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Departments of Studies at the School of Planning and Architecture, New Delhi

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Editorial

This issue of SPACE, SPA Journal of Planning and Architecture includes six articles that offer insight into diverse research topics that aim to delve into the impact of green infrastructure for sustainable urbanization in India, development of design quality indicators for school built environment in the context of India, exploration of the philosophy, beliefs and practices of Sikh religion for the benefits of environment, study of indicators to assess circularity in the construction and demolition waste, discussion of paradigm shift from sustainable to regenerative design, and mapping the role of materiality and housing preference in rural India.

"Protecting Urban Landscapes: Innovative Environmental Practices for Climate Adaptation and Mitigation" presents an extensive review of existing literature to identify best practices in climate change adaptation, disaster risk management, urban green space planning and ecosystem services enhancement. The article outlines how sustainable practices contribute to conserving biodiversity, mitigating climate impacts and risks, strengthening disaster resilience and enhancing ecosystem services, with a specific focus on Indian cities facing rapid urbanization. Future consideration should be given to a matrix of adaptable solutions in fostering sustainable and healthy urban environments by Indian urban planners, architects, and stakeholders.

"Design Quality Indicators to Assess School-built Environment in the Context of India" aims to identify the key indicators to assess design quality based on relevant building standards, codes, building environment assessment methods and best practices across the globe. Further, these key indicators are articulated for school-built environments using three-level Delphi, confirmatory factor analysis and analytical hierarchy process involving the Indian building professionals.

"Convergence in religious philosophy, beliefs and practices of Sikhism for environmental actions" explores the role of religion in bringing awareness aimed at protective and regenerative environmental actions. This paper analyses the verses in the sacred scripture Sri Guru Granth Sahib (Sikh religion) in the context of respect, appreciation and significance of the environment. The qualitative research proposes a strategic environmental action model for aligning individual, community, and institutional initiatives towards environmental protection.

"Indicator framework to assess circularity in the waste from construction and demolition" the study seeks to solve the challenges in creating circularity assessment indices in the construction and demolition waste (CDW) sector. By defining the important aspects and elements that influence circularity performance and measurement, a framework of measurements and indicators for evaluating the effectiveness of the CDW sector is constructed. It offers direction to those creating tools and making decisions regarding how to comprehend the reasoning behind circularity indices in the literature on building environments. The selection of building materials, design concepts, construction techniques, operational efficiency, and end-of-life management are all important factors to take into account when evaluating circular economy (CE) in buildings. There is a total of 22 measures, divided into eight standard assessment categories.

"Evolving sustainable built environment: a paradigm shift to regenerative design" compares well-known building environmental assessment methods: CASBEE, LEED, BREEAM and GRIHA, and the existing sustainability assessment methods: iiSBE's Sustainable Building Tool (SB Tool), German Sustainable Building Council's Certificate Program (DGNB), Living Building Challenge (LBC) and ARUP's Sustainable Project Assessment Routine SPeAR®. Further, well-known theories of ecological sustainability and regenerative support tools are reviewed. Finally, two case studies of regenerative design are presented.

"Mapping material patterns in housing preference in rural India using multinomial logistic regression" the research delves into the binary of *kacchā-pakkā* (raw/not durable/temporary) and pakkā (cooked/ durable/ permanent) and then maps the transformation of rural dwellings from the traditional (*kacchā*) to the 'modern' (*pakkā*) in terms of building materials. Using data from different fieldwork sites – Poonch (Jammu & Kashmir), Birbhum (West Bengal) and Barmer (Rajasthan)—this study employs a multinomial logistic regression analysis to examine the relationships between the sociocultural and economic status of people and the materiality of their homes.

CHITRAREKHA KABRE

EDITOR

Protecting Urban Landscapes:

Innovative Environmental Practices for Climate Adaptation and Mitigation

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Abstract: The historical trend of urban development exacerbating environmental degradation has shifted with the rise of sustainability principles. This paper addresses the gap in understanding how urban green spaces contribute to climate adaptation and mitigation efforts, particularly in Indian cities facing rapid urbanization. The importance of green space planning to conserve biodiversity, mitigate climate impacts, manage disasters, and enhance ecosystem services is emphasized. Air pollution and climate change pose severe health risks, especially in India's urban centres. While progress has been made, there's a need for innovative, inclusive practices prioritizing environmental sustainability. The methodology includes an extensive review of existing literature to identify best practices in climate change adaptation, disaster risk management, urban green space planning and ecosystem services enhancement, with a specific focus on Indian cities. By examining global best practices, including case studies from Vicenza's terrace restoration and London's urban food banks, the paper highlights innovative strategies to enhance urban resilience, manage disaster risks, and improve ecosystem services. Integrating green infrastructure and sustainable practices in urban planning can strengthen resilience and mitigate risks. This underscores the urgent need for Indian cities to adopt tailored, evidence-based environmental practices to address their unique challenges, such as rapid urbanization and population growth, which exacerbate air pollution and climate change. By examining successful initiatives in diverse regions, from flood management in Toronto to vertical greens in Sweden, the paper offers a matrix of adaptable solutions to guide Indian urban planners, architects, and stakeholders in fostering sustainable, healthy urban environments.

Keywords: Climate Change, Urban Landscape, Environmental Practices, Climate Adaptation

सार: शहरी विकास की ऐतिहासिक प्रवृत्ति जो पर्यावरण क्षरण को बढ़ाती है, वह स्थिरता सिद्धांतों के उदय के साथ बदल गई है। यह शोधपत्र इस बात को समझने में अंतर को संबोधित करता है कि शहरी हरित स्थान जलवायु अनुकूलन और शमन प्रयासों में कैसे योगदान करते हैं, विशेष रूप से तेजी से शहरीकरण का सामना कर रहे भारतीय शहरों में। जैव विविधता को संरक्षित करने, जलवायु प्रभावों को कम करने, आपदाओं का प्रबंधन करने और पारिस्थितिकी तंत्र सेवाओं को बढ़ाने के लिए हरित स्थान नियोजन के महत्व पर जोर दिया गया है। वायु प्रदूषण और जलवायु परिवर्तन गंभीर स्वास्थ्य जोखिम पैदा करते हैं, खासकर भारत के शहरी केंद्रों में। जबकि प्रगति हुई है, पर्यावरणीय स्थिरता को प्राथमिकता देने वाले अभिनव, समावेशी अभ्यासों की आवश्यकता है। कार्यप्रणाली में शहरी हरित स्थान नियोजन, जलवायु परिवर्तन अनुकूलन, आपदा जोखिम प्रबंधन और पारिस्थितिकी तंत्र सेवाओं के संवर्द्धन में सर्वोत्तम अभ्यासों की पहचान करने के लिए मौजूदा साहित्य की व्यापक समीक्षा शामिल है, जिसमें भारतीय शहरों पर विशेष ध्यान दिया गया है। विसेंज़ा की छत बहाली और लंदन के शहरी खाद्य बैंकों के केस स्टडी सहित वैश्विक सर्वोत्तम अभ्यासों की जांच करके, शोधपत्र शहरी लचीलापन बढ़ाने, आपदा जोखिमों का प्रबंधन करने और पारिस्थितिकी तंत्र सेवाओं को बेहतर बनाने के लिए अभिनव रणनीतियों पर प्रकाश डालता है। शहरी नियोजन में हरित बुनियादी ढांचे और संधारणीय अभ्यासों को एकीकृत करने से लचीलापन मजबूत हो सकता है और जोखिम कम हो सकते हैं। यह भारतीय शहरों के लिए अपनी अनूठी चुनौतियों, जैसे कि तेजी से शहरीकरण और जनसंख्या वृद्धि, जो वायु प्रदूषण और जलवायु परिवर्तन को बढ़ाती है, का समाधान करने के लिए अनुरूप, साक्ष्य-आधारित पर्यावरण प्रथाओं को अपनाने की तत्काल आवश्यकता को रेखांकित करता है। टोरंटो में बाढ़ प्रबंधन से लेकर स्वीडन में वर्टिकल ग्रीन्स तक, विविध क्षेत्रों में सफल पहलों की जांच करके, यह पेपर भारतीय शहरी योजनाकारों, वास्तुकारों और हितधारकों को टिकाऊ, स्वस्थ शहरी वातावरण को बढ़ावा देने में मार्गदर्शन करने के लिए अनुकूलनीय समाधानों का एक मैट्रिक्स प्रदान करता है।

मुख्य शब्द: जलवायु परिवर्तन; शहरी परिदृश्; पर्यावरण अभ्यास; जलवायु अनुकूलन

1. Introduction

Historically, there has been an inverse relationship between development and the environment. The more cities expanded and urbanized, the worse the environmental impact. This was the norm for a long time until this practice was challenged by sustainability thought leaders. Today, there is an ever-growing awareness and acknowledgement that a healthy environment is vital for sustainable development in cities. Extensive literature review by Ashraf, Sarkar, Greens and Area (2015) made it evident that there is lack of knowledge regarding the utilization of urban green spaces for climate adaption and mitigation. Several pieces of literature prove best practices in green space planning to conserve urban biodiversity, adapt to climate change, manage disaster risks, and enhance ecosystem services in Indian cities (Govindarajulu 2014).

A key challenge with environmental management is the gamut of issues that come under it, and the factors that influence these, change rapidly. For example, the rate at which urbanization in Indian cities is progressing is unprecedented. Likewise, one of the significant reasons for environmental degradation in India can be attributed to the burgeoning population which adversely influences the natural resources. Air pollution and climate change are pressing issues that have profound implications for human health and well-being. The World Health Organization (WHO) assesses that air pollution causes millions of premature deaths every year, while climate change aggravates these risks through severe weather events and other secondary impacts. This paper aims to elucidate the connections between air pollution, climate change, and mortality, with a focus on both global trends and the specific context of India.

Numerous studies have documented the adverse health effects of air pollution and climate change on mortality worldwide. For example, the Global Burden of Disease study estimated that outdoor air pollution caused 4.2 million premature deaths worldwide in 2019 (GBD 2019 Risk Factors Collaborators, 2020). Similarly, climate change contributes to mortality through heat-related illnesses, vector-borne diseases, and food insecurity (Watts et al. 2021). These findings underscore the magnitude of the public health crisis posed by environmental degradation. The increasing urbanization and growth of megacities such as Delhi, Mumbai, and Kolkata face high levels of pollutants due to rising population and vehicle numbers. The SO_2 levels have decreased due to reduced sulphur content in fuels, NOx levels have risen due to more vehicles. (Gurjar et al. 2016). Climate change, driven by greenhouse gas emissions from fossil fuel combustion, negatively impacts health through increased heat waves, floods, droughts, and shifting disease patterns. Low-income countries are particularly vulnerable, but high-income countries are also at risk, as shown by the 2003 European heat wave. Effective adaptation and mitigation strategies, including public health initiatives and a shift to renewable energy, are essential to address these health impacts and reduce air pollution. (Salvador et al. 2020)

With several forward-looking initiatives taken by the government and non-government stakeholders in the last few years, there has been some improvement on the ground. However, the situation is far from adequate. As our cities push forward their development agenda, they will need to adopt innovative and inclusive practices that respect the threshold of disturbance that the environment can withstand naturally. Several other cities around the globe have taken this path and discovered solutions that worked for this. This aspect is really important because what works in one city may not necessarily work in another. Each city is unique and therefore its solutions for environmental management are also unique. (Mingaleva et al. 2020)

Environmental management in cities is changing, making it all the more necessary for cities to innovate and unearth new unique solutions to address the challenge. As cities in other parts of the world have shown, innovation serves a dual purpose (Demuzere et al. 2014). In addition to solving the problem, it also sets a benchmark for other cities to follow. Most Indian cities have a rich history and tradition, and sometimes a glimpse into the past can serve as an inspiration for designing context-specific solutions.

Environmental problems create a significant risk to health and well-being of people. It is important to find evidence-based innovative practices in urban areas to help planners, architects, and other stakeholders in their practice of the profession. Environmental practices have coherence on urban environmental issues that work in the niches of recycling, conserving water, improving air, buying environmentally safe products, and limiting driving (Zuniga-Teran et al. 2020).

Urban environmental problems are defined and pursued too generally, and then almost all urban development initiatives are labelled as leading to environmental concerns (Campbell, Svendsen, and Roman 2016). These concerns are threats to present or future human well-being, resulting from anthropogenic destruction to the environment. Cities need to improve their environmental performances; these environmental practices are the way forward to activities and help to rejuvenate the environment (Doherty 2017). Environmental threats are the highest for vulnerable groups of people and wildlife.

2. Transition from traditional urban development to sustainable practices in Indian cities.

The paper could delve deeper into the evolution from conventional urban development, which often prioritized rapid expansion and economic growth over environmental health, to sustainable urban practices that aim to balance development with ecological preservation. This transition is particularly crucial for Indian cities, which are experiencing unprecedented rates of urbanization and population growth, leading to severe environmental degradation.

3. Transition in Indian cities, advancing urban environmental sustainability through best practices in mitigating climate change

Cities can adopt best practices to mitigate climate change while simultaneously promoting food security. By integrating these efforts, urban environments can become more resilient and sustainable, safeguarding the health and livelihoods of their residents. Indian cities are specifically addressing this transition through various innovative and inclusive practices.

(i) URBAN AGRICULTURE: Urban agriculture projects, like rooftop gardens, community gardens, and vertical farming, offer opportunities to increase food production and decrease transportation-related carbon emissions. (Attwell 2000).

(ii) SUSTAINABLE FOOD SYSTEMS: Implementing sustainable food production and distribution systems, including agroecology and farm-to-table initiatives, can minimize environmental impacts and enhance food security (Foley et al. 2011).

(iii) GREEN INFRASTRUCTURE: Green infrastructure offers sustainable urban drainage systems (SUDS) that manage water quality and quantity, alongside benefits like flood mitigation, improved air quality, local climate regulation, urban biodiversity, public green spaces, and increased health and well-being. Current policies and laws promote the integration of GI in both new and existing developments (Bowen and Lynch 2017).

- Water Management: Cities are implementing sustainable water management practices, including rainwater harvesting, the creation of wetlands, and the restoration of natural water bodies. These initiatives help manage stormwater, reduce flooding, and improve water quality.

(iv) SUSTAINABLE TRANSPORTATION:

- Public Transport Systems: Public transport systems such as bus rapid transit (BRT) systems and metro networks reduces the dependence on personal vehicles, thereby decreasing air pollution and traffic congestion.
- Non-Motorized Transport: Promoting cycling and walking through dedicated lanes and pedestrian-friendly infrastructure is another key focus.

(v) RENEWABLE ENERGY ADOPTION:

- Solar Energy Projects: Many Indian cities are adopting solar energy projects for public buildings, street lighting, and residential areas. This shift to renewable energy sources reduces carbon footprints and promotes energy sustainability.
- Energy-Efficient Buildings: Implementation of green building codes and energy-efficient construction practices is becoming more common, contributing to reduced energy consumption and lower emissions.

(vi) POLICY AND REGULATORY FRAMEWORKS:

- Climate-Resilient Urban Planning: Integrating climate resilience into urban planning processes, including zoning regulations, land-use planning, and building codes, can help cities adapt to climate change events such as sea-level rise and extreme weather (Romero-Lankao et al., 2014).
- Environmental Regulations: Strengthening environmental regulations and ensuring their enforcement is critical. Policies that mandate green building practices, waste management, and pollution control are being implemented more rigorously.
- Community Engagement and Education: Engaging communities in decision-making processes and raising awareness about the links between climate change, food security, and urban environments foster a sense of ownership and encourage sustainable behaviours (Pelling et al. 2015).
- Incentives for Sustainable Practices: Offering incentives for adopting sustainable practices, such as tax benefits for green buildings or subsidies for renewable energy installations, encourages wider adoption.

Table 1. Traditional Urban Development vs. Sustainable Practices

S. No.	Traditional Urban Development	Sustainable Practices
1	Rapid Urbanization: Historically, Indian cities have expanded quickly, often with little regard for environmental impacts. This led to the encroachment on natural habitats, loss of biodiversity, and increased pollution.	Proactive Planning: There is a growing recognition of the need for proactive environmental management. This involves integrating green spaces into urban planning, using nature-based solutions to manage urban challenges, and prioritizing sustainability in policy-making.
2	Economic Prioritization: Economic growth was often pursued at the expense of environmental sustainability. Industrialization and infrastructure development took precedence over green spaces and sustainable planning.	Holistic Approaches: Sustainable urban development now considers the interconnectivity of various factors such as climate change, disaster risk management, and ecosystem services. This holistic approach ensures that solutions are multi-faceted and address multiple urban issues simultaneously.
3	Reactive Environmental Management: Environmental issues were typically addressed reactively rather than proactively, with policies often implemented only after significant environmental damage had occurred.	Community Engagement: Engaging local communities in decision-making processes has become essential. This participatory approach ensures that solutions are tailored to the specific needs and contexts of different urban areas.

4. Protecting and enhancing the urban environments - best practices adopted across diverse regions

The transition from traditional urban development to sustainable practices in Indian cities marks a pivotal shift in urban planning paradigms Table 1. This transition comprises of holistic approaches that consider the interconnectivity of factors like disaster risk management, ecosystem services and climate change. Moreover, sustainable urban development prioritizes community engagement, ensuring that solutions are tailored to the specific needs of different urban areas. This transition is particularly vital for Indian cities experiencing unprecedented urbanization and population growth, driving the imperative for balancing development with ecological preservation. These initiatives encompass diverse strategies such as urban agriculture, sustainable food systems, green infrastructure, sustainable transportation, renewable energy adoption, and robust policy and regulatory frameworks. By embracing these practices, Indian cities can mitigate environmental degradation, enhance resilience, and safeguard the well-being of their residents, thus heading towards a more sustainable urban future. The selection of the two projects, "Adopt the Terrace" and "Grow-A-Row, Share-A-Row," stems from their unique contributions to urban sustainability, as reflected in the matrix provided in Table 2A, 2B, 2C. These projects stand out due to their distinctiveness within the spectrum of best practices outlined.

a. Adopt the Terrace - Landscape of abandonment to adoption, Vicenza (Italy)

The Brenta River Valley boasts a remarkable series of dry-stone terraces spanning 30 kilometres in length and ascending 500 meters along mountain slopes, earning it recognition as a UNESCO World Heritage site. Originally, these terraces were cultivated for tobacco by residents, sculpting a distinctive landscape within the Venetian region. However, following World War II, industrial development led to the collapse of this terrace-based farming system, leaving the terraces idle for three decades and compromising slope stability (Hartswick 2013).

In 2010, a small-scale yet impactful initiative emerged to rejuvenate this traditional landscape by repurposing abandoned terraces, primarily through part-time voluntary efforts focused on environmental and heritage preservation. The goal was to reclaim these neglected lands for sustainable use. Specifically, the initiative targets the revitalization of terraces in Vicenza, Italy, situated within the steep and narrow valley terrain historically associated with tobacco cultivation. To date, over 100 terraces covering approximately 40,990 square meters have been adopted and restored through agricultural activities (Pristeri et al. 2021).

Approach and Method

The project centred on the conservation of heritage sites, involves two distinct phases for research and other activities related to terraced landscapes. The initial phase comprises scientific surveys focusing on historical and ethnographic aspects, particularly delving into the farming culture surrounding tobacco cultivation. Thereafter, specialized research teams were founded in association with local authorities, the Veneto regional government, and universities to establish a "local landscape observatory."

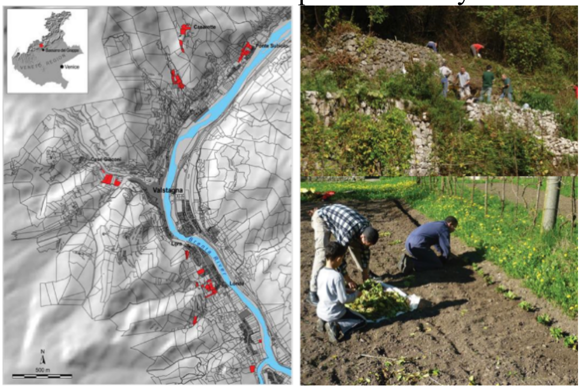

Figure 1. Location of the farming lands, Cadastral map of the territory of Valstagna, with the land adopted as of the end of 2013 highlighted in red. (Map by Luca Lodatti)

The process begins by identifying unused lands suitable for adoption, followed by contacting their owners to negotiate the adaptation of terraces under renewable five-year contracts. This procedure is facilitated through the project's website (www.adottaunterrazzamento.org), which promotes the initiative and helps long-distance adoptions through an annual cost paid by committee for dry-stone wall repair.

The project monitoring system includes a register of adoptions, featuring a digital database containing information on the new farmers (age, residence, education, occupation and distance from the project area) and the allocated plots (altitude, initial terrain conditions, width, surface area of terraces, dimensions of dry-stone walls, proximity to roads and water sources, end-use, and final conditions). Additionally, a geographic information system (GIS) was developed, utilizing the cadastre of the Valstagna municipality and integrated with the database.

This practice is being adopted by several countries globally, nowadays the modern term used as an umbrella to such kinds of practices is called Green Infrastructure. But the difference in the practice adopted by Vicenza, Italy is they focused on traditional abundant structures that need attention to save them historically, and that led to an environmentally conscious approach towards rejuvenation. This concept can be further implemented in Indian cities while understanding the Roof Top potentials of different built-ups. As Government offices and Institutional Buildings have larger rooftop surfaces, the first approach could focus on these types of land uses. Figure 1.

b. Grow-A-Row, Share-A-Row - Creating an urban food bank, in London (United Kingdom)

Originating in 1986, the initiative took root in Winnipeg, Manitoba, initiated by Ron and Eunice O'Donovan under the name Grow-A-Row. Since then, similar programs have sprouted in numerous communities across North America. In 2010, a non-profit organization (NGO) led by community directors was established in London to support the establishment of food banks in the region.

The Grow-A-Row, Share-A-Row initiative encourages gardeners to cultivate an additional row of their favourite vegetables and donate the produce to local food banks. This endeavour aims to support individuals in need while fostering a sense of community and the joy of cultivating and sharing fresh, nutritious food at no cost. The program welcomes participants of all ages, from young children to seniors, and caters to individuals with various gardening spaces, from large vegetable plots to balcony gardens with pots.

Approach and Method

Gardeners and volunteers sow seeds and tend to the garden, nurturing it until harvest time. Once the produce is ready, it is either donated directly to nearby food banks or collected by representatives. The harvested food is then weighed and recorded, adding to the contributor's tally. Keeping track of these donations is crucial for assessing the community's collective effort and reporting on the initiative's success. The committee assists gardeners and volunteers, offering guidance on composting techniques, compost usage, and recommending suitable crops for donation. This support helps optimize the impact of the program.

Figure 2. Haydn- Farm coordinator, He came to the garden via the kitchen. After 10 years working behind the scenes in restaurants, he stumbled into a job with the non-profit Lifecycles building raised vegetable gardens for people of low income, while teaching them the basics of home garden care

Table 2A. Urban Resilience and Climate Change (Urban Flooding): Matrix of the best practices across diverse regions

S. No.	Region	Best Practices & Overview
1.	**Toronto, Canada**	Adaptation to flooding Investment in stormwater management, parks, and urban forests.
2.	**Augustenborg, Sweden**	During the regeneration period from 1998 to 2002 • Significant physical changes in infrastructure occurred, focusing on development of sustainable urban drainage systems • Initiatives included the construction of ditches, retention ponds, green roofs, and additional green space • As a result, rainwater runoff rates have decreased by half, and increased greenspace has improved the image of the area As a result, rainwater runoff rates have reduced by 50%, and increased green space has enhanced the appearance of the area
3.	**Katrina, Louisiana City of New Orleans**	The resilience of the city to sea level rise – Hurricanes • restoration and conservation of wetlands as a buffer zone between the city and the sea • Wetland restoration and conservation activities in the New Orleans masterplan signal a significant change to flood-defense strategies
Urban Resilience and Climate Change (Urban Heating)		
4.	**Melbourne**	• Urban Forest Programme, Diverse urban forest • Increasing the canopy cover by forest and improving vegetation health • Water-sensitive city and urban design
5.	**Tokyo, Japan**	Since 2002, Tokyo's Metropolitan Govt has focused on mitigating Urban Heat Island (UHI) effects in its environmental master planning: • Installing pavements that reduce heat absorption and absorb moisture • Increased greening of roofs and walls, roadside tree plantings • Enhancing the wind flow through the city to dissipate heat
6.	**Stuttgart**	Stuttgart anticipates extreme weather events, a doubling of heatwaves in summer, an increase in the average annual temperature of up to 5°C, dry periods and increased water shortages Planning and traffic strategies of the city includes: • regional atlas for climate, as a basic planning tool for the communities; • landscape planning as "green infrastructure"; • promote public transport by rail; • housing development through streets suitable for short-distance traffic; • flood protection measures; • international networking and projects. Economic development strategies of Stuttgart include: • holding events, fairs, and international projects; • supporting clustering initiatives and demonstration projects; • establishing a centre of competence for (regenerative) fuel cells; • advising communities on measures for climate protection; • promoting electro-mobility and new technologies
Green infrastructure (Vertical greens as a building material)		
8.	**Sweden**	• Biotechnology approach studying both green wall modules and climbing vegetation • Solar-powered irrigation and storm-water recirculation will be tested. Guidelines for selecting substrate, plant species, and vegetation system and best practices for installation and maintenance will be produced
Green infrastructure (Incentive Green Roofs)		
9.	**Basel in Switzerland**	Basel initiatives aimed to increase the provision of green roofs initially driven by energy-saving programmes, and subsequently by biodiversity conservation • Highest area of green roofs per capita in the world • financial incentives and building regulations
Green infrastructure (Water Sensitive)		
10.	**Philadelphia**	Green City, Clean Waters is Philadelphia's 25-year plan to transform the health of the City's rivers and creeks primarily through a land-based approach. Green stormwater infrastructure projects such as rain gardens and stormwater planters Bio Swales
Green Spaces/ Open areas		
11.	**Vienna**	• Minimal soil sealing, planting of trees, shading, a high degree of urban greening, and greened façades and roofscapes, rainwater management are equally important • Conservation of cold air source areas and fresh air corridors
Urban farming		
12.	**Berlin**	Z Farm: urban farming with zero acreage • A policy framework that supports building integrated agriculture in Berlin • The inner-city cultivation of vegetables and fruits in existing buildings • Various stakeholders - including politicians, policymakers, urban planners, agricultural experts, active urban farmers, potential operators and interested residents - will be invited to participate. • New developments are required to integrate a proportion of greenspace. This is the Biotope Area Factor (BAF or BFF for BiotopFlächenfaktor). This requirement is part of a larger suite of directives relating to landscape design and planning, and species protection. It responds to the need to promote more green space in dense urban locations.

Table 2B. Resilience building process (permits and planning): Matrix of the best practices across diverse regions

13.	**Building level**	Chicago, USA	**Department of Buildings** The Green Permit Programme offers a fast-track permit process to promote developers to integrate environmentally conscious design features, including green roofs on new buildings.
14.	**Adopt a terrace**	Veneto, Italy	**Traditional Terracing** • The Committee "Adotta un terrazzamento" (Adopt a Terrace) acts as a mediator between people and landowners interested in "adopting" a terrace": with a contribution of 10 euros, any private citizen can be allocated a terraced plot to set up a vegetable garden. In exchange, the private citizen promises to restore and take care of the terrace assigned to him/her. • The recovery of the terraces raised the local resources, combining social/economic aims with the need to safeguard infrastructures that prevent hydro-geological instability.
15.	Project level - Building construction material	London, UK	**Sustainable construction for the London Olympics** • It has been built from materials 75 percent lighter than steel, the most conventional material used to construct other stadiums • Low-carbon concrete was utilized in its construction, which comprises of 40 percent less carbon than conventional concrete. • The Aquatics Centre contains many key low-carbon attributes including an outstanding ceiling above the pool fabricated from 30,000 sections of sustainably sourced Red Lauro wood.
16.	Plan Formulation	Calgary, Canada	**Resilient Strategy Plan** that was based on 4 pillars related to The Future of Calgary's Economy, Inclusive Futures, Natural Infrastructure, Future Ready Infrastructure Shared theme Integrating Resilience into Municipal Government
17.	Area-specific approach	Rotterdam, Netherlands	**Aimed to be fully climate-proof by 2025** **Green Blue adaptation** An area-specific approach • A robust and resilient water system by expansion and creation of new lakes called climate buffers • Rain gardens and facade gardens • Green banks enhance the water quality • Infiltrating, linear vegetation such as 'pavement planters' and 'bioswales' are effective strategies in public areas: green roofs, plazas, parks

The exploration of urban resilience and climate change adaptation strategies across various cities reveals diverse approaches aimed at mitigating environmental risks and fostering sustainability. From Toronto's investment in stormwater management to Augustenborg's regeneration with sustainable urban drainage systems, cities are taking proactive measures to address flooding challenges. Similarly, cities like New Orleans are enhancing resilience to sea-level rise and hurricanes through wetland conservation and restoration. Efforts to combat urban heating, exemplified by Melbourne's Urban Forest Programme and Tokyo's initiatives to reduce the urban heat island effect, showcase innovative approaches to temperature regulation and vegetation management. Stuttgart's comprehensive planning strategies anticipate and address future temperature increases and extreme weather events through landscape planning, public transport promotion, and flood protection measures.

Moreover, advancements in green infrastructure, including vertical greens in Sweden, green roofs in Basel, and water-sensitive projects in Philadelphia, highlight the multifaceted benefits of integrating nature-based solutions into urban development. Vienna's emphasis on open spaces and Berlin's Z Farm initiative underscores the importance of incorporating greenery and urban farming into city planning for biodiversity conservation and community well-being.

Resilience-building processes, ranging from Chicago's Green Permit Programme to Rotterdam's area-specific green-blue adaptation approach, underscore the significance of regulatory frameworks and collaborative efforts in enhancing urban resilience. Furthermore, initiatives like the Sendai Framework in Japan and Masdar City in Abu Dhabi demonstrate the global commitment to disaster risk reduction, renewable energy adoption, and sustainable urban development.

Table 2C. Urban resilience in sustainability: Matrix of the best practices across diverse regions

Sendai Framework for Disaster Risk Reduction, where 'build back better in rehabilitation, recovery, and reconstruction		
18.	**Japan**	**Disaster and 'Build Back Better' Policy Enforcement** • Enactment and enforcement of the law titled 'Disaster Countermeasures Basic Act' • Improvements of land use regulation to ensure the safety of areas from the same scale of hazards and improvements in the quality of embankments and dykes along the coasts. • Formulation of the Basic Disaster Management Plan • Institutional strengthening of government instrumentalities including ministries to reduce and manage disaster risk • The 'build back better' policies after the earthquake should be included higher investment in land adjustments (e.g., re-zoning, road widening and creating new spaces), disaster-resilient infrastructures, and citizen participation in recovery planning. • Disaster preparedness is part of the Japanese lifestyle, such as early-warning systems in buildings, community escape routes, evacuation signs at train stations, disaster-related apps on mobile phones, hazard maps, instructive comics as well as disaster-related programs on radios and TVs
19.	**Tokyo, Japan**	**Zero Carbon Cities** • Tokyo's zero-emission strategy • Move towards pitching out modernized urban amenities: "safe city," "smart city," and "diver-city" (the latter is an amalgamation of "diverse "and "city" as per Japanese script) • Seeks to integrate various water supply, treatment, and management infrastructures into a single infrastructure system perspective that considers the full life cycle of water provisioning in urban areas • Built a platform for subnational (prefectural and municipal) models of "local revitalization" SDGs • National Resilience Plan (Umbrella Plan) • Energy, environmental, city-planning, ageing society, forestry, space, and other plans. An additional 18 plans are slated to be added to the list, including the Comprehensive Innovation Strategy, the Global Warming Counter-Measures Plan, and the Basic Plan on Ocean Policy.
20.	**Masdar, Abu Dhabi**	Masdar City aims to be one of the world's most sustainable urban developments powered by renewable energy • Ensuring a low carbon footprint during and after its construction. • Being completely powered by renewable energy. • Reducing waste to as near to zero as possible, through encouraging changes in behaviour and regulating materials that can be present in the city. • Leading research and education into sustainable technology. • Designing the city streets and buildings to help create comfortable environments reducing the need for air conditioning, heating, and artificial light. • Educating three-quarters of the 40,000 residents with 5 hours of sustainability education each year. • Led research at its university to ensure the city retains its sustainable identification and leading knowledge in sustainable living. • Implementing full pedestrianization within the city, with the transport network below ground.
21.	**Frederiksted, Norway**	Frederiksted municipality -climate plan in 2007, decided to map Frederiksted's vulnerability to future climate change – in addition to efforts to reduce greenhouse gas emissions. The project report is the first total documentation in the NORADAPT project of a municipal strategy for climate adaptation: The vulnerability analysis is extensive and can serve as a model for other municipalities. It is divided into five main topics: • plan for the city areas and municipal plan; • roads, water and drainage; • health and pollution; • agriculture and forestry; and biodiversity. • Vulnerability under current climate conditions, • Societal characteristics of vulnerability, future challenges, and possible measures are all reviewed

5. Conclusion and recommendations

Urban resilience in sustainability requires a multifaceted approach encompassing policy interventions, community engagement, and innovative infrastructure solutions. By adopting inclusive and forward-thinking strategies, cities can effectively address climate change challenges, enhance environmental quality, and ensure the well-being of present and future urban populations.

The integration of green landscapes with spatial plans is not a new concept and many global cities have already integrated within their spatial plans and transition, driven by exacerbating climate impacts and events. It is crucial to consider urban green landscapes alongside the ecological while planning for adaptation and resilience.

Based on the insights gained from the case studies and literature review, here are specific policy recommendations for urban planners and policymakers:

(i) Integrated Urban Planning Framework: Develop an integrated urban planning framework that incorporates principles of sustainability, resilience, and community engagement. This framework should prioritize the preservation of green spaces, promotion of sustainable transportation, and implementation of climate-resilient infrastructure.

(ii) Green Infrastructure Mandates: Enact policies mandating the inclusion of green infrastructure in all urban development projects. This includes requirements for green roofs, permeable pavements, and urban forests to mitigate the urban heat island effect, improve air quality, and enhance biodiversity.

(iii) Incentivize Sustainable Practices: Offer incentives for adopting sustainable practices in urban development. This could include tax benefits for green buildings, subsidies for renewable energy installations, and grants for community-led sustainability initiatives.

(iv) Climate-Resilient Zoning Regulations: Update zoning regulations to incorporate climate resilience considerations. Designate flood-prone areas as conservation zones, restrict development in high-risk zones, and incentivize green infrastructure implementation in vulnerable areas.

(v) Climate-Resilient Building Codes: Strengthen building codes to incorporate climate-resilient design principles. Require new constructions to adhere to green building standards, including energy efficiency measures, natural disaster resilience, and sustainable materials usage.

This paper revealed that innovative practices have many environmental potentials that cater to environmental issues and need to encompass spatial plans that acknowledge green landscapes with the development plans of the city. Innovative practices in cities are one of the tools for a healthy environment. The objective of these innovative practices in the field of environment could be implemented to curb certain environmental issues at different scales of planning. For example, vegetation in urban areas offered many tangible benefits like urban trees sequestering polluted air and helping stormwater management. Their shade cools down city streets during summer and provides a habitat for native and migratory birds. Apart from filtering air pollutants and abating noise pollution, trees and green spaces aid in the regulation of thermal comfort through the passive cooling of the environment.

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Design Quality Indicators to Assess School-Built Environment in the Context of India

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Abstract: The National Education Policy 2020 has initiated a new era of learning in India and thus needs to rethink the design quality of the built environment of schools. Objective assessment of the quality of design is a complex issue in any built environment. In India, several standards and codes and different building environment assessment methods are used to evaluate different aspects of design. However, an integrated framework that assesses the quality of the design objectively for the built environment is yet to be formulated. So far, generally, design quality is a matter of perception and subjectivity of the individual. An extensive literature review identifies the need for a comprehensive design quality assessment framework. A theoretical background was established based on a review of several international and national standards, codes, and best practices. The Design Quality Indicator (DQI) of the Construction Industry Council, UK has been used as the basis for the formulation of the quality assessment framework in the context of India. A total of forty-four scholastic papers addressing the quality of school building design were selected for consideration. To identify the factors of the design quality, a questionnaire with 128 questions was created and a three-level Delphi was conducted online mode using a Likert scale. A total of 68 responses were considered for the relative relevance of each question was determined by calculating its average RII, and following three rounds of Delphi, the total number of questions were articulated to 110. A relative priority matrix was created using the "Required" (more than 4.5 RII), "Desired" (four to 4.5), and "Inspired" (less than 4) qualities. These 110 factors are run through Confirmatory Factor Analysis to test the DQI's factor structure to increase the framework's reliability, accuracy, and simplicity. Which further articulates the factors from 110 to 65. Finally, an AHP has been conducted with the help of 36 experts in the field of architecture to conduct a pairwise weighing survey to generate an objective framework to assess the design quality of the school buildings in the Indian context.

Keywords: Design quality indicators, School built environment, Delphi technique, Analytical Hierarchy Process, and Confirmatory factor analysis.

सार: राष्ट्रीय शिक्षा नीति 2020 ने भारत में सीखने के एक नए युग की शुरुआत की है और इसलिए स्कूलों के निर्मित वातावरण की डिज़ाइन गुणवत्ता पर पुनर्विचार करने की आवश्यकता है। किसी भी निर्मित वातावरण में डिज़ाइन की गुणवत्ता का वस्तुनिष्ठ मूल्यांकन एक जटिल मुद्दा है। भारत में, डिज़ाइन के विभिन्न पहलुओं का मूल्यांकन करने के लिए कई मानकों और कोडों और विभिन्न भवन पर्यावरण मूल्यांकन विधियों का उपयोग किया जाता है। हालाँकि, एक एकीकृत ढांचा जो निर्मित वातावरण के लिए उद्देश्यपूर्ण रूप से डिजाइन की गुणवत्ता का आकलन करता है, अभी तक तैयार नहीं किया गया है। अब तक, आम तौर पर, डिज़ाइन की गुणवत्ता व्यक्ति की धारणा और व्यक्तिपरकता का मामला है। एक व्यापक साहित्य समीक्षा एक व्यापक डिजाइन गुणवत्ता मूल्यांकन ढांचे की आवश्यकता की पहचान करती है। कई अंतरराष्ट्रीय और राष्ट्रीय मानकों, कोडों और सर्वोत्तम प्रथाओं की समीक्षा के आधार पर एक सैद्धांतिक पृष्ठभूमि स्थापित की गई थी। निर्माण उद्योग परिषद, यूके के डिजाइन गुणवत्ता संकेतक (डीक्यूआई) का उपयोग भारतीय संदर्भ में गुणवत्ता मूल्यांकन ढांचे के निर्माण के आधार के रूप में किया गया है। स्कूल भवन डिजाइन की गुणवत्ता को संबोधित करने वाले कुल चौवालीस शैक्षिक पत्रों को विचार के लिए चुना गया था। डिज़ाइन की गुणवत्ता के कारकों की पहचान करने के लिए, 128 प्रश्नों के साथ एक प्रश्नावली बनाई गई और फिर लिकर्ट स्केल का उपयोग करके ऑनलाइन मोड पर तीन-स्तरीय डेल्फ़ी आयोजित की गई। कुल 68 प्रतिक्रियाओं पर विचार किया गया, प्रत्येक प्रश्न की सापेक्ष प्रासंगिकता उसके औसत RII की गणना करके निर्धारित की गई थी, और डेल्फ़ी के तीन राउंड के बाद, प्रश्नों की कुल संख्या 110 तक कम हो गई थी। फ्रेमवर्क की विश्वसनीयता, सटीकता और सरलता को बढ़ाने के लिए DQI की factor analysis का परीक्षण करने के लिए इन 110 कारकों को पुष्टिकारक कारक विश्लेषण के माध्यम से चलाया जाता है। जो कारकों को 110 से घटाकर 65 कर देता है। अंत में, 36 विशेषज्ञों की मदद से एक एएचपी का आयोजन किया गया है, ताकि डिजाइन की गुणवत्ता का आकलन करने के लिए एक वस्तुनिष्ठ ढांचा तैयार करने के लिए जोड़ीवार वजन सर्वेक्षण किया जा सके।

मुख्य शब्द: डिज़ाइन गुणवत्ता संकेतक, स्कूल निर्मित वातावरण, डेल्फ़ी तकनीक, विश्लेषणात्मक पदानुक्रम प्रक्रिया, और पुष्टि कारक विश्लेषण।

1. Introduction

The National Education Mission (Samagra Shiksha Abhiyan) of India launched in 2018 is a programme for school education from preschool to class 12 (K12). It was allocated a budget of ₹385.72 billion in the 2019 Interim Union Budget of India. There is an increase in the budget for school education in India from 2021-22 to 2024-25 by 46 per cent (refer to Table 1). There has been an overall increase of ₹12,024 crore (19.56%) in the Budget Allocation of Department of School Education and Literacy in the FY 2024-25 from RE 2023-24. It is clear from Table 1 that the investment in the education sector has increased, therefore, there is a need for physical spaces to make this investment work efficiently. The Sustainable Development Goal 4 (SDG4) mandates the provision of 'equitable' and 'inclusive' quality education for all by 2030 and it is UNESCO's (2020) global education agenda. It, therefore, demands high design quality of school-built environment since it plays a vital role in shaping the students' behaviours, health and well-being and their educational success (Cassidy 1997). Additionally, an evaluation of the design of the existing schools must be conducted to determine the standard of the spaces that have been established.

Table 1. Budget allocation in the education sector in India, 2023- 24 (Reference: Expenditure budget 2021- 22 & Notes on Demands for Grants, 2023-2024, 2024-25 (https://www.indiabudget.gov.in/) and https://pib.gov.in/ as accessed on 31.05.2024

Notes on Demands for Grants, 2023-2024			
Budget 2022-2023	Revised 2022-2023	Budget 2023-2024	Budget 2024-2025
63,449	59,052	68,804	73,498
All figures are in crore			

Therefore, to assess the design quality a framework is required which will quantify the appropriateness of the design of school buildings in India and make a DQI framework for the future design of the schools.

Quality is one of the triple attributes in any project; the other two are time and cost. The value of any project is dependent chiefly on these three pillars (Refer to Figure 1). Project Management Institute defines project value as the value it creates for its stakeholders in terms of effectiveness and satisfaction (Lechler 2010). The success of any project is primarily a balancing act of managing these three attributes. While there are measuring tools for both time and cost, quality is not assessed objectively.

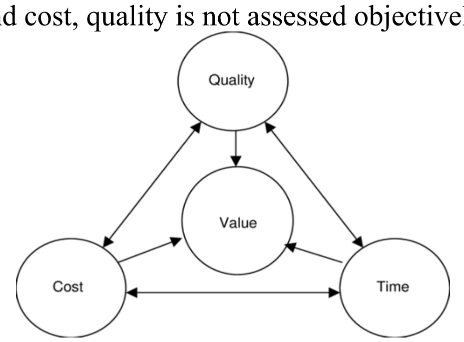

Figure 1. Value as a function of time, cost, and quality, source: author

Cambridge Dictionary defines quality as "of a high standard" or "the degree of excellence of something, often a high degree of it". The Oxford Dictionary defines quality as "The standard of something as measured against other things of a similar kind".

The value of design to its user can be considered as the quality of design. The design could be for any product, service, system, or experience. The design quality is a function of any combination of usability, performance, aesthetics, reliability, predictability, stability, consistency, safety, and security (Amanda et al 2018). Assessing design quality is still in a very elementary stage in developing countries like India, though it significantly impacts the satisfaction of the end users. The building is a product of design, and the quality of the building depends on the quality of the design. ISO 9000 (2015) on Total Quality Management includes customer satisfaction in the organization's objectives. In the case of buildings, the end users are the primary customers of the product. The quality of design improves the efficiency of the building. Assessing the design quality in different stages of the project life cycle is essential. The quality can be evaluated during the briefing, predesign, construction, and pre- and post-occupancy stages. Also, all the factors in the design might not have the same weightage on the assessment scale (Cardellino et al 2010).

2. Review of literature and theoretical framework

The idiosyncrasy of the architectural design process is that it is a fusion of creative and scientific infusion resulting in the architectural potential for the adaptation of the environment to identified human purposes (Herbert 1966). As per the Domain Theory, architectural design is both the process and the product, which is made up of several phases and phases consisting of parallel and serial activities (Bax et al 2001). With the invention of new technology, architectural design is becoming more complex day by day. A participated design approach requires the will and competence of each team member, including architects, engineers, urban planners, and contractors. The procurement process for the building has become complicated due to various factors like the quality of projects, cost to the client, and time of completion. From traditional design-bid-build through design-build and management system of procurement, to public-private partnership the procurement process has transformed a great deal (Greenhalgh and Squires 2011). ISO 9001: 2015 promotes the application of a process-based approach for developing, implementing, and upgrading the effectiveness of a quality management system to raise client satisfaction. Total quality management (TQM) is a management theory whose goal is to increase a company's capacity to provide quality to its clients on a foundation of continuous improvement. This applies to both the product and the services. As a building is a product of design total quality management applies to building design as well. Indicators of design quality vary with the location of buildings, building typology, types of users etc. To study the factors influencing the design quality of school buildings in the context of India, it is important to know various building environment assessment tools used worldwide and specifically in India. To establish the theoretical background of the design quality assessment of school buildings, various codes and standards, like, the National Building Code of India (BIS 2016), IS 8827 (BIS 1978), Recommendations for basic requirements for school buildings), Compendium of Architectural Norms & Guidelines for Educational Institutions by CPWD, BS7850 – 1: 1992, British Standard were studied and compared. Various design quality assessment tools have been produced and followed in various countries for more than a decade now. While the Housing Quality Indicator (HQI) of the UK, 'Building for Life' by CABE in the UK, and the Home Quality Mark by BREEAM are used specifically for residential buildings, the Design Quality Indicator (DQI) of the United Kingdom by the Construction Industry Council provides separate indicators for school buildings along with other typologies. The quality criteria for Indian schools were finalized from the criteria mentioned in the aforementioned bylaws, standards, and quality indicators. Along with that a thorough literature survey of 177 research papers has been done on the topics mentioned below,

i) Architectural design process: 45
ii) School Design: 35
iii) Design quality indicators: 47
iv) Post-occupancy evaluation: 50

The study of the above literature formed the theoretical background and the scoping review. Then the literature survey was narrowed down to 44 research articles discussing the school's design quality. Out of those 44 research papers, 13 papers were selected to identify the categories and the criteria of design quality indicators. Those criteria were used to formulate the questionnaire for the expert survey.

2.1 Significant findings from the literature review

Among the 44 research papers on design quality and school design, 13 have been selected, which have listed down all the criteria from DQI of the Construction Industry Council, UK that make a project successful and validated them involving the project stakeholders in different stages of projects. The DQI criteria, namely Use, Access, Space, Performance, Engineering Systems, Construction, Internal Environment, Form and materials, Character and innovation, Urban and Social Integration, and their various attributes are mapped through these 13 research papers to understand the frequency of occurrences of different indicators also the inclusion of quality indicators in each literature (refer to Table 5 in appendix 1). Out of 44 indicators of DQI, individual research papers covered as low as three to a maximum of twenty-three indicators and/or attributes. A higher number of indicators included in the assessment framework means a high success rate and accuracy of the design assessment, which brings stakeholders' involvement and satisfaction to the project, making a project a delight. On the other hand, the frequency justifies the importance of one indicator in the entire list and people's acceptance of the indicator while assessing the design quality.

3. Methodology

3.1 Problem statement

Design quality management is a complex issue in any construction project. In India, several standards and codes like the National Building Code 2016, several BIS standards and different building environment assessment methods are used to judge different design aspects. However, no tool or method has been developed yet to assess design quality objectively. As a result, design quality has remained a matter of perception of individuals and subjectivity. As there is a need for a new age education system in India and the Government has been allocating more budget towards it (refer to Table 1), there is a need for physical space to make this investment work efficiently. Further, these schools would be functionally efficient if the design quality is good and also the increased budget towards built facility should be justified. Therefore, to assess the design quality, a framework is required to quantify the appropriateness of the design of school buildings in India and make a DQI framework for the future design of the schools.

3.2 Research aim and objectives

The aim of research is to develop a design quality assessment framework for school buildings in the context of India based on the Indian codes and standards and building environment assessment methods. The objectives of research are as stated hereinafter:

i) To review the state-of-the-art design quality assessment methods and classify them based on their application and domain.

ii) To review building environment assessment methods and relevant Indian codes and standards pertinent to the design of school buildings.

iii) To identify different applicable categories and criteria to form the dimensions of the design quality assessment methods by participation and consensus of experts in the design field.

iv) To determine an intermediate weightage of all the criteria and their relative importance in determining the design quality of schools in India.

3.3 Scope and limitations

The design requirements vary depending on the type of building. As a result, the evaluation tool will vary depending on the type of building. The design assessment of the Indian urban education sector will be the main emphasis of this study. In India, the education sector is growing. As previously mentioned, there is a great need for well-designed schools in India because of advancements in teaching methods. The outdated infrastructure is unable to keep up with the rapid advancement of information technology-based teaching practices. The spatial requirements in the school buildings are also changing. In this research, the author will develop a framework to assess the design criteria which will be applied on three case study schools. The schools selected as case studies could be one Government school, one Government school and one private school. This variety of types of schools will provide a wide range of assessment criteria. However, the study will be limited to the Indian urban context only.

3.4 Significance of the research

Traditionally, architectural design used to be handled in a more repetitive, consistent, and intuitive manner (RIBA, 2020). With the altering disposition of clients' team, design team, and project team the design of projects is now a more complex issue and requires to be dealt with more understanding. Throughout the project's life cycle, there are numerous stakeholders whose connections with the project may or may not be contractual. Managing and responding to numerous types of opinions coming from various stakeholders at different stages could be complex. A systematic involvement of various project stakeholders can minimize the complexity. This collaborative design process can bridge the gap between the users' aspirations and the designer's imagination (Coughlan and Macredie 2002). Studies have established that inadequate stakeholder management is one of many causes of project failure (McManus 2008). Conflicts between users, large numbers of users, lack of users' participation, non-willing users, and unrealistic expectations are some of the causes (Taherdoost and Keshavarzsaleh 2015) that lead to project failure. Therefore, there is a need to involve project stakeholders systematically throughout the project lifecycle to assess the design quality. Till today, assessing design quality remains a subjective process which highly depends on the experience of the individual. Many countries have already started to assess design objectively. In the United Kingdom, the Construction Industry Council developed the Design Quality Indicator tool and has already applied it to 1400 projects worldwide over 19 years since 2003 till date. In India, there is no such single assessment tool available as of now, which evaluates any project holistically. The buildings which are designed as per the local and national bye-laws and codes, sustainability, and energy conservation guidelines, only cater to the fundamental quality aspects. However, for the design quality to reach the value added or excellence stature, there is a need to develop a single assessment tool which could objectively quantify the architectural design quality.

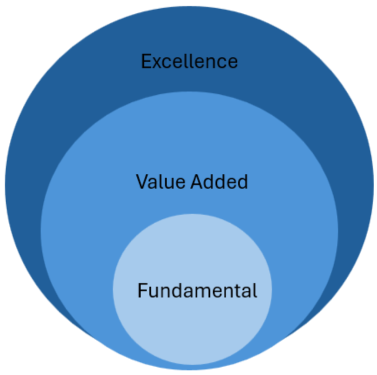

Figure 2. Quality of design (Fundamental, Value added and excellence). Source: Construction Industry Council of UK, 2003

3.5 Research Design

Research design involve six discrete steps to meet the objectives of the research and are delineated in Figure 3.

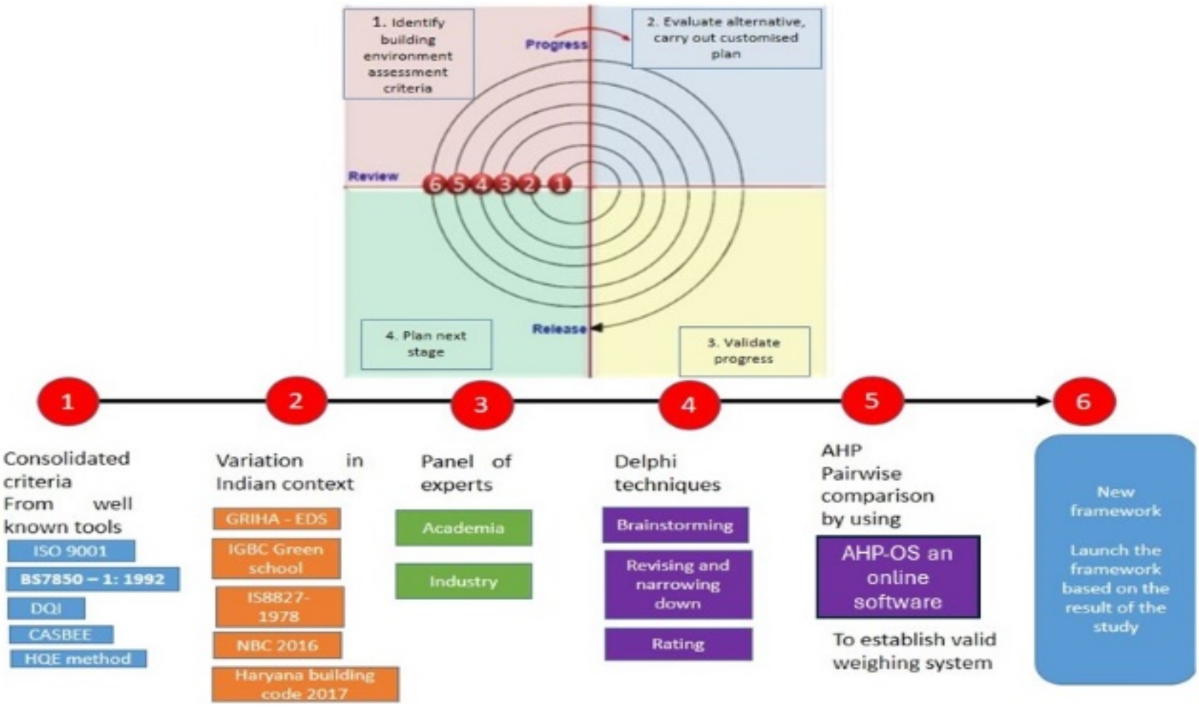

Figure 3. Research Design to develop Design Quality Indicators for School built environment, source: author

4. Delphi data collection process

A survey questionnaire was formed which includes all the questions from DQI meant for school. Following the same format of DQI of the United Kingdom an expert survey was conducted with experts from industry and academia. The panel consists of the faculty of architecture, practising architects, project managers, school principal, and retired NCERT personnel. The intent of doing the expert survey was to validate the questionnaire consisting of design quality criteria being followed in the UK, and in the Indian context and to determine the relative importance of the criteria.

4.1 The relative importance index from the Delphi technique

The questionnaire consists of 128 questions, representing the criteria for design quality were divided into 11 subgroups. The 10 subgroups consisting of 122 questions, namely Use, Access, space, building performance, building engineering services, Construction, Internal environment, Forms and materials, Character and innovation, and Urban and social integration were taken from DQI introduced by the Construction Industry Council, UK (Gann, 2003). The sustainability criteria have been added to the already existing framework as the sustainability and design quality have started overlapping their paradigm (Gwilliam 2018). The responses are based on a Likert scale of zero to six. Where 'zero' is "not applicable" and six is "strongly agree". The first level of Delphi consists of 36 respondents. The panel consists of faculty of architecture, practising architects, project managers, school principal, and retired NCERT personnel and their experience ranged from 7 years to 35 years. The experts were selected based on their expertise in the field of education, and architecture. The Delphi questionnaire was sent to the experts with the help of Google Forms and telephonic discussions were conducted for clarifications of the questions. The questions asked in the first Delphi which scored a RII (discussed in 3.6.1) lesser than 4.0 were discarded and the total number of the criteria came down from 128 to 113. Then the second level of Delphi was carried out by following the same process as followed in the first Delphi. The respondents of the first Delphi were communicated through email for their availability and willingness for the second level of Delphi. This time the survey was answered by 25 respondents. A third level Delphi was conducted involving 7 users namely school administrators, and teachers. The third level Delphi was paper-based and conducted by meeting the respondents in person by the author.

4.2 Factor reduction and scale development

4.2.1 Creating importance level for variables

The total responses of 68 (36+25+7) respondents were taken into consideration in three-level

Delphi while calculating the RII of the criteria. The RII is given as

RII = ΣW/ (A*N)

Where W is the weighting given to each question by the respondents (ranging from 1 to 6), A is the highest weight (i. e. 6 in this case), and N is the total number of respondents. The 'not applicable' criteria, as it was assigned 'zero' do not have any bearing on the calculation of the RII. The higher the value of RII, the more important the criteria in measuring design quality. The importance level of RII is given in Table 2

Table 2. Importance level from RII

Level	Score
High (H)	0.8<RII<1.0
High- Medium (H-M)	0.6<RII<0.8
Medium (M)	0.4<RII<0.6
Medium - Low (M-L)	0.2<RII<0.4
Low (L)	0.0<RII<0.2

The final RII showed a high value for most of the criteria and High – Medium for only 4 criteria namely

i) There should be sufficient car parking
ii) The building and site layout should cater for cyclists
iii) The building will cater for the needs of people with impaired sight
iv) The boundary treatment is suitable

Table 3. Credit distribution based on weightage

Weightage	Credit
5.5 to 6	3
5 to 5.5	2
4.5 to 5	1

It follows that every criterion selected to determine the level of school building design excellence is crucial and necessary.

A category ranking was obtained by taking an average of the weights of all the criteria coming under a category. Each criterion was assigned with a credit of either 1, 2, or 3 based on the final weightage calculated after three levels of Delphi. The distribution of the credits is shown in Table 3.

4.2.2 Factor reduction through Factor analysis and reliability test of variables

Though the variables of DQI are established in the public domain, however, a Confirmatory Factor Analysis was conducted to purify the list and articulate the number of variables which should be suitable for school buildings in the Indian context. The objective would be to determine the degree to which the factors and assessment items associated with each dimension account for the variability in the responses in that dimension. The analysis that is produced facilitates to average or aggregate of all of the pertinent measurement data items corresponding to each relevant factor. It extracted 65 variables from 122 total variables based on the correlation matrix. The rotation method followed in this analysis is Varimax with Kaiser Normalization which decreases the standard errors of the loadings for the variables with small commonalities. All these 65 variables were then run through a reliability analysis. The reliability test evaluates the consistency between various measures of a variable. The Cronbach's Alpha test was applied here. The value of Cronbach Alpha thus received is given in Table 4.

Table 4. Experts' factor analysis and reliability

Functionality	Number of factors (eigenvalue >1)	19
	Variance explained	79.382%
	Cronbach's Alpha Based on Standardized Items	0.929
	KMO	0.565
Build Quality	Number of factors (eigenvalue >1)	17
	Variance explained	81.266 %
	Cronbach's Alpha Based on Standardized Items	0.963
	KMO	0.682
Impact	Number of factors (eigenvalue >1)	16
	Variance explained	76.591%
	Cronbach's Alpha Based on Standardized Items	0.947
	KMO	0.771

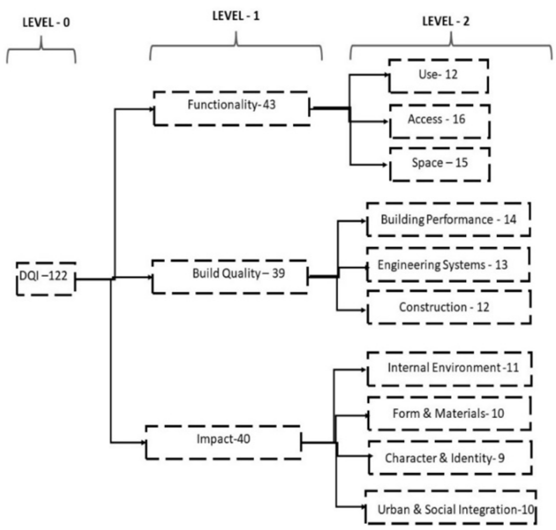

Figure 4: Revised DQI structure using original factors and dimensions.

5. Analytical Hierarchy Process

Thomas L. Saaty in the 1970s pioneered the use of AHP, a multi-criteria decision-making (MCDM) strategy (Harputlugđl 2009). It makes use of a multi-level hierarchical structure for its goals, decision-makers, criteria, and alternatives. A series of pairwise comparisons is used to get the relevant data. These comparisons are used to determine the relative performance measurements of the alternatives about each choice criterion as well as the weighted significance ratings of the decision criteria. It offers a way to increase consistency if the comparisons are not entirely accurate (Saaty 1980, Harputlugil et al. 2009).

36 experts from the field of architecture, construction and education were requested to fill out an AHP format prepared with the help of Google form. The first two levels of criteria were considered for AHP in this stage (refer to Figure 4). The experts were asked to provide relative importance on a scale of 1 to 9 as mentioned in AHP (Satty 1970).

Based on the responses of the experts a decision hierarchy was generated by the online software where the consistency ratio was accepted below 10 percent. Table 5 shows the category-wise weighing coefficients of the variables. For any project design design quality can be achieved by the the following formula:

Design Quality Indicator = Σ (Achieved credit / Available Credits - Not applicable credits) x weighing Co efficient x 100

Table 5. Category ranking, factors, credits, and weighing coefficient of variables

S. No.	Variable	Overall ranking of category (Mean)	Number of factors	Number of Credits	Weighing coefficient from AHP
A1	Use	5.237	7	12	0.2180
A2	Access	5.069	10	18	0.1069
A3	Space	5.389	9	22	0.1465
B1	Building Performance	5.394	7	16	0.1937
B2	Building Engineering Systems	5.924	8	18	0.0673
B3	Construction	5.421	7	15	0.0519
C1	Internal Environment	5.381	5	14	0.1200
C2	Forms and material	5.327	5	12	0.0477
C3	Character and Innovation	5.218	4	8	0.0270
C4	Urban and social integration	5.107	3	5	0.0203
	Total		**65**	**140**	**1.0**

6. Discussion and Conclusion

The variable reduction was done through three stages Delphi and confirmatory factor analysis. The confirmatory factor analysis has purified the numbers of variables in a most parsimonious way. It has articulated the number of factors from 122 to 65. These 65 variables have been selected for the formulation of the framework. A reliability analysis has also been conducted on the variables separately for functionality, build quality and access. The value of Cronbach's Alpha for reliability ranges between 0 and 1. The more it is close to 1, more higher the reliability. The value of Alpha for functionality, Build quality, and impact are 0.929, 0.963, and 0.947 respectively (refer to Table 4). Therefore it can be concluded that the variables taken under the factors are highly reliable and create a consistent data set for the framework. All the 110 variables distributed under functionality(43), Build quality (39) and impact (40) have been considered for the reliability test and no variable has been removed by the software. However, as it was extracted by the factor analysis, 65 factors were finally retained to create the framework, Figure 5.

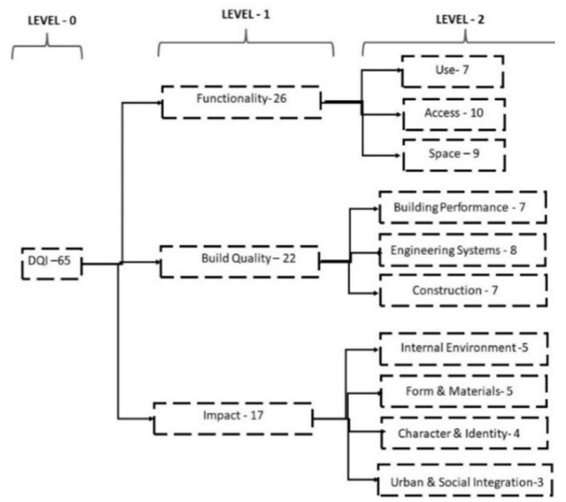

Figure 5. Revised DQI structure using original factors and articulated dimensions.

The Analytical Hierarchy Process helped in a pairwise comparison and helped achieve the weighting coefficient to normalise the result of Delphi. As shown in Table 5, the maximum credit calculated for "space" is 22 whereas the global weightage of the same is 0.1465. Similarly, weightage was assigned for all the factors along with the credits. The total achievable credits thus calculated is 140. Therefore the design Quality Indicators of any project can be achieved by summing the total achieved credits upon the available credits of the project and multiplying it with the weighting coefficient.

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Appendix 1 Frequency of occurrences of different indicators in the literature

	Indicators	Gibson et al., (2003)	Zemke, et al., (2008)	Ruddock et al., (2009)	Cardellino et al., (2010)	Giddings et al., (2010)	Deliberador et al. (2011)	Giddings et al. (2013)	Harputlugil et al. (2014)	Hatem et al. (2014)	Suratkon, (2016)	Gordon and Page (2017)	Zemke et al. (2018)	Eilouti (2020)	Frequency
A	Functionality														
A1	Space														3
1	Space size and proportions														3
2	Fit for purpose														4
3	Relation with spaces														3
4	Privacy														3
5	Circulation														8
6	Open space														7
7	Settlement														
A2	Access														10
1	Local access/ access to public transport														3
2	Interior access														2
3	Inter-unit access														1
4	Universal accessibility														1
5	Parking														3
6	Layout														6
A3	Use														2
1	Fit for functionality														3
2	Flexibility														6
3	Adaptability														5
B	Build Quality														1
B1	Engineering Systems														4
1	Natural Lighting														7
2	Artificial Lighting														3
3	Natural ventilation														3
4	Artificial ventilation (HVAC)														4
5	Electrical systems-Automation														4
6	Security														3
7	Acoustic (Noise control)														7
B2	Construction														4
1	Durability														3
2	Code Compliance														2
3	Structural elements and systems														6
4	Finishings														7
B3	Building Performance														
1	Easy to maintain														2
2	Easy to clean														1
3	Energy Performance														5
C	Impact														
C1	Internal Environment														
1	Easy-to-understand layout														8
2	Indoor Air Quality														3
3	Visual effect / Visual comfort														2
4	Thermal comfort/ Thermal adaptation														2
5	Security and safety														6
C2	Form and Materials														
1	Colour and texture														5
2	Form														7
3	Material														4
C3	Character and innovation														
1	Aesthetics														3
2	Context														7
3	Age														1
4	Identity and character														3
5	Human Factors and Social Interaction														1
C4	Urban and social integration														5
1	Connection with the local community														2
2	Neighbourhood quality														6
3	Social and economic regeneration														6
	Total No. of the indicator	14	23	14	7	3	16	12	21	6	15	11	22	12	

Convergence in Religious Philosophy, Beliefs and Practices of Sikhism for Environmental Actions

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Abstract: The existence and sustenance of global communities are in danger due to the environmental concerns evident in the form of climate change, depletion, and pollution of natural resources. The fast-paced economic growth, population increase and urbanisation are the key drivers for environmental degradation since infrastructural services required to support them consume natural resources as inputs, and dispose-off the waste as outputs into the natural environment. The role of Religion needs to be explored to bring awareness aimed at protective and regenerative environmental actions. This paper aims to highlight the role of beliefs and practices of Sikhism (Sikh religion) and analyse the verses in the sacred scripture Sri Guru Granth Sahib, in the context of respect, appreciation and significance of environment. The qualitative research proposes a strategic environmental action model for aligning individual, community, and institutional initiatives towards environmental protection.

Keywords: Sikhism; beliefs and practices; Sri Guru Granth Sahib; nature; environmental concerns.

सार: जलवायु परिवर्तन, प्राकृतिक संसाधनों के प्रदूषण और कमी के रूप में स्पष्ट पर्यावरणीय चिंताओं के कारण वैश्विक समुदायों का अस्तित्व और जीविका खतरे में है। तेज़ गति वाली आर्थिक वृद्धि, जनसंख्या वृद्धि और शहरीकरण पर्यावरणीय गिरावट के प्रमुख चालक हैं, क्योंकि उन्हें समर्थन देने के लिए आवश्यक बुनियादी ढाँचागत सेवाएँ इनपुट के रूप में प्राकृतिक संसाधनों का उपभोग करती हैं, और आउटपुट के रूप में प्राकृतिक पर्यावरण को प्रदूषित करती हैं। सुरक्षात्मक और पुनर्योजी पर्यावरणीय कार्यों के उद्देश्य से जागरूकता लाने के लिए धर्म की भूमिका का अन्वेषण करने की आवश्यकता है। इस पेपर का उद्देश्य सिख धर्म की मान्यताओं और प्रथाओं की भूमिका को उजागर करना और पर्यावरण के सम्मान, प्रशंसा और महत्व के संदर्भ में पवित्र ग्रंथ श्री गुरु ग्रंथ साहिब में छंदों का विश्लेषण करना है। यह गुणात्मक शोध पर्यावरण संरक्षण की दिशा में व्यक्तिगत, सामुदायिक और संस्थागत पहल को संरेखित करने के लिए एक रणनीतिक पर्यावरणीय कार्रवाई मॉडल का प्रस्ताव करता है।

मुख्य शब्द: सिख धर्म; मान्यताएं और प्रथाएँ; श्री गुरु ग्रंथ साहिब; प्रकृति; पर्यावरणीय चिंताएं

1. Introduction

The global community is facing extreme threats to its existence due to environmental challenges. The environmental issues manifest in developed as well as developing countries are affecting the health of Mother Earth. The survival of the present generations is endangered in the wake of the overexploitation and pollution of natural resources for economic development. This has also put the fate of future generations at stake. The immediate and direct impacts of environmental degradation are visible in the form of global climate changes, ozone depletion, increased incidence of fatal diseases, extinction of species, and accumulation of toxic wastes in soil, water, and air pollution (Gottlieb 2004; Kanozia 2016; Singh 2021). The current state of the environment testifies that the anthropogenic actions of humans are leading us towards the destruction of our natural setting (Gottlieb 2004). Mankind needs to be aware of its responsibility, live in harmony with nature, and value its elements (Pedersen 1998). Since environmental concerns cannot be confined to territorial domains, it is imperative to understand that a nation's environmental degradation shall have regional and global impacts (Rosencranz, Divan, and Noble 1991). Rapid urbanization, the higher density of population, loss of biodiversity, and depletion of natural resources, have disrupted the ecological balances and worsened the environment in India as well. Therefore, environmental protection, conservation, and enhancement have emerged as key challenges in India (Verma 2021). Concerted efforts are required for conserving and protecting nature which includes land, water, air, plants, animals, and other species. The need of the hour is to look for environmental actions aimed at ensuring the protection of the planet through sustainable economic growth and technological developments for a healthy future, where more than eight billion people are expected to have a harmonious existence with nature (UNEP 2016; Preston and Baimel 2021). It is the accepted worldview that all world religions can help in shaping one's understanding, conduct and sensitivity towards Nature (Gottlieb 2004; Chuvieco 2012; Mcleod and Palmer 2015; Tarusarira 2017). Religions are a treasure trove of belief systems and rituals, with the capacity to provide ethical orientation leading to spiritual connection. This paper aims to explore the religious beliefs and practices of Sikhism (Sikh religion) to seek convergences on learnings that can be used for engaging individuals and communities towards achieving shared goals for environmental action. The philosophy of Sikhism states that humans are an inseparable part of Nature, which must be preserved and worshipped to sustain its pure splendour. This study presents the religious excerpts emphasizing the "Respect for Nature" as embedded in the holy scripture of Sikhism, *Sri Guru Granth Sahib* (SGGS). The research is positioned in the context of "LiFE" which elaborates into "Lifestyle for Environment", motivating to live a Pro-Planet Life at individual levels by making judicious choices for an environmentally sustainable clean, green and blue future (NITI Aayog 2022). The research also dwells in the intersection domains of Sustainable Development Goals (SDGs), G20 and the religious beliefs of Sikhism. The objectives of the research are:

i) To study the ethical conduct practices, and religious teachings related to the significance of nature and environment as mentioned in SGGS.
ii) To explore the interrelationships between these teachings and anticipated actions targeted for conserving the environment.
iii) To propose a strategic model for environmental actions, and an implementation framework of action plan at individual, community, and institutional levels.

2. Materials and Methods

The research is qualitative and shall be firmly grounded through a review of literary sources including books, research papers, articles, online reports, and blogs related to the Sri Guru Granth Sahib, Sikh religion, environment, social sciences and psychology. The research methodology is exploratory and aimed at establishing interrelationships between religious teachings from *Sri Guru Granth Sahib* and various actions anticipated in line with them. Furthermore, the research incorporates case studies identified as best practices aligning with research objectives. The research progresses to formulate a strategic model developed from the outcomes of actions, and envisaged for implementation through a hierarchical framework, reaching out to various levels of society in pursuit of conservation of the Natural Environment.

2.1 Religion and Environment

The prevailing environmental situation has been termed a "crisis of our civilization" by Gottlieb (2004), who raised doubts about the ability of current technological systems and theoretical sciences to deal with the issues and challenges of the day. The author further mentions that "corporate greed", fascination for fast-changing technologies, and anthropocentric attitudes are prime reasons pushing mankind and Earth towards destruction. These scenarios are linked to the "take-make-dispose" approach in which huge quantities of finite natural resources are consumed, and disposed of in the environment without proper treatment. Former UNDP Administrator, Gus Speth in 2014, also asserts that the environmental issues are the outcomes of insensitive consumption of natural resources. It was further highlighted that the need of the hour is to put concerted efforts into bringing a paradigm shift through spiritual and cultural spheres (UNEP 2016). The significance of religion in bringing awareness to humans through spiritual teachings has been established by various researchers. Religion is seen as a powerful instrument capable of bringing about social awakening and direction through its teachings. Religious teachings as the foundation of a belief system have also been a voice of nature which highlights the significance of nature for human sustenance. The efficacy of religious traditions is underlined by Chuvieco (2012) in research to explore the potential of religious approaches for water conservation. The author mentions the theocentric approach of religion as significant in inspiring humans to be empathetic towards nature and others. The role of religion is further expanded by the author where it is asserted that greater involvement of environmental issues with religion can build much required appreciation and care towards nature.

Religion acts as a guiding source of light for humans, to tread on a path of morality, with responsibilities towards the natural world. It influences, motivates and regulates the actions of people towards environmental conservation pursuits. This is made possible, as religious values are interwoven in the daily lifestyle of humans, and religion has the capacity to reach out to a wider audience (Northcott 1996; Rappaport 1999; Tucker and Grim 2009). Moreover, collaborative efforts can easily be envisioned and contemplated when communities come together for religious activities. The literary thoughts and findings gravitate towards the fact that the evermounting pressures of environmental crisis cannot be dealt with by scientific innovations alone, and religious interventions must be explored to deal with the issue. We must accept the need to build a harmonious relationship with nature and its elements as a vital source of human existence, survival and well-being. The notion of "Respect and Care" for Natural Environment is seeded in most of the world religions such as Hinduism, Jainism, Christianity, Islam, Buddhism, Confucianism, Taoism, Sikhism and all others. The universe is acknowledged as a self-expression of God. As a common belief system, life in every form is considered valuable, with its specific role and significance in the universe. Humans have been assigned a steward's role to maintain a balance of the universe by protecting all living beings and resources from pollution as well as mindless overconsumption (UNEP 2016). The research by Zhang (2023) highlights the viewpoint of Lai (2001), who asserts that environmental actions can be successful if one does not act as a steward and looks at these actions as an obligation towards the environment, but develops an appreciative outlook towards it. Adopting such an appreciative outlook towards the environment in day-to-day life shall automatically develop the desire for environmental protection. The significance of "acknowledging" and "appreciating" the Almighty's wonderous creations is further underlined by the author (Zhang 2023). From this discussion it is evident that all religions must deliberate on this issue by simultaneously transcending geographic and generational divides to formulate effective environmental actions. It is also important to study religious scriptures from the perspective of environmental protection and disseminate this traditional knowledge to develop a positive attitude toward caring for nature and the environment.

2.2 Sikhism - Origin, Philosophy, and Belief Systems

Sikhism is a relatively new religion in comparison to other world religions (Arshi 1986). It was initiated as a belief system in the late 15th century by *Guru Nanak* in the region of Punjab in North-West India (Cole 1997). He propagated to worship the Almighty while living a worldly life, and his followers used to congregate in a "*Dharamsal*", for recitation of God's praises. Guru Angad as the second guru started community kitchens to provide free meals known as "*Langar*" for the needy, and the devotees contributed to the same (Arshi 1986; Sangat Singh 2005; Singh 1998). The *Dharamsal* was eventually named "*Gurudwara*" literally meaning "a doorway to God" in 1604 by the fifth guru, *Arjan Dev*, who enshrined the sacred Sikh scripture - *Adi Granth*, centrally in the Sikh temple (*Harimandir*) in Amritsar. It included the spiritual teachings and verses of the first five gurus composed in rhythmic forms. In 1699, the tenth guru, *Guru Gobind Singh*, brought the Sikh followers under one umbrella and formed the "*Khalsa Panth*" meaning "brotherhood of the Pure". He was also instrumental in giving the status of a "*Guru*" to the sacred scripture in 1708. He decided to discontinue the practice of successorship of living gurus, and since then "*Guru Granth Sahib*" (SGGS) has been followed as an immortal form of Sikh Guru. SGGS is positioned in the centre of the prayer hall of every *Gurudwara* and is referred to as an authoritative sacred guide for leading a life (Cole 1997; Tatla 2008).

2.3 Sri Guru Granth Sahib

Sri Guru Granth Sahib is the compilation of the verses of six gurus, many *bhakats*, and saints including *Kabir, Farid* and *Namdev*. It is available in a standardized format of 1430 pages and is written in "*Gurmukhi*". The followers of Sikhism are known as "Sikhs" which implies "Learners". The philosophy and belief systems of Sikhism as embedded in SGGS, encourage and guide for leading a life based on community interaction or "Congregation". The three duties of a Sikh are: "*Naam Japnaa*" - to Worship, "*Kirt Karnaa*" - to Work, and "*Vand Chhaknaa*" - to Serve. Furthermore, the activities of "Kirtan" (singing God's praises), "*Langar*" (serving free meals to the needy), and "*Seva*" (selfless service), have to be performed for the "*Sangat*" (the community) (Cole 1997; Singh 2008; Dhesi 2009; Singh 2021). Gurudwaras, recognized by the presence of "*Nishaan Sahib*" (saffron triangular flag hoisted on a high pole) are primarily built for congregational worshipping, serving the community, and seeking strength in events of happiness and grief. Congregation is at the core of Sikhism, and it provides opportunities for knowledge dissemination through "*Katha*" (elaborations on Guru's teachings), and serving the community (Singh, Kaur, and Kaur 2017). Sikhs are supposed to visit Gurudwara on "*Gurupurb*" (birth and death anniversaries of gurus) and "*Sangrand*" (first day of every month) for the congregation. The prayers can be performed by individuals at any time of the day, but daily "*Paath*" and "*Ardaas*" are typical to

Gurudwaras where communities gather in the mornings and evenings. The *Paath* is for reaffirmation of Guru's teachings, and the *Ardaas* focusing on "*Sarbatt da Bhala*" provides an opportunity to pray and seek "blessings for all". SGGS can be termed as a spiritual heritage, which is referred to every day for seeking directions towards ethical conduct, practices and social responsibilities, to achieve eternal contentment. The seeds of congregational activities sown in Sikhism and the framework of its practice allow one to be a part of a larger inclusive community.

2.4 Role of Sikh Faith-Based Organizations in Environmental Awareness

The Sikh religion has emerged as a forerunner in environmental actions, based on the fact that the sacred scripture propagates the need to protect the defenceless. It is believed that Earth is defenceless in prevailing times due to pollution and needs to be protected by all through individual awareness and collective community participation. Few Sikh faith-based organizations and environment activists have always referred to SGGS for seeking answers to avert the current environmental crisis in Punjab, primarily due to the overuse of pesticides in agriculture, and pollution of air and waterbodies by industries. Some of the pro-environment initiatives include actions directed towards cleaning, deweeding and desilting river tributaries, reviving historic wells, and medicinal tree plantations, promoting organic farming, and conducting awareness drives. The *Kali Bein* Project is a successful case of regeneration of a tributary of the Beas River in Punjab. The project was envisaged and led by *Sant Balbir Singh Seechewal* in 2000. It is believed that Guru Nanak had taken a bath in this tributary at *Sultanpur Lodhi*. *Kali Bein* had become extremely polluted over the years due to the disposal of chemical effluents flowing into it from industries. It was also clogged with water hyacinth. The monumental task of its cleaning and revival was accomplished by several hundreds of volunteers mobilized by *Balbir Singh Seechewal* (Tatla 2008; Kanozia 2016). The project received attention at global and national levels. It has become a representative model for many such waterbodies in Punjab. Other projects are initiated by "*Fateh*"- a Chandigarh-based organization formed by American Sikhs, concerned with the worsening situation of the ecology and environment of Punjab. The volunteers of the organization visit Punjab and work for six months to conduct awareness drives about the use of renewable energy sources, and pollution control in the environment (Tatla 2008). The All-India *Pingalwara* Charitable Society founded by *Bhagat Puran Singh* is also engaged continuously in initiatives aimed at improving the health of humans and the environment. The Society raises awareness of environmental concerns through the publication and distribution of pamphlets and has recently established a "Zero budget Natural Farm" in Sangrur, Punjab to promote organic farming. Another initiative of organic farming has been taken up by *Kheti Viraasat* Mission in Faridkot which also refers to organic farming as spiritual since it does not harm Mother Earth by shunning the use of pesticides. Two organizations - *EcoSikh* and *KarmaGrow* based in America and Canada respectively, were established by the Sikh diaspora. Both aim for selfless service to humanity and the wellbeing of all, through conservationist and environmentalist approaches. A notable environmental initiative by *EcoSikh* is the celebration of a world "Sikh Environment Day", which received a religious sanction by the *Akaal Takht,* Amritsar – the highest temporal seat of the Sikhs signifying religious authority. It was celebrated in more than 2000 gurdwaras around the world. The day is celebrated prior to the *Baisakhi* fair as per the annual Sikh religious calendar, to raise awareness about waste, anticipating the large quantity of waste generation due to the huge gathering (Mooney 2018). *Shiromani Gurudwara Prabhandhak Committee* (SGPC) also initiated the use of rose petals for celebrating *Holla Mohalla* at *Anandpur Sahib*, instead of colours to save water (Kaur 2018). SGPC has also outlined the plan to harness solar power to generate steam in preparing food for *langar*. The technical assistance for this initiative has been given by the Punjab Energy Development Agency (Singh 2017).

It is evident that these environmental efforts align with the commandment of selfless service for the community and Mother Earth. However, such efforts need to be backed by a strategic framework for wider outreach and long-term sustenance. A study by Mcleod and Palmer (2015) has termed similar initiatives as ad-hoc, which may fizzle out with time. There is a need for a systematic approach to engaging communities, developing partnerships, and ensuring continuous communications related to environmental conservation. It is pertinent to mention that the leaders of the faith from most world religions including Sikhism have pledged to extend their support in implementing the 2030 Agenda of Sustainable Development. It is recommended in the 2030 Agenda to bring global communities together to build partnerships having multiple stakeholders (UNEP 2016). Individuals, communities, and religious bodies must join hands in undertaking and implementing environmental actions through organized action frameworks and models. Such strategic action plans shall also be helpful in stimulating, building and nurturing inter-religious and inter-community relationships. It opens up opportunities for environmental literacy at every level of society.

2.5 *Environmental Messages Extracted from Sri Guru Granth Sahib*

The current research is a pursuit towards extracting invaluable teachings from SGGS, which converge towards environmental actions. SGGS is the sacred scripture that abounds with verses highlighting the mesmerising beauty and significance of Nature as well as the Earth. The teachings also provide directions for a righteous and ethical way of life to protect Nature, and Earth, as well as service to all (Singh 2021). Significant teachings related to these aspects have been extracted from this vast body of spiritual heritage, and presented in this section. The verses for Nature are related to its appreciation, its manifestations in various roles, and also to its environmental degradation. The verses mentioned in the study, have further been categorized as: Nature as God, Nature as Teacher, Nature as a Foundation of Life, Nature as a Source of Delight, and Environmental Degradation of Nature (Table 1). The verses related to Mother Earth are being categorized as Earth as a Place of Righteous Action, and Earth as God's Abode (Table 2). Lastly, the verses for Way of Life are classified as Honest Efforts, and Selfless Volunteer Service to All (Table 3). The verses, their meanings, and messages derived from teachings are also put forth in the same tables.

Table 1. Derivation of messages related to Nature and environment from SGGS (Source: Author).

Category	Verses	Messages
Nature as God	"ਜਲਿ ਥਲਿ ਮਹੀਅਲਿ ਰਵਿ ਰਹਿਆ ਸਾਚੜਾ ਸਿਰਜਣਹਾਰੋ॥(ਰਾਗੁ ਵਡਹੰਸੁ ਮਹਲਾ1, ਸਗਗਸ ਪੰਨਾ 579)" God, the creator is present in Water, Land and Air. (Raag Wadahans, First Mehl, SGGS, p 579)	God = Nature Nature is a manifest of God
	"ਨਾਨਕ ਸਚ ਦਾਤਾਰੁ ਸਿਨਾਖਤੁ ਕੁਦਰਤੀ ॥(ਸਲੋਕੁ ਮ.1, ਸਗਗਸ, ਪੰਨਾ 141)" O Nanak, God as the creator Himself reveals through the Nature. (Shalok, First Mehl, SGGS, p141)	
Nature as Teacher	"ਚੰਦਨ ਅਗਰ ਕਪੂਰ ਲੇਪਨ ਤਿਸੁ ਸੰਗੇ ਨਹੀ ਪ੍ਰੀਤਿ॥ ਬਿਸਟਾ ਮੂਤ੍ਰ ਖੋਦਿ ਤਿਲੁ ਤਿਲੁ ਮਨਿ ਨ ਮਨੀ ਬਿਪਰੀਤਿ॥ ਕਰਿ ਪ੍ਰਗਾਸੁ ਪ੍ਰਚੰਡ ਪ੍ਰਗਟਿਓ ਅੰਧਕਾਰ ਬਿਨਾਸ॥ ਪਵਿਤ੍ਰ ਅਪਵਿਤ੍ਰਹ ਕਿਰਣ ਲਾਗੇ ਮਨਿ ਨ ਭਇਓ ਬਿਖਾਦੁ॥(ਮਾਰੂ ਮਹਲਾ 5, ਸਗਗਸ, ਪੰਨਾ 1018)" Neither does Nature get pleased with fragrant things, nor it is disturbed by unpleasant odours. Similarly, the Sun rises and pushes away the darkness with its brightness. Its heat and light reach all without any discrimination. (Maru, Fifth Mehl, SGGS, p 1018)	Nature a manifest of God is unbiased
	"ਸੀਤ ਮੰਦ ਸੁਗੰਧ ਚਲਿਓ ਸਰਬ ਥਾਨ ਸਮਾਨ॥ ਜਹਾ ਸਾ ਕਿਛੁ ਤਹਾ ਲਾਗਿਓ ਤਿਲੁ ਨ ਸੰਕਾ ਮਾਨ॥ ਸੁਭਾਇ ਅਭਾਇ ਜੁ ਨਿਕਟਿ ਆਵੈ ਸੀਤੁ ਤਾ ਕਾ ਜਾਇ॥ ਆਪ ਪਰ ਕਾ ਕਛੁ ਨਾ ਜਾਣੈ ਸਦਾ ਸਹਜਿ ਸੁਭਾਇ॥(ਮਾਰੂ ਮਹਲਾ 5, ਸਗਗਸ, ਪੰਨਾ 1018)" The cool fragrant soothing wind blows over all places equally. It does not differentiate to touch while touching things. In the same manner, the Fire gives heat and takes away the cold without any discrimination. (Maru, Fifth Mehl, SGGS, p 1018)	
Nature as Foundation of Life	"ਅਪੁ ਤੇਜੁ ਵਾਇ ਪ੍ਰਿਥਮੀ ਆਕਾਸਾ॥ ਤਿਨ ਮਹਿ ਪੰਚ ਤਤੁ ਘਰਿ ਵਾਸਾ॥(ਮ.1,ਸਗਗਸ,ਪੰਨਾ 1031)" The human body is created by the five elements of Nature - Water, Fire, Air, Earth and Space. (First Mehl, SGGS, p 1031)	The human body is a manifest of nature, hence God
	"ਪਵਣੁ ਗੁਰੂ ਪਾਣੀ ਪਿਤਾ ਮਾਤਾ ਧਰਤਿ ਮਹਤੁ॥ ਦਿਵਸੁ ਰਾਤਿ ਦੁਇ ਦਾਈ ਦਾਇਆ ਖੇਲੈ ਸਗਲ ਜਗਤੁ॥(ਮ. 1, ਸਗਗਸ, ਪੰਨਾ 8)" Air is Guru, Water is Father and Earth is the great Mother of all. Amidst the days and nights, these rejoice in harmony. (First Mehl, SGGS, p 8)	
Nature as a Source of Delight	"ਪਰਪੰਚ ਵੇਖਿ ਰਹਿਆ ਵਿਸਮਾਦੁ ॥(ਮ. 3, ਸਗਗਸ, ਪੰਨਾ 1174)" One gets charmed and awestruck by looking at the creations of God. (Third Mehl, SGGS, p 1174)	The ecstatic beauty of Nature demands to live with it in harmony
	"ਬਿਸਮੁ ਭਏ ਬਿਸਮਾਦ ਦੇਖਿ ਕੁਦਰਤਿ ਤੇਰੀਆ ॥(ਮ. 1, ਸਗਗਸ, ਪੰਨਾ 521)" I am ecstatic at the sight of Almighty's creativity. (First Mehl, SGGS, p 521)	
Environmental Degradation of Nature	"ਸੂਤਕੁ ਅਗਨਿ ਭਖੈ ਜਗੁ ਖਾਇ ॥ ਸੂਤਕੁ ਜਲਿ ਥਲਿ ਸਭ ਹੀ ਥਾਇ ॥ ਨਾਨਕ ਸੂਤਕਿ ਜਨਮਿ ਮਰੀਜੈ ॥(ਆਸਾ ਮਹਲਾ 1, ਸਗਗਸ, ਪੰਨਾ 413)" Pollution in the Water, Land and everywhere is like a fire engulfing the entire world. O Nanak, people are giving birth and dying in a polluted world. (Aasaa, First Mehl, SGGS, p 413)	Human actions have polluted Nature, and in turn, have borne the brunt of the consequential diseases
	"ਪਉਣੁ ਪਾਣੀ ਬੈਸੰਤਰੁ ਰੋਗੀ ਰੋਗੀ ਧਰਤਿ ਸਭੋਗੀ॥(ਭੈਰਉ ਅਸਟਪਦੀਆ ਮਹਲਾ 1, ਸਗਗਸ, ਪੰਨਾ 1153)" The world meant for enjoyment is diseased, since the elements of Nature are polluted. (Bhairao, Ashtapadees, First Mehl, SGGS, p 1153)	

Table 2. Derivation of messages related to Earth from verses of SGGS (Source: Author).

Category	Verses	Messages
Earth as a Place of Righteous Action	"ਰਾਤੀ ਰੁਤੀ ਥਿਤੀ ਵਾਰ ॥ ਪਵਣ ਪਾਣੀ ਅਗਨੀ ਪਾਤਾਲ ॥ ਤਿਸੁ ਵਿਚਿ ਧਰਤੀ ਥਾਪਿ ਰਖੀ ਧਰਮ ਸਾਲ ॥(ਮ. 1, ਸਗਗਸ, ਪੰਨਾ 7)" Amidst days, nights, weeks, seasons, air, water, and fire, God established the Earth as a home (Place) for Dharma (ethical action). (First Mehl, SGGS, p 7)	Earth created by God is the Place for Ethical Actions
	"ਧਰਤਿ ਉਪਾਇ ਧਰੀ ਧਰਮ ਸਾਲਾ ॥(ਮਾਰੂ ਮਹਲਾ 1, ਦਖਣੀ, ਸਗਗਸ, ਪੰਨਾ 1033)" God created Earth as the home for honest ethical efforts. (Maru, First Mehl, Dakhani, SGGS, p 1033)	
Earth as God's Abode	"ਪਉਣ ਪਾਣੀ ਧਰਤੀ ਆਕਾਸੁ ਘਰ ਮੰਦਰ ਹਰਿ ਬਨੀ ॥(ਮ. 4, ਸਗਗਸ, ਪੰਨਾ 723)" God dwells in Air, Water, Earth, Sky, and considers them as temples. (Fourth Mehl, SGGS, p 723)	God resides on Earth along with Air, Water and Trees
	"ਸਾਂਤਿ ਪਾਵਹਿ ਹੋਵਹਿ ਮਨ ਸੀਤਲ ਅਗਨਿ ਨ ਅੰਤਰਿ ਧੁਖੀ ॥ ਗੁਰ ਨਾਨਕ ਕਉ ਪ੍ਰਭੂ ਦਿਖਾਇਆ ਜਲਿ ਥਲਿ ਤ੍ਰਿਭਵਣਿ ਰੁਖੀ ॥(ਸੋਰਠਿ ਮਹਲਾ5,ਸਗਗਸ, ਪੰਨਾ 617)" The Guru revealed the presence of God to Nanak in the peace-giving world of Nature - Water, Earth and Forests. (Sorath, Fifth Mehl, SGGS, p 617)	

Table 3. Derivation of messages related to Way of Life from verses of SGGS (Source: Author).

Category	Verses	Messages
Honest Efforts	"ਸਚਹੁ ਓਰੈ ਸਭੁ ਕੋ ਉਪਰਿ ਸਚੁ ਆਚਾਰੁ ॥(ਮ. 1, ਸਗਗਸ, ਪੰਨਾ 62)" Truthful living is the highest form of conduct. (First Mehl, SGGS, p 62)	Truthful and sincere actions lead towards a life full of peace and contentment
	"ਉਦਮੁ ਕਰੇਦਿਆ ਜੀਉ ਤੂੰ ਕਮਾਵਦਿਆ ਸੁਖ ਭੁੰਚੁ ॥ ਧਿਆਇਦਿਆ ਤੂੰ ਪ੍ਰਭੂ ਮਿਲੁ ਨਾਨਕ ਉਤਰੀ ਚਿੰਤ ॥(ਸਲੋਕੁ ਮ. 5, ਸਗਗਸ, ਪੰਨਾ 522)" Making prompt honest efforts to live a peaceful life. (Shalok, Fifth Mehl, SGGS, p 522)	
Selfless Volunteer Service to All	"ਸਭੇ ਸਾਝੀਵਾਲ ਸਦਾਇਨਿ ਤੂੰ ਕਿਸੈ ਨ ਦਿਸਹਿ ਬਾਹਰਾ ਜੀਉ ॥(ਮ. 5, ਸਗਗਸ, ਪੰਨਾ 97)" God's grace and blessings must be shared with all for inclusivity. (Fifth Mehl, SGGS, p 97)	Selfless volunteer service to All shall bring happiness
	"ਸੁਖੁ ਹੋਵੈ ਸੇਵ ਕਮਾਣੀਆ ॥(ਸਿਰੀਰਾਗੁ ਮਹਲਾ 1, ਸਗਗਸ, ਪੰਨਾ 25)" Selfless service gives happiness. (Sri Raag, First Mehl, SGGS, p 25)	

3. Discussions

The messages derived from the teachings of SGGS were analysed and further categorized into three distinct domains namely: Realization, Appreciation, and Directions. The messages in each domain are taken forward to outline the actions perceived for environmental protection (Table 4). The first domain of Realization is very important to understand the gravity of the situation. The ill effects of pollution are mentioned in SGGS, where the pollution of the environment is directly related to diseases of mankind. This domain serves as an eye-opener for humans to understand the urgent need to take action for the sustenance of all. The succeeding domain of Appreciation highlights the value of the Natural Environment which has been mentioned as the Home of God, and develops an appreciation for it. Furthermore, the elements of Nature - Air, Water, Land, and Sky are termed as invaluable as they are a manifestation of God. The teachings in this domain highlight the significance, respect and protection deserved by the natural environment. The final domain of Directions guides towards the ethics of actions to be followed by humans for the welfare of all. The sincerity and honesty of actions have been equated with devotion to God, which must be performed voluntarily and without any selfish motives.

3.1 Proposed Strategic Model

The perceived actions derived from the teachings of SGGS form the basis for developing the proposed strategic model as a way forward in the implementation of an environmental action plan. The three distinct domains of Realization, Appreciation, and Directions, serve as the foundation of the stepped model and are therefore kept at the base. The three receding blocks signify the initiatives to be undertaken by all. The first step The perceived actions derived from the teachings of SGGS form the basis to develop the proposed strategic model as a way forward in the implementation of an environmental action plan. The three distinct domains of Realization, Appreciation, and Directions, serve as the foundation of the stepped model and are therefore kept at the base. The three receding blocks signify the initiatives to be undertaken by all. The first step signifies the role of apex religious organisations who shall take the lead in task/s at an institutional level. The second step indicates initiatives that involve the communities in addition to the institutions. The third step represents the actions that can be taken at individual, community and institutional levels. The model along with the description of various initiatives at all strata is presented in Figure 1.

Table 4. Derivation of perceived actions for environmental protection from SGGS (Source: Author).

Domains	Messages	Perceived Actions for the Environment	Initiatives for Environmental Action
Realization	Human actions have polluted Nature, and in turn, have borne the brunt of the consequential diseases	Human actions have polluted Nature, and in turn, the Natural Environment has borne the brunt in the form of harmful consequences. The pollution must be stopped and corrective regenerative actions need to be adopted and propagated by one and all.	**Awareness Initiatives** ⇒ Minimize garbage production ⇒ Segregation of garbage ⇒ Reduce use of Fuel ⇒ No wastage of Food and distribution of excess food to needy ⇒ Harvest Rainwater ⇒ Use of Solar Energy ⇒ Use of E-vehicles and Energy Efficient Appliances **Regenerative and Green Initiatives** ⇒ Biodiversity restoration and regeneration drives ⇒ Talks and Lectures for optimum use of resources ⇒ Tree Plantation Drives ⇒ Organic Farming ⇒ Task Force of Volunteers ⇒ Cleanliness Drives ⇒ Celebration of Environment Commemorative Days **Research Initiatives** ⇒ Establishing Research facilities in Religious Institutions and Universities ⇒ Scholarships, Fellowships and Prizes for volunteers ⇒ Formation of Publication cells ⇒ Establishing Libraries (including mobile libraries)
Appreciation	God the Creator lies in Nature, i.e., Air, Water and Land	Nature and its Elements deserve utmost Devotion and Protection since God lies in it.	
	The elements of Nature are the foundation of life in the world	One must appreciate and acknowledge that humans owe their existence and sustenance to Nature.	
	God resides on Earth along with Air, Water and Trees	Since Earth is the dwelling of God, therefore, all human actions must be directed to restore and protect its pristine beauty.	
	The ecstatic beauty of Nature demands to live with it in harmony	The ecstatic beauty of Nature must be seen as a blessing bestowed upon all by God. It must be preserved to maintain a harmonious relationship.	
Directions	Earth created by God is the Place for Ethical Actions	Earth must be Protected with the same devotion, as praying to God. All actions on Mother Earth must be Ethical Actions and aimed at Preserving and Protecting its Environment.	
	Truthful and sincere actions lead towards a life full of peace and contentment	Every human action must be truthful, sincere and unbiased actions for the Protection of the environment in order to ensure a life full of peace and contentment.	
	Selfless volunteer service to All shall bring happiness	One must be ready to offer a Selfless volunteer service and motivate others to create a task force for the welfare of the communities and the Environment.	
	Nature teaches us to be an unbiased provider	Nature must be Respected like a Guru who teaches us to be selfless providers to all.	

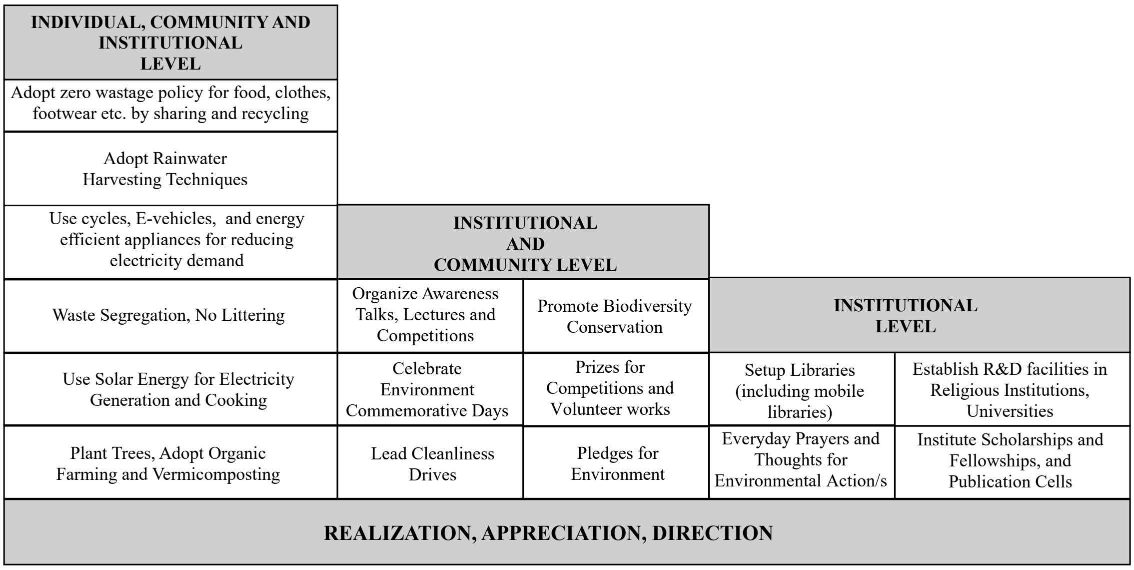

Figure 1. Proposed Strategic Model for Implementation of Environmental Actions at Individual, Community and Institutional Levels (Source: Author)

3.2 Implementation Framework for the Model

The hierarchical framework for initiating environmental actions identified in the proposed strategic model is shown in Figure 2. The highest temporal seat of the Sikh religion, i.e., the "*Akaal Takht*" as an authoritative religious power centre may issue *hukamnaama/s* (edicts) related to environmental action plan/s. The *Akaal Takht* may outline the mission and vision, as well as provide directions to the other "*Takhts*" and the

Gurudwara management committees, which manage *Gurudwaras* at regional and state levels. The committees are to play a proactive role in spreading directional messages to *Gurudwaras* in urban and rural areas for implementing environmental action/s. The *Gurudwaras* can bring the communities together to undertake these actions at a grassroots level. Further, the community heads can form smaller teams of individuals for specific environmental tasks. This framework ensures the effective percolation of environmental action/s through guidance and motivation from the highest level to the individuals. Each individual carries forward the realizations, appreciations, and directional teachings of SGGS in pursuit of a cleaner and healthier environment for present and future generations.

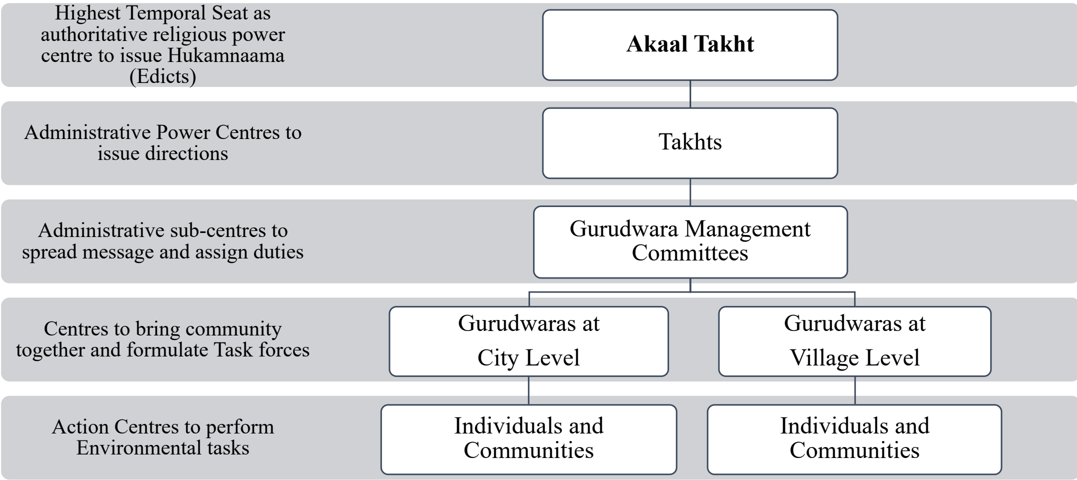

Figure 2. Implementation Framework for Environmental Action Model (Source: Author)

4. Conclusions

The prevailing environmental crisis is evidence of the insensitive approaches of humans towards the Natural Environment. The mindless over-exploitation of natural resources has led to their depletion and pollution to the extent of worrisome permanence. The air is poisonous due to emissions of smoke from industries and vehicles, and the dumping of non-biodegradable wastes in water as well as land has led to the loss of many species and has put many more on the brink of extinction. It is essential to explore all possibilities to avert the crisis, for saving mankind and Mother Earth for future generations. Religious scriptures through their teachings provide a ray of hope in this despair. The Sikh sacred scripture - SGGS also provides affirmative leads and directions for environmental actions. The philosophy of Sikhism revolves around the concept of congregational activities to pray and volunteer for the "welfare of all." SGGS is a source of spiritual teachings which guide and show ways to accomplish this endeavour. The analysis of the teachings of SGGS as undertaken in this research has showcased their remarkable potential in the context of formulating environmental action plans. The verses have proved to be a beacon of light for the Realization of issues for an awakening of Mind and Soul, developing Appreciation of the invaluable assets of the Natural Environment, as well as providing Directions to tread on the right path. The messages from verses converged as learnings for the development of a strategic model for implementing the environmental action plan. The model proposed in the research can be applied to engaging individuals and communities through the leadership of institutions. The model also exemplifies the potential of sacred scriptures to translate "Beliefs" to "Actions" for the protection of the Natural Environment to ensure "Sustenance of All on Mother Earth.

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Indicator Framework to Assess Circularity in the Waste from Construction and Demolition

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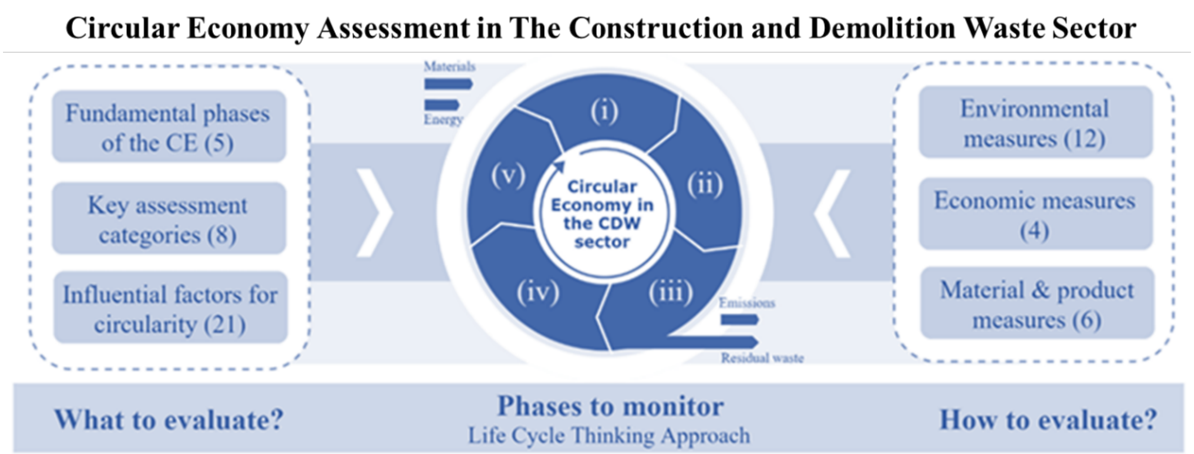
Abstract: By introducing new patterns of production and consumption, the circular economy (CE) attempts to address environmental concerns in the linear economy model that is currently in use. The selection of building materials, design concepts, construction techniques, operational efficiency, and end-of-life management are all important factors to take into account when evaluating CE in buildings. Sufficient monitoring of CE actions is essential for a smooth transition, particularly in vital industries such as construction and demolition waste (C&DW). However, there aren't many indicators and measuring tools available that are specifically focused on CE because of recent developments in the sector and legislation. By offering a general framework for index creation, the study seeks to solve the difficulties in creating circularity assessment indices. It offers direction to those creating tools and making decisions regarding how to comprehend the reasoning behind circularity indices in the literature on building environments. By defining the important aspects and elements that influence circularity performance and measurement, a framework of measurements and indicators for evaluating the effectiveness of the C&DW sector is constructed. Three circularity dimensions environment, economy, and innovation/materials are assessed using a methodical way in the proposed framework. There is total 22 measures, divided into eight standard assessment categories.

Keywords: Circular Economy; Construction and Demolition; Circularity Indicator; Building Materials; Environment

सार: उत्पादन और खपत के नए पैटर्न पेश करके, परिपत्र अर्थव्यवस्था (सीई) रैखिक अर्थव्यवस्था मॉडल में पर्यावरणीय चिंताओं को दूर करने का प्रयास करती है जो वर्तमान में उपयोग में है। भवन निर्माण सामग्री का चयन, डिजाइन अवधारणाएं, निर्माण तकनीकें, परिचालन दक्षता और जीवन के अंत में प्रबंधन सभी महत्वपूर्ण कारक हैं जिन्हें इमारतों में सीई का मूल्यांकन करते समय ध्यान में रखा जाना चाहिए। विशेष रूप से निर्माण और विध्वंस अपशिष्ट जैसे महत्वपूर्ण उद्योगों में सुचारू परिवर्तन के लिए सीई कार्यों की पर्याप्त निगरानी आवश्यक है (CDW). दुर्भाग्य से, ऐसे कई संकेतक और माप उपकरण उपलब्ध नहीं हैं जो इस क्षेत्र और कानून में हाल के विकास के कारण विशेष रूप से सीई पर केंद्रित हैं। सूचकांक निर्माण के लिए एक सामान्य रूपरेखा की पेशकश करके, अध्ययन परिपत्र मूल्यांकन सूचकांक बनाने में कठिनाइयों को हल करने का प्रयास करता है। यह उन लोगों को दिशा प्रदान करता है जो उपकरण बनाते हैं और इस बारे में निर्णय लेते हैं कि निर्माण वातावरण पर साहित्य में परिपत्रता सूचकांकों के पीछे के तर्क को कैसे समझा जाए। वृत्ताकार प्रदर्शन और माप को प्रभावित करने वाले महत्वपूर्ण पहलुओं और तत्वों को परिभाषित करके, सीडीडब्ल्यू क्षेत्र की प्रभावशीलता का मूल्यांकन करने के लिए माप और संकेतकों की एक रूपरेखा का निर्माण किया जाता है। सुझाए गए ढांचे में एक व्यवस्थित तरीके का उपयोग करके पर्यावरण, अर्थव्यवस्था और नवाचार/सामग्री के तीन परिपत्र आयामों का मूल्यांकन किया जाता है। कुल 22 उपाय हैं, जिन्हें आठ मानक मूल्यांकन श्रेणियों में विभाजित किया गया है।

मुख्य शब्द: सर्कुलर इकोनॉमी; निर्माण और विध्वंस; सर्कुलरिटी इंडिकेटर; भवन निर्माण सामग्री; पर्यावरण

Graphical Abstract (चित्रमय सार:):



1. Introduction

Building sector is known for consuming large amounts of energy and resources, producing large amounts of waste, and emitting pollutants (Gallego-Schmid et al. 2020). Over one-third of waste in the EU and 60% of waste in the UK is made up of construction and demolition waste (European Commission 2022). It constitutes the largest waste stream worldwide, accounting for 30-40% of all generated waste globally (Jain et al. 2020). Consequently, it is imperative to promote the adoption of circular economy (CE) with an emphasis on construction and demolition waste (C&DW) reduction and management as well as production and usage of more sustainable material; and to measure the results. Due to the fact that buildings produce 40% of greenhouse gas emissions and more than 50% of world material usage, circular construction principles have a substantial impact on the construction industry as shown in Figure 1. In the building industry, this strategy guarantees sustainable practices. In order to address resource depletion and greenhouse gas emissions in the built environment, policymakers are realising the necessity of making the shift from linear economy to circular economy (CE). The implementation of CE in the construction industry makes tracking the progress towards this transition more challenging. In order to precisely gauge and assess success during the transition, monitoring and assessment systems must be put in place. Circularity indicators (CIs) are essential for facilitating the transition to a CE because they make information interchange easier and foster understanding, both of which are critical components of the transition process. By establishing goals and evaluating the effectiveness of different CE tactics, CI can help practitioners and policymakers to achieve circularity.

The minimal scientific literature mostly addresses C&DW management techniques, barriers and challenges, and specific concepts of construction engineering, such includes the manufacturing, recycling, and application of prefabricated components. Limited advancements in measuring-monitoring instruments for capturing CE performance and there isn't a comprehensive foundation for CE evaluation because of advancements. Research on circularity measurement methods and indicators, like C&DW, mostly focused on tracking constructing circularity projects rather than including notions connected to CE. There are currently no particular indicators in the research that monitor the development of circularity in the C&DW industry. According to Moraga et al. (2019), the lack of evaluation frameworks to gauge the sustainability and possible advantages of CE measures may make them more difficult to execute. The C&DW shift to CE is hampered by the absence of relevant indicators and adequate data on minimising waste (Mahpour 2018). For the purpose of measuring and monitoring circularity within the C&DW industry which takes into account both direct and indirect factors impacting its performance, a comprehensive system of indicators is required. Applying a Life Cycle Thinking (LCT) framework, a distinctive approach for assessing construction and demolition interventions has been developed, with a focus on waste reduction, material recycling, and circularity impact, the study seeks to close a gap in the evaluation of CE interventions.

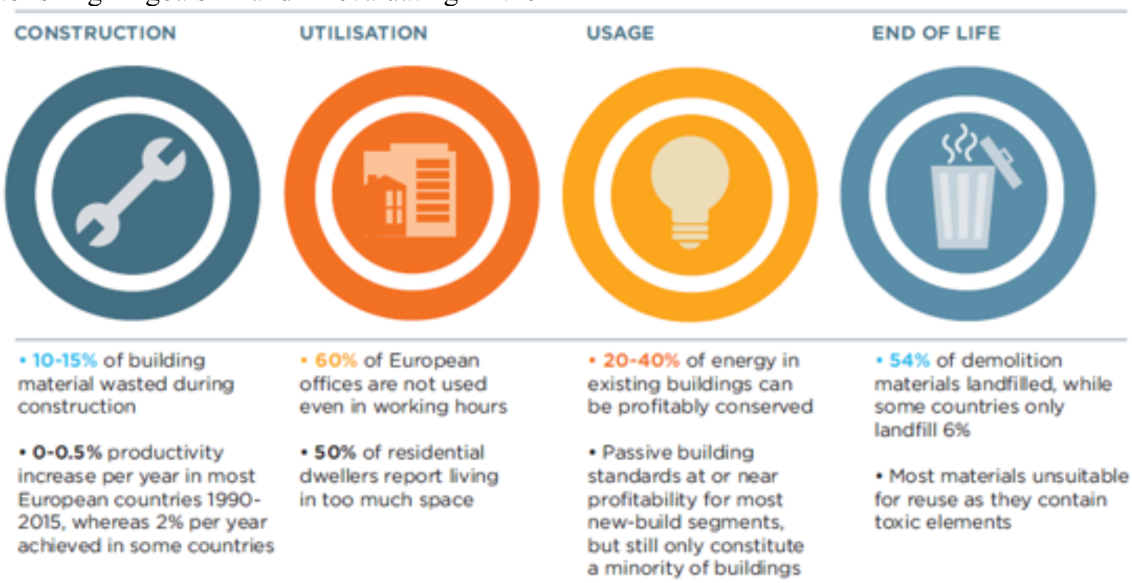


Figure 1 Construction waste in the built environment (Source: Arruda et al., 2021)

1.2 Fundamental aspects of the Circular Economy concept and Circularity Indicator

The circular economy minimises resource input, waste, emissions, and energy leakage while maintaining the value of resources, goods, and components. It is a regenerative system built on business concepts (Bocken et al. 2016). Instead of using an end-of-life strategy, companies are switching to slowing, closing, and narrowing strategies. These strategies try to extend the life of products through reuse and recycling, minimise resource use, and increase manufacturing efficiency. The shift to renewable energy sources for maximum efficiency is the foundation of the circular model. With its ability to provide societal benefits, economic value generation, and environmental preservation in all three aspects, CE is essential to sustainable development. Indicators are not universally defined, however, the European Commission's rules for tracking and assessing them characterise them as measures of objectives, resources, effects, quality gauges, or context variables (European Commission 2013). A measuring unit, a value, and a definition should be included in an indicator. According to scientific research, the main purposes of indicators in complex systems or entities are to communicate, simplify, and summarise pertinent information. In order to offer information about the characteristics or consequences of a system, indicators are variables or functions that assess both quantitative and qualitative data. A comparison to a baseline scenario or reference value is provided by indicators. A group of indicators, each supplying particular details about the entity, that together offer a full picture of a system or entity is called an indicator framework (Wisse 2016). To measure the success of interventions and their progress towards their goals, monitoring frameworks collect data on particular indicators in a systematic manner (OECD 2014).

2. Current approaches to CE measurement

Researchers, practitioners, and decision-makers stress how important it is to develop monitoring frameworks in order to evaluate the effectiveness and impact of CE interventions as well as the degree of circularity of the tactics that are already in use. These indicators and other measurement instruments facilitate reporting and decision-making by providing evidence and an understanding of the effects of implementing CE. Because of their recent introduction and attention to the subject, there haven't been any widely recognised indicators that take into account all aspects of the CE concept since 2017 (Kristensen and Mosgaard 2020). The Ellen MacArthur Foundation's Circulytics and the Material Circularity Indicator are commonly utilised instruments for assessing the micro-level restorative rate of material flows and the overall circularity of an organisation (EMF 2020a). Life Cycle Thinking is used in the Circular Transition Indicators framework, while the Cradle Certified assesses the environmental and social performance of products in categories such as material health, circularity, clean air, water stewardship, and social justice. Even though organisations use practice contributions extensively, the majority of innovations in the field of CE can be traced back to academia, which accounts for 60% of the current set of indicators (Kristensen and Mosgaard 2020). Table 1 explains the importance of each indicator within the framework of the CE. The article offers a thorough list of both academic and practical circularity indicators.

2.1 Key features of circularity and types of indicators

CE indicators can be classified into three different categories: analytical tools, composite indicators, and single quantitative indicators. A product or service's single effect information is measured using single quantitative indicators. For managerial decision-making, circularity indicators like the Longevity Indicator (LI) and the Ease of Disassembly Metric (eDiM) offer a single figure (González et al. 2021). Analytical indicators, such as the Circular Economy Toolkit and Circularity Design Guidelines, are decision-making tools that help businesses assess their potential for development (Kristensen and Mosgaard 2020). Synthetic indices, like the Disassembly Effort Index and Sustainability Indicators in the CE, are examples of composite indicators that simplify complex or multifarious problems (Yeheyis et al. 2013). According to Kristensen and Mosgaard (2020), academics have only looked at composite indicators, whereas businesses and organisations favour single quantitative and analytical indicators since they are simpler and more useful.

Buildings are highly customised, and context-dependent, have various stakeholders, varied materials, and longer service lives than most manufactured goods. The building industry has several unique characteristics that make it difficult to apply standardised circularity metrics. Assessing the progress made towards the CE requires the use of trustworthy indicators. To objectively evaluate important facets and dimensions of circularity in building and built environments, the majority of circularity indicators employ quantitative measurements. Many techniques, including observations, measurements, computations, or a sophisticated combination of techniques, can be used to quantify or qualify an indicator. In order to create the Building Circularity Indicator (BCI) and its derivatives, takes into account complimentary design elements and focuses on using the Material Circularity Indicator (MCI) in building contexts. Additionally highlighted is the Building Circularity Methodology (BCM) developed by HOUSEFUL (González et al 2020). Applying a single set of circularity indicators, the European Union's circular economy monitoring framework tracks the progress of theCE implementation at all levels and offers a complete picture of many elements connected to circularity (Wisse 2016). As analytical tools, these metrics fall within that category. Three types of assessments can be applied to CE indicators: when evaluating CE, indirect CE indicators look at auxiliary methods while direct CE indicators concentrate on certain tactics like recycling rates. Whereas indirect CE ranks European nations according to eco-innovation characteristics using supplementary techniques like the Sustainability innovation indicator from the Resource Optimisation Scoreboard, direct CE focused on many methods, such as water detoxification, employs non-specific strategies.

Table 1. Core Classifications for Assessing the Circular Economy (Source: Author Own)

Evaluation Tool	Using Resources	Power	Water	Emits Emissions	Destruction	Sustainable Design	Monetary/ Profit aspects	Expenditures /Savings
Decision Support System with Multiple Criteria for Product Recovery (Alamerew and Brissaud 2019)		●		●			●	●
Baseline structure for CE indicators (Stewart and Niero 2018)	●		●	●	●	●		
Micro-level applications have been tailored to fit inside the EC's CE monitoring framework (Rincón-Moreno et al. 2021)		●	●		●	●		
An adaptive reuse framework for tradition structures is built upon indicators (Foster, 2020)	●	●	●	●	●			
Indicators for CE evaluation is analyzed at this time (Bilal et al. 2020)	●	●	●	●	●	●		●
Indicators are being examined and grouped in relation to CE components (Parchomenko et al. 2019)	●				●	●	●	
Construction sector is in the process of developing a CE measurement scale (Nuñez-Cacho et al. 2018)	●	●	●	●	●	●		
An extensive analysis of the developments in the subject of circular economy is presented in this report (European Environment Agency 2016)	●				●	●		
A thorough grading system for evaluating each individual's performance (EMF 2020b)		●	●			●	●	
A collection of measurements called the Material Circularity Indicator is used to gauge how circular various materials are (Bracquené et al. 2020)	●	●	●	●	●	●		
To guarantee the quality and safety of products, the certification of product standards is an essential procedure (Cradle to Cradle Products Innovation Institute 2016)		●	●	●		●		
With use of Circular Transitions Indicator Framework, system mobility may be monitored (Algerie 1986)	●	●	●		●	●	●	
A technique for tracking and assessing the efficacy of different areas of a business's operations is the Framework for CE Monitoring (Dodd et al. 2020)	●				●		●	

2.2 *Measurement scope and implementation level of circular indicator*

Using the Life Cycle Thinking (LCT) paradigm, (Moraga et al. 2019) classification framework for CE indicators offers three circularity indicator measurement scopes as follows: *scope 0* without using LCT involves measurements of physical attributes, including recycling rate. Scope 1 using LCT, entails evaluating physical qualities, such as the mass and possible rate of material recycling associated with the Recyclability metric. Scope 2 examines the effects of social, economic, and environmental issues like the recycling benefit rate. Micro, meso, and macro spatial levels are among the many spatial levels at which CE can be applied and assessed (Pauliuk 2018). Companies, goods, and customers are the main emphasis of the micro-level strategy (Saidani et al. 2019). At this stage, businesses prioritise company expansion and process optimisation, with eco-design and cleaner production techniques being used to address CE (Geng et al. 2012). When it comes to energy efficiency, integrated waste management, and product policies, micro-level indicators which concentrate on particular materials or products provide vital data for company-level decision processes. The environment and the regional economy are benefited by the meso-level through inter-firm networks like industrial symbiosis and eco-industrial parks. Meso-level indicators offer a wealth of information about consumption patterns, production sectors, and materials at the individual level. The primary sources of waste and pollution, as well as areas where specific industries or consumer groups may be more efficient, are identified at this level with the use of indicators. Macro-level consists of nations, cities, provinces, and regions, which aim to prioritise resources, waste management, and interconnected waste flows in order to promote environmentally friendly production and utilisation. The evaluation of CE's territorial impact by macro-level indicators aids in the creation of sustainable strategies and action plans, as well as trade, economic, and environmental policy decisions such as national management of waste and environmental preservation laws.

2.3 Conceptualization of the referential assessment parameters

Measuring instruments for particular sectors, such as C&DW, are developed using the framework for evaluating CE interventions in technological cycles. This framework identifies the critical metrics that need to be measured as well as the primary traits of circularity indicators. Incorporating the LCT concept and illustrating monitoring procedures, the CE stages and assessment categories are two essential elements to be measured. Various circularity strategies that have been put into practice are also included in the list. Eight common parameters are defined by the framework to be evaluated: waste, eco-design, energy, water, greenhouse gas emissions, natural resource use, eco-design, revenue, and savings. The type of indicators, measurement scope, and implementation scale are the three primary characteristics of circularity indicators that are described. Three levels are evaluated by the measuring scale: industrial symbiosis at the meso-level (industry), municipal, regional, and national levels (macro-level), and products and companies at the micro-level. The research takes into account two measurement scopes, one measuring effects and the other concentrating on physical attributes. CE plans can be assessed using three different types of indicators: statistical instruments, cumulative indicators, and single quantitative metrics.

3. Constructing a structure for CE monitoring in the C&DW sector

The components of a monitoring system are discussed with a view to the development of CE adoption in the building and demolition industry. Environmental effects are greatly reduced in the building and demolition industry by using the circular economy strategy (Ghaffar et al. 2020). Moreover, it fosters the regional economy and social progress. Utilising sustainable resources, applying waste avoidance techniques, and maintaining material value are the main ways that the CE system in this industry aims to reduce the material environmental impact. Despite certain breakthroughs in the application of CE principles in building and demolition activities, the majority of attention has been concentrated on waste management approaches such as reuse and recycling. From a LCT standpoint, there are five main phases and fourteen methods that make up the C&DW sector's CE (López Ruiz et al. 2020):

a) The preconstruction strategy optimises material utilisation in construction, renovation, and demolition operations by minimising waste through the use of design, guidelines, conceptual frameworks, and C&DW management plans.
b) Based on on-site waste management plans (SWMPs), the study focuses on the most effective waste management techniques for building and remodelling.
c) In order to ensure effective distribution, the procedure entails streamlining C&DW collection and segregation as well as putting in place effective transport procedures.
d) By means of pre-deconstruction/demolition audits and selective deconstruction, the end-of-life approach seeks to enhance material recovery.
e) In order to recover resources for the manufacturing of new products, recycling, low-grade recovery techniques, energy recovery, and reuse are crucial.

3.1 Approaches to determine circularity of C&DW

Fewer metrics and measuring techniques are available for assessing circularity of C&DW as a result of the sector-wide adoption of CE. Although some of the procedures created by the construction and building industry only address a subset of the C&DW management, others are still useful (Hossain et al. 2017). Implementing CE policies successfully is hampered by the lack of standard indicators and clear information, which can cause misunderstandings. The overall composition of the current CE indicators is examined in Table 2, which provides a full analysis of each indicator in the C&DW sector. A comprehensive assessment of circularity that takes into account every facet of CE measurement is absent from current methods for assessing CE performance in C&DW. Eight of the twelve examined works have C&DW included in the circularity assessment. The majority of research focuses on developing circularity indicators specifically for structures. When making decisions throughout a building's end of life, Fregonara et al. (2017) adopted a rigorous approach that takes the economy and the environment into account. In order to evaluate the effectiveness of circularity methods, circularity metrics are frequently employed; nevertheless, there is an abundance of indicators due to the increasing number of frameworks and indices concerning sustainability and resource efficiency. This section examines circularity indicators for material and achieving circularity, with a particular emphasis on three areas: establishing the foundation for existing metrics, evaluating their applicability in light of predetermined criteria and a sustainable CE definition, and offering suggestions and guidelines for creating circularity metrics. Constructions are highly customised, have a variety of materials, many stakeholders, and longer service lives than most manufactured goods. Because of these particular qualities, it is difficult to use standardised circularity metrics in the building sector. Assessing the progress of CE requires the use of trustworthy indicators. The majority of circularity indicators that are currently in use rely on quantitative metrics, which makes them unsuitable for evaluating important facets of C&DW. An innovative endeavour that focuses on material standards and disassembly-friendly design, Verberne's Building the Circular Economy Indicator establishes full building circularity indicators. This thorough procedure serves as the foundation for further circularity model construction.

In order to evaluate how well the building industry in underdeveloped nations is implementing CE, experts have ranked 24 variables of the barriers to CE and suggesting mitigating approaches (Bilal et al. 2020). According to the CE perspective, waste indicators are the most overlooked part of the building industry, whereas energy-related indicators are given priority. Nuñez-Cacho et al. (2018) presented a scale to gauge the degree of circularity implemented in structures. In order to determine whether to embrace Community Engagement interventions, a scale consisting of 21 items is used. Although it does not include indicator computations, this research paper addresses the majority of CE evaluation topics. With an emphasis on circularity measurement at the design stage, the prediction of building circularity indicator was introduced by Cottafava and Ritzen (2021) as a way to measure the possibility of material and component recovery at the end of their useful lives in residential constructions. Embodied energy and embodied carbon, along with the Material Circularity Indicator (MCI), are combined to improve the Building Circularity Indicator (BCI). Akinade et al. (2017) created the Deconstructability Assessment Score, which is based on Building Information Modelling (BIM), to assess a structure's ease of disassembly and material recovery at the end of its life. The factor of Recyclability and the factor of Design Recyclability, which are based on material hierarchy, are two indicators that Vefago and Avellaneda (2013) suggested using to evaluate the reuse, recycling, infra-cycle, and infra-used materials in building design. Foster and Kreinin (2020) conducted research on critical environmental parameters for evaluating the effects of adaptive reuse of historic buildings has been extremely helpful in the evaluation of various architectural components. In order to assess natural resource consumption, eco-design, and carbon dioxide waste during construction, Heisel and Rau-Oberhuber (2020) suggested a system for producing material passports for building supplies and goods. They also suggested computing a Circularity Indicator Building Score. Comprising three sub-indicators pertaining to distinct stages of the lifecycle, the indicator is a modification of the Material Circularity Indicator developed by the Ellen MacArthur Foundation. Though there has been few research specifically concentrating on C&DW, Yeheyis et al. (2013) offered a conceptual framework to maximise the 3Rs that are important when managing C&DW. Decisions on material selection, waste management, and treatment alternatives can be made easier with the use of the building waste LCA-based sustainability index. There are three sub-indicators pertaining to each Environmental, social, and economic sustainability are the three foundations and nine C&DW management indicators that make up the composite indicator

Table 2. Overall Structure of the Current Circular Economy (CE) Indicators in Construction & Demolition Sector.

Index/Measures	Description
Recyclability of building index (Vefago and Avellaneda 2013)	⇒ Design Factor for Recyclability ⇒ Factor of Recyclability after Deconstruction
Life Cycle Assessment based sustainability index for calculating the construction and demolition waste (Yeheyis et al. 2013)	⇒ **Environmental Indicators:** construction and demolition (C&D) waste generated, recycled, composed, landfilled; avoided emissions to air and water from waste management facilities, etc. ⇒ **Economic Indicators:** Cost of C& D waste disposal; net cost of operating and maintaining recycling facilities; Fuel consumption (transport), etc. ⇒ **Social Indicators:** Public acceptance of C&D waste management plans and actions; Public participation in planning and implementation; Workplace safety, etc
The Deconstructability Assessment Score (DAS), based on Building Information Modelling (BIM), evaluates building's structural integrity (Akinade et al. 2017)	⇒ **Deconstruction assessment:** different material kinds, quantity of materials, connection type, and prefabricated materials ⇒ **Assessment of recovery:** materials that can be recycled, reusable, secondary finishes, and toxicity of the material
Economic and environmental Indicators to support investment decision for Buildings' end-of-life (Fregonara et al. 2017)	⇒ Phase I—environmental indicators within LCA defined by ISO 14040/44:2006 and LCT; ⇒ Phase II —economic indicators with LCC Analysis defined by ISO 15686-5:2008; ⇒ Phase III—economic-environmental synthetic indicator.
On-site waste management of plasterboard (Jiménez-Rivero et al. 2017)	Five stages of management to minimize waste ⇒ (i) Plasterboard distribution: transport to minimize the damage; ⇒ (ii) Plasterboard installation; ⇒ (iii) Construction waste storage at the installation area; ⇒ (iv) Plasterboard waste at the installation area; and ⇒ (v) Plasterboard waste transfer to the PB container and storage
Circular Economy Indicators for a company (Nuñez-Cacho et al. 2018)	⇒ **General CE Indicators:** use BIM, transform to a circular economy model, use indicators for management of materials, account for environmental issues, promote environmentally awareness; design according to circular economy principles. ⇒ **Material Indicators:** decrease the output of primary mineral resource; apply indicators of Improvement of use of materials; use of environmentally responsible materials; dispose of a lead indicator for resource productivity; maintain complete invoice of materials and substances for the product; analyze the iron resource efficiency; reduce the direct material input; maintain high production of crude steel; asphalt pavement recycled in order to reclaim bitumen; the product's materials passed back into the supply chain, ⇒ **Energy Indicators:** use agro-industrial energy (sugar, ethanol biomass); use of indicators of energy efficiency improvement; lower fuel consumption; reducing the energy used per ton of asphalt mix produced; raise energy saving amount; enhance new, renewable or clean energy consumption. ⇒ **Water Indicators:** recycle and reuse water; develop indicators of Industrial water reuse ratio; use environmental friendly chemicals in the process of treating water; develop indicators of Improvement of Water Efficiency ⇒ **3R's Indicators:** improve the recycling rate of solid waste; increase ratio use of recycled materials/production; use efficient technologies for recovery of materials; dispose of a material recovery scheme; develop products/services that can be redesigned, reused and repaired. ⇒ **Indicators of Emissions:** reduce energy environmental footprints, CO_2 emissions, carbon footprint and energy indirect greenhouse gas emission level. ⇒ **Indicators of Waste**: manage efficiently the waste; improve recycling rate of solid waste; reduce the non-hazardous waste (to be recycled); employ measures to prevent, recycle and eliminate waste; use a complete invoice of solid waste for the manufacturing process; eliminate hazardous waste; develop the product so that it reduces waste through its use
Circular economy barriers mitigation framework for building sector of developing countries (Bilal et al. 2020)	⇒ **Lack of environmental regulations and laws:** Government support, amend environmental laws for building codes, penalties for non-compliance and incentives for compliance, tools to analyze the effectiveness of the CE rules and laws, compliance with CE regulations. ⇒ **Lack of customer/public awareness:** CE awareness through electronic media and seminar/workshops, CE advantages to be highlighted for public awareness, incentives to those building sector organizations who contribute to CE awareness, Public education on sustainable development, advertisement emphasizing need of CE ⇒ **Lack of support/backing from public institutions:** Fund CE research, subsidize technology for CE, initiatives to improve public awareness, monitor CE implementation, support in tax and duty relaxation for green products, Act as role model for CE implementation, coordinate different CE initiatives, support from local authorities, Public Private Partnership. ⇒ **Inadequate financial resources:** launch platforms for CE investment, generate revenue through penalties for non-compliance; promote charity donations from public with logo 'save our plane'; allocate sufficient government budget, promote financially sustainable projects.

Table 2 Cont…

Index/Measures	Description
European Union framework of core sustainability indicators for office and residential buildings (Dodd et al. 2020)	⇒ **Greenhouse gas emissions along a building life cycle:** Use stage energy performance; Life cycle Global Warming Potential. ⇒ **Resource efficient and circular material life cycles:** bill of quantities, materials and lifespans, construction and demolition waste and materials; design for adaptability and renovation; design for deconstruction, reuse and recycling. ⇒ **Efficient use of water resources:** use state water consumption; ⇒ **Healthy and comfortable spaces:** Indoor air quality; lighting and visual comfort; acoustics and protection against noise. ⇒ **Adaptation and resilience to climate change:** protection of occupant health and thermal comfort; increased risk of extreme weather events; increased risk of flood. ⇒ **Optimized life cycle cost and value:** life cycle costs; value creation and risk exposure.
Circular Environmental Impact Indicators for ARCH (Foster and Kreinin 2020)	⇒ **Indicators of direct reductions to new natural materials extraction due to the adaptive reuse:** maintain embodied energy in reused concrete, stone, brick, steel etc (carbon dioxide CO_2 equiv. GHGs per ton avoided or tons avoided/reused); Water efficiency/fresh water consumption (kiloliters/person/year); Construction and Demolition (C&D) Waste to landfill through recovery and reuse on or off-site (cubic meters); increase land use efficiency due to the adaptive reuse (square meter reductions to space requirements of new purpose) ⇒ **Indicators of direct reductions to energy use due to the adaptive reuse:** Greenhouse Gas emissions (CO_2 equiv GHGs tons/year); increase energy efficiency/consumption per (megawatt hours or kilojoule/user/year); increase amount of renewable versus non-renewable energy use (megawatt hours or kilojules) ⇒ **Indicators of direct environmental improvements due to the adaptive reuse:** reductions to air emissions including CO_2, nitrogen oxides (NO_x), sulphur oxides (SO_x), and particulate matter (PM); improve water quality measured as eutrophication potential based on nutrient loads (phosphorous or nitrogen g/liter or dissolved oxygen) ⇒ **Indicators of indirect reductions to energy use or pollution due to the adaptive reuse:** maintain embodied energy in reused concrete, stone, brick, steel etc (carbon dioxide CO_2 equiv. GHGs per ton avoided or tons avoided/reused); limit Land use change (farmland maintained or reduction to urban sprawl in hectares); indirect emission reductions due to adaptive reuse e.g. reduction in vehicle use (CO2 equiv. GHGs per year avoided)
Circularity Indicators for the built environment (Heisel and Rau-Oberhuber 2020)	⇒ **Construction phase:** the ratio of virgin materials to recycled, re-used or rapidly renewable materials ⇒ **Use phase:** the expected lifespan of utilized products, compared to the average life span of status-quo products in the same application ⇒ **End of life phase:** ratio between waste materials and reusable and/or recyclable materials generated when building is refurbished or demolished.
Bridge Circularity Indicator, a technique for determining a bridge's circularity (Coenen et al. 2021)	⇒ Material input, robustness, and design input ⇒ Accessibility of Resources — Limited Stock ⇒ Strengthen ability, Heighten ability, Extensibility, and Adaptability ⇒ Transportability, Disassembly, Reusability, and Uniqueness

The European Union (EU) established the Level(s) common set of indicators in 2021 to evaluate the sustainability of workplace and residential buildings (Dodd et al. 2020). Considering environmental performance, health, comfort, value, cost, and other dangers, the study evaluates the building life cycle in its entirety. In addition to 16 common indicators and the Life Cycle Assessment (LCA) methodology, the framework outlines six macro-objectives for building sustainability: reduced emissions of greenhouse gases and air pollutants; resource-efficient material life cycles; efficient use of water resources; creation of healthy spaces; adaptation to climate change; and optimized life cycle cost and value. The three levels of the system, Level 1-Cognitive design, Level 2-Comprehensive planning and construction performance, and Level 3-As-built and usage performance, are the stages of building project execution. The construction and demolition waste and materials indicator gives information by calculating the entire amount of waste and materials created during building, remodelling, and end-of-life operations, as well as their recovery rate. The level is an effective instrument that offers several advantages, including giving comparisons of sustainable building progress a common language and allowing for cross-application across various life cycle stages and construction activities. The intricacy of user manuals and their dependence on outside processes and databases makes the monitoring architecture difficult to apply in practice (Díaz-López et al. 2021).

With regard to construction and demolition operations, Table 3 presents an extensive summary of the CE evaluation contributions, including the evaluated CE categories along with the execution level. The use of digital technologies in design, quantification, evaluation, and collaboration have been extensively studied. These instruments can make the circular built environment (CBDW) more efficient by removing human error and cutting waste throughout the planning process. Additive/robotic manufacturing, neural networks, analytics and large-scale data, the use of blockchain technology, e-commerce, digital twins, and the global web of things are some other digital technologies that facilitates the circular built environment. It provides guidance to develop an integrated methodology through the identification of connection nodes, the drawing of system boundaries, and the creation of visual aids. Design thinking is an iterative, human-centred, sustainability-oriented framework methodology for problem-solving that integrates tools and ideas of system thinking to concentrate on system leverage points. These frameworks, which provide answers for challenging issues, are founded on multidisciplinary, creativity, ease of use, and technology innovation.

Table 3. Current Initiatives for The CDW Sector's CE Measurement

Assistance / Characteristic	Analytical type	Function	Scale	Assessment category							
				Use of resource	Power	Water	Emissions	Destruction	Sustainable Design	Monetary/Profit	Expenditure/ savings
Building Information Modeling-Based Score for Deconstructability Assessment	Development, experimentation, and critical analysis	Structures	Medium						●		
Framework for mitigating the effects of construction industry in underdeveloped nations to assess the degree of CE implementation	Critical evaluation, categorization, and literature review	Construction industry	Medium	●	●	●	●	●	●		
The indicator of bridge circularity	Characteristics, categorization, and application	Infrastructure Projects	Medium	●					●		
Optimal Structure Circularity Measurement	Making and experimenting	Plan for Dismantling Residential Structures	Medium		●		●				
Level(s) of the European framework for environmentally friendly construction	Governmental initiative	Buildings for offices and homes	Medium	●	●	●	●	●	●		●
Important environmental indicators for the adaptive reuse of historically significant structures	Literature review, description, critical analysis and classification	Reusing culturally significant structures in an adaptable way	Medium		●	●	●	●			
Artificial economic-environmental metre for structures nearing their end of life	Description, classification and experimentation	Structures	Medium		●		●	●	●		●
Construction Score for the Circularity Indicator	Description and	Structures	Medium	●				●	●		
Most effective metrics for assessing end-of-life gypsum management	Description, classification and experimentation	Gypsum residue	Small	●			●	●			●
Construction industry's circular economy measuring tool	Critical evaluation, categorization, and panel of experts	Construction industry	Small	●	●	●	●	●	●		●
Recyclability of building index	Describe, create, and test	Structures	Medium					●	●		
Sustainability score based on Life Cycle Assessment (LCA) of construction waste	characterization, categorization, and advancement	Management of CD Waste	Medium				●	●			●

4. Effective implementation and assessment of circularity criteria

The successful application and evaluation of the CE is a challenging undertaking that calls for a variety of methods and approaches from a systemic viewpoint. Starting with the first design phase, the building and demolition industry needs to put waste prevention first and use less raw materials. For the purpose of creating value and recirculating materials, effective recovery procedures are essential (Akanbi et al. 2018b). Based on the most important variables and circularity standards in the C&DW industry, the eight typical assessment categories are: (a) Waste avoidance design involves precise estimates of construction and demolition waste generation and composition, as well as design for recycling and reuse; (b) Deconstruction or disassembly design (c) Modular/standardized building and component design and utilisation; (d) Layer design approach; (e) Reducing the variety and quantity of construction components; (f) Using long-lasting materials and components; (g) Using prefabricated parts; (h) Using recyclable and recycled materials; (i) Connect materials mechanically rather than chemically (e.g., by using bolt and nut joints rather than glue and nails); (j) Staying away from secondary finishes (such chemical preservatives for wood); (k) Refusing composite materials; (l) Refusing poisonous or hazardous materials; (m) Maintaining embodied energy and/or energy efficiency; (n) Deconstruction that is selective (o) Waste collection and segregation on-site; (p) Materials for passports; (q) Processes for transportation that are efficient; (q) Reusing materials, parts, and constructions; (r) Reusing Recovering energy; (s) Utilise in inferior applications.

4.1 Development of the framework and classification of CE measures

The indicator framework integrates essential elements and criteria for a successful assessment of corporate social responsibility in the building and demolition industry. The monitoring procedure was made clearer by implementing the multilevel metrics structure for indication classification suggested by (Kazancoglu et al. 2018). The primary criteria, sub-criteria, and measures/indicators comprise the three-dimensional hierarchy used in this approach. Environment, economy, and innovation/materials are the three CE elements that are the main emphasis of this study. The eight typical assessment categories for CE evaluation constitute the sub-criteria. These include the following: The rate of primary resource utilisation, energy consumption, freshwater consumption, water quality (eutrophication), greenhouse gas emissions, embodied emissions, indirect emissions by transportation, waste (generated CW and CDW), the rate of recovery of C&DW (general and per recovery option), the disposal of C&DW in landfills, revenue (resource efficiency, circularity revenue), and cost reductions (net recoverable cost, total product cost). In conclusion, the measures for materials and products indicate the particular aspects that need to be measured. These were derived from the circularity criteria that were identified, as well as from an analysis of the methods that have been used to measure the circularity of CDW-related strategies. Various techniques are employed in this process, such as the degree of disassembly or deconstruction, the index of recyclability and reusability, the rate of recoverability at the end of product life, the durability of materials, products, and components, the utilisation of recyclable and recycled materials, and the application of non-toxic nor hazardous materials.

4.2 Conceptualization of the CE monitoring framework

The assessment of the environmental, economic, material, and product aspects of CE is outlined in the first level. Based on established CE evaluation instruments and common assessment categories, the three primary criteria are divided into eight sub-criteria (level 2).

In the third level, the primary circularity performance criteria for practices related to C&DW are outlined, along with the procedures for evaluating CE advancement. The following are the five stages of the C&DW life cycle that determine its circularity as the main emphasis of the suggested framework's systemic analysis, which can be fully assessed or monitored separately:

4.2.2 Assessing circularity in the C&DW using an environmental framework

a) Using primary sources, such as the Material Circularity Indicator, Circular Economy Performance Indicator, Circular Transition Indicators, Global Resource Indicator, Circularity Indicator Building Score, and Bridge Circularity Indicator, is the rate at which natural resources are used.
b) Energy: Consumption of energy (Material Durability Indicator, indicators for the adaptive reuse of buildings with cultural property, utilising integrated economic-

environmental indicators for the end of building life and circular transition indicators, as well as embodied energy and renewable energy use.

c) Water: Evaluation of freshwater consumption and water quality both essential for the adaptive rehabilitation of culturally significant buildings is done through the use of circular transition indicators.
d) Emissions: Greenhouse Gas (GHG) Emissions (A multi-criteria decision-making tool for evaluating signs of adaptive restoration for culturally significant structures); Embodied emissions: (An artificial economic-environmental metric for structures nearing their end of life); Indirect emissions (The best performance measures for gypsum waste at the end of its life, indices for the adaptive reuse of cultural heritage structures).
e) Waste: Construction waste, generated construction and demolition waste (LCA-based sustainability rating for construction waste, recovery rate of construction and demolition waste, circular transition indicators, artificial economic-environmental indicator for buildings reaching their end of life).

4.2.3 Assessing circularity in the C&DW using an economic framework

a) Cost/Savings: Net Recoverable Cost (Product Recovery) Building waste life cycle assessment (LCA)-based sustainability index, multi-criteria decision tool; Overall cost of the product (life cycle cost, artificial economic-environmental indicator for buildings reaching their end of life.
b) Revenue: Circularity (Circular Transition Indicators, Design Method for End of Use Product Value Recovery); Resource efficiency (Circular Transition Indicators, Value-based Resource Efficiency, Product Level Circularity Metric, Eco-costs Value Ratio Model, Circular Economy Index).

4.2.3 Assessing circularity in the C&DW using material and products framework

a) The Eco-Design incorporates various Performance measures for gypsum waste at the end of its useful life, such as the Recyclability and Reusability Index (Potential Reuse Index, Buildings' recyclability index, Potential Recycle Index, Global Resource Indicator).
b) Building end-of-life and Ease of Disassembly Metric: Deconstructability Assessment ranking based on BIM, Predictive Building Circularity Indicator, and Synthetic Economic-Environmental Indicator.
c) Recoverability rate: Deconstructability Assessment Score based on BIM, the recycling desirability index, the circular transition indicators, the material circularity indicator, and the reuse potential indicator.
c) Index of Recyclability of Buildings: Predictive Building Circularity Indicator and Circularity Indicator Building Score.
d) Longevity/durability: longevity indicator, circularity indicator building score, combination matrix, material circularity indicator and material durability indicator.
d) Using recyclable and recycled materials: Building Score, Material Circularity Indicator, Bridge Circularity Indicator, Circularity Indicator Building Score, Artificial Eco-Environmental Metric for Building End-of-Life Assessment.
e) Using hazardous and non-hazardous materials: Deconstructability Assessment score based on BIM.

5. Conclusion

The paper suggests a methodology for practically evaluating the progress made in the field of construction and demolition waste (C&DW) for environmental sustainability. A thorough knowledge of the role of the CE for C&DW is provided by this framework. The main variables that affect how well construction and demolition projects operate in a circular manner are outlined in this paper. Scientific understanding is advanced by this study, which lays the foundation for the development and refinement of indicator frameworks across several industries. Although academia, policymakers, and industry professionals are beginning to recognise CE more and more, there is still ongoing development in the understanding and application of CE techniques. The lack of measures and indicators to assess the status of circular economy implementation and calculate potential social, environmental, and economic benefits presents obstacles to the shift to a circular economy. It's critical that CE programmes be assessed using thorough, consistent measures. A Life Cycle Thinking methodology is required for an effective evaluation of CE systems since indicator frameworks provide thorough monitoring. Circularity metrics in the C&DW industry are now only marginally improving. Comprehensive approaches to CE are lacking in the majority of recent contributions, which concentrate on the building use phase or waste management solutions. Eight common assessment categories for assessing CE and 21 criteria for the circularity of C&DW were found in the study. Using the characteristics, 22 metrics were proposed for a thorough circularity assessment in the C&DW industry. To evaluate the chosen CE measures, the indicators that were already in place were examined and defined. The paradigm under consideration is the first approach to evaluate C&DW's circularity. Further study may be carried out regarding the pragmatic implementation of the framework. Improvements to the circularity indicators that are developed and further integrated to improve the strategy. All four of the other CE dimensions societal, technological, governmental, and behavioural should have their CE measured. The circular economy indicator framework, presented in Table 4, consists of four key elements: principles, drivers, stakeholders, and strategies. It focuses on in-use product and material maintenance, natural and economic capital preservation, resource productivity maximization, and design for the circular economy. Key principles include waste revalorization, innovation, efficiency, design, and systemic thinking. Most principles include environmental and technical aspects but lack social ones.

Table 4. Current Initiatives for the C&DW Sector's CE Measurement (Source: Author)

The factors that promote the implementation of corporate environmental initiatives. (D*)	**The Elements Essential guidelines for making decisions or figuring out behavior.** (P*)	**Participants in any decision-making process or activity undertaken by the organization are known as stakeholders.** (ST*)
D1-Political and economic benefits D2-Environmental concerning and resources depletion D3-Social development D4-Technological an d informational innovation DS-Organizational development D6-Supply Chain Management	P1-Preserving natural and economic capital P2-Maximize resource productivity P3-Retention of value P4-Promote the use of renewable energy P5-Design for the Circular Economy P6-Material balance P7-Minimize and gradually eliminate negative externalities P8-Close the system P9-Educating for the circular economy P10-Extended producer liability P11-Innovation P12-Collaboration P13-Rethinking the business model P14-Transparency P15-Resilience P16-Systemic thinking P17-Reduce	STI-Consumers and users ST2-Society ST3-Autorithies and government ST4-Suppliers activity of the organization STS-Shareholders/Investors /Financiers ST6-Employees ST7-Companies ST8-NGOs ST9-Local Communities ST10-Acadmey ST11-Resource Managers ST12-Designers and Material experts

Strategies: Approaches or ways to accomplish tasks (S*)

- S1-Training, Education and Campaigns about environmental and CI issues
- S2-Creations of collaborative networks
- S3-Establishing laws and policies towards CI
- S4-Implementation of certifications promoting CI
- S5-Implementation of taxes and subsides to support CI
- S6-Promoting end of life strategies
- S7-Adoption of service-based business model
- S8-Increasing private sector investment in CI
- S9-Reducing waste generation
- S10-Reduce and improve efficiency resources usage
- S11-Use of renewable energy
- S12-Use of environmental performance indicators
- S13-Use of cleaner materials, processes or technologies
- S14-Use of secondary resources
- S15-Reducing pollutant emissions
- S16-Designing adequate infrastructure
- S17-Designing products for reuse, recycle or recovery of material/ component
- S18-Use of standardised materials/components
- S19.Designing process for minimisation of waste
- S20-Designing transparent, reproducible and scalable products
- S21-Generate employment
- S22-Selecting suppliers using environmental criteria

5.1 Future Research

In addition to suggestions for concepts and perspectives for future research, the research on CE models is a large field that needs further investigation and diversity:

a) For the purpose of adding value and reducing waste, the building and demolition industries should investigate complementing tactics and circularity practice components. An analysis of the current legislative and regulatory frameworks, a standardisation of circular building goods, comprehension of stakeholders, and creative circular business models are some of the main motivators. Focusing on recyclable materials, modularity, and simplicity of disassembly and reuse are some examples of this. Using this all-encompassing strategy will assist avoid waste production and provide value.
b) Expanding the scope of circularity alternatives research to encompass cross-sectoral applications could improve the overall use of the CE model.
c) It is suggested that, in addition to the economic and environmental assessment put out in this work, a thorough analysis of the social component of circularity interventions be conducted, taking into account any possible social risks or benefits.
d) A thorough assessment of CE progress at the small, medium, and large levels is advised through the integration of indicators that take into account sociological, technological, governmental, and behavioural elements.

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Evolving sustainable built environment:
A paradigm shift to Regenerative Design

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Abstract: This paper aims to delve into the dichotomy of anthropocentric and biocentric perspectives to the design of the built environment and the consequent paradigm shift from sustainable to regenerative design. It starts with a critical review of the well-known building environmental assessment methods: BREEAM, LEED, CASBEE and GRIHA, and sustainability assessment methods: iiSBE's Sustainable Building Tool (SB Tool), ARUP's Sustainable Project Assessment Routine SPeAR®, Living Building Challenge (LBC) and German Sustainable Building Council's Certificate Program (DGNB). Further, seven theories of ecological sustainability are reviewed. This paper also reviews the four regenerative design frameworks: Eco-Balance, Perkins+Will, REGEN, and LENSES. The paper presents two exemplar studies, one from the USA and the other from India; to delineate the concept of integrated regenerative design of built environments. Finally, the paper summarises the evolution of the design approach from conventional to regenerative. This article argues that it is essential to evolve the current building environmental assessment and sustainability assessment methods at the same time biocentric approach is anticipated for the future of built environments.

Keywords: Anthropocentric; biocentric; built environment; sustainable design; regenerative design

सार: इस पत्र का उद्देश्य निर्मित पर्यावरण के डिजाइन के लिए मानव-केंद्रित और जैव-केंद्रित दृष्टिकोणों के द्वंद्व और इसके परिणामस्वरूप संधारणीय से पुनर्योजी डिजाइन में प्रतिमान बदलाव की गहराई से जांच करना है। यह प्रसिद्ध भवन पर्यावरण मूल्यांकन विधियों: BREEAM, LEED, CASBEE और GRIHA, और संधारणीयता मूल्यांकन विधियों: iiSBE के संधारणीय भवन उपकरण (SB Tool), ARUP के संधारणीय परियोजना मूल्यांकन रूटीन SPeAR®, Living Building Challenge (LBC) और जर्मन संधारणीय भवन परिषद के प्रमाणपत्र कार्यक्रम (DGNB) की आलोचनात्मक समीक्षा से शुरू होता है। इसके अलावा, पारिस्थितिक संधारणीयता के सात सिद्धांतों की समीक्षा की गई है। यह पत्र चार पुनर्योजी डिजाइन ढांचे की भी समीक्षा करता है: Eco-Balance, Perkins+Will, REGEN और LENSES। निर्मित पर्यावरण के एकीकृत पुनर्योजी डिजाइन की अवधारणा को चित्रित करने के लिए पत्र दो अनुकरणीय अध्ययन प्रस्तुत करता है, एक यूएसए से और दूसरा भारत से। अंत में, पत्र पारंपरिक से पुनर्योजी तक डिजाइन दृष्टिकोण के विकास का सारांश देता है। इस लेख में तर्क दिया गया है कि वर्तमान भवन पर्यावरण मूल्यांकन और स्थिरता मूल्यांकन विधियों को विकसित करना आवश्यक है, साथ ही निर्मित पर्यावरण के भविष्य के लिए जैव-केन्द्रित दृष्टिकोण की अपेक्षा की जाती है।

मुख्य शब्द: मानव-केंद्रित; जैव-केंद्रित; निर्मित पर्यावरण; संधारणीय डिजाइन; पुनर्योजी डिजाइन

1. Introduction

The trajectory of environmentally responsive design distinguishes two perspectives: anthropocentric (technological) and biocentric (ecological) (Moffatt and Kohler 2008, Mang and Reed 2012), Figure 1. The technological perspective led to development of building environmental assessment methods and sustainability assessment methods, the paper aims to review the same. While ecological view point led to evolution of regenerative design and development; a process to create a positive impact in the environment and allow other species to thrive or balance the negative impact due to human intervention in creating the built environment. This paper also intends to review ecological theories and regenerative design.

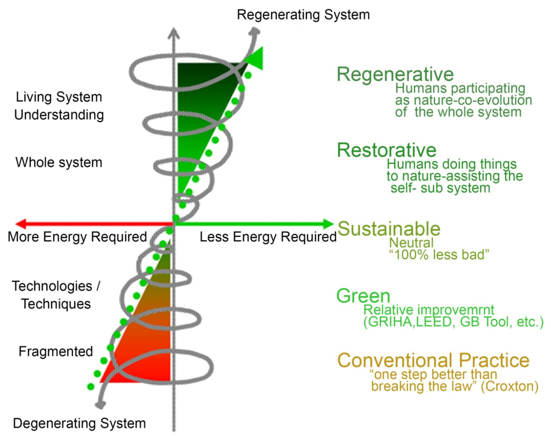

Figure 1. Environmentally responsive trajectory (adapted from Reed 2007a)

The paper discusses paradigm shift from conventional to regenerative design and envisions future generation of built environment.

2. Anthropocentric perspective to a sustainable built environment

The ASHRAE (2006) Green Guide "defines green design as '…one that is aware of and respects nature and the natural order of things; it is a design that minimizes the negative human impacts on the natural surroundings, materials, resources, and processes that prevail in nature." Globally the construction sector is awash with a number of green building rating systems accentuating high-performance, energy-efficient, and environmentally friendly cost-effective buildings (Gowri 2004). The extant green rating systems are classified into Building Environmental Assessment methods and Sustainability Assessment systems (Robinson 2004).

The building environmental assessment methods lay emphasis on environmental aspects of sustainability with the aid of criteria concerning to site selection, water management**,** energy management, occupant comfort and health**,** building materials**,** waste management, etc (Saunders 2008). A comparison of BREEAM (BRE 2016), LEED (GBCI 2018), CASBEE (JSBC 2014), and GRIHA (2021) is presented in Table 1. These methods mainly adopt a scoring system for design features that can minimize a built environment's impact The total of credits usually determines the level of certification.

While as the sustainability assessment methods take into account other aspects of sustainability: social and economic. A comparison of iiSBE's Sustainable Building Tool (SBTooL), Arup's sustainable Project Assessment Routine (SPeAR®), Living Building Challenge (LBC) and German Sustainable Building Council's Certificate Program (DGNB), is presented in Table 2.

Table 1. Comparison of four building environmental assessment methods

Salient features	BREEAM	LEED	CASBEE	GRIHA
Location, year	UK, 1990	US, 1998	Japan, 2001	India, 2021
Name of organization	Building Research Establishment (non-profit 3rd party)	US Green Building Council (non-profit 3rd party)	Japan Green Building Council (joint of academy- government-industry)	GRIHA (non-profit 3rd party)
Building Typology	School, office, retail, health care, court, prison, multi-function building, industrial unit, unusual building Residence	Healthcare, Retail, School, Multifunction building, Commercial building Residence	Retail, Industrial temporary construction, Multi-function building Residence (multi-unit)	Commercial/ Institutional/ Hospitals/ Hotels/ Office
Levels of Ratings	Uncertified < 30 Pass >= 30 Good >= 45 Very good >=55 Excellent >= 70 Outstanding >=85	Certified 40 – 49 points Silver = 50-59 points Gold = 60-79 points Platinum = 80+ points	BEE=0.5~1.0 (Fairy Poor) BEE=1.0~1.5 (Good) BEE=less than 0.5 (Poor) BEE=1.5~3.0 (V. Good) BEE=3.0 (Excellent)	1 star=25-40 2 star = 41-55 3 star = 56 - 70 4 star = 71 - 85 5 star = 86 or more
Categories of Sustainability	Management, Energy, Transport, Health & Wellbeing, Materials, Water, Waste, Land Use, & Ecology, Pollution & Innovation	Sustainable site, Indoor Environmental Quality, Water Efficiency & Resources, Innovation, & Regional Priorities	Building Environmental Quality: "Indoor Environment Quality of Service, Outdoor Environment on Site" Environmental Load: "Energy, Resources & Materials, offsite Environment"	Sustainable Site Planning Construction Management Energy Optimization Water management Solid Waste Management Sustainable Building Materials Life cycle costing Socio-Economic Strategies Performance metering & Monitoring Innovation
Assessment criteria	A simple additive credits	A simple additive credits (1 for 1)	Special	A simple additive credits (1 for 1)
Adaptability	Adaptability in the United Kingdom and relatively high abroad	Adaptability in the North America, and relatively high abroad	Adaptability in Japan, and relatively low abroad	Adaptability in India (Composite, hot dry temperate, and warm humid, except cold)
Reference	BRE (2016); Horvat and Fazio (2005)	GBCI (2018), Horvat and Fazio (2005);	JSBC (2014)	GRIHA Council (2021)

Table 2. Comparison of four sustainability assessment methods

Salient features	SBTool	Arup's Sustainable Project Assessment Routine (SPeAR)	Living Building Challenge	DGNB Certificate Program
Location, year	Canada, 1998	United Kingdom, 2000	North America, 2006	Germany, 2009
Developed by	iiSBE (international non-profit collaboration)	ARUP	International Living Building Future (non-profit third party)	German Sustainable Building Council (DGNB)
Level of Ratings	-1=unsatisfied 0= minm acceptable performance 2 = normal default 1 to 4 = intermediate performance levels 5 = best practice	Score	Petal certification (three petals-one of which must be the Water, Energy or Materials) Net-zero energy certification Living certification (seven petals)	Bronze (~35%) Silver (~ 50%) Gold (~65%) Platinum (~ 80%)
Building Typology	Practically any building	Practically any building	Practically any building Renovation, landscape or infrastructure (non-conditioned development)	Practically any building
Sustainable Categories	Site Selection, Energy & Resource, Environmental Loadings, Indoor Environmental Quality, Service Quality, Project Planning, and Development, Economic & Social aspects, Cultural & Perceptual Aspects	Environment & Natural Resources 60 indicators Environment Air Quality, Land Use, Water, Ecology & Cultural Heritage, Design & Operation & Transport Natural Resources Materials, Water, Energy, Land Utilization, & Water hierarchy Economic (26 indicators) Social benefits & costs, transport, employment/skills, competition effects, viability Societal (34 indicators) Health & Welfare, User comfort/ satisfaction, form & space, access, amenity, & inclusion	Place, Water, Energy, Materials, Health & Happiness, Equity & Beauty	Site Environment Socio-Cultural & Functional Economic Technical Process
Assessment criteria	Additive improved weighted credit method	Special (SPeAR diagram)	Actual recorded performance	Special (Performance Index)
Adaptability	High adaptability globally	High adaptability globally	High adaptability globally	High adaptability globally
References	Horvat and Fazio (2005); IISBE (2016)	ARUP	ILFI (2010)	DGNB

Source: Kumar et al. (2022)

3. Biocentric perspective to a sustainable built environment

Ecological approach to sustainability germinated post the 1970s oil crisis on account of the philosophy of eminent researchers like Leopold (1949) *A Sand County Almanac* and McHarg (1992) *Design with Nature* and their consideration of the profound connect between humans and nature. A review of seven ecological principles is presented in Table 3; which set the constrains of nature on design of built environment. While holistic view of the built environment is needed; which requires a balanced and an integrated approach.

Table 3. Comparison of Biocentric theories/concepts.

Malcolm Wells (1982): wilderness-based checklist	Nancy Jack Todd and John Todd (1984): Living machines	Brinda Vale and Robert Vale (1991)	Ian McHarg (1992): Design with Nature	John Tillman Lyle (1994): Regenerative design strategies	Sim Van der Ryn (1996): Ecological Principles	William McDonough (2005): Cradle to cradle design philosophy
1. Creates pure air 2. Creates pure water 3. Stores rainwater 4. Produces its own food 5. Creates rich soil 6. Uses solar energy 7. Stores solar energy 8. Creates silence 9. Consumes its own wastes 10. Maintains itself 11. Matches nature's pace 12. Provides wildlife habitat 13. Provides human habitat 14. Moderates climate and weather 15. .... and is beautiful	1. Self-sustaining. 2. Based on the living relationship between our biotic and abiotic environment. 3. Based on ecosystem technologies. 4. Treat sewage and purify water with plants, animals, and microorganisms. 5. Maintain ecological balance in nature.	1. Conserving Energy 2. Working with climate 3. Minimizing new resources 4. Respect for users 5. Respect for site 6. Holism	1. Negentropy 2. Apperception 3. Symbiosis 4. Fitness and fitting 5. The presence of health or pathology	1. Let nature do the work 2. Consider nature as both model & context 3. Aggregate, not isolate 4. Seek optimum levels for multiple functions, 5. Match technology to needs 6. Use information to replace the power 7. Provide multiple pathways 8. Seek standard solutions to disparate problems 9. Manage storage as a key to 'sustainability.' 10. Shape form to guide the flow 11. Shape form to manifest process 12. Prioritize for sustainability	1. Solutions grow from place. 2. Ecological Accounting. 3. Design with nature. 4. Everyone is a Designer. 5. Make nature visible.	1. Believes in repaying the Earth in return for what it has given us. 2. Suggests to protect and enrich ecosystems and nature's biological metabolism. 3. Categorizes all the material into 'technical' and 'biological.' 4. This suggests the use of organic and technical nutrients. 5. Suggests removing dangerous technical materials from the current life cycle.

Source: Kumar et al. (2022)

6. Regenerative design explorations

Globally, there is an increased emphasis on the whole-systems design concept, which dynamically integrates the human and non-human ecosystems of the built environment (Reed 2007b, Moffatt and Kohler 2008). The regenerative thinking entails to move beyond the linear throughput model of 'inputs-consumption-waste' that describes the current development. It further goes beyond being net-zero energy or carbon neutral, it is a primary repositioning of the question. Regenerative intends to go beyond not harm - it is the co-evolution of human and natural systems to design to restore the environment actively. A regenerative system affords continuous replacement, through its functional procedures, of the materials and energy consumed in its operation. Figure 2 distinguishes linear throughput model with regenerative model.

A comparison of four regenerative design frameworks: Perkins+Will (2008), REGEN (Svec, Berkebile and Todd 2012), LENSES (Living Environments in Natural, Social and Economic Systems, Plaut, Dunbar, Wacherman & Hodgin 2012) and Eco-Balance (Fisk 2014), is presented in Table 4.

First, looking at their compositions and illustrations, all four systems of regenerative design have a common postulation of sustainable design as a circle and cycle, Figure 3. The Perkins & Will framework is the most explicit, which sets resource-related design strategies within cycles-from nature and back to nature (Cole 2012).

The second common point is **coverage; it** seems more ambitious in defining sustainability and its indicators. For example, the REGEN framework comprises nested systems (Svec et al. 2012). The LENSES framework uses a similar layered visual model to illustrate interconnections and assist users in seeing and understanding whole systems (Plaut et al. 2012).

Third, all four frameworks provide a conceptual design system to lead **dialogue** rather than quantitative criteria or conditions. For instance, REGEN envisages that a project team can input basic information about their project location, type and scale and the framework will immediately populate with everything that is known within it about that location and its current state of health.

Fourth, these frameworks explicitly distinguish **positive and negative impacts** and emphasize on producing positive outcomes. Most strategies impact multiple components, sometimes positively and sometimes negatively. For instance, the REGEN contains these positive and negative effects in a complex web of connections. By inserting one or more components, participants will find the strategies that are connected to the components.

In the essence these regenerative design support tools intends to assist design teams for:

- thinking about whole systems
- designing for a specific place/location
- facilitating conversations and meaningful dialogue between the stakeholders
- encouraging stakeholders (occupants/users) to consider the interconnectedness of the different components
- ensuring positive impacts for the socio-ecological whole.

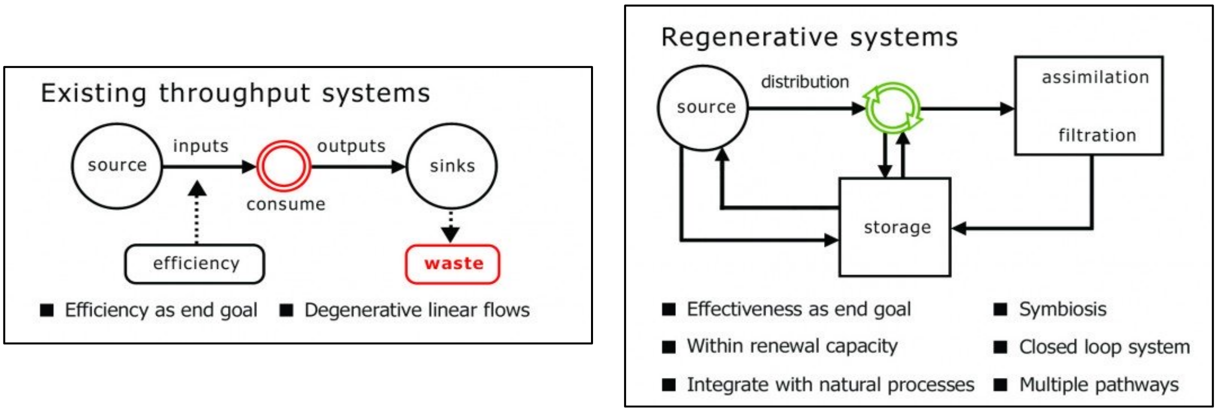

Figure 2. Comparison between flows in degenerative and in regenerative (adapted from Lyle 1994) (http://akihan.hubpages.com/hub/Regenerative-Architecture)

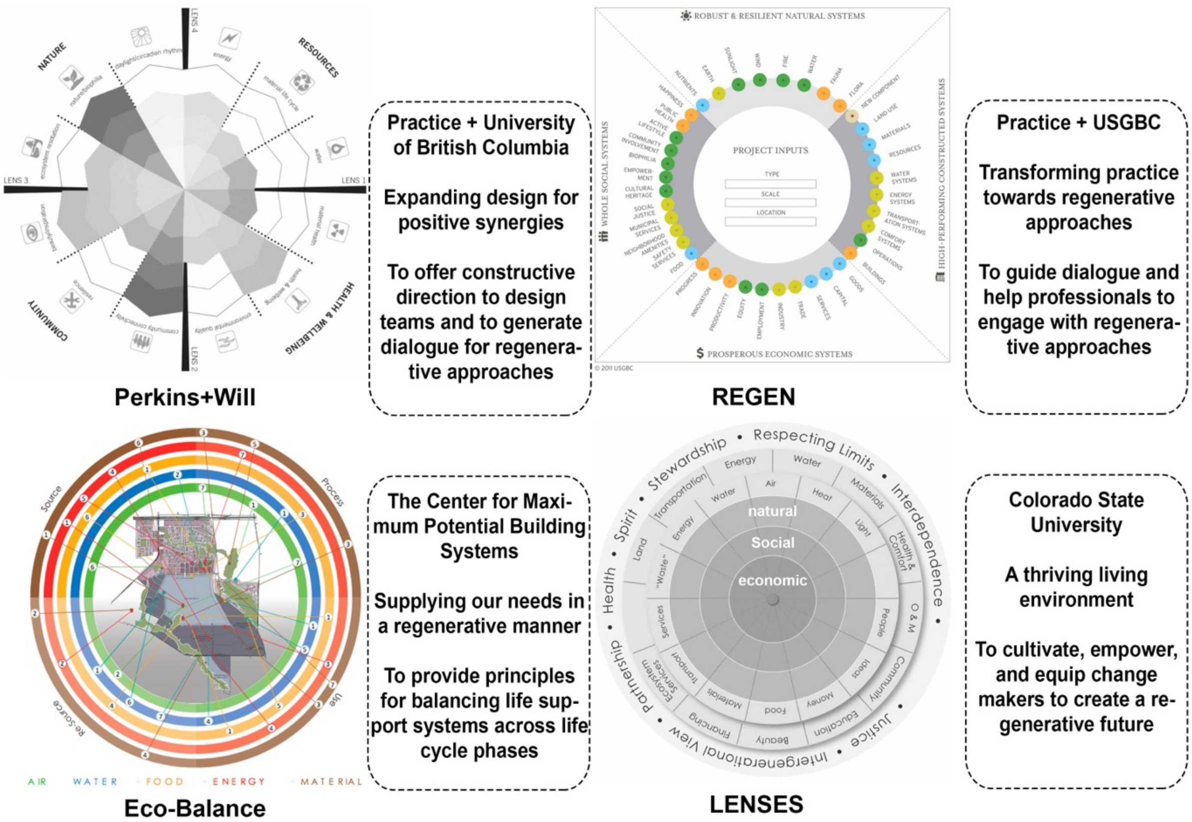

Figure 3: Comparison of Regenerative Design Support Tools (adapted from Gou and Xie 2017)

Table 4: Comparison of Regenerative design frameworks

	Eco-Balance (Fisk 2009)	**REGEN** (Svec, Berkebile, and Todd 2012)	**Perkins + Wills** (2015)	**LENSES** (Plaut, Dunbar, Wacherman & Hodgin 2012)
Developer	Plinky Fisk and Gail Vittori	BNIM	Perkins + Wills	CLEAR
Types of Developer	Non-profit organization	Architectural firm	Architectural firm	Non-profit organization
Background	The Center for Maximum Potential Building Systems	Practice + USGBC	Practice + University of British Columbia	Institute for Built Environment at Colorado State University
Goal	Providing the needs in a regenerative way	Transforming practice towards regenerative methods	Enhancing design for positive synergies	A thriving living environment
Mission	To offer principles for balancing life support systems across life cycle phases	To lead dialogue and assist professionals to engage with regenerative methods	To provide constructive direction to design teams and to generate dialogue for regenerative methods	To nurture, empower, and equip change-makers to develop a regenerative future
What?	A design and planning framework	A web-based tool with rich data	Issues and process-based frameworks	A process and a metrics framework
Structure	Series of graphics	Linking specific strategies to the whole	Challenging questions	Overlaid three lenses
Main categories	i) LIFE SUPPORT SYSTEMS (Air, water, food, energy and materials) ii) LIFE CYCLE PHASES (source, process, use and resource)	i) ROBUST AND RESILIENT NATURAL SYSTEMS (nutrients, earth, sunlight, wind, fire, water, flora-fauna), ii) HIGH-PERFORMING CONSTRUCTED SYSTEMS (new component, land use, materials, resources, water and energy systems, transportation system, comfort systems, operations and buildings) iii) PROSPEROUS ECONOMIC SYSTEMS (Goods, capital, services, trade, industry, employment, equity, productivity, innovation, progress) iv) WHOLE SOCIAL SYSTEMS (food, safety service, neighbourhood amenities, municipal services, cultural heritage, empowerment, biophilia, community involvement, active lifestyle, public health, happiness)	ISSUE-BASE FRAMEWORK: representation of place and representation of flows PROCESS-BASED FRAMEWORK: Human needs (health and well being, social vibrancy, cultural vitality, healthy economy) ECOSYSTEM FUNCTIONS (habitat, regulation and production) Foundation, sandbox and toolbox	FOUNDATION LENS (Stewardship, respecting limits, interdependence, justice, intergenerational view, partnership, health and spirit) FLOWS LENS (Culture, materials, wellbeing, education, energy, ecosystems, landuse, transport, money, beauty and water) VITALITY LENS (regenerative, degenerative)
Audience	Professionals and businesses	Professionals and community members	Practitioners of Perkins+Will	Professionals, government, business, students and non-profit teams
Verification	No	No	No	No

Source: adapted from Akturk (2016)

The Willow School, Gladstone, New Jersey, USA
ırce: http://www.farewell-architects.com/the-willow-school-1/
Designer: Phase I: Farewell Mills Gatsch Architects, LLC;
Phase II: Hone+Associates;
Landscape: Back to Nature.
Consultant: Regenesis Group

TERI Retreat, Gualpahari, Gurugram
Source: http://shift.org.in/teri-retreat.php
Designer: Sanjay Prakash and TERI
Owner: The Energy Resources Institute (TERI)

Figure 4. Exemplars of regenerative architecture

5. Exemplars of Regenerative built environments

The researcher has established that a built environment designed adopting a whole-systems approach would be far better connected than a built environment designed using conventional methods. There is also a growth in application of regenerative design frameworks in real-life examples of built environments. This section presents two examples enunciating regenerative design approaches.

5.1 The Willow School, Gladstone, New Jersey, USA

The Willow School is a K-8 private primary school for 200 pupils (aged five to 13) and focusing on holistic education, Fig. 4a. The school site covers approximately 13 hectares. Regenesis Group collaborated with the site developers to assist them comprehend and foster a sense of place, revealed in the final development plan. Incorporating green buildings, two LEED Gold and Platinum rated buildings, into the school's design, along with the application of water management techniques including stormwater management systems, significantly contributes to the regeneration of the site. Willow School signifies a regenerative development, focusing on the following:

- a living systems model, which integrates the design into the prevailing ecosystems and helps to restore them
- development of a sense of place
- positive environmental outcomes.

5.2 TERI Retreat, Gurugram

TERI RETREAT (Resource Efficient TERI Retreat for Environmental Awareness and Training), Fig. 4b, is 35 km south of Delhi, at Gual Pahari, Gurugram, Haryana, covering an area of 36.5 hectares. This building does not put any pressure on the earth's fragile ecosystems and, in fact, actually regenerates what has been lost through neglect or misuse of nature's bounty (Mazumdar 1997).

TERI transformed the rocky and degraded wasteland with no vegetation into fertile land with lush green forests and gardens by scientifically improving land fertility and intense plantation. The climate-responsive building is energy efficient as it is day-lit all around the year and earth air tunnel keeps it cool in summer/warm in winter. The building integrates sustainable use of natural resources and efficient waste management. The building demonstrates application of clean and renewable energy technologies.

RETREAT campus epitomizes the nature-integrated model of sustainability, and it offers innumerable lessons of regenerative development focusing on:

- positive environmental consequences
- a living systems model, which integrates the design into the prevailing ecosystems and helps to restore them
- development of a sense of place/context

6. Conclusions

This paper examines two schools of thought on sustainable built environment: anthropocentric and biocentric. Appendix A summaries paradigm shift from conventional regulatory approach to a well-developed and holistic approach to design of the built environment (Kumar et al. 2022).

The regenerative frameworks lean to be more proactive and positive than current green building conservative thinking. The usage of these frameworks mainly relies on the designers who are using them and on the context in which they are applied. These frameworks do not generate level of certification or a new rating system and no comparable outcomes or measurements are generated from these frameworks.

In conclusion, the regenerative frameworks can complement current green rating systems by permitting negotiation, reflection and learning, thus articulating solutions for particular contexts and places, specifically on the flow of the resource, which is an essential measurement of the positive or negative impact of a built environment on nature. This synergy of anthropocentric and biocentric approaches will pave the path to resolve environmental dilemma (Kabre 2020).

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Appendix A. Transition from conventional to sustainable and regenerative design concepts.

Design	Key points	References
Conventional	**i)** A prevalent sector of business-as-usual is termed green building due to increasing focus on energy efficiency and moving towards becoming more sustainable as human-oriented only design **ii)** Designs generally aim to comply minimum codes or regulations BIS (2016), BEE (2017) for the lowest first cost **iii)** Resource-intensive **iv)** Modicum thought is given to the environmental impact of the design.	Kellert (2004); McDonough (2002); Reed (2007b)
Eco-efficiency Sustainable design	**i)** Aims neutral environmental impact and maximum efficiency. **ii)** Thrust on reducing the negative environmental impact. **iii)** Thrust on individual building performance. **iv)** Minimized energy intensity of goods and services. **v)** Minimized activity footprint. **vi)** Improved material recyclability. **vii)** Maximized use of sustainable resources **viii)** Application of green building rating tools to measure performance, such as GRIHA, LEED, IGBC.	ISO (2011); McDonough and Braungart (2002); Birkeland (2002)
Restorative	**i)** Questions how humans can restore ecosystems through development **ii)** Acknowledges environmental damage done by human activities and seeks to redress this through further development **iii)** Is a process of humans managing and manipulating ecosystems	Reed (2007a); Couchman (2007)
Cradle-to-cradle	**i)** Questions and redesigns the goals and methods of design to produce products, buildings, or systems without negative environmental or social outcomes (termed 'good' design). **ii)** Restores the health of air/water/soil. **iii)** Eliminates waste by using 100% biodegradable or 100% recyclable materials. Thus waste becomes a resource and 'waste equals food.' **iv)** May extend to economic, business, and social structures.	McDonough (2005); McDonough (2002)
Bio-inspired design	**i)** Design that has an understanding of the relationships between biology/ecology and humans to improve human technology (biomimicry) or to improve human psychological wellbeing (biophilia). **ii)** May result in regenerative, restorative, eco-efficient, or conventional outcomes depending on the understanding of the design team. It has the potential to contribute to regenerative design goals.	Benyus (1997); Zari (2008); Zari and Storey (2007)
Ecological design	**i)** Design strategies may be modelled on ecosystems. **ii)** Design creates processes that are compatible with nature and maybe mutually beneficial for improved human and non-human health.	Wells (1982); Todd and Todd (1984); Van der Ryn and Cowan (1996); Graham (2002); Kibert, Sendzimir and Guy (2002); Van der Ryn and Pena (2002)
Reconciliatory design	**i)** Acknowledges humans as an integral part of nature and that the two operate in one system.	Reed (2007b)
Regenerative development	**i)** Examines how humans can contribute in ecosystems through development to foster optimum health. **ii)** Visualizes humans, human developments, social structures, and cultural concerns as an intrinsic part of ecosystems. **iii)** Envisages restoring or creating the capacity of ecosystems and bio-geological cycles to function without human management. **iv)** Comprehending the diversity and uniqueness of each place (environmental, social, & cultural) is critical to the design. **v)** Visualizes the design process as in progress and indefinite. **vi)** May integrate strategies for positive psychological results, for example implement traditional design wisdom (provide climate responsive design and add a 'sense of place'); and apply biophilic design (forms from nature)	Lyle (1994); Natural Logic Inc. (2003); Kellert (2004); Cole, Charest and Schroeder (2006); Reed (2007b)
"Integrated approach a. Coordination of planning and management activities associated with land use and land resources (including buildings, transport, urban design, and infrastructure) to achieve added value. b. May result in regenerative, restorative, eco-efficient, or conventional outcomes. United Nations Division for Sustainable Development" (UNCED 1992)		

Source: (Adapted from Kumar et al 2022)

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Mapping Material Patterns in Housing Preference in Rural India using Multinomial Logistic Regression

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Abstract: Within the binary of *kacchā-pakkā* (raw-cooked), a metaphor that pervades the everyday dialect in Indian society, pakkā becomes a privileged term. Such an unequal status of the terms becomes evident in an empirical study of rural landscapes, where the authors map the transformation of houses from the traditional vernacular (*kacchā*) dwellings to the 'modern' (*pakkā*) houses. Why does this shift in materials occur? The research begins with the hypothesis that the preference of the pakkā house is an outcome of the changes in sociocultural dynamics and the its entanglements with the caste and class systems of Indian society. Using data from 387 respondents from at different fieldwork sites – Poonch (Jammu & Kashmir), Birbhum (West Bengal) and Barmer (Rajasthan)—this study employs a multinomial logistic regression analysis to examine the relationships between the status of people and the materiality of their homes. The results show that caste hierarchies play a substantial role in the preference for a pakkā house. For *kacchā* and hybrid house types, the independent variable of age becomes significant, as older people see value in their traditional vernacular dwelling.

Keywords: caste, housing preference, materiality, rural dwelling, sustainable building.

सार: कच्चा-पक्का (कच्चा-पका हुआ) के बाइनरी के भीतर, एक रूपक जो भारतीय समाज में रोजमर्रा की बोली में व्याप्त है, पक्का एक विशेषाधिकार प्राप्त शब्द बन गया है। शब्दों की ऐसी असमान स्थिति ग्रामीण परिदृश्यों के एक अनुभवजन्य अध्ययन में स्पष्ट हो जाती है, जहां लेखक पारंपरिक स्थानीय (कच्चा) घरों से 'आधुनिक' (पक्का) घरों में घरों के परिवर्तन का नक्शा बनाते हैं। सामग्रियों में यह बदलाव क्यों होता है? शोध इस परिकल्पना से शुरू होता है कि पक्का घर की प्राथमिकता सामाजिक-सांस्कृतिक गतिशीलता में बदलाव और भारतीय समाज की जाति और वर्ग प्रणालियों के साथ इसके उलझाव का परिणाम है। विभिन्न फील्डवर्क साइटों - पुंछ (जम्मू और कश्मीर), बीरभूम (पश्चिम बंगाल) और बाड़मेर (राजस्थान) से 387 उत्तरदाताओं के डेटा का उपयोग करते हुए - यह अध्ययन लोगों की स्थिति और भौतिकता के बीच संबंधों की जांच करने के लिए एक बहुराष्ट्रीय लॉजिस्टिक रिग्रेशन विश्लेषण का उपयोग करता है। उनके घर। नतीजे बताते हैं कि जातिगत पदानुक्रम पक्के घर की प्राथमिकता में महत्वपूर्ण भूमिका निभाते हैं। कच्चे और मिश्रित घरों के लिए, उम्र का स्वतंत्र चर महत्वपूर्ण हो जाता है, क्योंकि वृद्ध लोग अपने पारंपरिक स्थानीय आवास में मूल्य देखते हैं।

मुख्य शब्द: जाति, आवास वरीयता, भौतिकता, ग्रामीण आवास, धारणीय भवन।

1. Introduction

In the last few decades, the building industry in urban India has moved towards using sustainable design strategies, with the goal of lowering its ecological impact. A significant aspect of this change becomes apparent in the renewed focus on building materials with low embodied carbon or naturally climate-responsive ones, thereby valorising natural materials with minimum or no processing. While building with earth, bamboo or other natural materials has seen some currency in urban areas, albeit slowly, India's rural hinterlands, to the contrary, show a decline in traditional dwellings made in *kacchā* (raw/ not durable/ temporary) materials, rapidly being replaced by houses in *pakkā* (cooked/ durable/ permanent), often industrially produced materials. Many architects recognise that "built techniques in the innards of Indian rural communities are ready-made lessons in sustainability" (Kuriakose quoted by Govind 2014) or the "timeless" quality that traditional building practices offer (Bhatia 2006). Equally, academics conduct research with students to learn from these 'vernacular' constructions (R & S 2020). Although professionals see merit in building naturally, the ostensible *villager*[1] is in the process of completely discarding these indigenous values and ancient wisdom embedded in their traditional dwellings made of natural materials. It may be pertinent to reverse this trend if the sustainability goals for the nation need to be achieved for which it is necessary to know its reasons. This paper studies this shift by conducting a material-based study of housing preferences in rural India to understand the most influential factors driving it.

There are many studies done on rural vernacular dwelling or more generally housing in the Indian context. Some of these studies discuss the transformation of the tribal/ rural landscape within the broader social and historical construct of the context of which the vernacular dwelling is an essential unit of study (Menon 2018; Bharat 2019) and use historical or ethnographic methods. Some studies have recorded transformation by documenting house typologies in a particular locale (Daketi and Srikonda 2022) using exploratory, descriptive and explanatory methods for the built-form analysis and are case-specific in their approach. A few scholars have attempted to use space syntax (Kaushik 2020) for spatial analysis of the vernacular building enabling an assessment of the changing forms. Some scholars discuss the form in stylistic terms as representing vernacular identity (Belz 2013) or more recently, conceptualise the indigenous built environment as a dynamic socio-ecological system (Dhingra 2021). Studies on sustainability indicators for vernacular architecture (Jagatramka et al. 2020) or thermal performance of dwellings (Kumari 2022) made in natural materials have been undertaken by scholars as part of energy efficiency and building performance research.

A study done to understand the factors favouring or limiting the construction and daily use of earthen houses using an informal survey suggested that 'Image' is the key barrier against a wide acceptance of traditional earthen houses which are linked to poverty (Kulshreshtha et al. 2020). There are fewer studies on housing priorities and preferences conducted in the Indian context. A recent study of slum communities' housing priorities focused on learning how they structure their concerns and identify specific solutions that could enable access to improved housing facilities (Killemsetty et al. 2022). Another study was done to understand customers' preferences for housing attributes in India whilst purchasing residential property (Gupta and Malhotra 2016). However, there is no substantive research conducted on rural housing using the housing preference framework.

Siddharth Menon goes on to study the embodied and the affective dimensions of house transformation in villages in Himachal Pradesh, India; arguing that, the transformation of the house is also the transformation of traditional caste and gender identities into new middle-class identities. His work extends literature in infrastructure studies and urban political ecology by highlighting how the materiality of infrastructures interacts with everyday dimensions of difference to reproduce the marginalisation of historically oppressed groups along intersectional lines of class, caste, and gender (Menon 2022). Menon's research uses ethnographic data to narrate how these different groups use the materiality of cement houses for their purposes. In some ways, Menon's findings seem to suggest that the material transformation to cement/ concrete houses is a given and people may have moved away completely from building in indigenous ways. The question that can be asked is, whether it is possible to quantify the correlations between the various intersectional identities of an individual and the material transformation to cement/ concrete houses.

Since the rural housing policy (PMAY Gramin) aims for sustainable development as a key agenda for the rural sector by promoting the development of house design typologies embedded with an indigenous knowledge system (UNDP 2016), it becomes imperative to examine how to retard, even reverse, the material transformation of houses from the ubiquitous cement or concrete houses towards houses made in natural materials as per local context. To enable acceptance of these 'sustainable' rural house design typologies by the rural populace, it is crucial that in-depth research on the factors that affect material patterns is undertaken. This research attempts to identify these factors as essential to the individuals' identity. Using an intersectional approach (Bentley et al. 2021), this research examines multiple aspects of a person's identity such as their background, age, gender, education, occupation, caste and current house and seeks to find a quantifiable correlation of these factors with material based housing preferences. It uses multinomial logistic regression to derive parameter estimates with the intention to measure results. This paper begins with a conceptual framework that provides the theoretical grounding and moves into a methodology that explains the model structure and survey design, which is followed by results and discussion to derive conclusions.

2. Conceptual Framework

The research builds upon the theoretical discourse of binary categories using a structuralist stance. It works on the assumption that binary oppositions are a method adopted by all societies to make a sense of the phenomenal world in which they exist and that these manifest in various forms of social differentiation (Claude 1969). However, it is mindful of how one of the terms assumes dominance and the need to go beyond binary constructs (Cloke and Johnston 2005). The first sub-section on the kacchā-pakkā briefly examines the binary as it exists in Indian culture and specifically in the built environment. The second sub-section seeks to connect kacchā-pakkā materiality to caste hierarchies as the foremost social structure that leads to differentiation in Indian society. Lastly, the third sub-section introduces the concept of housing preference as the 'aspirational' house and emphasizes on role of materiality.

2.1 Kacchā-Pakkā

The binary construct of the kacchā-pakkā is part of our language[2] and is used in everyday cultural practices for determining many aspects of life. It pervades our imagination of food, as raw or cooked *(roti as kacchā- poori as pakkā),* of clothes as fast colour or the kind that bleeds *(pakkā rang- kacchā rang*) and of buildings based on the materiality of earth or brick-cement *(kacchā ghar- pakkā makān)*[3]. These terms define the qualitative nature of the object under examination as per the materiality that was meant to be used in varied contexts. Traditionally, *roti* would be everyday food and *poori* would be reserved for festive occasions, meant to be celebratory in nature. Both types of Indian bread have their context of consumption.

Historically, cities being centres of political governance, economic generation and/ or religious significance, had pakkā buildings becoming the norm due to the need for security, durability and monumentality. This coupled with easier availability of resources such as material, knowledge and labour, the pakkā became the urban technological praxis with time, as the municipalities continuously tried to propagate the use of pakkā construction as an index of an improved urban condition (Sengupta 2012). This would be the city's cores, while in urban infills or peripheries housing common folks, those who would be serving the city by their labour continued to house themselves in earth, mat or bamboo kacchā houses to evade higher municipal taxes. In a sense, these areas were much like the villages in terms of materiality. The villages, on the other hand, continued to live in the traditional vernacular dwelling mostly made in local materials, invariably natural. Those who were higher in the social hierarchy would have larger or higher dwellings in the same materials and technology. The pakkā house eventually finds a way into the village through the *Zamindars* (landowners) or *Lambardars* (revenue collectors) having urban connections. In the context of the built environment, much of this has continued well into post-colonial independent India leading to the socio-cultural construct to become a true binary opposition such that, pakkā has become the dominating one, the privileged term.

2.2 Caste Hierarchies

While the context of the use of the kacchā-pakkā materiality is imperative; who uses what, and in which situation, also needs to be understood. In Indian society, caste hierarchies were and still are, a kind of social code that determines multiple aspects of life and to think that caste identities are not at play in contemporary times would be misleading. Caste *(jati)* is ascribed by birth and is based on the occupation of the family in which one is born and the relative ritualistic purity (Mickevičienė, 2003) that ensues in everyday and religious practices of living. While it is hierarchical in nature, with some castes considered higher than others, it is a system that not only categorises, it also differentiates and segregates. It may determine what you do, what you eat (Khajuria et al., 2020) or wear and where you live. The materiality of caste is as important as its ideology, if not more (Jodhka 2018). Caste is not a mere state of mind and has a role in creating inequalities in material life and reproduction. Jodhka quotes James Manor who argues that "The old caste hierarchies were rooted in materiality. They did not just exist in people's minds—-at the level of ideas, beliefs and imaginings ... Caste and caste hierarchies had—and still have-—tangible substance" (Kothari and Manor 2012, p.96).

Caste ends up dictating the nature of social relations with those of the same or other castes, of the lower or higher in the hierarchy and that has implications in terms of material exchange and accessibility to resources. In effect, it is the hegemonic structure within society leading to social order, creates worldviews within communities, attributes levels of agency to actors and ends up regulating access to resources. Caste is found to be a complex institution, simultaneously weakened and revived by current economic and political forces in post-independent India; it is a contributor to persisting national socioeconomic and human capital disparities, and has major impacts on subjective well-being (Mosse, 2018). Caste has shown tremendous resilience in the face of modernity and development, although the hierarchical logic is declining.

Transformations on one side and increasing resistance to change on the other are part of a multifaceted interweaving of humiliation, eagerness for self-respect, privileges and domination. Post-liberalisation of the economy has complicated matters of caste further, ‘‘[c]aste has a perplexing capacity to dissolve, as ascriptive characteristics give way to acquired ones (such as skills, compliance and trust, experience and creative competence), and as capital becomes mobile. But at the same time it persists and transforms itself as a regulative structure of the economy — sometimes in the same site” (Harriss-White 2017). Caste works as both a structure of disadvantage or discrimination and as a structure of advantage or accumulation working (Mosse 2018) involving processes of “categorical exclusion” and “opportunity hoarding” (Tilley 1998, p.10).

Current research done across the country reports a levelling of the caste-based markers of social recognition- food, dress, grooming, styles of worship and ways of living. The pakkā house is the most outward symbol representing the act of self-emancipation through material accumulation and the ability to afford. *The hypothesis of this research is that the preference of the pakka is an outcome of the changes in social structure and sociocultural dynamics— the intertwining of the aspects of the caste system and class system and is an attempt to be free from the social trappings in which people have been caught for generations. In other words, the subaltern (subordinated for caste or ethnicity), that are rising in class by acquiring capital, chooses housing preference for pakkā and uses it for its intrinsic value for representation of self-family as gaining social status.*

2.3 Housing Preference

The house is much more than a mere shelter. It is a safe enclosure for the family providing a sense of security and safety. At the same time, it is a representation of the family in the social domain. The house holds multiple meanings for those who dwell in it and it is the experience of living that makes it their home. Through the process of living, residents create their own sets of criteria based on which they transform their house or change to a new house entirely. Depending on the context of the house and the residents, the criteria would differ. The concepts of housing preference and choice are widely used in research. Preference refers to *the relative attractiveness of an object (house),* while choice *refers to actual behaviour* (Jansen et al., 2011). In a sense, housing preference is aspirational in nature and the domain of desire while housing choice is the translation of aspirations (or the lack of it) in the house, based on the means available to the resident family. Many housing attributes are studied as a basis for housing preferences and choices by scholars. These may be number of rooms, size of spaces, connection of spaces, outside spaces, levels of privacy, features of facade and location, amongst many others. In the Indian context, the materiality of the house is also a significant attribute determining housing preference. This is due to the social construct of *kacchā-pakkā* materials where the term *pakkā* is the dominating one, leading to natural *kacchā* materials becoming inferior. This research focuses on material-based housing preference in the rural Indian context.

3. Methodology

This research paper begins with the question of housing preference and uses stated preferences as expressed by respondents in a semi-structured interview from three regions in the northern part of India. Some methods and analytical techniques to describe, predict and explain housing preference and housing choice have been formulated by scholars of the housing research domain. The emphasis of these related to the practical framework of goals in housing studies, in particular, "Why do people move?", "what do customers want?" and "Which choices do they make?" (Jansen et al. 2011). Most of the methods and techniques have been an outcome of research done within developed countries and urban geographies. As given in the comprehensive compilation on housing analysis methods, 'The Measurement and Analysis of Housing Preference and Choice', there are many methods that can be used as per different research objectives. Traditional Housing Demand Research (Boumeester 2011) method is used to obtain accurate insight into current and future demand for housing. The decision Plan Nets method is used to reveal people's choices and is a process based on individual mixes of dwelling characteristics that are supposed to be essential. Meaning Structure method (Coolen 2011)can assess what people's housing preferences are and why they have these preferences. The multi-attribute Utility method is used to make a rational choice between available alternatives based on the dwelling profile that yields the most utility. The Conjoint Analysis method (Molin 2011)is used to estimate a utility function that can be used to predict the overall utility of residential profiles and thus can compare residential alternatives in terms of peoples' preferences.

It is possible to apply some of these research methods in the context of the developing world albeit with some modification and contextualisation. This paper presents research that uses a modified version of the Discrete Choice Conjoint Analysis method. It is quantitative in nature and uses multinomial logistic regression for analysis. It correlates to age, gender, caste, educational and occupational identities and the existing house to the stated housing preference in terms of three material-based house typologies- kacchā, hybrid, and pakkā. Using the regression coefficients from the parameter estimates of the analysis, there is an attempt to form a probability model, predicting the overall utility of house profiles based on their materiality for the rural context in India. This model would allow for a comparison of house alternatives in terms of people's preferences according to their individual demographic and social profile that is in accordance with the intersectionality of age, gender, occupational, educational and caste/ ethnic identities and existing house. The two sub-sections elaborate on the model structure applied for the multinomial logistic regression analysis and the survey design of this research with details of fieldwork sites and the logic of sample size from the total rural population of India.

i) **Kacchā house type-** structure/s made in natural materials like earth, bamboo, stone in dry masonry, wood, and thatch, using indigenous techniques and technologies.
ii) **Hybrid house type-** a mix of natural materials using indigenous techniques and technologies and industrial materials such as brick, cement, concrete, and metal sheets, using modern technologies where necessary.
iii) **Pakkā house type-** structure/s made in industrial materials such as brick, cement, concrete, and metal sheets, using modern technological know-how.

3.1 Model Structure

The choice has to be made from a set of alternatives, each of which is characterised by different attributes. To choose the preferred alternative, the decision-maker needs a decision rule to process. One of the four categories of the decision-making rule is based on utility maximization.

The utility of an alternative is an objective function of the attribute vectors and the decision-maker characteristics, which can be represented for the selection of preferences as per the following relationships, in the form of these equations:

$$U_{Kaccha} = \beta_k + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots + \beta_n X_n \quad (1)$$

$$U_{Hybrid} = \beta_h + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots + \beta_n X_n \quad (2)$$

$$U_{Pakka} = \beta_p + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots + \beta_n X_n \quad (3)$$

Where the first term on the left in each equation is the Utility for that alternative (dependent variable), the first term on the right is the Intercept for that alternative which is a constant and all other terms are co-efficient of the respective independent variable (age, gender, education, occupation, caste, existing house) multiplied by the specific data point of that variable based on the observations.

There are several types of data analysis that are used to sort and assess impact statistically.

Regression analysis is one of them. Regression analysis is a way of mathematically sorting out which of the variables have an impact on a particular phenomenon under examination. It answers the question: Which factors matter most? Which can we ignore? How do those factors interact with one another? And, perhaps most importantly, how certain are we about all these factors (Gallo 2015)? There is a dependent variable (housing preference), the outcome from the logistic function, and the phenomena that are to be understood or predicted. And there are independent variables (age, gender, occupation, education, caste and existing house type), which are all the factors that impact the dependent variable, essentially impacting the phenomena under study. In this research, Multinomial Logistic Regression (MLR) is used to model the nominal outcome variables as it is an analytical method that can be used for unordered categories of the independent variables and the nominal categorical form of the outcome. In a typical MLR model, log odds of the outcomes are modelled as a linear combination of the predictor variables.

There are three assumptions to formulate the MNL. Firstly, the random components of the utilities of the different alternatives are Independent and Identically Distributed (IID). Secondly, the MNL model maintains homogeneity in responsiveness to attributes of alternatives across individuals, and finally, the error variance-covariance structure of the alternatives is identical across individuals (Sekhar 2014 quoted in Paul et al. 2022). MLR models how a multinomial response variable Y (kacchā, hybrid, pakkā; 3 housing preferences) depends on a set of k (6 in this research) explanatory variables, X=(X1, X2,…, XK) (Ed@PSU 2023). The aim of this study is to explore all the factors behind the aspiration of acquiring a pakkā makān in the rural regions of India ending up denigrating indigenous ways of building. It seeks to understand the correlation between these factors by taking them as independent or explanatory variables and how each of these impacts the dependent or response variable. The focus of this paper is to quantitatively prove the hypothesis that caste is the major factor at play in the preference of the pakkā due to its intrinsic value that lends it to represent rising social status and alignment with being modern.

The following equation establishes the Probability of a decision-maker to prefer a pakkā house. Such equations are used for the other two alternatives of housing preference (kacchā and hybrid) as well.

$$\frac{e^{(U_{Pakka})}}{\sum_m e^{(U_m)}} = \text{P(Pakka)} \qquad (4)$$

where,

U_m means utility of all preferences

U_{Pakka} means utility of housing preference Pakka

P (Pakka) is the Probability of utility for the housing preference, Pakkā

3.2 Survey Design

The study design included three analytical steps. First, categorization of the existing house and its homestead was carried out, based on materials, construction and technology as per the degree of *pakkafication* on a kacchā-pakkā continuum[4]. Second, the aspirational housing preference was recorded along with personal narratives of the perception of the kacchā-pakkā materiality of the house as a rationale for these subjectivities. Third, the housing preferences were used as dependent variables in the multinomial logistic regression model to explore possible social and demographic factors and the existing house type, that influence material-based housing preferences. To begin with, let us describe the data and the sample.

In this study, we follow the housing preferences of rural India. The housing preference was operationalised with a focus on the materiality of the structure- building materials, construction techniques and technologies, much in line with the categorisation developed for documenting the existing house. The housing preference is based on the experience of the rural individual, as the current house types serve as material possibilities for a future aspiration. While the categories emerge from the current house types (one of the independent variables), it results in being the three categories for the response/ dependent variable- the outcome, as well.

The images in Figure 1 give a good idea of the current houses and possible housing preferences in the three fieldwork sites. The housing preference, the aspirational house the prediction of the house in the future, the multinomial response variable or the dependent variable, Y.

Figure 1: These are examples of Kacchā, Hybrid and Pakkā houses in the three fieldwork sites. At the same time, these are references for Housing Preferences in the experience of the individuals. (Source: Authors)

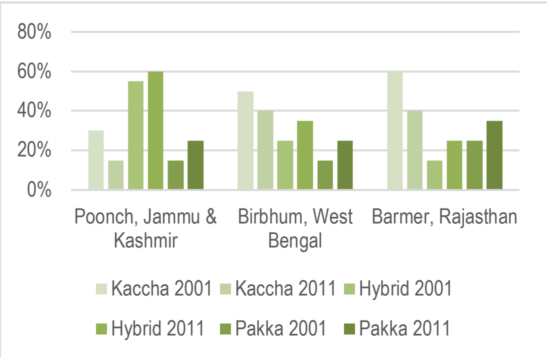

Figure 2: Comparison of percentage range of pakka (permanent), semi-pakka (semi-permanent) and kaccha (temporary) houses in the selected fieldwork sites in 2001 and 2011 (Source: Author)

The sample consists of people living in rural India and that is a total population of 903 million (Rathore 2024). A representative sample for the survey was calculated to a minimum size of 384 respondents keeping a balance of social and demographic factors. Also, in keeping with an understanding of the kacchā houses as vernacular architecture; specific to place as per climate and topography and hence local material availability as well as socio-cultural practices, three distinct locales were selected for the study. A set of villages in Poonch district, Jammu and Kashmir with cold climate and mountainous terrain, villages in Birbhum district, West Bengal with warm humid climate and river systems with red soil, bushy zones and fertile alluvial plains, and villages in Barmer district, Rajasthan with a hot dry climate and arid desert areas, were selected for the fieldwork (BIS 2016). These three districts were chosen not only on the basis of maintaining variety in climatic, topographical or cultural aspects but also because they have had a steady rise in the stock of pakkā housing as per the Atlas of Houses, Household Amenities and Assets Census of India (2011). As shown in Figure 2, it can be observed that there is a steady 10% increase in pakkā (permanent)[5] houses from 2001 to 2011 in all three regions, 5-10% increase in hybrid houses (semi-permanent) and 10-20% decrease in kacchā (temporary) houses.

In keeping with an intersectional approach to research, data was collected from a total of 387 respondents across the three field work sites in the categories of age, marital status, income, education level and occupation (traditional and current) categories of gender, religion, ethnicity, caste and hence, social status. Table 1 explains which data categories are taken up as the explanatory or independent variables for the model. It also lays out the sub-categories formed under each variable (these were coded for the multinomial logistic regression analysis) and the frequency of observations under each of the categories as per recorded value and percentage from the total sample size.

4. Results and Discussion

Table 2 presents the parameter estimates (also known as the coefficients of the model) (UCLA: Statistical Consulting Group, n.d.). There are three sets of logistic regression coefficients (sometimes called three logits), for each of the housing preference types, kacchā, hybrid, and pakkā. After several iterations of the regression analysis using SPSS, it was observed that the variables gender and current house Most of the independent variables except age for all three sets of coefficients are not statistically significant as the p-value is more than 0.05 ($p > 0.05$; the "Sig." column). The only significant independent variable is age with p value= 0.001 for Kacchā house preference and the adjusted odds ratio with its 95% CI is above 1.0, the risk of the outcome occurring increases. The same holds good for hybrid house preference with p-value= 0.004. Interestingly, for the pakkā house preference with significance level p value= 0.006 and the adjusted odds ratio with its 95% CI is below 1.0, then the risk of the outcome occurring decreases.

Table 1. Explanatory variables used in multinomial logistic regression to explain individuals' housing preference based on materiality, in rural India [n=387 observations] (Source: Author)

Variable and Description	Sub-categories	Frequency (Percentage)
Age	Three categories were made-	
Based on generational differences in terms of individual/ familial practices in rural India, recorded in 2021.	Young Generation (16-36 years)	145 (37.5%)
	Middle Generation (37-56 years)	146 (37.7%)
	Old Generation (57 years and above)	96 (24.8%)
	(Ref=Young Generation)	
Gender	Hence, categorised as	
As expressed by respondents, based on heterosexual norms.	Female	160 (41.4%)
	Male	227 (58.6%)
	(Ref=Female)	
Educational Qualification	9 categories-	
Classification of formal education of individuals, at school and college level.	No Education	171 (44.2%)
	Primary School (V Class)	37 (9.5%)
	Middle School (VIII Class)	38 (9.8%)
	High School (X Class)	47 (12.1%)
	Higher Secondary (XII Class)	30 (7.8%)
	Diploma (Vocational Training)	04 (1.1%)
	Bachelors (Undergraduate Studies)	46 (11.9%)
	Masters (Postgraduate Studies)	13 (3.3%)
	PhD	01 (.3%)
	(Ref=No Education)	
Occupation	9 categories-	
The work done by individuals to generate livelihood, irrespective of the traditional occupation as per caste system. This is recorded at the time of survey (2021).	Homemaker/ No occupation	177 (45.7%)
	Student	12 (3.2%)
	Farmer/ Shepherd	66 (17%)
	Labour/ Mason/ Factory worker	33 (8.5%)
	Craftsman/ Tailor/ Carpenter	10 (2.7%)
	Shopkeeper/Part-time work	20 (5.2%)
	Service/ Job	33 (8.5%)
	Teacher/ Lawyer/ Doctor/ Engineer	21 (5.4%)
	Business/ Zamindar	15 (3.8%)
	(Ref= Homemaker/ No occupation)	
Caste/ Ethnicity	Four Categories:	
As per the caste hierarchy/ ethnicity of the region in which the individual resides. Middle castes are those that are not the dominating upper, neither the marginalised lower or outcasted.	Tribal	118 (30.5%)
	Lower Caste	46 (11.9%)
	Middle Caste[6]	141 (36.4%)
	Upper Caste	82 (21.2%)
	(Ref= Tribal)	

Note- The sixth variable, the current (existing) house has the same sub-categories as the Housing Preference.

Using the B values (regression coefficient) for the analysis from the table, the following can be observed. A one-unit increase in the variable **age** is associated with a 0.997 increase in the relative log odds of preferring a kacchā house, with a 0.416 increase in the odds of preferring a hybrid house, but a 0.282 decrease in the relative odds of preferring a pakkā house. Similarly, a one-unit increase in the variable **education** is associated with a 0.153 increase in the relative log odds of preferring a kacchā house, with a 0.001 increase in preferring a hybrid house but a 0.018 decrease in the relative odds of a pakkā house preference. Furthering, a one-unit increase in the variable **occupation** is associated with a 0.035 decrease in the relative log odds of preferring a kacchā house, with a 0.005 increase in odds of preferring a hybrid house and a 0.001 increase in preferring a pakkā house. Lastly, a one-unit increase in the variable **caste** is associated with a 0.096 decrease in the relative log odds of preferring a kacchā house, a 0.007 decrease in the odds of preferring a hybrid house and yet, a unit increase in caste yields a 0.014 increase in preferring a pakkā house. This is one way of reading the estimates and analysing the data.

For the purpose of relating our findings with the hypothesis, it is required that the B values for all the variables in the third logit, pakkā housing preference are seen in conjunction with each other. The variables, age and education have negative values implying that with a one-unit increase in age and education, there is a decrease in the relative odds of preferring a pakkā house by 0.282 and 0.018. The variables, occupation and caste have positive values that imply that a one-unit increase in occupation and caste leads to an increase in the odds of an individual preferring a pakkā house. The coefficient value of occupation, 0.001 being lower than the coefficient value of caste, 0.014 implies that caste is a relatively more substantial factor in the pakkā housing preference.

Table 2. Parameter estimates for material-based housing preferences in rural India (n=387)

Housing Preference		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Kacchā	Intercept	-5.495	.801	47.026	1	.000			
	Age	.997	.287	12.030	1	.001	2.710	1.543	4.761
	Education	.153	.099	2.365	1	.124	1.165	.959	1.416
	Occupation	-.035	.082	.177	1	.674	.966	.822	1.135
	Caste	-.096	.174	.301	1	.584	.909	.646	1.279
Hybrid	Intercept	-2.844	.373	57.999	1	.000			
	Age	.416	.144	8.319	1	.004	1.516	1.143	2.011
	Education	.001	.057	.001	1	.981	1.001	.896	1.119
	Occupation	.005	.045	.014	1	.907	1.005	.920	1.099
	Caste	-.007	.091	.006	1	.940	.993	.831	1.187
Pakkā	Intercept	-.597	.234	6.499	1	.011			
	Age	-.282	.102	7.645	1	.006	.754	.617	.921
	Education	-.018	.037	.229	1	.633	.982	.913	1.057
	Occupation	.001	.031	.002	1	.966	1.001	.942	1.064
	Caste	.014	.062	.053	1	.818	1.014	.898	1.146

a. The reference category is .00.

The results show that caste has the highest coefficient in relation to the housing preference of pakkā house as compared to other variables, denoting that caste hierarchies appear to play a compelling role. For kacchā and hybrid house types, the independent variable age figures as the most significant with the highest coefficient values.

Using the intercepts and coefficient from the table above (column B, Table 2), the Utility of each alternative of housing preference can be determined using equations (1, 2, 3) mentioned earlier. Thus, the following equations are derived based on 387 observations.

U (Kacchā) = -5.495 +0.997* Age+0.153* Education + Occupation*-0.035 + Caste*-0.096

U (Hybrid)=-2.844 + 0.416*Age + 0.001*Education + 0.005*Occupation+ Caste*-0.007

U (Pakkā) = -0.597 + Age*-0.282 +Education *-0.018 + 0.001*Occupation+ 0.014* Caste

The ratio of the probability of choosing one outcome or response category over others is often referred to as relative risk (Andrade 2015). Exponentiating the linear equations above yields relative risks. Regression coefficients represent the change in log relative risk (log odds) per unit change in the predictor. Exponentiating regression coefficients will therefore yield relative risk ratios (UCLA: Statistical Consulting Group, n.d.). Using Equation 4 mentioned earlier, the Probability Model is constructed and is used to predict the housing preferences of individuals as examples.

Table 3. Example 1

Age	Education	Occupation	Caste
Middle Age	Nil	Nil	Tribal

Kacchā	Hybrid	Pakkā
6%	28%	66%

Table 4. Example 2

Age	Education	Occupation	Caste
Young age	Middle School	Factor Worker/ Labour	Lower Caste

Kacchā	Hybrid	Pakkā
2%	**18%**	**80%**

Table 5. Example 3

Age	Education	Occupation	Caste
Old Age	Postgraduate	Teacher/ Doctor/ Lawyer/	Upper Caste

Kacchā	Hybrid	Pakkā
27%	**36%**	**37%**

This paper demonstrates three examples of the model. For example, 1 (Table 3), the result of the model expresses that an individual with age between 37-56 years, having no education, no occupation and having caste/ ethnicity as tribal has a 6% chance of this individual making a kacchā house, 28% chances of making a hybrid house and 66% chances of making a pakkā house.

In example 2 (Table 4), it can be observed that a lower caste individual of the age group 16-36 years, with middle school (till class VIII) education and working in a factory or labouring on the farms has only a 2% chance of building a house in natural materials, 18% chance of building a hybrid building and 80% chances of building a pakkā house in industrial materials. In example 3 (Table 5), it can be seen that an older individual above the age of 57 years, with postgraduate education and engaged in professional services for livelihood and belonging to the upper caste has a tendency to acknowledge the goodness of kacchā and hybrid houses at 27 % and 36 % respectively and has a lower probability of building in pakkā industrial materials, at 37%.

5. Conclusion

This research set out to identify factors essential to the individuals' identity that affect material patterns in rural housing in India. Using an intersectional approach, it has examined multiple aspects of a person's identity such as their age, gender, education, occupation, caste and current house in relation to their material-based housing preference in terms of kacchā, hybrid and pakkā forms and attempted to quantify these. It used discrete choice conjoint analysis in which the respondents were asked to state their housing preferences and use utility theory. The model developed utilizes several iterations of multinomial logistic regression analysis to arrive at the results. Interpretation of results for the set of pakkā housing preferences yields the output that relates to the hypothesis that traditional caste hierarchies matter and individuals use their growing capital to build pakkā houses to *appear* as higher caste groups.

The results reflect that the independent variable of 'Caste' plays the most significant and influential role in a rural individuals' housing preference for pakkā house. It foregrounds caste as the most significant factor for the shift, with people from lower caste using their rising class to acquire a pakkā house for its intrinsic value of representing higher social status. The research brings forward that people from marginalised backgrounds, in terms of caste or ethnicity, have a stronger desire for the pakkā house as it represents rising economic status leading to social alleviation more generally. Castes at the bottom make a conscious effort to move up by emulating practices of the upper caste (Jodhka 2018) and this desire for change in status is recognised by the rest of the community. Aspiring for a pakkā house is much a part of the same narrative in every village across the country.-

The results also show that the preference for kacchā and hybrid house types, the independent variable of 'Age' plays the most significant role given its highest coefficient value. This signifies that older people show a preference for indigenous materials as they regard their traditional vernacular dwelling as a symbol of ancestral and cultural memory. For the mid-old generation people, their traditional 'kacchā' dwelling has been integral to their lived experience making them value the vernacular and see its benefits better than younger generations that are more influenced by other forces and yearn for a modern image.

To lower castes or marginalised tribal ethnicities, the pakkā house symbolises modernity and progress, because of the use of industrially produced materials and mechanised construction technology. It is perceived to be imbued with strength and durability. Conversely, the kacchā house has come to signify poverty and backwardness and is perceived as temporary. Since binaries like the kacchā-pakkā are manifest as forms of social differentiation, the lower caste or tribal ethnicities are most affected by it, constantly yearning for a 'pakkā makaan' that will help them acquire social sanction. The pakkā house becomes an instrument of aspiration fulfilment and self-portrayal, signifying a rise in social status, and giving agency for self-representation to the marginalised. This process of material transformation reflects multiple forms of modernities, as evident pursued by subaltern populations. These shifts are influenced not only by local community discourse but also the public discourse that institutionalises the kacchā-pakkā in taxonomical terms, by the post-colonial governance apparatuses and exchanges due to rural-urban migration. In this process of disruptive transformation from the kacchā to the pakkā, as evident in these diverse settings across the Indian subcontinent, it becomes pertinent to question the loss of socio-cultural indigenous knowledge and building practices, given they bear a huge impact on the future course of sustainable action in rural development.

Author Statement

Parul Kiri Roy: Conceptualisation, Methodology, Investigation, Formal Analysis, Data Curation, Writing- Original Draft and Review & Editing, Visualisation. Prof. Dr P. S. N. Rao: Supervision. Prof. Manoj Mathur: Writing- Review and Editing, Supervision.

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Notes:

[1] The villager traditionally was entrenched in the rural context. With infrastructure development, this villager is not constrained to the village. While, the village is continued to be perceived as the 'homeland' (desh/ des in some north Indian languages), the villager could be someone having strong direct or indirect connections with the urban. In effect, the rural-urban/ village-city binary has broken down.

[2] Most north Indian languages have these terms. Hindi, Urdu, Bengali, Marwari, Haryanvi, Punjabi, Bhojpuri and Marathi are some that I examined by analysing dictionary entries for the terms kacchā and pakkā.

[3] Roti, is the traditional Indian bread made of wheat flour and roasted while poori is fried using ghee/ oil. In India, poori is pakkā as it is fried making it richer and more difficult to digest. In clothes, the fastness of colour of the fabric determines it being kacchā or pakkā, with pakkā being that which does not bleed. Today, that would be all mill produced cloth and kacchā would be hand dyed. In materiality of buildings, pakkā traditionally was brick or stone building in lime mortar, now replaced with cement. Kacchā buildings are ones that are built in natural materials as earth, bamboo, wood, thatch.

[4] This is where this research recognises that there is a need to go beyond binaries and recognise that the binary constructs may actually work as a gradient, a gradual process. In rural India, transformation had been a gradual process of pakkāfication (term used by Siddharth Menon in Deconstructing Concrete), modification of kacchā structures by adding cement/ concrete where necessary. Recently, the trend has shifted and the transformation has taken the form of replacing kacchā houses with pakkā house in many regions. The reasons are many and narrating them here is beyond the scope of this paper.

[5] The definitions of pakkā as permanent, hybrid as semi-permanent and kacchā as temporary houses is given in the details of house listing manual published by the Census of India. The Atlas on Houses, Household Amenities and Assets provides maps with 'Households Living in Permanent Census Houses, Rural' and 'Households Living in Semi-Permanent Census Houses, Rural' and this data for the year 2001 and 2011 has been derived from such maps.

[6] Jodhka (2018) mentions theorization of changing realities of caste and gradual institutionalization of democratic politics changing caste equations. He discusses power shifting to middle-level 'dominant castes'. In this research, I have included a middle caste as I extrapolate these castes impacting everyday practices of living as well.