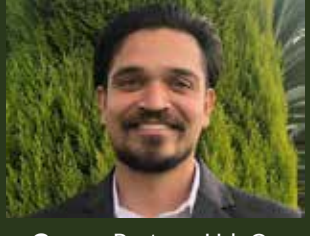
Habitat Design Collective (HdeCo)

Habitat Design Collective is a Delhi-based design and project management practice, founded by Gagan and Subhashree, on the principle that good design should be affordable and accessible for all, an idea that was incepted during their years in architecture school where following the principles of TVB School of Habitat Studies, which later became USAP (IPU) the role of architecture in making a just society, one habitable space at a time was often discussed by them. Two years after they were graduated and while still assisting experienced architects in Delhi with various institutional and commercial projects, the duo started the collective in 2017. Their belief—architecture for the masses is simple and primarily fuelled with economic design approach—with locally sourced and salvaged material, has application in passive cooling/heating techniques.



Gagan, Partner, HdeCo

Subhashree, Partner, HdeCo

Even before COVID made hybrid work mode a norm, the collective adopted the hybrid approach in 2019, as the partners moved to two different continents—one in Germany and the other in Australia. We thank our on-ground associates and a robust set of procedures of tracking the work progress along with an open and efficient channel of communication with the client and various subcontractors, that despite a radical step of adopting hybrid work mode, we have been able to stay true to our beliefs and our client's expectations.

Some common techniques we have applied in all the projects are rat-trap bond walls which passively insulate the building by increasing the time-lag while also reducing material usage. The houses are also designed for a reduced heat gain from roof surfaces like terrace by using traditional reflective broken-china mosaic finish and when feasible deeper last slab using inverted beams and cow-dung-filling, like in Sangwan House. Another key element in our designs is facilitating natural ventilation and day-light access even to deeper interior spaces. For this, we adapted the quintessential Indian architectural typology of courtyards to compact sky-lit courtyard which also houses the staircase, sitting well even in narrow, relatively smaller residential plots. Rainwater harvesting and wastewater treatment are some other indispensable elements of each of our projects. In Singh Residence, we have also introduced solar panels in the terrace which also act as additional terrace shading device.

However, we believe a truly sustainable change in the AEC industry, especially in the lower-budget residential sector, can only happen when the clients start to understand the impact of their house on the environment and decide to choose a lower impact, sustainable alternative. Therefore, being able to bring onboard our clients to take up alternative building and passive cooling techniques, opting for salvaged material and to primarily use locally sourced material, has been our contribution towards sustainable change. We have witnessed first-hand that once the clients start to inhabit such a house, they also slowly adopt a more conscious lifestyle. In some opportune cases, like Three Houses, the client's position as a community leader (Councillor) also helps generate awareness in the community.

Ancient Waters for the Future

Raj Kumar Baudh is senior executive – designer at TATA 1MG. He completed his graduation in the field of architecture from the University School of Architecture and Planning, New Delhi. He has more than 3 years of work experience in the field of sustainability in retails, hospitality, and hospital projects. He can be reached out at raazbdh72@gmail.com.

Mohd Salim did his graduation from the USAP, Delhi. He is passionate about experiential and sustainable architecture. He is a former executive council member at The National Association of Students of Architecture, India, and also headed the National Graphic Design Team and the Editorial Team of NASA India for its 61st Year. Currently associated with Studio Ar. S, Salim handles the architecture department of the company and has been awarded 'Best Sustainable Design of the Year – Concept 2021' for a low-budgeted school in Varanasi.

Water is fundamental to our survival. The planet earth became a life-supporting planet is largely attributable to water. There are many theories of how water came upon the earth. While the origin of earth's water may still be uncertain, its future is easier to predict. With the ever-increasing human population, industrial boom, and rapid urbanization, it does not look promising. In this article, **Raj Kumar Baudh** and **Mohd Salim** make us aware on relevance of water and how circular water management and circular water economy could be effectively utilized to achieve sustainable development in true means.

Our world is governed by water. Earth's evolution, to a large extent, is guided by water. Water is the lubricant that keeps plate tectonic going and keeps the rocks recycled. Water is where life took its shape and flourished for billions of years. In a nutshell, water defines the earth.

Earth is the only planet in our solar system with abundant water where more than 70% of its surface is covered with oceans and places plunging 10 km deep. Water is also present in rivers and lakes, which leave behind delicate, serpentine patterns on the surface of the ground. Underground aquifers contain fresh groundwater that can penetrate the rocks up to 2 km down. The many million cubic kilometre of water is locked as ice sheets, glaciers, and icebergs; and in the atmosphere too, in a form of gas. It's a small but substantial portion of the blanket of humidity that covers our planet and gives hot tropical evenings their stickiness. At higher altitudes, it exists as tiny drops suspended by rising air currents in the form of clouds, and at even higher altitudes the clouds froze to ice, ready to begin their descent back to the surface.

There are many theories of how water came upon the earth through various cosmic events, but from the first water molecules delivered to the earth all those billion years ago till today, the water has persisted and is still present today, moving through the land, sea, and air in a global water cycle. While the origin of earth's water may still be uncertain, its future is easier to predict. With the ever-increasing human population, industrial boom, and rapid urbanization, it does not look as glamorous as it's descend

from the heavens. Out of all the water on the planet, only 1% is freshwater which as of today is to be shared with 7.98 billion people. The current water crisis is one of the greatest challenges of our time (Figure 1).

Figure 1: Water shortage demonstartion

Urban Water Crisis

Urban regions, where for the first time in our history more than half of the world's population resides, pose significant water crisis. It is estimated that the urban population worldwide will nearly double by 2050 which will have serious implications for urban water demand. Today, the rapid increase in urban water use has led to more wastewater and water pollution. The quality of water has deteriorated over time due to global environmental changes, making the pre-existing water crises worse. These changes have an impact on the urban water cycle and are responsible for the degraded quantity, distribution, and quality of the water that is readily available. According to various studies, 80% of wastewater worldwide is released back into the environment without being treated or reused.

Circular Water Management

Water being a finite resource is generally treated as if it will always be in infinite supply. The key challenge today is to ensure the availability of enough clean water for use across all sectors while keeping environmental flows in consideration. The linear way of water consumption has today proven to be unsustainable, where the water is used only once without exploring its potential. From abstraction to disposal, most water is untreated which is directed into waterways. With freshwater supplies running down and large quantities of wastewater being released, it's imperative that governments with the help of the latest scientific and technological advancements in the water sector, consider more efficient models for managing water. In order to achieve water sustainability, circular water management strategies pave the way to maximize resources which at a basic level means using and reusing water and wastewater resources to improve the water supply and maintain the natural equilibrium.

The other aim of circular water management is also to reduce the waste going into the already polluted environment. In addition to the freshwater itself, the system aims to recycle all minerals in the contaminated water. The effluent from treatment, waste products, and contaminated water beyond potable refinement are all considered rich resources which can be used in other industries longing to satisfy their ever-increasing demands, thereby creating sustainable opportunities along with strengthening the economy in the water sector. This also helps in reducing waste across the supply chain, effectively regulating water demands.

Circular Water Economy

Applying the circularity principles to water management is not only more environmentally friendly, but it is also better for the major water consumers in society, including the city administrations and industry sectors like agriculture and textiles. Financially speaking, it makes sense. Circular water management investments have the potential to increase operational efficiencies, generate employment, and boost the local economy. The advantages for the environment and health also cannot be disregarded and will influence most policymakers (Figure 2).

Businesses all across the world are adopting the circular model of the economy as they strive for better sustainability, from local coffee shops to the automotive industry. The 'throwaway' mentality, however, doesn't just apply to things that might end up in a landfill. The linear model of production is everywhere in human history, from industry to urban design. We extract natural resources to make products and services and then discard what's left. It's imperative for the stakeholders to come up with schematic blueprints in order to change this mentality of 'take–make–waste' and to shift our approach towards better use and reuse of our resources as long as possible.

This can be understood with a small yet relevant example. The textile sector is extremely water intensive. According to UN estimates, the dyeing and processing of textiles produce

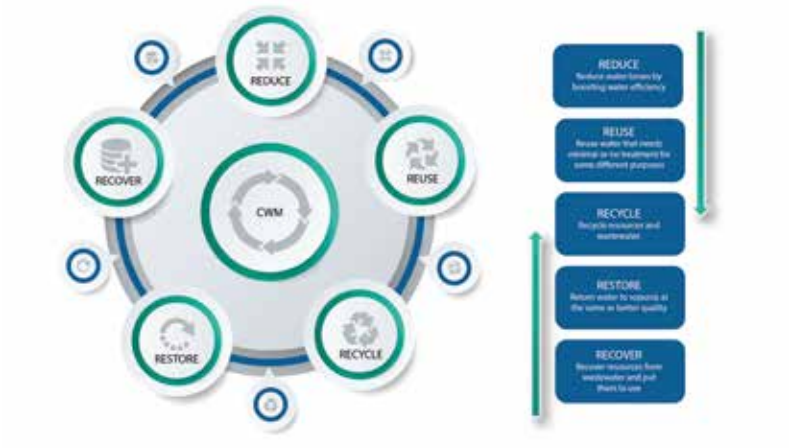


Figure 2: Circular water management

one-fifth of all global wastewater. Using the circular economy model this problem can be tackled to an extent by reducing water and reusing carbon dioxide. Captured carbon dioxide can be used to dye textiles without using water. This process can work well because when heated above its critical point, carbon exhibits properties of both liquid and gas. As a result, the dying process will take shorter times and lower operating costs. It's a closed-loop process that not only reduces water use but also links up with broader circular economy aims by using and reusing reclaimed carbon dioxide which would otherwise contribute to greenhouse gas emissions.

Similar examples can be understood in the agricultural industry. Modern water- and crop-growing technologies can significantly reduce water consumption in agriculture where water can be reused with or without minimal treatment for the same or different purposes. For example, using grey water to flush toilets, water plants, clean driveways, etc. can create a circular system within a home. Likewise, rainwater can be collected and used to irrigate nearby vegetation (Figure 3). Water can be used as a source of secondary materials once its full potential has been utilized. Nitrogen and phosphorus can be recovered from sewage sludge to produce high-quality fertilizers and ammonia compounds. The anaerobic digestion of sewage sludge can produce biogas, which can result in the cogeneration of renewable electricity and heat. Through this recovery, wastewater treatment plants can achieve complete energy independence while also supplying extra energy to the electrical grid.

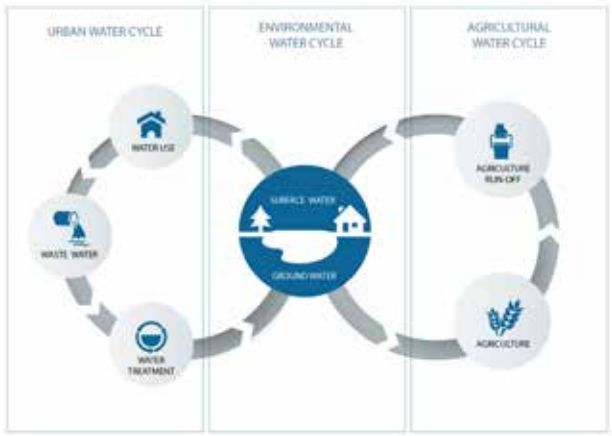


Figure 3: Circular water

The circular water economy can serve as a basis for sustainable water management through water saving and efficient use and therefore contributes to many sustainable development goals. In this context, circular economy strategies play a critical role in the establishment and application of circular economy solutions to water. That being said, these strategies require favourable conditions if they are to be adopted successfully. The mantra of 'reduce, reuse, recycle' is the future of sustainability, the future of water.

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Jayakeerthi Anand, Senior Vice President, Location Head, Nelamangala Factory, ABB India Limited

ABB Plant at Nelamangala, Bengaluru

Overutilization of water resources and contamination of river systems along with lack of water treatment facilities has aggravated the already existing water crisis in India. Cognizant to this, we at the ABB Plant, Nelamangala, Bengaluru sought to conduct a water audit and examine our water use pattern & management.

Based on recommendations from The Energy and Resources Institute (TERI), we achieved overall self-sufficiency of water on the site and are proud to be the first recipient of **GRIHA Council's Water Positive Certification**. We are extremely grateful to the handholding provided by both the GRIHA and TERI teams in achieving this certification.

Prior to the assessment, we had a Water Positive Index (WPI) of <1. Guided by TERI, we first reduced the freshwater demand by installing improved efficiency plumbing and irrigation fixtures. The rainwater harvesting system was upgraded to cater to the complete harvesting potential of the project and facilitate groundwater recharge through ponds, recharge wells and RWH tanks. Moreover, the excess treated water from STP, after meeting the irrigation requirements was also diverted to flushing. With these measures, we successfully improved our WPI to 1.24 that is Net Water Positive.

The process of attaining the certification has been a knowledgeable and enriching experience for the team at ABB. With this certification, we are now motivated to take a step towards holistic sustainability and are excited to learn that GRIHA Council has initiated a drive towards a zero-carbon mission namely the "Decarbonizing Habitat Program". We look forward to participating in this pioneering initiative by GRIHA, and do our bit to reduce our carbon footprint for the betterment of the planet inline with ABB's 2030 Sustainability commitment.

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आज तक

The Grind Behind the Glamour

Ar. Veena N, M. Arch is a postgraduate in Energy Efficient and Sustainable Architecture from NIT Trichy. Currently, she is working with GRIHA Council in rating green building projects. She has carried out extensive research pertaining to building envelope and indoor thermal comfort synergies. She can be approached via veena.n@grihaindia.org

Fashion industry is a resource-intensive industry and hence is a major contributor to the global carbon emissions. While the industry is experiencing a rapid expansion, there are workers whose conditions are deteriorating as they are forced to work under pathetic working conditions, overburdened with unrealistic targets without proper wages. In this article, **Veena N** makes us aware about some of the eye-opening facts of this developing industry. The argument is supplemented by the discussion on responsible consumerism, emphasizing, we, as customers should amend our approach on making clothing purchases.

What Does Fast Fashion Mean?

Answer to this question can be traced in Justine Leconte's words—"Fast fashion actually means how fast what you buy today is going to become out of fashion." As clothing is a domain that 'touches' upon every individual, it is a matter of concern to scrutinize the unchecked behaviour of this billion-dollar industry.

As we are aware, fashion industry is a major contributor to carbon emissions and is a resource-intensive industry. Estimates show that it is responsible for around 2.1 billion metric tonnes of greenhouse gas (GHG) emissions in 2018, which is about 4% of the global total (McKinsey research). In terms of water consumption, large quantities are used for processing textile, and toxic chemicals are used for dying, thus rendering water unfit for consumption. Most factories are also strategically located along rivers where these harsh effluents are discharged directly into rivers without appropriate treatment. Additionally, the industry generates tonnes of waste which are either dumped in landfills or incinerated, resulting in release of pollutants in the atmosphere. Microplastics from man-made fibres such as rayon and nylon disintegrate and end up in the food chain. In addition to these brute practices, there is a lesser-known evil that lurks within, which is labour exploitation.

Garments exchange multiple hands in its production process and the supply chain is often long from inception of design till sales. Several well-known fast fashion retailers participate in this process as both manufacturers and sellers. It allows for impossibly short supply chains that enable them to refresh their stores with new designs almost every fortnight. Fast supply cycles promote mass production, which means large quantities of each garment are created in surplus to meet high demands from customers. Large surpluses also mean that garment workers need to often work overtime in order to meet their demands. With the highly optimized supply chains of the brands, stitching, sewing, packaging, and all other intermediate stages of garment making are outsourced to countries where labour is cheap. Countries such as Bangladesh, the Philippines, Colombia, Brazil, and India are often targeted for cheap labour which widens the profit margins. This has the additional benefit of proximity to raw material in resource-abundant South Asian and South American countries (Figure 1).

Workers are overburdened with unrealistic targets to complete batches for export within a very short period without proper wages, labour protection laws, or working conditions. To put things in perspective, Figure 2 describes the cost of a T shirt, and how much of it ends up in the hands of the workers who made it. It is shocking to see that a 29-Euro or (INR2000 approx.) T shirt would fetch 18 cents or less than a rupee to the worker who contributes to sewing the same. Often times, wages to the workers are less than INR 100 per day where the working hours are 16 or more.

The Rana Plaza building collapsed in Bangladesh in 2013 is one of the deadliest incidents in modern history, highlighting the exploitation towards garment workers (Figure 3). The building hosted multiple garment factories, catering to multiple fast fashion brands in dingy spaces. As sewing is a meticulous and a low-contrast job, working in a dark environment could seriously impact the vision of workers. Similarly, fabric processing emits large number of suspended particles in the air which could give rise to respiratory ailments. Forced working hours for labours are amongst the common conditions. Workers are denied wages on violation of the unfair rules. The building was additionally constructed on reclaimed lake land and thus had a compromised foundation with illegally built floors, leading to its collapse on the fateful day of 24 April 2013. In the catastrophe, thousands of workers lost their lives and livelihoods, shedding light on the grave conditions of exploited workers in such factories. Further, the pandemic has pushed these workers under economic burdens as there are no laws that protect them. Vulnerable people in supply chains are largely women who are exploited by denying basic care such as maternity leaves. What is unacceptable is children are also employed who are unaccounted for this industry. As the vast wealth of the fashion industry becomes further concentrated among its top corporations, the profit model has pushed the economic and social pain of the pandemic onto the most vulnerable people in supply chains.

Figure 1: Countries with the corresponding labour costs

Figure 2: Breakdown costs of a T shirt

Figure 3: Collapse of Rana Plaza building in Bangladesh in 2013

What Needs to be Done as Customers?

On comparing the revenue distribution between a fast fashion brand and a fair trade brand (Figure 4), it is evident that the later brand can still manage to retain their profit margins without increasing the overall cost of the product significantly by increasing the fair wages of workers.

Through changes in the system at a policy level, margins set aside for different agents of retail can be kept at check, thus uplifting the life of garment workers.

The dizzying pace of apparel manufacturing has also accelerated consumption: the average person today buys 60% more clothing than in 2000. Further, not only we do buy more, but also discard more as a result. In many countries, 40% of the clothes bought end up never being used. If the lifestyle patterns continue as they are, global consumption of apparel will rise from 62 million metric tonnes in 2019 to 102 million tonnes in the next 10 years. As sustainability is a pressing issue, brands often involve green washing in their advertising campaigns to give customers a false belief of being sustainable. However, the loopholes lie hidden in the fine print, and it is the duty of the customer to scrutinize the gimmicks behind marketing. As customers, mindful shopping and choosing quality over quantity could significantly increase the impact on sustainable fashion. A positive change is to consider switching to a capsule wardrobe which encourages creative ways of combining garments and each piece is recycled after use.

Finally, being aware of where our garments are made can help us make a difference to the carbon emissions. India has a rich tradition of local communities of weaving artisans. India is also the world's second largest exporter of textiles in current times. Yet, the garments purchased from stores are often imported, travelling across the world before reaching us. Traditionally, weaving was a skilled occupation in India with multiple communities engaged in reputed local production. Increase in demand and innovation in machines have considerably brought down their numbers as they have been replaced for faster outputs. We must take pride and consciously choose locally made garments for enriching the lives of our artisans and support home grown brands.

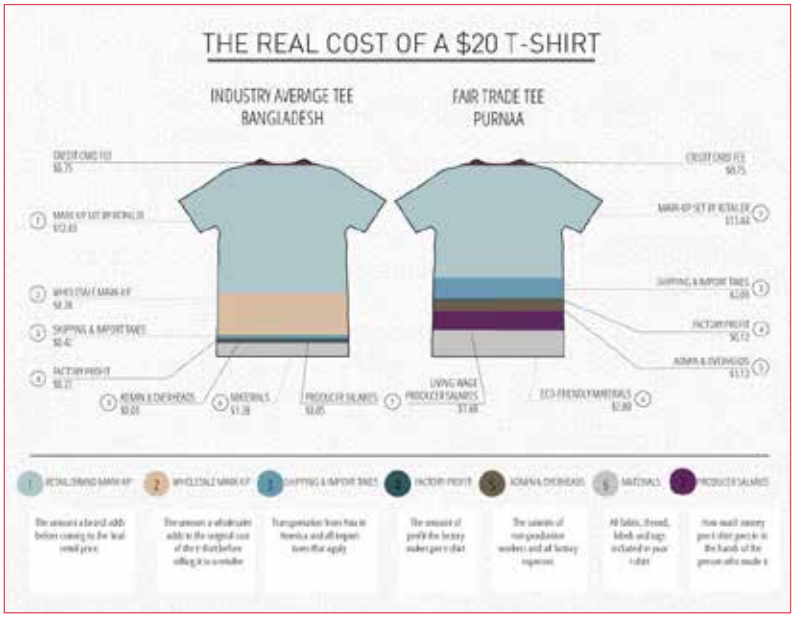

Figure 4: The real cost of a T shirt priced $20

Step into the world of landscape architecture

Based on the subject of landscape architecture, LA Journal of Landscape Architecture | LANDSCAPE explores the relationship of nature and culture in the realm of design, in context of the Indian subcontinent — looking at the subject as a multidisciplinary discipline where design professionals [nature, spatial, visual and experiential], natural scientists, artists, historians, and social scientists have a significant roles to play — an approach that helps it to understand diversity of perspectives across different cultures regarding the subject.

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Transforming Youth Behaviour for Sustainable Residence

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Youth make up a sizeable proportion of the global population and are key stakeholders in the process of behavioural transformation. To achieve the SDGs, sustainable residency necessitates behavioural change, and youth participation in this behavioural transformation is critical, as sustainability issues are primarily concerned with the next generation. There are numerous global and local initiatives that encourage youth involvement in environmental sustainability. Through the medium of this article—**Neha, Lovish Raheja** and, **Amarpreet Kaur**—accentuate significance of youths' contribution in realizing the true potentials of sustainable development.

Introduction

The hasty use of new technologies without regard for long-term consequences has resulted in the depletion of nature and its resources. As a result, the world is now facing a major challenge known as the 'Triple Planetary Crisis', which includes climate change, biodiversity loss, and pollution (Figure 1). Progress towards Sustainable Development Goals (SDGs) achievement could be critical in addressing this challenge. The current decade has been dubbed 'The 2030 Decade of Action' while the youth have been designated as the 'torchbearers'. In dealing with crises of various dimensions of these goals, the environmental dimension is critical. As a result, youth involvement in environmental issues is imperative. Living spaces and infrastructure have a significant impact on the environment (Moffatt and Kohler 2008); a vital focus on sustainable residency with the enhanced behavioural transformation of youth is required to effectively achieve global goals.

Figure 1: A visual representation of the Triple Planetary Crisis

Note: Adopted from Andersen (2021)

The environment influences these behavioural transformations because of being one of their critical determinants. The built environment is important in this context because it addresses the multi-faceted aspects (social, economic, and environmental) of sustainable development (Figure 2). The construction industry is one of the most responsible industrial sectors for resource use and environmental change, accounting for 38% of all energy-related CO_2 emissions (Elsevier 2017; Purvis, Mao, and Robinson 2018; UNEP 2020). People have a far stronger emotional bond with their homes than with other types of constructed environments, which influence their intentions to act in an environment-friendly manner (Anton and Lawrence 2014). This suggests that establishing an environment-friendly world may require long-term values-based residency. This can be accomplished through youth involvement, as they are the ones who serve as responsible torchbearers for the desired advancement.

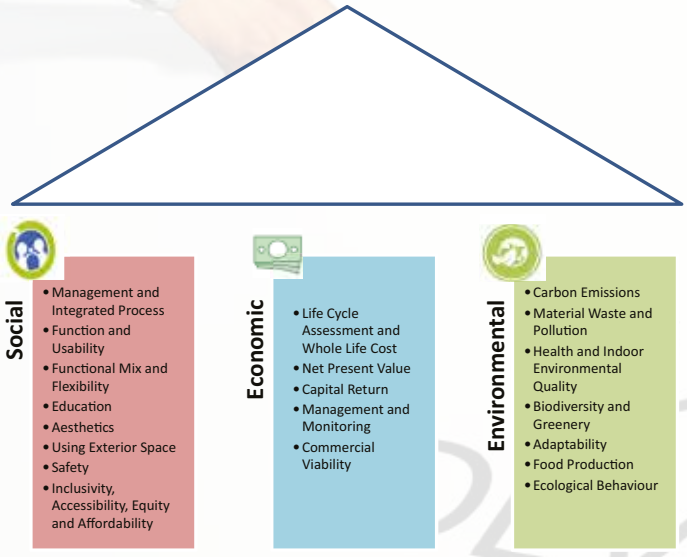

Figure 2: Pillars of sustainability contextualized for buildings

Source Eklova (2020)

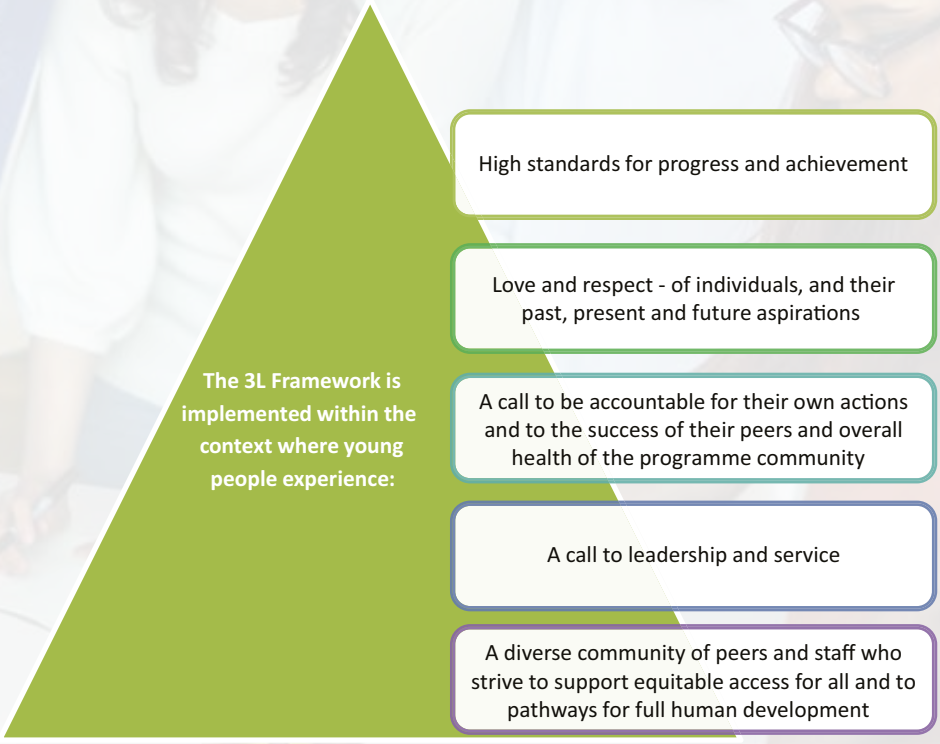

Figure 3: The 3L framework programme culture
Source: Youth Build

Youth Participation in Sustainable Residency—Global Initiatives

Globally, efforts to build youth capacity to achieve the SDGs by 2030 through local actions have been recognized. This includes their education, empowerment, mobilization, upskilling, and improving their social participation and stakeholdership to help progress towards achieving transformation and bringing about positive change in the lives of urban, rural, and tribal communities, and thus SDGs (Ntuli 2019; UNDESA 2022; UNV 2020).

As a result, youth engagement is constantly evolving, and a greater proclivity for behavioural change is emerging as a new trend for a more sustainable future. A series of global initiatives, such as the 3L framework, focused on livelihood, learning, and leadership (Figure 3), involving students in sustainable city planning that addresses issues such as climate change, inequality reduction (YCP 2021; TYPV 2021), and the establishment of strong institutions, among others programmes, such as the UN Volunteering Programme (UNV), World Programme of Action for Youth (WPAY), UN Major Group for Children and Youth (UN MGCY), UNESCO's Education for Sustainable Development 2030, etc.

Youth in India

India is one of the world's fastest-growing economies and a critical contributor to the SDGs. Youth is especially important in India, which has one of the world's youngest population, with 52% of the population under 30. India's green building market is growing, with a potential valuation of USD 35–50 billion by 2022, implying that the scope of sustainable living is expanding (Financial Express 2021). Recently, an ET Bureau survey in 2021 revealed that Indian youth are willing to participate in environmental actions and behavioural changes, demonstrating their interest in the well-being of cities and

communities (ET Bureau 2021). As a result, the role of youth as academics, managers, politicians, civil servants, entrepreneurs, and influencers in encouraging Indian society to adopt sustainable and green practices becomes more significant (Purohit 2016).

By encouraging responsible resource use, energy efficiency, pollution control on a personal level, and the selection of sustainable alternatives, youth can eventually lead to low-cost housing and residency. Government initiatives such as the National Mission for Sustainable Habitat, the National Policy on Resource Efficiency, the Green Skill Development Programme, and other behavioural change initiatives organized by think tanks, NGOs, and other organizations have shown that youth can be mobilized through innovative competitive programmes that help them create ideas for sustainable habitat and spaces based on real-world scenarios. These competitive methods encourage youth to create green architectural designs and sustainable ecosystems, which aid in changing perceptions of participating youth and influencing the future behaviour of intended beneficiaries.

Conclusion

Youth make up a sizeable proportion of the global population and are key stakeholders in the process of behavioural transformation. To achieve the SDGs, sustainable residency necessitates behavioural change, and youth participation in this behavioural transformation is critical, as sustainability issues are primarily concerned with the next generation. There are numerous global and local initiatives that encourage youth involvement in environmental sustainability. Overall, youth may have a greater impact on the lives of those in their community if they are empowered for this transformation due to their well-recognized superior capabilities to any other age group. Residences can be referred to as basic societal building blocks, implying that a transition in this aspect, namely, sustainable residency, will inevitably result in positive change in the entire system. 'Charity Begins at Home' could be one of the most effective steps to instil pro-environmental behaviour and move us closer to a sustainable world.

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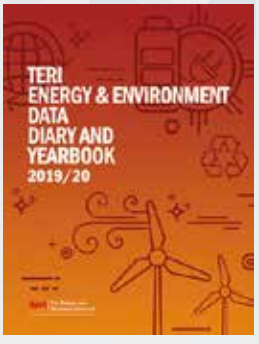

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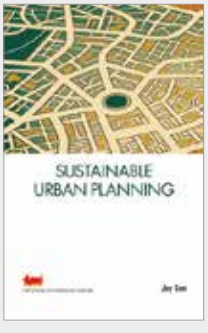

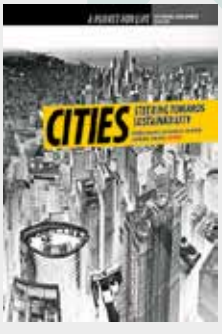

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A Net-zero Building

Provision of Deficient Sailors Married Accommodation

Through this article, **N. K. Ojha**, makes us aware about relevance of green buildings. The author explains how an energy-efficient building reduces its energy consumption through well-outlined focus areas. To facilitate understanding, the text has been supplemented with a case study pertaining to Military Engineering Services, a department under the Ministry of Defence, Government of India. The building has received GRIHA 4 Star Rating in Pre-Certification.

N. K. Ojha is a well-known name in green buildings. He has served Government of India in various capacities. Besides the author is a recipient of a number of awards and recognitions. Given below is the snapshot of some of his achievements and invaluable services he has provided to the nation.

- Technical Advisor and Green Building Consultant
  - i. Shri Govind Guru University, Godhra, Gujarat
  - ii. Bhakta Kavi Narsinh Mehta University, Junagadh, Gujarat
  - iii. Krantiguru Shyamji Krishna Verma Kachchh University, Bhuj
- Technical Expert, Centre for Entrepreneurship Development, Government of Gujarat,
- Arbitrator, INFLIBNET Centre, Gandhinagar, Gujarat
- Inquiry Officer, Deendayal Port Trust, Gandhidham, Gujarat
- Lokpal/Ombudsman, MGNREGA, Department of Rural Development, Gujarat State
- Patron – Green Rating for Integrated Habitat Assessment (GRIHA), TERI–MNRE
- Accredited Green Building Professional (IGBC AP)
- Fellow—Indian Green Building Council
- Certified Professional—Green and Eco-friendly Movement (GEM) ASSOCHAM

Awards

- HUDCO Award for Net Zero Building
- IGBC Fellowship Award
- Exemplary Performance Award by GRIHA

Project Brief

- Project name – Provision of Deficient Sailors Married Accommodation (464 DUS) (G+30) at Trombay, Mumbai, Maharashtra
- Location – Mumbai, Maharashtra
- Site area – 49,783.12 m^2
- Built-up area – 22,631.87 m^2
- No. of storeys – G+30
- No. of building blocks – 2
- Typology – Residential
- Building type – Non-air conditioned

Introduction

Military Engineering Services (MES) is a department under the Ministry of Defence, Government of India. All the buildings being undertaken by MES are mandated to be green buildings with minimum GRIHA 3 Star Rating. Hence, the project applied for GRIHA Pre-certification at the design stage itself.

Geo Design and Research Pvt. Ltd acted as Green Building Facilitator for MES and scored GRIHA 4 Star Rating for Pre-certification that was released on 10 August 2021. This will be the First Residential Building with Ministry of Defence with GRIHA 4 Star Rating in Pre-Certification.

After receiving the Pre-certification, the Competent Authority of MES proposed to further improve this rating, mainly by adding innovation in the design process so that the project can be projected at the national level.

Hence, it was proposed to design and construct the building as a net-zero building.

A net-zero building is a building which is self-sustained with regard to the requirement of energy. In the present project, the energy required to operate the building is simply not transferred to hybrid energy but the energy requirement is reduced by 30%–40% and is then transferred to hybrid energy.

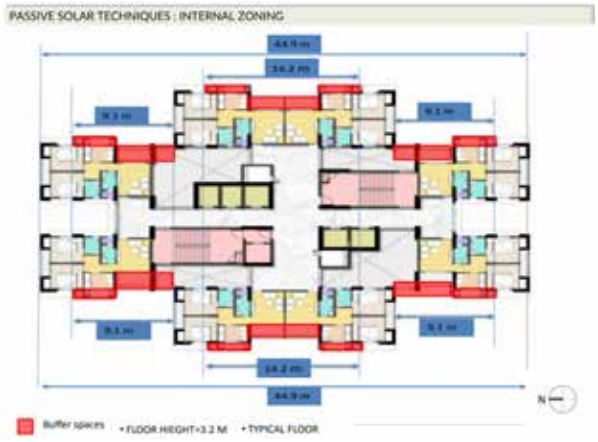
Hence, converting a building into energy efficient building is the first and the foremost requirement of net-zero building. This exactly defines the approach for this project.

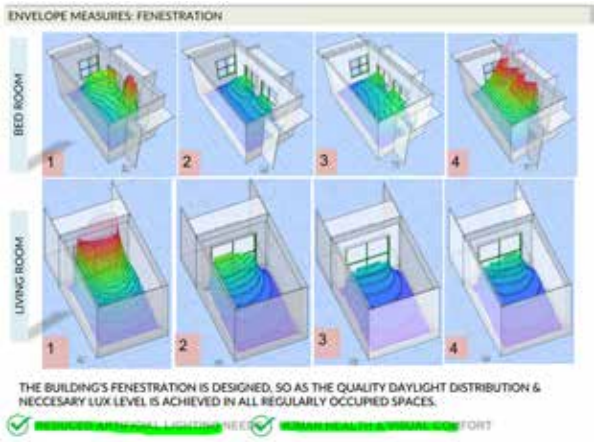
The foremost step for an energy-efficient building is to reduce building energy consumption through the following focus areas:

- Site selection and sustainable development: Leading to reduced building footprint, carbon footprint, closer distance of amenities
- Low energy architecture, passive solar techniques, enhanced ventilation, cross-ventilation and day-lighting in building
- Envelope measures, wall and roof options and energy-efficient building materials preventing solar heat ingress inside the building
- Energy-efficient equipment's/ lighting fixtures/heating, ventilation, and air-conditioning (HVAC) system
- Water conservation also leads to energy savings
- Post-occupancy waste management system
- Efficient operation and maintenance protocol

Reduced Insolation, Passive Solar Techniques, Enhanced, Ventilation and Cross- ventilation

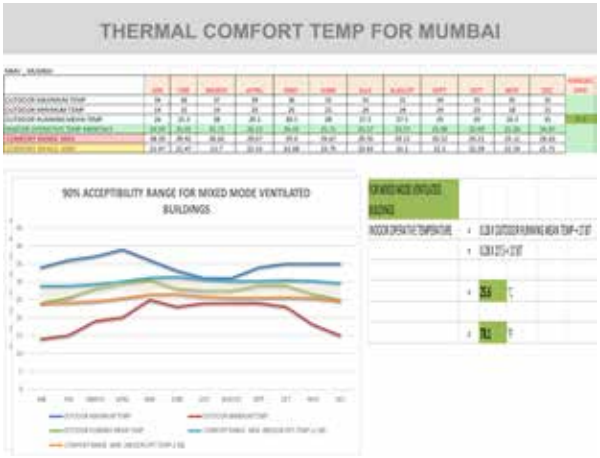
- More than 50% space on the critical sides of building, that is, eastern and western facade is planned such that there are buffer spaces and balcony to reduce the radiant/conductive heat gain into the dwelling units.
- Care has been taken for reduced insolation.
- AAC (Autoclaved Aerated Cement) blocks with thermal conductivity of less than 0.2 are used to prevent solar heat ingress inside the building.
- High-performance glazing with lower U-value and appropriate SHGC (solar heat gain coefficient) and SRI (solar

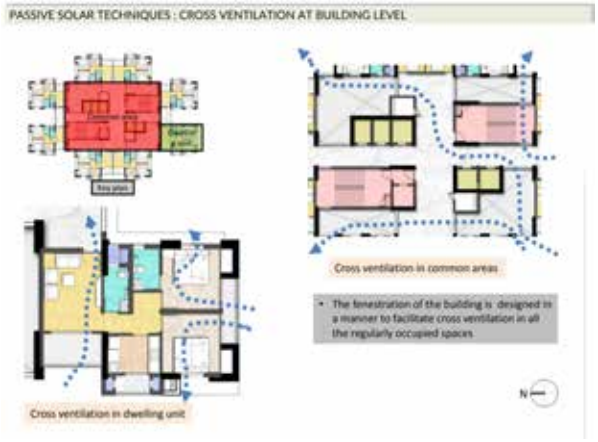


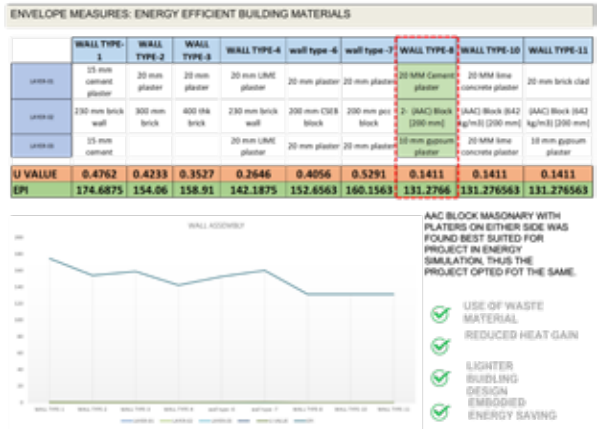


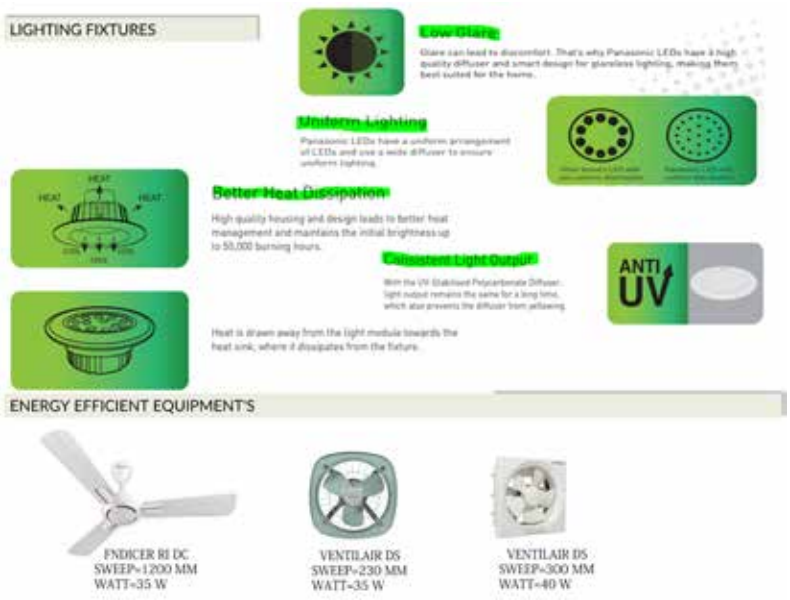
reflective index) is proposed to further curtail solar heat ingress through vertical fenestration.

- China mosaic is proposed on the terrace to reduce Heat Island Effect – Roof. This would also prevent solar heat ingress from rooftop.
- Building is surrounded with large open spaces and the landscape is developed to reduce Heat Island Effect – Non-roof. This would create comfortable micro-climate, also preventing any reflection of solar heat from surroundings on to the building.
- Care has been taken for enhanced ventilation and cross-ventilation. The windows and openings are located in a way to capture cool breeze from adjoining sea blowing across the building.
- In a nutshell, all solar passive measures are to be taken to create a comfortable environment inside the building even without operating air-conditioners, considering thermal comfort temperature for Mumbai.
- This will reduce the consumption of energy for operating air-conditioners and ceiling fans, and if at all it has to be operated then both ceiling fans and air-conditioners are to be energy efficient with BEE 3 Star Rating.









- The location of the windows and other openings is carefully designed to utilize maximum of the daylighting so as to reduce artificial lighting during the day-time.
- The VLT (visual light transmittance) of the glazing is properly selected to further improve the day lighting inside the building.
- Energy-efficient lighting fixtures, in the form of LED are proposed to reduce energy consumption for lighting load below 30%–40% of the LPD (Light Power Density) as prescribed by ECBC (Energy Conversation Building Code) 2017.
- A detailed building energy simulation and day-lighting simulation is conducted to justify the above-mentioned points.

Water Efficiency/ Conservation and Post-occupancy Waste Management System Leading to Energy Conservation

- The water requirement for the occupancy of the building and for the landscape is considered on the basis of the norms prescribed by NBC (National Building Code) 2016.
- Reduced water consumption of up to 70% is achieved as compared to the base case water requirements.
- Hence, appreciably less water will be required and this will lead to reduced pumping hours further, leading to energy saving.
- The STP (Sewage Treatment Plant) is proposed for the project using treated water for flushing and landscape. This will reduce the consumption of groundwater which will further avoid reduction in groundwater table. This will require lesser energy to pump water from higher water table.
- The slurry which will be a byproduct of the STP operation shall be dried up and used as organic manure for the landscape. This will reduce the transportation of inorganic manure from the shops and would further save the energy used for the manufacturing of this inorganic manure/ fertilizers. This will be intangible benefit/saving to energy. This will also reduce CO_2 emission off site.
- The use of organic manure creates humus in the soil and creates more voids in the soil which increases moisture/ water carrying capacity of the soil and this reduces the water requirement for the irrigation.
- The project has meticulously designed post-occupancy waste management system, leading to intangible conservation of energy. (This is described next).
- The segregation of different waste will be done on site and the waste in the form of plastic, glass, paper, etc. shall be sent to the recyclable industry. This will

reduce the load on landfill sites and will also reduce movement of municipal garbage vehicles plying on roads to collect the waste and take it to landfill sites. In addition, this will also reduce CO_2 emission.

- The organic waste can be treated in a mini biogas plant or composting pit. If it is treated in biogas plant, then methane gas will get generated that can be utilized as fuel for the kitchen.
- Hence, this is how the water conservation and the post-occupancy waste management system will lead to optimum use of energy and intangible conservation of energy.
- Installed RE of 20 kWp, which will generate 100 kWh of energy per day at the rate of 5 kW per 1 kW of solar panel and this would occupy 20 × 13 = 260 m^2 rooftop space at the rate of 13 m^2 per 1 kW
- We are generating 8 kW per day more than required 92 kW per day.
- Hence, this is not only a net-zero building but is also an energy positive building.
- The project will opt for net metering so that the use of batteries could be avoided which are non-eco-friendly. In addition, this would also reduce the cost of installing solar panels.

		Base case	Proposed case
Building envelope	Opaque construction	Conventional construction that has higher rate of heat tranfer.	AAC block masonary that has lower u-value & it is light weight construction. U-value: 0.76 W/m^2k
	Roof	RCC constrcution or low albedo finish on top that absorbs heat and emmits inside.	China mosaic: high reflectivite tile which relfects most of radiant heat to outside. U-value: 2.9 W/m^2k
	Fenestration	No-shading devices	Combination of vertical and horizontal shading devices leads to reduced heat transmission. Single glass unit windows: SC- 0.48 I U- vaule 4.6 W/m^2 I VLT -45%
Lighting	Daylighting	Direct solar ingress through windows causes visual and thermal discomfort	Low SHGC & shaded windows on exterior facade helps distribute daylight evenly inside the building
	Artificial lighting	Conventional lighting fixtures	LED lighting: lesser input and maximum output during non sunshine hours
Fan/ equipment	Ventilation system	The conventional fans (60-80 watt.)	Energy efficient equipment's (35 -40 watt) are employed that reduces the energy demand
EPI/total energy consumption		70 kWh.m^2.yr 16,30,692 Kwh annual energy consumption	34.42 kWh.m^2.yr 8,01,834.5 kWh annual energy consumption 2,196.8 kWh daily consumption = 92 kW/day
	51% Reduction in enrgy demand through Passive architectural and energy efficient equipments		
Renewable energy		18.5 kW	The 20 kW capacity of roof top solar

Summary

Energy management

- List of the strategies opted in the project to reduce the energy consumption
  - » SHGC of project: SC- 0.48 I U- Value 4.6 W/m^2 I VLT -45%
  - » WWR of project: 26.3%
  - » HVAC system installed: 3 star-rated 1.5 tonne inverter split AC of Voltas
  - » AAC Blocks 0.18 W/mk
- Type of external lighting fixtures installed: Phillips or equivalent make to meet the luminous efficacy requirements of GRIHA.
- Efficiency of motors installed: IE 2
- Operation and maintenance
  - » O&M policy and training for maintenance: The MES is a vast organization of defence department. It is equipped with highly skilled technical staff trained to maintain and upkeep all kinds of buildings.
  - » Contract for O&M: Lift, DG Set, STP, water tank cleaning and biogas plant, etc.
  - » List of maintenance team: Maintenance engineer, estate manager, liftman, valveman, DG set operator, STP operator, wireman, plumber, carpenter, housekeeping, gardener, etc.
- The extended energy meters shall be installed for internal lighting, common area, external lighting, air-conditioners, DG set, solar panels, and water pumps.
- Reduction of energy consumption (%) (HVAC and internal lighting)
  - » Benchmark EPI: 70 kWh/m^2/year

Proposed EPI: 34 kWh/m^2/year

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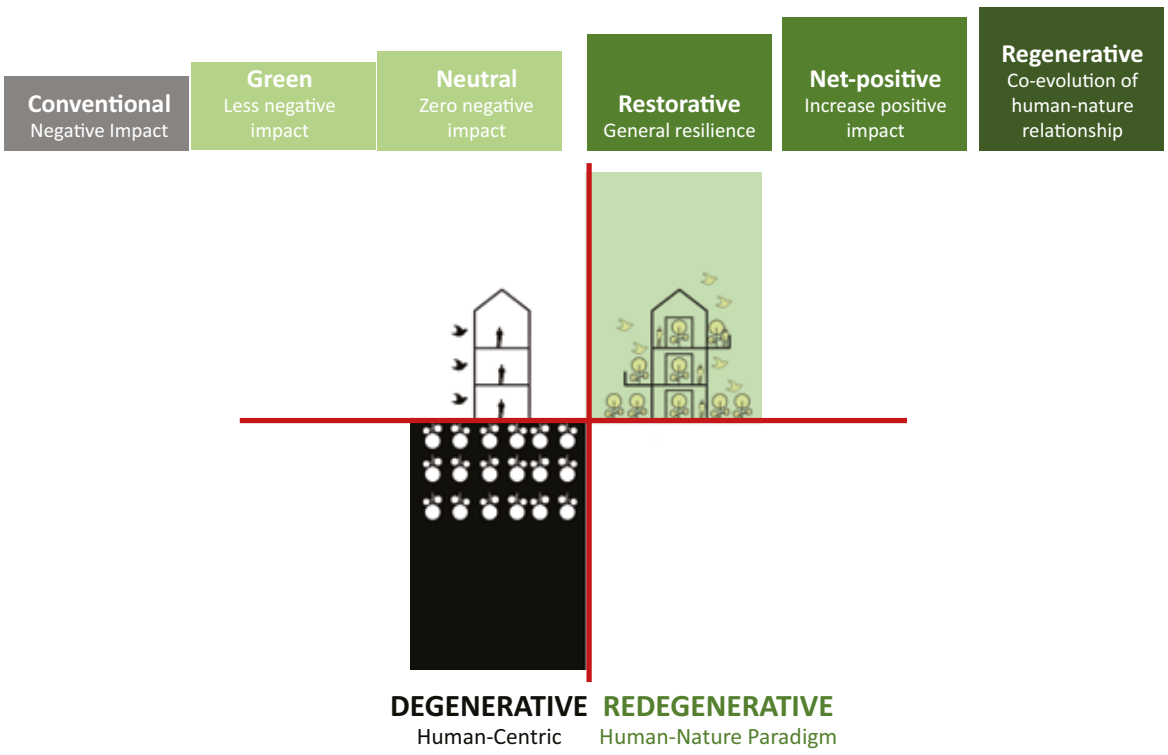
Towards Net-Positive Habitats

Ar. Anjali Dutt, a GRIHA CP and a postgraduate in Integrated Sustainable Design from National University of Singapore, has eight years of work experience in the field of Architecture and Sustainability. After working extensively on building maintenance framework and life cycle cost analysis policy for Government of Singapore, she founded Saankhya in India—a sustainability consultancy and an education initiative towards well-being in built environment. Her e-mail ID is anjali.saankhya@gmail.com.

The concept of 'net-positive' has been in discussion to solve the problems what even net-zero buildings have failed to solve. In this article, **Anjali Dutt** details how 'net-positive' serves as a direction that needs to be followed to make habitation for humans that also becomes generator of energy and source of life for other participants of human ecosystem. What becomes more relevant—the definition of net-positive— because the performance and expectations differ from those of net-zero buildings. More often, the term net-positive has been used as an extension of net-zero buildings.

The concept of living and building green is no longer a new trend now in a world with hasty urbanization. In India, building and construction sector in urban areas alone contributes 32% to the total national greenhouse gas (GHG) emissions (MoEFCC 2021). Realizing the speedy damage being caused by new construction, the discussion of environment friendly buildings in the last decade has gone even far to create 'net-zero' infrastructure. Yet, the struggle to mitigate the damage instigated has not been pacified to meet the demand of time. This can be established on the fact that, though, the number of green-certified buildings is increasing, the GHG emissions, urban heat island (UHI) effect, is continuing to increase that too with almost same pace. Climate change and carbon in the atmosphere is a symptom and not a problem. It's a symptom of lack of collaboration and support with the living systems that support us.



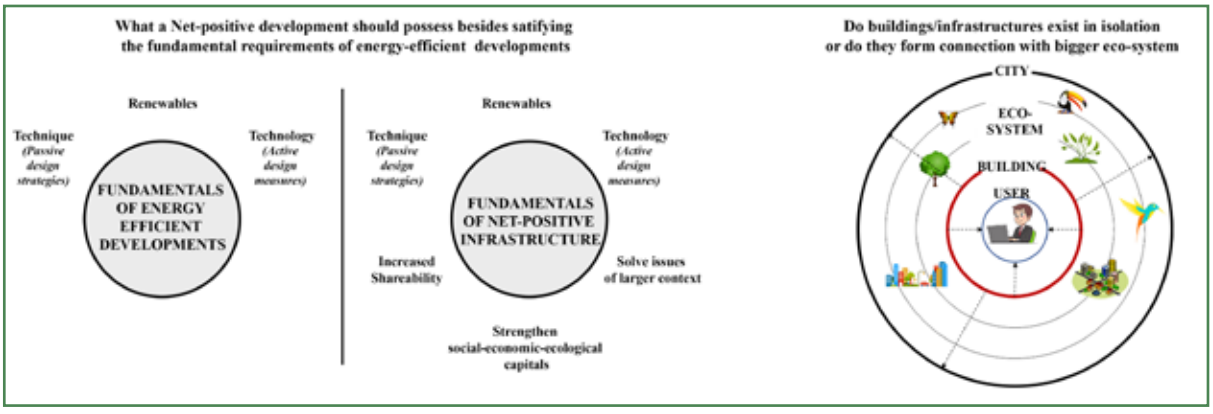
Difference between conventional and regenerative buildings

On the basis of the discussion it can be implied that there are gaps in the attempts and goals and whatever is being done to alleviate the impairment is not enough. There is a need to set new targets which have measurably rather 'positive' impacts that aim for doing more good rather than doing less bad. There is a need of a fundamental shift in the way of planning developments which besides getting the fundamentals done right, also look at the buildings in a bigger loop of systems where buildings are seen interacting with the ecosystem that we did not invent but were there before us. While the approach of green and sustainable design remain well-founded, the intention of net-positive design to do more good, offers considerable capacity to motivate positive change in the whole system where everything is connected to everything else.

Shifting Narrative

The term 'net-positive' is a very catchy expression that has been in discussion to solve the problems what even net-zero buildings have not been effective to solve. It serves as a direction that needs to be followed to make habitation for humans that also becomes generator of energy and source of life for other participants of human ecosystem. What becomes evident here is that the definition of net-positive because the performance and expectations differ from those of net-zero buildings. More often, the term net-positive has been used as an extension of net-zero buildings.

A summarized and vogue definition of net-positive buildings is as those parcels that generate more than what they consume and subsequently, add value to the environment and community. A crucial concern of net-positive developments is not merely consuming less and producing more, but it is to identify the potential of the site and strategies the deployment of excess generated waste to utilize it as a resource.



Features of a Net-Positive infrastucture

However, the conception of 'adding value' does not legitimize its value until the base state is known against which the value is added and how the yield caused by 'added value' is used. If the value is added just to cover the high consumption of the design or an existing development, then it should not be considered as an addition of value rather it is just the compensation / bribe so as to continue to create damage by paying (adding value) more for the damage a particular structure has caused. On the contrary, if this value is added after first reducing the appetite of a building for natural resources, and then increasing its yielding capacity which exceeds its demand, then only it should be considered as net-positive.

Moreover, to make net-positive approach holistic in nature, the performance parameters should not get limited to emphasize quantitative measures and ecological issues. Approach should also perceive the importance of other qualitative measures such as social participation as an ethical issue equally essential as the other two. Net-positive development values societal participation by understanding how a design is measured and valued by a society and how a design can help community understand the role of ecology as a part of ecosystem of web of life in which humans are one thread.

Therefore, design for net-positive demands distinct ways of thinking and re-evaluating the objective of design than just buying new mechanical knowledge. Designing for net-positive begins with questioning the process of change in upstream designing and thinking.

Therefore, before setting a vision for a new or existing infrastructure, there is a need to understand the story of place and have central information regarding the location and history such as where the site is located, what does it stand for, what values need to be added to the social and ecological system to allow it to be healthy and whole for a positive impact in the larger surrounding.

FROM	TO
Negative	Positive
Doing Less Bad	Doing More Good
Return on Investment	Adding Value
Technique+Technology	Technique + Technology + Ecosystem Services
Utilitarian approach	Exchange
Building Performance Improvement	User Well-being
Linear Flow of Resources	Resource Recovery (Circular Economy)

Importance of Net-positive Infrastructure in Asian Countries

To understand the need and importance of net-positive developments in Asian cities, there is a need to understand the most pressing issues first.

Rapid urbanization and large population density in Asian cities continue to sprawl, and the demand associated with fossil fuels, energy, food, water is plausible to further upsurge. From ecological worldview all this is happening at the expense of speedy exploitation of natural resources, depletion of environment, compromise to quality of life and imbalance in ecosystem and ultimately leading to loss of bio-diversity. It is significant to note here that loss of bio-diversity and ecology is not linked to extinction of birds and other species only, rather it adversely affects the food production also.

Further, growth of urban areas has led to the issue of uneven economic and social landscape. In this scenario, struggle to maintain quality of life and meet the basic needs become the priority. This is the reason that sustainability concerns in Asian developing countries are different in qualitative terms than those in the developed counterparts. On one hand, where the developed countries are following the measures which can help maintain their living standard and efforts to reduce their carbon footprint, in developing countries emphasis is on to provide resources to meet the demands of basic human needs such as food, water, and sanitation along with combating the hazardous environmental impact.

Owing to majority of population still living in rural areas overall carbon footprint of Asian cities is lower than those of the developed countries which are the biggest contributor of GHG emissions. This implies that even though the urban growth is happening at very fast pace in Asian countries, if net-positive developments are adopted in time to alleviate the negative environmental impacts, then it is possible to 'regenerate' the lost natural services.

Moreover, it is predicted that more than 55% of world's new construction activities is expected to happen in Asian countries only. This provides a golden opportunity to Asian cities to practise this holistic approach of net-positive to fight the socio-economic and environmental issues and emerge as the leader of sustainable development.

In urban areas, density and regenerative development must go hand in hand. Frequent cause of dense urban developments is lack of green and public space available per capita. Planning should suitably address these concerns to increase the shareability within and around a development. More is the shareability, more sustainable a development is and more positive impact it has on other ecosystems.

Net-positive approach has the potential to make a community or city generate more than what they consume. Successful implementation of net-positive developments would enable cities to strengthen their social–economical–ecological capitals and ensure the regeneration of lost ecosystem services in the evolution of mankind.

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Circular Economy and the Built Environment in India: Closed-loops as Leverages

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Linear-based economy was introduced in India during the mid-19th century. Influenced by the industrialization in Europe, the importance of preserving and recycling in India went down, especially in metro cities. A throw-away culture became the new normal. However, the time has come for us to go back to our roots. This path of sustainability leads to circular economy. **Tarishi Kaushik** and **Riya Malhotra** have given their invaluable insights on the concept of circular economy, also emphasizing the responsible role it can play in combating human-induced environmental changes.

Background

Ancient India has showcased a strong link between its culture, society and people, and their living practices with the circular economy. People in that era, rooted in their age-old practices, were reusing, renovating, sharing and upscaling products in building construction by utilizing locally available natural materials and indigenous construction techniques that were eco-friendly, had a lesser carbon footprint, and were aesthetically pleasing.

However, the emergence of industrialized economies in India during the mid-19th century, changed the course to a linear-based economy which extracted resources from nature to make things, sell, use, and dump. Influenced by the industrialization in Europe, the importance of preserving and recycling in India went down, especially in big metro cities. A 'throw-away culture' was swiftly developed and mainstreamed where consumers didn't see where things came from and where they went. Construction and demolition (C&D) waste started to end up in ecosystems in non-biodegradable forms. Productivity enhancement and excessive discarding of building materials created by-products like carbon dioxide and methane, which further degraded natural capital.

Fortunately, many small towns and villages in India have kept the ancient practices alive which are now seen as advanced models of the circular economy. These energy and resource-efficient traditions and practices have strengthened many national development strategies today.

> *"A circular economy may be defined as a 'regenerative system in which resource input and waste, emission and energy leakage are minimized by slowing, closing and narrowing material and energy loops."*
>
> *Source Geissdoerfer, Savaget, Bocken,* et al. *(2017)*

When the coronavirus crisis hit the economies worldwide, the Indian construction industry faced a big slump during the lockdown phase. GDP from construction fell during the second quarter of 2020, a record low of INR1314.37 billion and during the second quarter of 2021 with INR2251.66 billion. As the lockdown was eased and construction businesses gained momentum, the GDP from construction started to increase, reaching INR3382.83 billion in the first quarter of 2022 from INR2670.74 billion in the fourth quarter of 2021.

As India is on its path to becoming the world's third-largest construction market by 2025, it

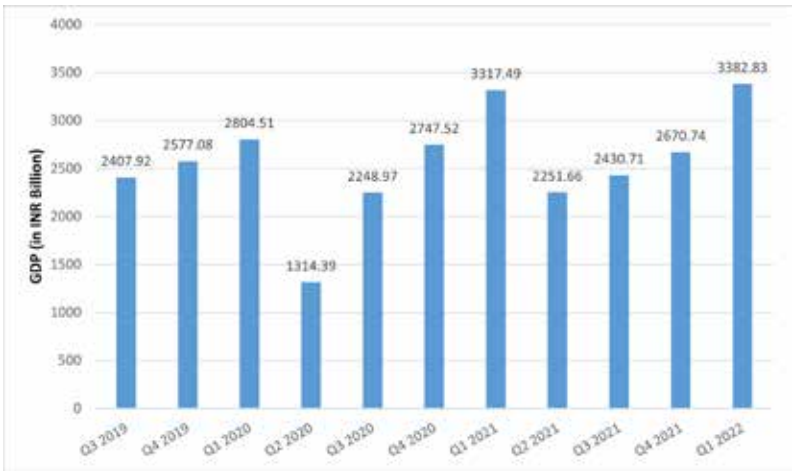

Figure 1: India GDP from construction: July 2019–March 2022 (in INR billion)
Source: Trading Economics (2022)

Table 1: Policy and initiatives in India to drive the circular economy in the built environment

Policy/ Initiative	Theme	Type	Year
Energy Conservation Building Code (ECBC)	Energy efficiency	Mandatory in notified states	2007
Mines and Minerals (Development and Regulation)	Resources extraction	Mandatory	2009
Perform, Achieve, and Trade (PAT) scheme	Energy efficiency	Mandatory	2011
Ash Utilization Policy Amendment (first released in 2009)	Waste management	Mandatory	2016
Rules for the Management of Construction and Demolition Wastes	Waste management	Voluntary	2016
Ready Reckoner for the Utilisation of Recycled Produce of Construction and Demolition Waste	Waste management	Voluntary	2018
Eco-Niwas Samhita (Residential Building Code)	Energy efficiency	Mandatory in notified states	2018
Building Materials Directory of India (BMDI)	Resource efficiency	Voluntary	2021
Policies focusing on up-gradation of resource re-utilisation and tax Incentives			
Year	**Policy/ Initiative**	**Description**	
2016	Bureau of Indian Standards	Bureau of Indian Standards (BIS) has issued a third amendment to IS-383:2016: Coarse and fine aggregate for concrete to include fine and coarse aggregate produced by processing of C&D waste.	
2017	Indian Road Congress	Indian Road Congress (IRC) has issued IRC-121: 2017 Guidelines for using C&D waste in the road sector.	
2017	Goods and Services Tax Council	The GST Council reduced tax rates to 12% on fly ash products. Presently, it is not at par with other building materials, such as red-clay bricks, earthen, or roofing tiles, with a 5% tax rate.	

Source: Malhotra, Behal, Choudhary, et al. *(2021)*

is projected that among all regions of the world, the fastest growth in buildings energy consumption through 2040 will occur in India (IBEF 2013). As far as C&D waste generation is concerned, India generates an estimated 150 million tonnes of C&D waste every year. However, the official recycling capacity is about 1%, that is, 6500 tonnes per day. The unofficial estimate of the total waste generated in India is three–five times more than the official counterpart. By 2017, 53 cities were expected to set up recycling facilities to recover material from the waste, but only 13 cities have done it till now (CSE India 2020).

In the last 15 years, the Government of India has been actively formulating policies and promoting projects to drive the country towards a circular economy. India has already realized the potential of this model in strengthening its economy and has started to develop regulatory measures and integrate them into its national policy frameworks to ensure a circular economy and closed loop systems.

Stages of the Circular Construction Life Cycle—Value and Outcomes

It is important to understand that a building's carbon footprint consists of the embodied carbon from the extraction, manufacture, and processing of building materials and construction, as well as the operational carbon from the energy use of its operations. Under the current ambit of the codes, it does not consider other sustainability parameters, such as embodied energy and life cycle assessment (LCA), that are significant for the selection and application of building materials. However, there are several green building rating bodies such as the GRIHA Council, and LEED that have incorporated LCA benchmarks for green building certifications.

Barriers and Recommendations

India's resource extraction per unit area is one of the highest globally (1579 tonnes/acre) compared to the global average of 454 tonnes/acre.

India's transition towards a circular economy depends on the market infrastructure, mandatory policies, and stakeholders in the value chains. The market demand per se in India overshadows the environmental necessities. Several studies underline that developing a reasonable business model for circular construction processes demands high costs of circular materials that hampers the circular economy implementation. Moreover, the reluctance of consumers to buy 'used' products and materials or pay a reasonable price with added community perception of the understanding of new technology is laborious. Considering these barriers, perhaps, leveraging on the circular transition with India's aim to achieve carbon neutrality by 2070 requires the embodiment of perseverance, constructive policy implementation, and knowledge dissemination on the global and national energy outlook.

Circularity is an integral element of the international policies on climate and is part of both adaptation and mitigation efforts. The mitigation actions include

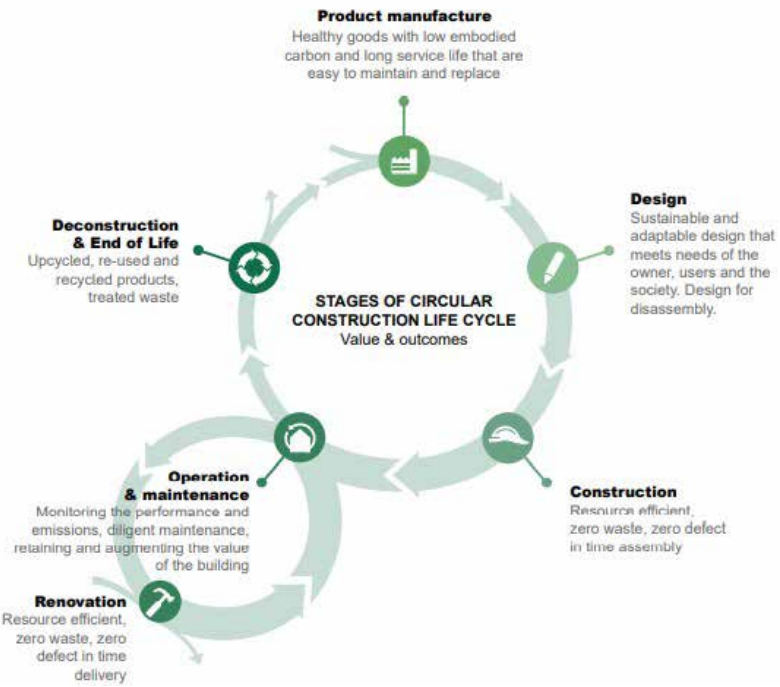

Figure 2: Stages of circular construction life cycle—value and outcomes
Source: Ninni Westerholm (2021). Developed from UNEP

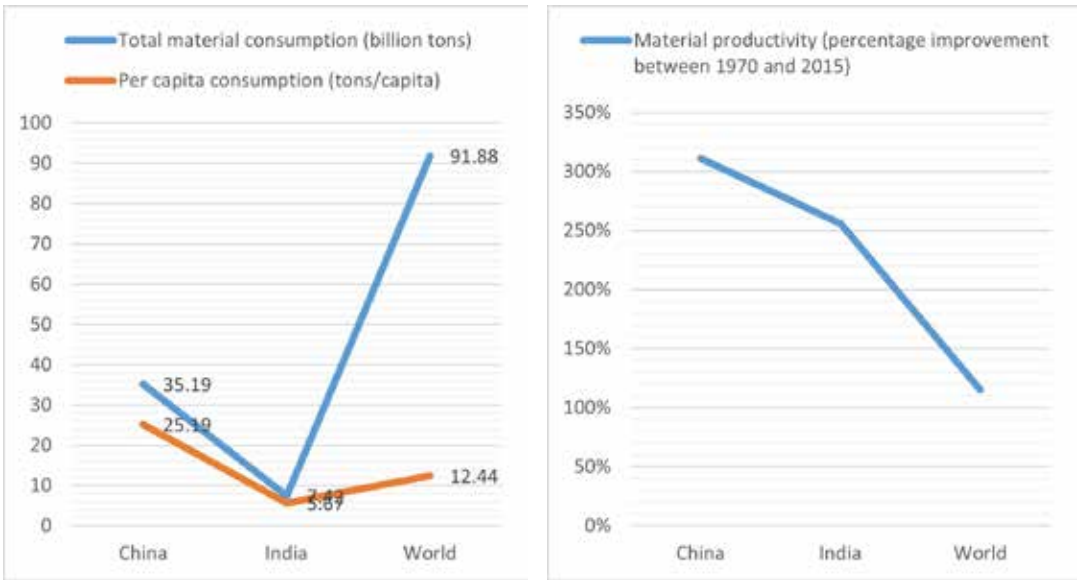

Figure 3: India versus global average: total material consumption and productivity
Source: Lin and Bhardwaj (2020)

achieving resource efficiency, through appropriate selection and design optimization, allowing reductions in the embodied carbon. The entire perspective of global- and national-level mitigation efforts to limit global warming to well below 2, preferably to 1.5 degrees Celsius is imperative.

Certainly, the necessary make-shift in India is not easy and requires a radical change in the value chains. To orchestrate significant close-loops to be possible at different socio-economic levels across all regions; enhanced data collection through material banks, development of metrics and labelling, advancements in new construction approaches, rigid and meticulous embodied energy policy mandates, and the disclosure of environmental performance data are some crucial instruments.

A detailed report on good practice case studies, policies at different life cycle stages, and an analysis of UN2030 agenda indicators were developed by the Sustainable Building Division at TERI as the Asia representative selected by the UN One Planet Network's Sustainable Building Construction (SBC). The report was launched at the United Nations COP26 Climate change conference. To deep dive into the circular built environment for India and other South Asian countries, reference to the detailed report available at <https://bit.ly/3lDvLzr> can be made.

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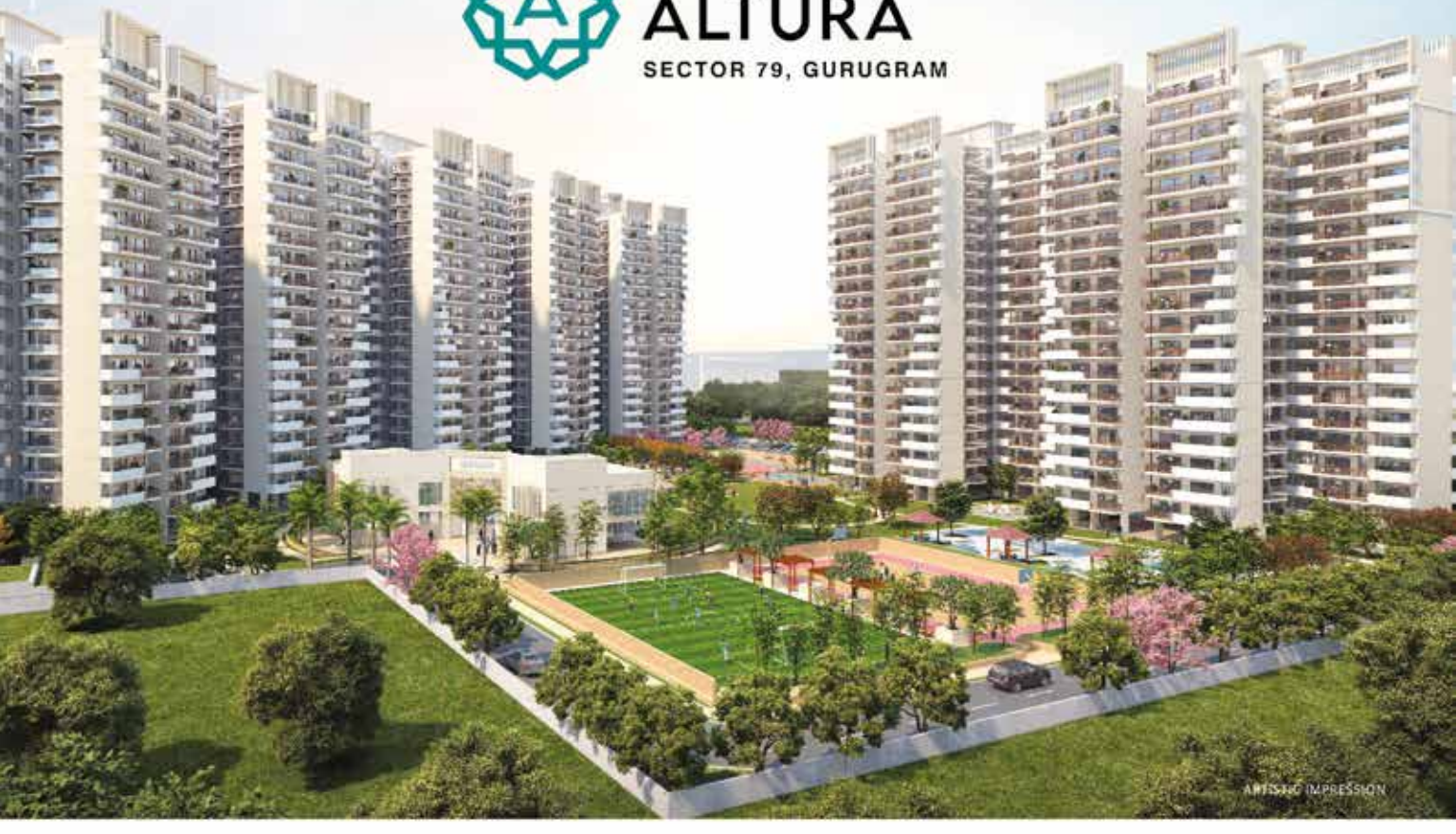

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Enlightenment on Indoor Air Quality

Ar. K. Saraswathi has more than 12 years of experience in field of sustainable design and green certification for high-performance buildings. She is a BREEAM Assessor (International) | LEED AP | WELL AP | IGBC AP | GEM CP | GRIHA CP and currently the Principal Architect-Partner at Conserve Consultants Private limited.
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Indoor air quality is significantly associated with a building's occupants' health. **Ar. K. Saraswathi** takes this concept further by emphasizing how materials that make a building have an impact on indoor air quality. Hence, care has to be taken while selecting such products, effectively to keep a check on their emission potential. The author aptly explains how carrying out indoor air quality assessment could be a determining factor in improving indoor air quality.

Imagine waking up in a heartfelt environment after a restless sleep at your home in spite of often dizziness created by the environment of the habitable space. Surprisingly, yes it is by the 'indoor environs' which has undergone a therapy to bring back the rejuvenation of human health.

In admiration of globalization, we, as humans, have lost the concentration on our health which our ancestors worshipped—the health as an ultimate goal in their way towards a seamless journey.

Interior building materials have a significant impact on indoor air quality. Paints, coatings, adhesives, sealants, flooring, wall panels, ceilings, insulations, and furniture are the major factors in the buildings where care has to be taken while selecting the products as these need to be low-emitting material.

Studies have mapped particulate matter (PM) exposure causes most of the coronary and respiratory diseases thereby has the potential to exceed the outdoor PM. The PM is a synthesis of solid and liquid particles string in air. Particles with 10 micrometres in diameter are highly hazardous and can be drawn in through nose and mouth.

Conserving excellent indoor air quality depends on checking the pollutant sources, removing contaminants and supplying outdoor air with due infiltration. Improper ventilation makes us exposed to volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and microbial pathogens.

Gaussian dispersion analyses and computational fluid dynamics are some of the computational tools that help us to analyse the pollutants entering the building. There are various standards to refer such as CDPH, CARB, SCAQMD, etc. Main methods of measuring VOCs are flame ionization detection and photo ionization detection. It measures the chemicals found in the air as most organic vapours produce positively charged carbon ions when they combust.

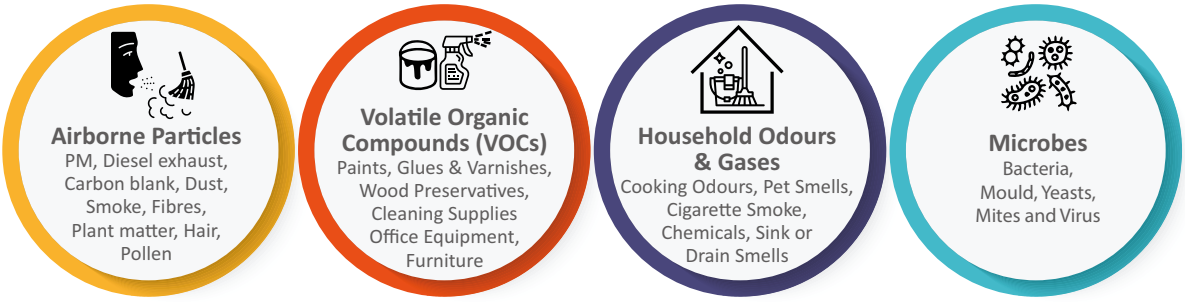

Figure 1: Factors affecting indoor air quality (IAQ)

Besides the combustion sources from cooking, burning candles, natural gas stoves and ovens, non-combustion sources such as laser printers, desktop 3d printers, steam irons, vacuum cleaner bags emit ultra-fine particles (UFP). Semi volatile organic compounds (SVOCs) which are stuck on the cooking pan also emit UFP when heated. Movements of a bed stirrup dust's resuspension rates increase with particle size and dust becoming detached from clothing are some invisible scenarios that typically occur in our day-to-day activities. $PM_{2.5}$ levels increase 2–5 times during vacuuming. PM emission would reach higher levels if the envelopes are sealed tightly to reduce the cost of air conditioning, then there is a higher chances of air exchange rate (AER) becoming more lower which in turn creates a higher humidity levels, thereby paving way for molds, bacteria, mites likely to be deposited (Figure 1). Care has to be taken on installing the ventilation and filtration systems with a proper maintenance has to be sought. Installation of High Efficiency Particle Arresting (HEPA) filtration units will be an added advantage.

Figure 2: Electrical low-pressure impactor (ELPI) device

One of the widely used measurements are obtained from instruments that use a weighing method called gravimetric method. Particles are collected in the filter as the air gets sucked up through a reweighed filter. Chemical analysis can also be done being the greatest advantage of this method. Methodology also involves pre-conditioning and post-conditioning of the filter. As substrates being sensitive to factors governing the environment such as relative humidity, choice of filter seems to play a major role.

PM_{10} concentrations' real-time monitoring can be achieved using optical instrument as it measures light scattering, light extinction, and absorption caused by a particulate matter. Optical Particle Counter (OPC) is another instrument using light source, kind of laser diode, illuminates the particles and a photodetector to measure the light scattered by those particles.

Electrical low-pressure impactor (ELPI) (Figure 2) and scanning mobility particle sizer (SMPS) (Figure 3) are the effective

Figure 3: Scanning Mobility Particle Sizer (SMPS) device

devices that help measuring the fine particles, and ELPI is a real-time device. Ultra fine particle surfaces are best characterized by the equipment called diffusion charger.

Natural or mechanical ventilation, magnitude of AER, HVAC systems, air tightness, penetration factor (which is the measure of efficiency of building envelope in terms of preventing particle infiltration) are the factors that drive variability in infiltration factors. When windows are open, AERs are 2–4 times higher depending on the wind speed and direction. After a retrofit, penetration factor undergoes a significant change.

Fresh air intakes needs to be designed to minimize the entry of air pollutants into the building. The openings should be at least 10m away from the source of external pollution.

Under the ventilation and monitoring of the indoor air there is a significant importance in carbon dioxide concentrations which needs to be monitored in each thermal zone at a height between 3 feet and 6 feet above the floor, thereby gives a warning when it exceeds the set point by 10%. Installation of direct exhaust airflow measurement and demand controlled ventilation regulates the outdoor air ventilation rate to keep carbon dioxide level in space below 800 parts per million (ppm).

Good indoor air quality not only leads us to a happy and healthy lifestyle but also supports energy and cost conservation, thereby initiating a step towards creation of 'healthy buildings' on the planet. Concentrating on the human health by improvising the indoor air quality is the need of the hour as the Covid has taught us the value of a human life, thereby avoiding sick building syndrome.

As a net-positive approach we need to take the responsibility for all our impacts, work for long-term benefits of the environment, embrace transformative partnerships and create positive outcomes for the stakeholders, thereby giving back more than that is being taken from the nature.

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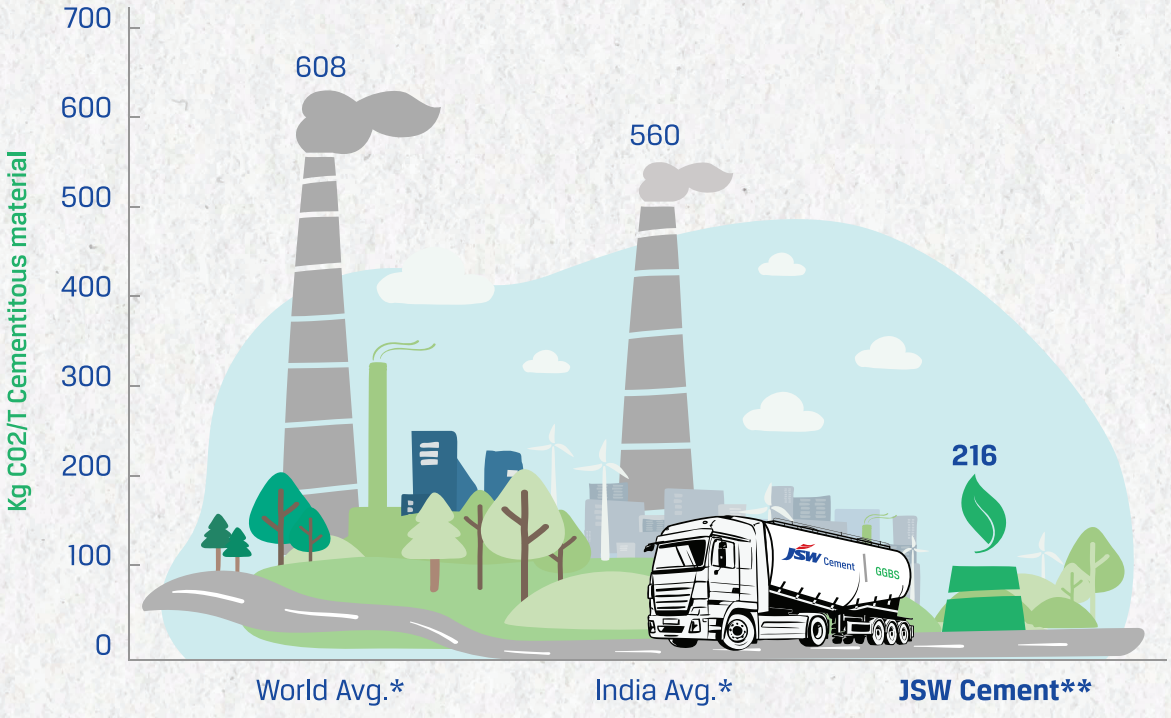

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