Shehernama

JMI Journal of Architecture

Vol 1, Issue 1, 2026

Biannual, Peer Reviewed, Open Access, e-Journal of Architecture

Department of Architecture, Jamia Millia Islamia

About the Cover

The cover for the Journal is designed by Ar. Imaad Nizami, using AI- assisted visual generation with manual post-processing and composition.

Editor

Prof. Taiyaba Munawer
Head, D/o Architecture, JMI
email : shehernama@jmi.ac.in
Phone : 011-26981717
extn. - 2471/75

Publisher

Department of Architecture, Jamia Millia Islamia, New Delhi.

About the Department of Architecture, JMI

Jamia Millia Islamia, an institution originally established at Aligarh in United Provinces, India in 1920 became a Central University by an act of the Indian Parliament in 1988. In Urdu language, Jamia means ‘University’, and Millia means ‘National’.

The story of its growth from a small institution in the pre-independence India to a central university located in New Delhi—offering integrated education from nursery to research in specialized areas—is a saga of dedication, conviction and vision of a people who worked against all odds and saw it growing step by step. They “built up the Jamia Millia stone by stone and sacrifice by sacrifice,” said Sarojini Naidu, the nightingale of India.

Under the colonial British rule, two dominant trends joined hands and contributed towards in the birth of Jamia. One was the anti-colonial Islamic activism and the other was the pro-independence aspiration of the politically radical section of western educated Indian Muslim intelligentsia. In the political climate of 1920, the two trends gravitated together with Mahatma Gandhi as a catalyst. The anti-colonial activism signified by the Khilafat and the pro-independence aspirations symbolised by the non-cooperation movement of the Indian National Congress helped to harness creative energies and the subsequent making of Jamia Millia Islamia. Rabindranath Tagore called it “one of the most progressive educational institutions of India”.

Responding to Gandhiji’s call to boycott all educational institutions supported or run by the colonial regime, a group of nationalist teachers and students quit Aligarh Muslim University, protesting against its pro-British inclinations. The prominent members of this movement were Maulana Mehmud Hasan, Maulana Mohamed Ali, Hakim Ajmal Khan, Dr. Mukhtar Ahmad Ansari, and Abdul Majid Khwaja.

Today, after 106 years, Jamia Millia Islamia is consistently performing well in national rankings, reflecting its strong academic standards and research environment. The university holds an A++ accreditation from NAAC, the highest grade awarded by the National Assessment and Accreditation Council. In the NIRF 2025 rankings, JMI is placed 13th overall in India and 4th among all universities, with the Architecture & Planning category ranked 5th nationally. The university also features in reputed surveys such as India Today’s architecture rankings, further underscoring its educational impact.

The Department of Architecture, established in 2001, at Jamia Millia Islamia (JMI) is a lively and creative hub for architectural education, rooted in the university’s long tradition of academic excellence and social engagement. As part of the Faculty of Architecture & Ekistics, the Department nurtures design-thinking, contextual awareness and professional rigour in every student’s journey.

The Department of Architecture offers a five-year Bachelor of Architecture (B.Arch) programme that blends conceptual design, technology, history, and practical studio work. For advanced study, it runs Master of Architecture (M.Arch) programmes with specializations such as Architecture Pedagogy, Ekistics, Building Services, Healthcare Architecture, Recreation Architecture, and Urban Regeneration encouraging research and deeper inquiry. In addition, Postgraduate Diploma programs provide opportunities to explore specialised areas in Artificial Intelligence and the building services domain. The under graduate and post graduate students get well placed in the market under various capacities. Guided by committed faculty and a vibrant student community, the department continues to shape thoughtful architects ready to contribute meaningfully to practice, research, and society.

***Shehernama* – JMI Journal of Architecture**

Chief Patron
Prof. Mazhar Asif,
Vice Chancellor , JMI

Patron
Prof. Mahtab Alam Rizvi
Registrar, JMI

Co- Patron
Prof. Qamar Irshad,
Dean,
F/o Architecture & Ekistics, JMI

Mentor
Prof. S.M. Akhtar
Founder Dean,
F/o Architecture & Ekistics, JMI

Editor
Prof. Taiyaba Munawer
Head,
D/o Architecture, JMI

About the Journal

The Department of Architecture, in its academic outreach launches Shehernama – JMI Journal of Architecture. The journal will serve as a platform for scholarly discourse, research dissemination, and critical engagement with emerging issues in architecture, urbanism, and the built environment. The journal would be an Open Access, Peer Reviewed, E-journal linked through the JMI website.

With rapid urban transformation, environmental challenges, and technological innovations shaping the built environment, there is a growing need for an academic platform that bridges architectural theory, design practice, sustainability, and future urban visions. The journal will encourage interdisciplinary dialogue between Architecture, Ekistics, Development Studies, Urbanism, Historic Cities, Building services, History of Architecture, Landscape, Pedagogy, Heritage, Conservation, Sustainability, Energy and Technology, Theory and Criticism, Urban Planning, Visual design, Practice or any other relevant subject pertaining to the built environment.

The journal will provide a publishing avenue for researchers, academicians, and practitioners in India and abroad. It will promote critical thinking and innovative approaches in architecture. It will document and disseminate cutting-edge research from India and globally. And will foster collaboration between academia and industry.

The journal aims to publish high-quality original research, theoretical analyses, design critiques, and case studies in areas including but not limited to:

- Architectural design and theory
- The Science of Human Settlements
- Urbanism and city futures
- Sustainable and green architecture
- Heritage conservation and adaptive reuse
- Building technology and materials innovation
- Landscape and environmental design
- Development Studies
- Digital tools and computational design in architecture

Who can contribute :

- Academic researchers in architecture and allied fields
- Practicing architects and planners
- Undergraduate, Postgraduate and Doctoral students
- Policy makers and urban administrators

Frequency & Format

- Frequency: Bi-annual (two issues per year)
- Format: Primarily digital (open access)
- Language: English

Call for Paper

***Shehernama:* JMI Journal of Architecture** invites original and unpublished contributions from academicians, practitioners, and students under the following FOUR categories.

Category 1: Research Papers
https://forms.gle/ADHWNBTf3DL2Kju97
Research papers (2000-5000 words) in the prescribed format. The research may be based on their ongoing or completed research. (Details of format are available in the Author's guidelines). All contributions in this category will be Blind Peer reviewed by academic experts before being accepted for publication.

Category 2: Articles
https://forms.gle/xtFpgw62ZGUdUbuR9
Essays, case studies, interviews, articles (1500- 2500 words), book reviews (600 and 750 words), travelogues, sketches and photo-essays in the areas of Architecture, Ekistics, Development Studies, Urbanism, Historic Cities, Building services, History of Architecture, Landscape, Pedagogy, Heritage, Conservation, Sustainability, Energy and Technology, Theory and Criticism, Urban Planning, Visual design, Practice or any other relevant subject pertaining to the built environment.

- Book reviews should be related to any discipline of Architecture/Habitat/Society. Please include the "Fact File" with the following details: book title, author name, publisher, year of publication.
- Please send a write-up of about 200-300 words along with sketches and photo essays.

Category 3: Student Work
https://forms.gle/rwZTrFhiVWUHKHAt6
Summaries of dissertations (1500-2000 words) at the level of B.Arch. & M.Arch., and Thesis at the Ph.D. level.
The Guide for that work will be mentioned as the Co-author.
Category 4: Cover Design
https://forms.gle/RBJkiX1co16My2ts8

Students from Architecture, Design and Arts are invited to submit the designed cover page. This should be a graphic based on some aspect of architecture/cities/its people/ Indian knowledge system. The submission will include the graphic file (jpeg or coral draw); a theme note (with a title) of about min. 100 words explaining the concept of the graphic. Please note that the image you send will be adjusted as per the layout requirements of the magazine Cover.

In order to be accepted for publication, all material sent in these categories should have the following components:

a. MS Word document file with text only. Please do not format it in any way. The numbered captions for all the Images will also be in this document.
b. Folder with all images (minimum 300 dpi), numbered according to the captions given in your text file
c. Photograph of the author/s (minimum 300 dpi).
d. Author biodata – Maximum 50 words.
e. PDF (optional) – showing the intended layout. This pdf should include text and all images, with numbered Captions.

Please note:

1. Submissions will be accepted through email to shehernama@jmi.ac.in with the **Category** of write-up clearly mentioned in the subject of email.
2. Any queries to be addressed to: shehernama@jmi.ac.in.
3. In your correspondence, please give your email id and your contact number
4. The review process takes 4-6 weeks. We will revert if and when your work is accepted.
5. JMI does not charge any fees for the publication of any Professional or Academic work.
6. It is understood that the submission from an author is an Original work, unpublished anywhere else, and that JMI is in no way responsible for any matter or dispute arising out of the publication of the same.
7. It is mandatory to give a signed declaration along with your work. The format is available on JMI website
8. All authors are requested to refer to the Author's guidelines and strictly stick to the format of the paper.

Biannual, Peer Reviewed, Open Access, e- Journal of Architecture
Contact us : shehernama @jmi.ac.in

Forthcoming Issues:

- Sustainable Architecture, July 2026
- Indigenous Knowledge System, Jan 2027
- Humane Habitat, July 2027

Table of Contents

Khalsa College, Amritsar: An Architectural Masterpiece

Dr. Ripu Daman Singh
Associate Professor in GZS School of Architecture and Planning, arch_rdsingh@mrsptu.ac.in
Dr. Jatinder Kaur
Associate Professor, Architecture School of Planning and Architecture,
New Delhi

***Abstract* - The paper Khalsa college , Amritsar talks about the intelligent layout of the college along with the integration of traditional Sikh architecture along with Mughal, and Rajput elements. The features of all these are put together, thus creating a masterpiece as well as a significant landmark building for the city.**

***Keywords* -** *Indo-Saracenic, introvert and extrovert planning, exposed brick, traditional Sikh architecture Introduction*

1. INTRODUCTION

Khalsa College, Amritsar is a significant landmark building for the holy city of Amritsar and represents the hybrid architecture of Punjab. The Khalsa College was designed by legendary architect Bhai Ram Singh in 1891-92 (Bhatti, 2020). Singh had received his initial training in the Mayo School of Art, Lahore in undivided India from 1875 to 1883 under John Lockwood Kipling (Vandal & Vandal, 2007). The Khalsa College campus with a site area of more than 100 acres is located on the Grand Trunk Road with the main academic block aligning with the road having a frontage of about 500 feet (Singh et al., 2024). The building (Figure 1) stands as a prominent architectural marvel to the city of Amritsar and serves as an educational hub with Guru Nanak Dev University as its next door neighbor.

Fig.1 *Main academic block, Khalsa College, Amritsar*
Source: Authors

2. HISTORY

The Khalsa College was envisioned in 1883 as an institution for Sikh and Punjabi studies by Khalsa Diwan in their annual convention in Lahore. The Lieutenant Governor of Punjab, Sir James Lyall had laid the foundation stone of Khalsa College in 1892 (Figure 2) but the construction of the main academic block started in 1904 (Singh, 2021). The buildings in the campus were constructed with the financial aid from various rulers of Punjab who were approached for the task of establishment of setting up of the Khalsa College. The college initially started functioning in a rented accommodation near Hall Gate of Amritsar in 1893, much before the first building, a boarding house, was constructed. In 1896, the classes were held in the campus for the first time with the completion of its first hostel building (Vandal & Vandal, 2006). Most of the buildings, including the Academic block were completed by 1920s, but some elements like the clock tower got delayed till the year 1930. The Khalsa College remained extremely relevant during the freedom struggle as many freedom fighters visited the college to motivate students to join the struggle (Singh, 2021).

Fig. 2 *Foundation Stone of Khalsa College, Amritsar*
Source: Authors

2. ARCHITECTURAL DESIGN

The Khalsa College has been categorized as an Indo-Saracenic building by various scholars as the timeline of its establishment coincides with the prevalent style of late 19th century British India (Singh et al., 2023b). The Architectural style of the Khalsa College is a reflection of Punjab's regional style of architecture that incorporates a mix of Sikh, Mughal, and Rajput elements and features. The layout plan of building is a symmetrical balanced composition of linear forms in a mix of introvert and extrovert planning. The main rectangular academic block incorporates Principal's office, Administrative office, and other teaching departments. The rear block comprising of classrooms and labs is inward looking with a courtyard on either side. The central block contains the auditorium or multipurpose hall, which is the highlight of the main building. The building is entered from the central part of the block that is topped with a massive domical tower resembling that found in Sikh Gurudwaras (Singh et al., 2023a). The block incorporates a four faced clock tower, a reminiscent feature of the institutions built during the colonial rule in India. The secondary entrances are provided at the end of front and rear blocks. The linear building blocks have multi-foliated arcaded verandahs on both sides and along the periphery of the building, used primarily as corridors. The majority of the academic block is double storied with the exception of the central part which is triple storied. The unified façade displays a rhythmic hierarchy of rich blend of elements like foliated cusped arches, onion domes, chhatris, towers, turrets, chajjas, parapets, and jallies (Figure 3). The building edges are highlighted by corner towers, each having a domical chattri or pavilion.

Fig.3. *Architectural features in Khalsa College, Amritsar*
Source: Authors

The other buildings in the Khalsa college campus are the hostels, gymnasium, dispensary, Principal's residence, faculty houses, and some ancillary blocks, some of which have been reconstructed over the years due to maintenance issues (Vandal & Vandal, 2007). The new blocks also follow the same design and architectural style as used in the original design. A Gurudwara is the highlight of the campus which was also designed by Bhai Ram Singh and was one of the first few buildings constructed on the campus.

3. MATERIALS AND TECHNIQUES

The building facade is constructed in exposed brick with minute detailing such as moldings, capital, and string courses also in moulded or carved brick (Singh et al., 2023). The relief brickwork lends a wonderful effect of light and shade. Apart from brickwork, sandstone is also employed as a highlight and for intricately carved perforated Jallies. The flooring is primarily in Kota stone and marble, while the roofing is Jack arch and Timber batten roof, apart from the trussed roof with walnut Khatamband ceiling in the multipurpose hall. The frames for doors, windows, and ventilators, as well as their shutters use timber as the building material (Singh, 2025).

Fig. 4. *Use of exposed brickwork and sandstone in façade*
Source: Authors

4. CONCLUSION

The Khalsa College campus is more than 100 years old but has retained its original character, form, materials, and finishes. Khalsa College was granted the status of heritage institution by University Grants Commission in 2014-15 (HT, 2015). The iconic building stands as a powerful witness of architectural heritage symbolizing expression of traditional Sikh architecture articulated through the orderly and unified composition of elements, features, and building materials.

5. ACKNOWLEDGEMENT

The authors acknowledge the contribution of Prof. Nisar Khan and Prof. Hina Zia, Professors, Department of Architecture, Jamia Millia Islamia for the mentorship received as Ph.D. supervisors of corresponding author.

6. REFERENCES

Bhatti, S. S. (2020). Bhai Ram Singh: Inventor and Master of Sikh Architecture. https://Worldarchitecture.Org/ https://worldarchitecture.org/article-links/eencz/bhai-ram-singh-inventor-and-master-of-sikh-architecture--a-tribute-by-dr-ss-bhatti.html

HT. (2015, July 6). UGC confers heritage status on Khalsa College, Amritsar. Hindustan Times. https://www.hindustantimes.com/punjab/ugc-confers-heritage-status-on-khalsa-college-amritsar/story-onVBGAN5aWGURVtGWVTD2H.html

Singh, G. (2021). A History of the Khalsa College, Amritsar (Second).Khalsa College.

Singh, R. D. (2025). A study of Bhai Ram Singh's contributions in the paradigm of Indo-Saracenic Architecture.JamiaMilliaIslamia.

Singh, R. D., Khan, N., & Zia, H. (2023a). Tracing the Journey of Bhai Ram Singh in Indo-Saracenic Architectural Style. In T. Teba& A. Di Raimo (Eds.), Conservation of Architectural Heritage (CAH): Sustainability. IEREK.

Singh, R. D., Khan, N., & Zia, H. (2023b). Understanding the Rich Traditional Craftsmanship of Punjab through the Architectural Works of Bhai Ram Singh. JIIA, 88(12), 30–37. https://indianinstituteofarchitects.com/pdf/jiia/2023/JIIA_December__2023.pdf

Singh, R. D., Khan, N., & Zia, H. (2024).Deciphering the Underlying Geometry in the Buildings of Bhai Ram Singh: The Case of Khalsa College, Amritsar. The International Journal of Architectonic, Spatial, and Environmental Design, 18(2), 203–224. https://doi.org/https://doi.org/10.18848/2325-1662/CGP/v18i02/203-224

Vandal, P., & Vandal, S. (2006). The Raj, Lahore and Bhai Ram Singh (1st ed.). NCA, Lahore.

Vandal, P., & Vandal, S. (2007). Khalsa College: A Legacy of Bhai Ram Singh. NishaanNagaara, IV, 22–33.

The Socio-economic Efficiency of AI and Analytics in Tourism-related Urban Regeneration within Smart Cities: A Smart Initiative of Kochi, Kerala

Fazlur Rahman, D/O Architecture, Jamia Millia Islamia, New Delhi-110025
arfazlur121@gmail.com

Abstract - **This study designed to investigate the socio-economic preposition of AI adoption and analytics in tourism-related urban regeneration in the context of smart city framework of Kochi heritage city, Kerala. Addressing a research question, 'How can AI and analytics optimize urban regeneration processes and promote sustainable tourism for socio-economic development?' the study performed a quantitative approach that includes case studies and surveys to analyse the efficiency of these tools in sustainable urban regeneration. The findings demonstrate a strong positive correlation between the effective deployment of AI and decipherable outcomes of urban regeneration which highlights the transformative potential of employing AI and analytics in streamlining urban services to optimize resource management, refine decision-making, and mitigate ethical concerns. Conclusively, it suggests practical recommendations and insights for urban planners and policymakers to foster inclusive, resilient, and sustainable development for a heritage city.**

Index Terms - *Urban services, AI, Consumer behaviour, Resource optimization, Smart City, Urban Regeneration*

1. INTRODUCTION

The emergence of smart cities marks a significant transformation in urban development, where advanced technologies are increasingly integrated to improve quality of life, optimise resource management, and support sustainable economic growth. Particularly across developing nations, artificial intelligence (AI) and analytics have gained prominence as strategic tools for developing innovative approaches and business models that can contribute to sustainable urban regeneration (Rieder et al., 2022). Whereas cities across the world are confronting a range of interconnected challenges, including rapid urbanisation, uncontrolled urban sprawl, environmental degradation, pressure on existing infrastructure, and the growing complexity of urban systems. In this context, AI and data analytics offer considerable opportunities to address these challenges in a more informed, responsive, and efficient manner (Cugurullo et al., 2024; Kitchin, 2014; Zanella et al., 2014). Hence, the integration of AI and analytics into urban development and planning has assumed an increasingly important role in urban and regional planning, particularly in supporting the revitalisation of urban systems through improved assessment of planning regulations, decision-support mechanisms, and data-driven urban analysis (Panori et al., 2023).

Urban regeneration involves the renewal and revitalisation of urban spaces to improve their economic, social, and environmental conditions. Rahman and Halim (2021) conceptualised urban regeneration as the planning and development of an urban pocket that connects the 'past' with the 'present' to serve the needs of future generations. With the integration of automation and intelligent technologies, this process is becoming increasingly reliant on data-driven decision-making, with AI and analytics offering deeper insights into the complex dynamics of urbanism. AI algorithms can process large datasets to identify patterns, anticipate future developments, and generate tailored solutions for the specific needs of urban areas (Batty, 2013). Such capabilities can support the development of efficiency models that address contemporary urban challenges while anticipating future scenarios and opportunities for urban tourism development (Kitchin, 2014; Rodriguez & Mercedes, 2024).

The incorporation of AI and analytics into urban regeneration has been curate with a range of applications, including the optimisation of public transit networks and improvements in building energy conservation (Lai, 2022). Existing studies provide several examples of how AI-powered predictive infrastructure maintenance can reduce the operational costs of urban infrastructure, while data analytics can improve the real-time distribution of urban assets and make services such as sanitation, waste management, and public safety more responsive and efficient (Lai, 2022; McLoughlin et al., 2021; Rodriguez & Mercedes, 2024). Furthermore, smart platforms supported by AI and analytics can collect and analyse community feedback, creating opportunities for a more inclusive and participatory planning process for sustainable urban regeneration. Such approaches can strengthen transparency within the development process while contributing to more effective efficiency modelling (Banihashemi & Sohi, 2022). Ultimately, this dynamic, data-driven, and citizen-centred approach to urban regeneration has the potential to foster a more equitable and sustainable urban future while strengthening the prospects for tourism development.

However, the integration of AI and analytics into tourism-related urban regeneration (TrUR) presents a complex range of challenges that require careful consideration. Achieving equitable and sustainable outcomes in tourism planning and urban modelling requires particular attention to issues such as data privacy, unequal access to technology, often described as the digital divide, and the ethical implications of AI-driven decision-making within smart cities (Cugurullo et al., 2024). Moreover, the effective application of these technological advancements is closely associated with the establishment of robust governance structures, the promotion of interdisciplinary collaboration, and the continuous adaptation of business models in response to the evolving urban environment (Allam & Newman, 2018; Cavalheiro et al., 2020).

Therefore, this study aims to comprehensively examine the integration of AI and analytics in developing an efficiency model for tourism-related urban regeneration within the context of smart cities. Through case studies focusing on Kochi's art, architecture, and tourism, the study critically examines the technological advancements that underpin this integration and considers their broader socio-economic implications. In doing so, it seeks to contribute to the growing body of knowledge on smart urban development and tourism promotion. By offering a nuanced understanding of the intersection between AI, analytics, and urban regeneration, the study further provides practical insights and recommendations for policymakers, tourism planners, urban planners, and business leaders involved in shaping the cities of the future.

2. LITERATURE REVIEW

Urban regeneration with respect to smart cities, AI, and business analytics that enhance tourism across the nations has been considerably focusing the scholarly attention in recent years. Research on urban regeneration towards tourism business development emphasizes the prospects of rejuvenation and revitalization of urban spaces that address the social, economic, and environmental challenges (Coletti & Rabbiosi, 2021; Rahman; et al., 2025). Studies stated that, the process of urban regeneration traditionally has been project-based site-oriented, often focusing on physical redevelopment in the name of regeneration, however, in many developing countries with smart development studies highlight the increasing adoption of technologies towards effective urban regeneration (Gomes et al., 2024; Putra et al., 2018; Roberts et al., 2017).

The concept of smart cities, discussed by Harrison and Donnelly (2011), stated that it integrates information and communication technology (ICT) with the regeneration process to manage and promote urban resources efficiently. Advancements in technologies and adoption in data-driven development initiatives that promote tourism is associated with the efficiency of the smart city mission (Alahi et al., 2023). By harnessing the power of ICT, urban resources can be managed with unprecedented precision, leading to a significant enhancement of urban living (Sun et al., 2016). From intelligent planning systems to optimized energy grids, and from cutting-edge healthcare solution to innovative public services, the scope of smart city initiatives is vast and multifaceted (Calza et al., 2022; Yousefimehr, 2019). Furthermore, as Zanella et al. (2014) insightfully demonstrate, the Internet of Things (IoT) has the potential to weave together disparate urban elements, fostering a network of interconnected urban environments that elevate service delivery and citizen engagement to new heights.

As the urban landscape continues to evolve, artificial intelligence (AI) and analytics have emerged as potent catalyst for transformative change within the smart city paradigm (Panori et al., 2023). Batty (2013) discussed on the pivotal role of big data in informing city planning, revealing how AI-driven insights can unlock the full potential of urban management, paving the way for more sustainable, resilient, and adaptive cities. Bibri et al. (2023) delves deeper into the profound impact of real-time data analytics on urban governance, underscoring the critical importance of continuous data flows in illuminating the decision-making process and fostering a more responsive, agile, and citizen-centric approach to urban leadership.

Since urban regeneration initiatives strive to rejuvenate and transform urban landscapes that promote tourism, business analytics plays a pivotal role in harnessing the power of data to inform and optimize business models and planning strategies (Chung et al., 2021). The confluence of technological innovation and urban dynamics has given rise to a new era of smart, connected products, as eloquently demonstrated by Rivadeneira et al. (2023). By leveraging the transformative potential of AI, traditional development models can be reimagined to become more adaptive, responsive, and attuned to the nuances of urban environments (Samara et al., 2020). Moreover, Alahi et al. (2023) discussed on the imperative of creating energy-efficient and low-carbon urban districts, where data-driven approaches can help unlock sustainable and resilient urban future towards tourism promotion.

Notwithstanding the plethora of existing research, a profound void persists in the scholarship on Artificial Intelligence (AI) and analytics in the context of urban regeneration within smart cities. a critical lacuna remains unaddressed, namely, the absence of in-depth examinations into the ways in which AI-driven efficiency models can catalyse and optimize urban regeneration. Thereby, an increase of regional planning research delves into the technological underpinnings of smart cities, the synergy between AI and urban regeneration remains underexplored. Furthermore, the trailing tendency among existing research is to focus on discrete applications of AI and analytics in silos, such as tourism or heritage management and promotions, thereby neglecting to consider the holistic implications of these technologies in concert, and their potential to synergistically support comprehensive urban regeneration initiatives.

Moreover, when talked about socio-economic implications of AI and analytics in tourism-related urban regeneration, it remain obstinately underexamined (Peponi, 2023). While, Allam and Newman (2018) discussed the concept of cultural and governance systems for a smart city mission, an in-depth study is needed to unleased the constructs of AI-driven efficiency models that can effectively use to mitigate the issues of such social inequality and promote inclusivity.

Unfortunately, the current studies are rather silent on the transformative possibilities of AI and analytics in narrowing the digital divide and in providing the last first mile to the remaining inhabitants of such urban regeneration, thereby exacerbating the existing social schisms.

Furthermore, in account of consideration of the ethical issues and regulatory structures surrounding AI in urban functionaries as these areas remain underexplored in the literature, the use of AI in urban functional model triggers a series of crucial questions concerning data privacy, user's security, surveillance, and algorithmic injustice, which has been ignored at some extent in current literature. While Raharja et al. (2024) has shaded lights on the technical aspects of cloud-based big data analytics, their work have failed to provide a detailed analysis of the governance mechanisms that are required to address the issues and concerns of such technological advancements.

In conclusion, the review of literature (refer Fig 1) has provided an understanding of significant contribution around urban regeneration, tourism, smart cities, AI, and business analytics. However, it also reveals the essential gap that need to be addressed, and thus, met to promote the application of AI and analytical approaches for the creation of efficiency model for the revitalization of urban areas. Future studies should therefore target to work towards the efficient and more systematic implementation of these technologies, and also focuses on the socio-economic impacts, ethical queries, and governance challenges associated with smart tourism, and thus providing empirical evidence for the successful implication of these advancements in technologies for sustainable urban regeneration. Hence, planners and scholars can harness the effective application of AI and analytics to foster favourable, inclusive, and resilient urban development.

Fig.1. *The relationship indicates the gap of current research related to the urban regeneration within the perspective of smart cities*
Source: Author

3. METHODOLOGY

This research designed to employ a quantitative methodology integrating with case-study approach that provide a comprehensive understanding of the role of AI and analytics and used to develop an efficient model for urban regeneration related to tourism within smart city initiatives. The implication of quantitative methodology allows to collect and analyse data in a systematic way which helps identifying trends, patterns, and relationships within sub-constructs of the research (Goertzen, 2017). The study is a pre-structured deductive quantitative survey that is based on the analysis of variables. The survey is carried on 218 respondents effectively at Kochi, Kerala (see Table 1). Questionnaire are based on 5-point Likert's Scale, and questions are pilot tested. Means, modes, and values deviations are descriptive in nature and results are tested to determine whether there is any significant difference between item mean score, and perception of respondents. To validate the results, triangulation of survey findings was performed through a pre-structured interviews with experts and business stakeholders of the region.

Table 1 . *Survey brief*

Research Design Element	Description
Type	Quantitative Methodology
Approach	Exploratory (use to explore the role of AI and big-data analytics in urban regeneration), descriptive in nature
Strategy	Case-study (stakeholder perceptions examination of Kochi Heritage City)
Target Sample	All stakeholder (having belongings to Kochi Heritage City), aged 18 and above
Location	Kochi Heritage City, Kerala, India
Sample Size	218 valid responses
Sampling error	±3.50% (consideration)
Significance Level	95%
Survey time	Oct-Dec 2025

Case Study	
Survey Element	**Description**
Type	Pre-structured deductive quantitative survey (On-site and online)
Respondents	207 (valid participation)
Purpose	To gather survey information on stakeholder's perception and expectation of AI and analytics integration in urban regeneration
Questions	Questionnaire based on 5-point Likert's scale and questions are open-ended related to implementation of AI and analytics in urban regeneration towards tourism promotion

To provide a detailed and contextualized examination, this survey has been performed which is based on the specific information gathered on perceptions of stakeholders and their expectation on implementation of AI and big-data analytics in urban regeneration projects at Kochi heritage city. The case studies have been selected based on the scale of the project, implementation techniques and the diversity of AI and data analytics, and the documented outcomes. For the data collection, multiple sources of evidence have been performed which are categorised as project reports, inferential data observations, responses of stakeholders, opinion of experts and planners, and secondary data from industrial and academic publications. Therefore, the following two case studies have been selected based on individual criterion: Fort-Kochi; Mattancherry.

1.1. DATA ANALYSIS

To analysis of quantitative data descriptively, statistical analysis technique has been performed where descriptive statistics and inferential statistics methods are executed (refer Table 2). Data is including case study survey (on-site and online), experts' opinion, and physical observations. Software used for the analysis of data are SPSS 27v, and R to perform correlation analysis with multiple regression techniques.

Table 2 . *Brief of analytical instrument*

1. Descriptive Statistics	
Descriptive Statistical Analysis Element	**Description**
Data	Survey data (both on-site and online)
Purpose	Used to identify the pattern and then analyse the survey data using relationship between variables descriptively.
Measures	Statistical data has been analysed descriptively through frequency distribution, mean score, standard deviations, and percentage of responses
Software	SPSS27v and R
2. Inferential Statistics	
Inferential Statistics Analysis Elements	**Description**
Data	Survey data (1° and 2°)
Purpose	To develop the inter-factorial relationship and assess the correlation between AI and analytics adoption and their outcomes in the process of urban regeneration and tourism promotion
Test	Correlation analysis followed by multiple-regression techniques
Software	SPSS27v, Power BI, and R

The data from primary sources, case study, opinions from experts, and survey (both on-site and online) is standardised statistically to identify the patterns and trends in the process of implementation related to the role AI and analytics in urban regeneration initiatives. For the collection of data, a purposive sampling has been opted to select experts for the interviews which are based on their expertise and experiences in the field of AI, analytics, tourism, and the process of urban regeneration. A convenient sampling strategy has been adopted to select and segregate the nature of respondents which is based on their availability and interest of participation. Thereby, for analysing the data, statistical instrument has been utilized. The descriptive statistical method has been performed to analysed the survey data and the results are measured through frequency distribution, mean score, values in standard deviations, and percentages of responses. It is thereafter followed inferential statistical method to assess the correlation between variables of AI and analytics adoption in the process of urban regeneration and tourism developments. Therefore, the survey data is examined through correlation analysis followed by multiple-regression techniques. Triangulation of data is performed to check and increase the validity and reliability of the findings.

4. ANALYSIS AND FINDINGS

This research aims to examine the inter-factorial relationship and provide a comprehensive and validated understanding of how and to what extent the role of AI and big data analytics can be efficiently incorporated and effectively integrated into business model for a sustainable urban regeneration initiatives and tourism in Kochi Heritage City, Kerala. Hence, the results and findings of this approach of integration used to ensure that the application of AI and analytics are trustworthy, substantiated, validated, and hence capable of prompting with credible solutions to the existing challenges in developing sustainable efficiency model for such urban regeneration initiatives of the region. Therefore, a case-study approach has been performed, and data is collected by survey. The strata of the respondents have been categorised accordingly (refer Table-3).

Table 3 . *Strata of the respondents for survey*

Demographic Variable	Category	Number	Percentage (%)
Gender	Male	122	56 %
	Female	96	44 %
Age	18-25	47	21.55 %
	26-45	80	36.69 %
	46-60	63	28.89 %
	61 and above	28	12.84 %
Sector	Residential	46	21.10 %
	Public	62	28.44 %
	Private	110	50.45 %

4.1. STATISTICAL ANALYSIS

A. Descriptive Statistical Analysis

Assessment of perception on implementation of AI and analytics in the process of urban regeneration related to tourism has been analysed descriptively through the adoption of case-study. A survey on three main strata of respondents with total of 218 (effective) respondents were performed to gather the data and results has been obtained through statistical analysis method (refer Table 4 and Table 5). Perception of respondents has been measured on 5-point Likert's Scale and analysed accordingly.

Table 4. *Descriptive Statistical Analysis*

Variables	**Statement**	**N**	**Mean**	**Variance**	**Std. Deviation**
AI Adoption	Adoption of AI to improvise urban regeneration efficiency	218	2.73	2.01	1.39
Analytics use	Improvised use of analytics to provide better resource management	218	2.96	1.44	1.18
Ethical concerns in TrUR	Ethical concerns address to support and promote the process of urban regeneration related to tourism	218	4.02	0.87	0.97

Table 5 . *Frequency Distribution of Responses from Participants*

Response category / Variable	Strongly Agree (5)		Agree (4)		Neutral (3)		Disagree (2)		Strongly Disagree (1)		
	Number	%	Number	%	Number	%	Number	%	Number	%	Total
AI adoption to improve UR efficiency	118	54.12	69	31.65	20	9.17	7	3.21	4	1.83	218
Analytics use for better resource management	108	49.54	74	33.94	19	8.71	10	4.58	7	3.21	218
Ethical concerns to support TrUR	43	19.72	61	27.98	51	23.39	44	20.18	19	8.71	218

1. AI Adoption to Improve Urban Regeneration Efficiency

AI adoption has been opted as variable for this research to measure the perception of the respondents descriptively, and examine the effectiveness of AI technologies and their implementation in enhancing the efficiency of urban regeneration initiatives related to tourism in city i.e., Kochi Heritage City, Kerala. This variable is further divided into two sub-constructs; streamlining processes, and predictive capabilities, and each construct is designed with three items. Hence, total of six (6) items has been designed as questionnaire for the survey to measure the efficiency and effectiveness of the variable and the data is analysed statistically.

Assessment of findings from the survey, the analytical results has concluded as total of 118 respondents (54.12%) have strongly believe that adoption of AI has a substantial positive impact on efficiency of urban regeneration initiatives related to tourism in Kochi. Also, a large number of participants has observed (31.65% of respondents) have shown their agreement on adoption of AI reflecting a general consensus with a benefit in planning and development and thus increases the efficiency of such regeneration projects. A small group of participants recorded as neutral reply (9.17%), and results concluded as it may due to lack of public involvement and understanding of AI's potential. Moreover, a very small group of respondents i.e., 1.83% of total respondents have shown disagreement on the efficiency of AI adoption in urban regeneration and tourism promotion.

Therefore, the pursuit of urban regeneration and tourism planning the results from survey are often staggered by the complexity of urban systems, and the sheer volume of data-driven analytics required to inform and validate the decision-making. However, the strategic deployment of artificial intelligence (AI) and advancement in technologies, such as machine learning algorithms and predictive analytics can helps in reducing the stress by automating routine tasks and providing a rich and contextual insight to urban planners. Hence, the process of urban regeneration in Kochi becomes data-driven, the potential for AI to users' decision-making and expertise becomes increasingly evident. And therefore, by empowering urban planners and business developers to make them more informed, nuanced decisions, AI plays a crucial role in the formulation of resilient, sustainable, and equitable urban environments.

2. Analytical Use for Better Resource Management

Use of analytics is opted as another variable for the survey to examine the perception of the respondents on the role of data analytics in promoting and enhancing the experience of urban infrastructures through resource management. This variable is therefore subcategorized into two constructs; resource optimization and cost reduction, and each of them is further designed with three items for the survey. Thereby, total of six (6) questions has been designed to measure and examine the perception of the respondents on the use of analytics to provide better resource management.

The survey is analysed descriptively, and the results are concluded as total of 108 (49.54% of total participants) respondents have shown their interest on strongly agree, and a considerable proportion (33.94%) respondents agreed on statement that data analytics significantly improve urban resource management in Kochi. Although, a small number of responses (4.58%) are also recorded with a neutral agreement, whereas only few of the participants have shown their disagreement that the use of analytics can be beneficial for improvised resource management.

Therefore, the results from the survey findings suggested that the optimized application of data analytics can enhance the experience of users through urban resource management, and enabling urban areas more effectively to allocate and utilize the urban infrastructures efficiently. By opting a selective pattern and trend within complex datasets, it helps analysts to forecast future demands, thereby leading to more cost-effective and sustainable management practices in the process of urban regeneration and tourism of the region. As a result, it is concluded that, by integration of significantly enhanced operational efficacy through analytics, yielding tangible benefits for the development houses like, municipalities and other urban local bodies and citizens alike.

3. Ethical Concerns to Support Tourism-related Urban Regeneration (TrUR)

Ethical concerns to support urban regeneration is third variable for this research, and it is responsible to assess the ethical issues which may hinder the implementation of AI and analytics in the process of urban regeneration and tourism. The concerns are therefore designed to examined under three sub-constructs; data privacy concern, biasness in algorithm, and community trust. Each construct is itemized to address their respective issues and further designed with five (5) questions for the survey (refer Table 05 and Table 06).

The findings from the data analysis of survey are concluded as a small group of respondents (19.72% of total participants) have shown a strong agreement that in such regeneration initiatives with adoption of AI and analytics, ethical issues are being adequately addressed. However, majority of respondents with total of 61 participants (27.98%) are showing their believe that the ethical concerns are being considered to a satisfactory level, hence, indicating a general perception on the consent towards a fair address of these issues. Similarly, a considerable group of respondents as of 51 out of 218 participants (23.39%) have been observed with a neutral consent, this is because of lower public interaction and inadequate supply of information to the users or may be due to undecided nature of participants. Whereas, a significant number of respondents (as 20.18% on disagree and 8.71% on strongly disagree) are being recorded with the dissatisfied agreement, thus, quantifies their perceptions towards the ethical issues consideration while performing the AI and big-data analytics in the process of TrUR.

Hence, on analysis of data descriptively, the findings are concluded as the integration of AI and analytics on implementation in urban regeneration process, the urban milieus raise significant ethical quandaries that requires careful consideration. The judicious implementation of these technologies and adoption of advancements ensuring the ability of secured use of data and their privacy, preclude the potential for surveillance abuse, and confirming the rectification of algorithmic biasness in AI based decision-making processes. Therefore, it is concluded that the ethical issues incumbent upon policymaker and all stakeholders to deployment of robust measures and guidelines which helps in mitigating the risk associated with the integration of AI and analytics in such urban regeneration initiatives and thus, the concerns are being served consonant with the values of transparency, accountability, and social justice to construct of sustainable urban environment.

B. Inferential Statistical Analysis

Inferential analysis is another analytical method for the statistical data to quantify the survey with regressions. In this study, the data is being processed inferentially and perform a construct correlation analysis followed by multiple-regression techniques, and results are concluded on surveys' findings. Thereby, the data is being collected based on three respective constructs; AI adoption to improve efficiency, analytical use for resource management, and ethical concerns in TrUR. Each construct is further categorized with dedicated sub-constructs (refer Table 6), and following sub-constructs are further dedicated with their respective items. Therefore, in this research questionnaire, total seventeen (17) items have been deployed to perform the survey.

Table 6. *Inferential statistical analysis*

Construct	Sub-construct	Number of Items	Frequency	% on agreement	Explanation
AI adoption to improve efficiency	Streamlining Process	3	158	72%	Adoption of AI increases the efficiency thus significantly reduces the time in planning and execution process.
	Predictive Capabilities	3	124	57%	Use of AI with predictive analytics can help in increase the project feasibility by anticipating future urban needs in Johor Bahru.
Analytical use for resource management	Resource Optimization	3	144	66%	Use of data analytics helps to optimize the urban resources and increase efficacy while planning.
	Cost reduction	3	127	58%	Data analytics enhances to better resource management and reduces cost by 20% (avg.) and increases productivity.
Ethical concerns in TrUR	Privacy issues	2	126	58%	Management of individual data privacy have significant concern on implementation of AI in regeneration initiatives towards tourism promotion.
	Biasness in Algorithms	2	107	49%	AI algorithms and analytics shows issues of baseness, and hence need to be more transparent in decision making.
	Community trust	1	79	36%	Building community trust among stakeholders is another ethical concern, and thus become essential for effective implementation.

Hence, the inferential statistical analysis has been performed to identify the correlations between the constructs of AI and use of analytics, and ethical concerns in respective urban regeneration initiatives and the data is being analysed inferentially followed by multiple-regression techniques. The results are concluded on principal components, and data analysed based on perception of the respondents individually. Under variable AI adoption, sub-construct 'streamlining process' has been appeared through three itemized statements where 72% of respondents showed their agreement on adoption of AI reduces the time and increases the efficiency of the projects. Similarly, 66% of respondents have agreed on the use of analytics can promote optimized resource management. Progressively, regarding variable 'ethical concerns', individuals' data privacy and algorithm biasness need to be address exponentially to minimized the stress on implementation techniques in such urban regeneration initiatives related to tourism.

4.2. CORRELATION ANALYSIS

Correlation analysis is a statistical analytical tool that progressively used to examine the inter-sectoral dependency, strength and direction of the relationship between two continuous variables (Cohen et al., 2013). In this research, correlation analysis used to assess the decisive dependency of covariance which is measured with values of correlation coefficient. Table 7 showing a correlation matrix which examine relationships between three variables. The correlation coefficient with individual variable is 1.000, which shows the variable is perfectly correlated with itself. However, the correlation coefficient between AI adoption and use of analytics has been recorded with 0.721, which indicates a positive correlation, and it is statistically significant at a certain level ($r = 0.721$, $p < 0.01$). The positive correlation indicated that as AI adoption increases, the use of analytics also tends to increase. Whereas, the correlation between variable AI adoption and ethical concerns in TrUR been measured with a coefficient value of 0.833 at a significant level ($r = 0.833$, $p < 0.01$), which signifies a strong positive correlation. Similarly, the value of 'r' between ethical concerns in TrUR and use of analytics has been measured with 0.902 at a significant level ($r = 0.902$, $p <0.01$), which indicates an extremely strong positive correlation. It signifies that, if use of analytics increases, ethical concerns in TrUR also increase.

Table 7. *Correlation analysis*

Variable	AI adoption	Use of Analytics	Ethical concerns in TrUR
AI adoption	1.000		
Use of Analytics	0.721**	1.000	
Ethical concerns in TrUR	0.833**	0.902**	1.000

The results suggested that the positive correlation between AI adoption and use of analytics concluded as the adoption of AI are more prominent to use of analytics while decision-making in planning. And the strong correlation between AI adoption and ethical concerns may increases due to raise in concerns about individual data privacy, surveillance, and biasness. However, an extremely strong positive correlation between variables suggested that the use of analytics have close relation to the identification and effective management of ethical concerns while implementing in urban regeneration initiatives related to tourism in Kochi.

For the comparison between two distinct or independent groups, Two-sample T-test has been performed. Two-sample T-test is a parametric test that used to assess the mean values between items (Table 8).

$$CI = \bar{X} \pm Z\alpha * \sigma\sqrt{(1/n)}$$

Where, $\bar{X}$ = mean score for group
$Z\alpha$ = is the t-statistic (1.96) standard value @95% CI (confidence interval)
σ = is the pooled Stand. Error
n = sample size

$$CI = 2.89 \pm 1.96 * 0.22\sqrt{(1/218)}$$

$$= 2.46 \text{ to } 3.32$$

Table 8. *Two-Sample T-test*

Group	Mean	Std. Dev.	Std. Error	CI @95%
AI adoption (Group 1)	2.89	1.14	0.22	(2.46, 3.32)
Analytics use (Group 2)	3.78	1.21	0.29	(3.21, 4.35)
T-test Result				
Variable	**T**	**df**	**Sig. (2-tailed)**	
AI adoption vs Use of Analytics	-16.96	214	0.000	

The test is performed and thus concluded as the data provided to T-test help to compare the mean scores of two independent groups which is used to determine whether there is a statistically significant difference between mean values. The analytical results asserted that the mean score for Group 1 (2.89) is significantly lower than mean score of Group 2

(3.78), which signifies that the mean scores for the groups with 95% confidence level do not overlap and the differences are statistically significant. The T-statistics (T) is -16.96 which indicates that how pooled standard errors and the mean difference is away from the null hypothesis with no difference. Hence, a large T-value indicates that the group mean score have a significant difference. The negative T-value indicates that the mean of Group 2 is greater than Group 1. The p-value (sign. 2-tailed) is 0.000, which is lower than the conventional alpha level of 0.05, and thus it rejects null hypothesis and the population means indicates a true significant difference.

To re-validate the results, a non-parametric test, 'Wilcoxon Rank-Sum Test' has been executed which compares the itemized distribution of varied components in their groups, and it doesn't require normality or equal variance that is more robust to outliers and non-linear relationships compare to parametric test. The correlation between the itemized variables indicates the strength of the monotonic relationship, and the p-value (refer Table 9) further stated the probability of observing the correlation by chance. Since the p-value is observed as 0.001 which is less than conventional value (0.05), it rejects the null hypothesis and concluded as the correlation is statistically significant.

Table 9. *Wilcoxon Rank-Sum test*

Group	N	Sum of Ranks	Mean Rank
Group 1 (AI adoption)	109	13957	126.40
Group 2 (use of Analytics)	109	31348	143.51
Test Statistics			
W	**p-value**		
13427	< 0.001		

The test is performed with two groups and each of them have assessed with 109 observations (N) that comprises 218 total sample size (n). On analysis of responses, the Rank-Sum test yields a W statistic of 13427 indicates the sum of the ranks is considered for the group with the smaller rank sum (Group1). The p-value is observed as < 0.001, which is significantly lower than the typical alpha level (as prescribed value 0.05) thus, it leads to reject the null hypothesis. Therefore, the W statistic and p-value stated significant differences between the groups with the median of group 2 is higher than group1. Hence, the findings have shown an important implication for the development of businesses and related organizations which seeks to maximize the benefits of adoption of AI and the use of analytics.

Analysis of Variances

For the analysis of variance, One-Way ANOVA has been performed to check the homogeneity of variances using Levene's test. To evaluate the significance differences between the groups, analytical results of the ANOVA followed by Post-Hoc test has been performed to determine the differences (see Table 10 and Table 11). The result concluded as the variances are not significantly different where p value is 0.008, and therefore the ANOVA asserted equal variances.

Table 10. *One-Way ANOVA*

Variances	df	SS	MS	F	p-value
Between Groups	4	32.17	16.066	4.91	0.008
Within Groups	214	437.41	2.03		
Total	218	469.58			

Mean and Standard Deviation		
Group	**Mean**	**Std. dev.**
Adoption of AI	2.89	1.14
Use of Analytics	3.78	1.21
Ethical concerns in TrUR	3.31	1.08

Post-Hoc test using Tukey's Honest Significant Difference (HSD) method has been performed to determine the mean score of which specific group is significantly different. Therefore, to analyse the result of post-hoc test, first must calculate the Tukey's HSD:

$$HSD = q * \sqrt{\frac{MS_{within}}{n}}$$

Where: q = standardized range statistic (obtained from statistical table based on number of groups and degree of freedom within

MS $_{within}$ = mean square within groups

n = the number of observations per group (assume equal sample size for simplicity). Since the sample size is equal for each group (assumed), from the ANOVA data, we have: MS $_{within}$ = 2.03, and the 'q' value for 3 groups with df (214) at 95% CL is approved approximately 3.314 (from Tukey's HSD table).

Studentized Range Critical Value (q): For $\alpha = 0.05$, $k = 3$, and $\mathrm{df} = 214$ (using large sample approximation or lookup for df > 120), the critical value for q is approximately 3.314.

The value of 'n' is:

From the calculations, total degrees of freedom is $\mathrm{df}_{\mathrm{total}} = N - 1 = 218 \Longrightarrow N = 219$. With $k = 3$ groups, the balanced sample size per group is approximately $n = \frac{N}{k} = \frac{219}{3} = 73$ (or we can use the individual group sizes if available, but $n \approx 73$ is standard for balanced/average group estimations here). Let's use $\boldsymbol{n = 73}$

Hence,

$$HSD = 3.314 * \sqrt{\frac{2.03}{73}}$$

$$= 0.553$$

Table 11. *Post-Hoc Tests*

Comparison	Mean Difference	Std.Err.	p-value	Comparison to HSD
AI adoption vs Use of Analytics	-0.89	0.21	0.001	0.89 > 0.553(significant)
AI adoption vs Ethical concerns in TrUR	-0.42	0.27	0.126	0.42 < 0.553(not significant)
Use of Analytics vs Ethical concerns in TrUR	0.47	0.21	0.185	0.47 < 0.553(not significant)

The post-hoc test with Tukey's HSD method indicates that the mean score between group 1 and group 2 have shown a significant difference, as the mean difference exceeds the HSD value. However, the mean score difference between group 1 and group 3 (0.42) is less than the HSD value (0.553), which shows no significance difference between mean scores. Similarly, the mean score difference between group 2 and group 3 is less than the HSD value that stated no significance difference. Hence, the test one-way ANOVA reveals that there is a significance difference among the three groups. The post-hoc test using Tukey's HSD method therefore stated as only group 1 and group 2 have shown a significant difference.

Multiple Regression Analysis

Using the given data, the regression analysis has been performed to calculates the coefficients and other statistics. The standard errors, t-values, and p-values are further computed using statistical regression techniques to identify the multicollinearity (refer Table 12). If a 'p-value' less than 0.05 recorded, that signifies the coefficient is significantly different from zero at 5% significance level.

The t-statistic is independently verified by dividing the unstandardized coefficient (*B*) by its standard error (*SE B*):

$$t = \frac{B}{SE\ B} = \frac{0.72}{0.24} = 3.00$$

The exact two-tailed significance value (p-value) corresponding to t = 3.00 with residual degrees of freedom df = 214 is:

$$p \approx 0.003$$

Table 12. *Multiple Regression Analysis*

Regression	B	Beta	SE B	t	Sig.
Statistics use	0.72	0.61	0.24	3.00	0.003

The unstandardized coefficient (B) is 0.72, indicated that the mean score for dependent variable is expected to increase by 0.72 units, and thus holding all other variables are constant. The observed standardized coefficient (Beta) is 0.61 signifies a strong positive correlation between the use of statistics and the mean score. It is therefore suggested that, since the beta value is higher, the use of statistics has shown a substantial effect on the dependent variable with respect to other components. The higher t-value (3.00) signifies that the coefficient is significantly different from zero. Therefore, the results concluded that the higher t-value and a very low p-value is providing strong evidence towards the use of statistics and the mean score which is not due to random chance, however, the standard error is observed relatively small, which signifies a high degree of precision in the estimated coefficient.

5. DETAILED DISCUSSION AND RECOMMENDATIONS

This study therefore discussing on how AI and data analytics can be integrated through a comprehensive analysis that enhances urban regeneration initiatives and promote tourism, particularly within the context of Kochi heritage city, Kerala. The perception of stakeholder towards adoption of AI and analytical use, and consideration of ethical concerns is observed significantly different which is supported from the findings of the ANOVA and post-hoc tests. Further, a strong positive relationship indicated by a Beta value of 0.61 (p = 0.003) through the regression analysis has demonstrate the use statistics which predicts the successful implementation of AI and use of analytics in the process of tourism-related urban regeneration. This is supported by the study of Bakhtiar and Samsudin (2023), as stated that the strong positive relation between variables can helps in successful integration of technologies in smart city mission.

Further, the study discusses the integration and adoption of AI and use of analytics into the process of tourism-related urban regeneration, which is transformative in nature that offers an enhanced efficiency with its maximized potential in resource management, optimized service providers, and predictive maintenance with consideration of ethical concerns. Reduced AI algorithm biasness can further provide a tailored solution in forecasting future needs for the sustainable urban development. This is therefore supported from the studies where AI-powered urban infrastructure maintenance can helps in significant reduction in operational costs, and also enhances the distribution of urban assets in real-time through big-data analytics that ensures efficient and responsive services (Alahi et al., 2023; Bibri et al., 2024; Kamchatova et al., 2021; Mahor et al., 2022).

Whereas, it is also concluded that, these technological advancements and their integration is fraught with complexities. Notably, the ethical concerns of data privacy, the exacerbation of social inequalities through digital divide, and the ethical concerns of AI-driven decision-making processes require rigorous scrutiny and vigilant supervision that used to ensure the attainment of equitable and resilient outcomes, which is critical to establish a robust but stable governance structure. It fosters interdisciplinary collaborations through the dynamic adaptation of reformed business model with rapid evolving cutting-edge technologies in urban landscape rejuvenation (Ahmad et al., 2022; Allam & Newman, 2018; Rahman et al., 2024).

However, in this study, the discussed case studies from Kochi, Kerala used to serve as critical component for paradigmatic illustration of adoption and their integration of AI and use of analytics in such government based urban development initiatives. These innovative initiatives potentially demonstrate the transformative capacity of such advanced technologies that helps in reshaping urban landscape, stimulate sustainable economic growth, and significantly upraise the overall well-being of urban habitants.

Hence, the study from discussion has the following recommendation that can enhances the efficiency and effectiveness of the program:

1. Enhanced Governance and Policy Framework: To mitigate the challenges associated with data privacy and ethical implications it is necessitate to develop a comprehensive governance and effective policy framework (Malleson et al., 2022). To ensuring transparency, accountability, and inclusivity in utilization of AI and analytics in tourism-related urban regeneration processes, these frameworks should be designed efficiently, as recommended by Allam and Newman (2018).
2. Promotion of Interdisciplinary Collaboration: For the successful integration of AI and analytics, it become necessary to collaborate across numerous disciplines that combines to support in enhancing the productivity of the program. It is supported by the study that fostering interdisciplinary collaboration which leads to more holistic and sustainable urban regeneration initiatives related to tourism (Cugurullo et al., 2024).
3. Investment in Digital Infrastructure and Capacity Building: To reduce the stress on biasness in decision-making, bridging the digital divide which ensures equitable access to advancements in technologies, a significant investment in digital infrastructure is needed. This instance encompasses an expanding access to high-speed internet and promoting digital literacy among users of the region (Cavalheiro et al., 2020).
4. Public Engagement and Local Participation: Public participation and their engagement in planning and development process is crucial phenomena the accounts the success of urban regeneration initiatives (Rahman et al., 2022). Thereby, through leveraging AI adoption and analytics to itemized and analyse community feedback, it can make the planning process more inclusive and transparent that helps in fostering the public trust and thus local participation.
5. Ethical Consideration in AI Deployment: Consideration of ethical concerns should be assigned as the forefront factor in AI deployment in the process of tourism-related urban regeneration. This is supported by recommendation of the study that addressing the issues related to algorithmic biasness in decision-making, and protecting individual privacy in the process of implementation (Cugurullo et al., 2024).
6. Continuous Assessment and Reflexive Evaluation: To identifying the area for improvement, it become imperative to implementing a robust system of continuous monitoring and reflexive evaluation of AI analytical applications, that helps in ensuring the effectiveness of these technologies in contributing to sustainable urban regeneration (Wei et al., 2024).

It is therefore, based on the following analysis and discussions, it is recommended to develop an efficiency model that integrates the techniques of AI and data analytics and their adoption in the process of urban regeneration related to tourism that can increase the efficiency of the program through the promotion of tourism to the heritage city.

5.1. RECOMMENDATION OF AN EFFICIENCY MODEL FOR A HERITAGE CITY REGENERATION: CUSTOMER VS CONSUMER SEGMENTS

The recommendation to develop an efficiency model that support and enhance the experience of tourism in a heritage city within smart city initiatives. By creating a development model which is used to integrate AI and analytics in the process of TrUR within smart city concept that involve in identifying key component to enhance the productivity of the region. This model will support in strengthening the AI and data analytics to improve the feasibility of urban regeneration projects in the heritage cities, i.e., Kochi, Kerala through addressing the efficiency, resource management, and ethical considerations.

The resource efficiency model (Figure 2) is a strategic modulation template to support in enhancing proposed development model efficacy. It consists of seven segments: Customer segment, value proposition, collaborative channels, customer relationship, cost structure, engagement and partnerships, and revenue stream. Each segment is designed to perform with their respective subconstructs to its ideal situation in consideration of all three variables of this research.

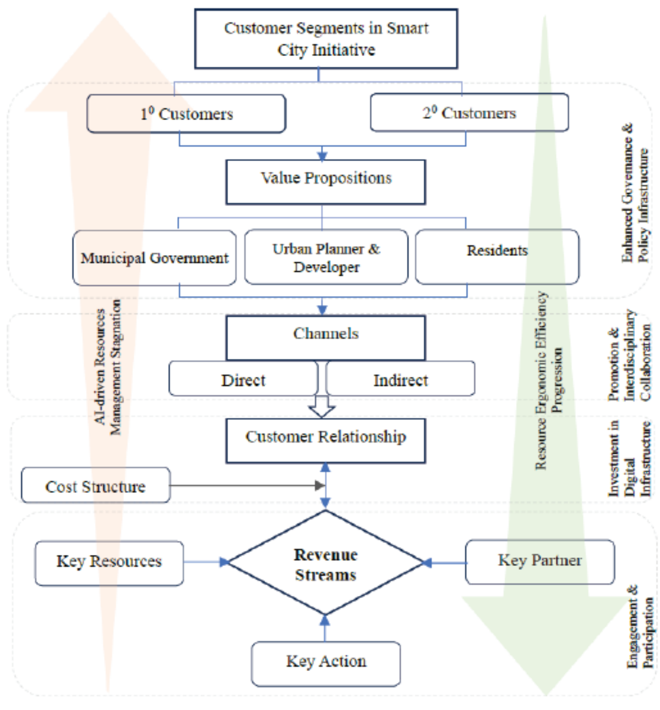


Fig.2. *Efficiency Model for a Heritage city to support Tourism-related Urban Regeneration*
Source: Author

Therefore, the recommended efficiency model proposed to underscore the comprehensive approach which is seamlessly integrates AI and data analytics into tourism-related urban regeneration initiatives within smart cities. This integration of framework designed to align with the research findings and addresses the key areas of concerns as identified:

Efficiency Enhancement: The shrewd application of AI and analytics are crucial for enhancing the efficiency and efficacy of such regeneration projects. It is therefore, by harnessing the capabilities of these technological advancements, the municipal governments, ULBs, and urban planners and policy makers are able to make informed data-driven decisions, rationalize workflows, and anticipate urban needs with greater precision.

Optimization of Resources Management: From the analysis and discussion it is concluded that the data analytics plays a critical role in optimizing resource management which leads to a substantial cost saving and efficient resource allocation. Hence, this model is proposed particularly to the infrastructure companies, urban planners, and policy makers to navigate the complexities of resource management and ensuring the successful execution of projects.

Addressing Ethical Concerns: The recommended efficiency model acknowledges the paramount importance of ethical considerations while implementing AI and analytics in smart city initiatives. For fostering community trust, the model can ensure the privacy of citizen data and minimize biasness in AI algorithms through efficient implication, which guarantee the long-term sustainability of such government-based urban regeneration projects for the heritage cities, such as Kochi, Kerala.

Similarly, while discussing the implications of this resource modelling, it is poised to have a profound impact on the trajectory of tourism-related urban regeneration projects in smart cities which has significant consequences for various stakeholders. Therefore, the broad implications of this model are as follows:

Municipal Governments- Enhanced Urban Governance: The synergistic implication of AI and analytics shows enormous potential for municipal government and ULBs that enabling them to orchestrated highly efficient and effective regeneration projects (Awad & Jung, 2022; Sohi et al., 2024). By promoting these technological advancements, the local governments can optimize resource allocation, streamline automated decision-making processes, and create more liveable and sustainable cities. Furthermore, AI-driven analytical insights can facilitate data-driven policy decisions which allows municipal governments to respond more effectively to the projected urban needs and create more resilient urban ecosystems. Ultimately, this implication makes the model to culminate in better-manged cities, improvise the quality of life for residents, and enhance social cohesion.

Urban planners and Developers- Augmented Planning and Resource Management: The implementation of this model can harness the power of AI-driven analytics which helps to urban planners and developers to enhance planning accuracy, optimize resource management, and mitigate potential risks associated with projects. Hence, it can lead to more successful projects with cost reductions, and improvised returns on investment.

Residents- Enhanced Trust and Satisfaction: The utilization of this model can integrate AI analytics in such tourism-related urban regeneration projects which have a profound impact on resident's trust and satisfaction with smart city initiatives. Hence, this model can ensure the responsible and ethical use of data analytics and AI augmented systems to urban planners and municipal governments, who will be benefitted from improved urban infrastructure and services that are more responsive to urban needs. Therefore, the model can suggest the assurance of data privacy and ethical concerns that fostering a more collaborative and trusting relationship between users and service providers.

5.2. CONCLUSIONS

Therefore, in conclusion this model helps in bridging the gap between theory and praxis, facilitating the translation of academic research into tangible outcomes that can be operationalized in diverse urban context. This innovative business model therefore contextualized within the unique urban landscape of Kochi, which presents a comprehensive framework for harnessing the transformative potential of AI and analytics in smart city regeneration. It is sued to triangulating the strategic partnerships, utilization of cutting-edge technologies, and a rigorous ethical scaffolding to amplify efficiency gains, optimizing resource allocation, and mitigate the complexities in ethical considerations in such regenerative projects. By acknowledging the distinctive urban character, art and architecture, heritage, and tourism aspirations, this grounded framework can ensure the benefits of AI-driven urban regeneration which are equitably distributed, socially responsible, and environmentally sustainable that helps in yielding tangible improvements in the quality of life for Kochi's residents while fostering a liveable, resilient, and equitable urban ecosystem.

Hence, this study is concluded as it become evident that the judicious deployment of AI and analytics is significantly augment the operational efficiency and resource coordination of tourism-related urban regeneration initiatives within smart cities. However, this potential is technically counterbalanced by profound ethical concerns, primarily the preservation of individual privacy and algorithmic biasness, which is imperative in addressing the development and implementation of comprehensive ethical frameworks, and ensuring the integration of AI and analytics in urban regeneration endeavours that is not only effective but also morally grounded, socially responsible, and transparent. By doing so, we can unlock the transformative potential of these technological advancements while mitigating their risks, ultimately fostering sustainable, inclusive, and equitable urban futures.

6. REFERENCES

Ahmad, K., Maabreh, M., Ghaly, M., Khan, K., Qadir, J., & Al-Fuqaha, A. (2022). Developing future human-centered smart cities: Critical analysis of smart city security, Data management, and Ethical challenges. Computer Science Review, 43, 100452.

Alahi, M. E. E., Sukkuea, A., Tina, F. W., Nag, A., Kurdthongmee, W., Suwannarat, K., & Mukhopadhyay, S. C. (2023). Integration of IoT-enabled technologies and artificial intelligence (AI) for smart city scenario: recent advancements and future trends. Sensors, 23(11), 5206.

Allam, Z., & Newman, P. (2018). Redefining the smart city: Culture, metabolism and governance. Smart Cities, 1(1), 4-25.

Awad, J., & Jung, C. (2022). Extracting the planning elements for sustainable urban regeneration in Dubai with AHP (analytic hierarchy process). Sustainable Cities and Society, 76, 103496.

Bakhtiar, I. S., & Samsudin, N. A. (2023). Comparative review of Smart City from an urban planning perspective in Johor Bahru City and Petaling Jaya City. IOP Conference Series: Earth and Environmental Science,

Banihashemi, S., & Sohi, S. Z. (2022). Data-centric regenerative built environment: big data for sustainable regeneration. Routledge.

Batty, M. (2013). Big data, smart cities and city planning. Dialogues in human geography, 3(3), 274-279.

Bibri, S. E., Alexandre, A., Sharifi, A., & Krogstie, J. (2023). Environmentally sustainable smart cities and their converging AI, IoT, and big data technologies and solutions: an integrated approach to an extensive literature review. Energy Informatics, 6(1), 9.

Bibri, S. E., Krogstie, J., Kaboli, A., & Alahi, A. (2024). Smarter eco-cities and their leading-edge artificial intelligence of things solutions for environmental sustainability: A comprehensive systematic review. Environmental Science and Ecotechnology, 19, 100330.

[Record #878 is using a reference type undefined in this output style.]

Cavalheiro, M. B., Joia, L. A., & Cavalheiro, G. M. d. C. (2020). Towards a smart tourism destination development model: Promoting environmental, economic, socio-cultural and political values. Tourism Planning & Development, 17(3), 237-259.

Chung, N., Lee, H., Ham, J., & Koo, C. (2021). Smart tourism cities' competitiveness index: a conceptual model. Information and Communication Technologies in Tourism 2021: Proceedings of the ENTER 2021 eTourism Conference, January 19–22, 2021,

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). Applied multiple regression/correlation analysis for the behavioral sciences. Routledge.

Coletti, R., & Rabbiosi, C. (2021). Neighbourhood branding and urban regeneration: performing the 'right to the brand'in Casilino, Rome. Urban Research & Practice, 14(3), 264-285.

Cugurullo, F., Caprotti, F., Cook, M., Karvonen, A., McGuirk, P., & Marvin, S. (2024). The rise of AI urbanism in post-smart cities: A critical commentary on urban artificial intelligence. Urban Studies, 61(6), 1168-1182.

Goertzen, M. J. (2017). Introduction to quantitative research and data. Library Technology Reports, 53(4), 12-18.

Gomes, S., Lopes, J. M., & Ferreira, L. (2024). Looking at the tourism industry through the lenses of industry 4.0: a bibliometric review of concerns and challenges. Journal of Hospitality and Tourism Insights, 7(1), 436-457.

Harrison, C., & Donnelly, I. (2011). A theory of smart cities. Proceedings of the 55th International Society for the Systems Sciences. University of Hull Business School, Hull, United Kingdom. https://journals.isss.org/index.php/proceedings55th/article/view/1703

Kamchatova, E. Y., Chashchin, V. A., & Dong, Z. (2021). Development of urban infrastructure through the introduction of digital technology. Socio-economic systems: paradigms for the future, 159-167.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. GeoJournal, 79, 1-14.

Lai, Y. (2022). Urban intelligence for carbon neutral cities: creating synergy among data, analytics, and climate actions. Sustainability, 14(12), 7286.

Mahor, V., Bijrothiya, S., Mishra, R., Rawat, R., & Soni, A. (2022). The smart city based on AI and infrastructure: A new mobility concepts and realities. Autonomous Vehicles Volume 1: Using Machine Intelligence, 277-295.

Malleson, N., Birkin, M., Birks, D., Ge, J., Heppenstall, A., Manley, E., McCulloch, J., & Ternes, P. (2022). Agent-based modelling for Urban Analytics: State of the art and challenges. AI Communications, 35(4), 393-406.

McLoughlin, S., Maccani, G., Puvvala, A., & Donnellan, B. (2021). An Urban Data Business Model framework for identifying value capture in the Smart City: The case of Organicity. Smart Cities and Smart Governance: Towards the 22nd Century Sustainable City, 189-215.

Panori, A., Kakderi, C., & Komninos, N. (2023). Transformation of smart city public services through AI and big data analytics: towards universal cross-sector solutions. In Handbook of Research on Artificial Intelligence, Innovation and Entrepreneurship (pp. 292-307). Edward Elgar Publishing.

Peponi, A. (2023). Smart cities, smart growth: paving the way to urban regeneration.

Putra, H. Y., Putra, H., & Kurniawan, N. B. (2018). Big data analytics algorithm, data type and tools in smart city: A systematic literature review. 2018 International Conference on Information Technology Systems and Innovation (ICITSI)

Raharja, U., Sanjaya, Y. P., Ramadhan, T., Nabila, E. A., & Nasution, A. Z. (2024). Revolutionizing Tourism in Smart Cities: Harnessing the Power of Cloud-Based IoT Applications. CORISINTA, 1(1), 41-52.

Rahman, E. Z., Aziz, S., Shah, S. B. A., & Asrifan, A. (2024). The Effect of the Regenerative Tourism Movement on the Global Industry and the Role of Artificial Intelligence. In The Role of Artificial Intelligence in Regenerative Tourism and Green Destinations (pp. 165-183). Emerald Publishing Limited.

Rahman, F., & Halim, N. (2021). Tourism-related Urban Regeneration of Historic Cities: A Regeneration Strategies for Kochi, Kerala. Environment, 6(26), 130-142.

Rahman, F., Halim, N., & Ahad, A. (2022). ASSESSING PUBLIC PARTICIPATION IN TOURISM-RELATED URBAN REGENERATION: A CASE OF KOCHI HERITAGE CITY, INDIA. Malaysian Journal of Sustainable Environment, 9(3), 1-19.

Rahman;, F., Rahman;, N. A., Shafique;, A., Ahad;, A., & Shukla, A. (2025). Urban Regeneration and Heritage Tourism: A Bibliometric Analysis Over Three Decades. International Journal of Research and Innovation in Social Science-IJRISS, 9(6), 4239-4262. https://doi.org/10.47772/IJRISS.2025.906000321

Rieder, E., Schmuck, M., & Tugui, A. (2022). A scientific perspective on using artificial intelligence in sustainable urban development. Big Data and Cognitive Computing, 7(1), 3.

Rivadeneira, J. E., Sánchez, O. T., Dias, M., Rodrigues, A., Boavida, F., & Silva, J. S. (2023). CONFLUENCE: An Integration Model for Human-in-the-Loop IoT Privacy-Preserving Solutions Towards Sustainability in a Smart City. IEEE Internet of Things journal.

Roberts, P., Sykes, H., & Granger, R. (2017). Urban regeneration: A handbook. Sage Publications.

Rodriguez, P., & Mercedes, J. (2024). Integrated Semantic Method for Software Development in Data-Driven City Management: Convergence of Urban Metabolism, IoT/AI, and Remote Sensing.

Samara, D., Magnisalis, I., & Peristeras, V. (2020). Artificial intelligence and big data in tourism: a systematic literature review. Journal of Hospitality and Tourism Technology, 11(2), 343-367.

Sohi, S. Z., Banihashemi, S., Sheikhkhoshkar, M., & Roshan, P. A. (2024). From data to design: Social network insights for urban design and regeneration. Frontiers of Architectural Research.

Sun, Y., Song, H., Jara, A. J., & Bie, R. (2016). Internet of things and big data analytics for smart and connected communities. IEEE access, 4, 766-773.

Wei, Y., Yuan, H., & Li, H. (2024). Exploring the Contribution of Advanced Systems in Smart City Development for the Regeneration of Urban Industrial Heritage. Buildings, 14(3), 583.

Yousefimehr, A. (2019). Smart cities; analyzing themes and concepts of smartness in urban environments Bilkent Universitesi (Turkey)].

Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of things for smart cities. IEEE Internet of Things journal, 1(1), 22-32. https://doi.org/10.1109/JIOT.2014.2306328

Colonial Imprints and Indigenous Continuities: The Urban Evolution of Chandannagar

Dr. Madiha Rahman
Department of Architecture, Jamia Millia Islamia, rahmanmadiha@jmi.ac.in

Abstract - **This paper examines the historical and spatial evolution of Chandannagar, a former French colonial settlement along the Hooghly River in West Bengal, with a focus on how colonial governance, trade networks, and socio-political transformations shaped its urban form. Drawing on archival cartography, official records, scholarly literature, and oral narratives, the study constructs a chronological framework that traces the town's transition from a rural, temple-centred settlement to a structured colonial urban centre and, later, a politically charged space of resistance. The analysis highlights how French colonial planning practices introduced new spatial typologies, administrative zones, and residential patterns that coexisted—often uneasily—with indigenous settlement systems. Through a combination of narrative history and cartographic interpretation, the paper demonstrates that Chandannagar's urban morphology cannot be understood merely as a product of colonial imposition, but rather as the outcome of layered interactions between imperial ambitions, local agency, and shifting political realities. By foregrounding the town's hybrid spatial character, this study contributes to broader discussions on colonial urbanism, cultural exchange, and the long-term legacies of European settlements in South Asia.**

Index Terms **-** *Chandannagar, French colonialism, colonial urbanism, Hooghly River, urban morphology, historical cartography, colonial planning, West Bengal*

1. Chandannagar: A Historical Overview

European settlements began expanding along the Hooghly River in the fifteenth century, as the river served as a crucial route for trade and commerce. Its navigability allowed European ships to transport goods inland, leading to the establishment of trading posts by the Danish, Portuguese, French, Dutch, and British (Ivermee R., 2017). Over time, the Hooghly became the lifeline of several prominent colonial settlements, including Calcutta (British), Serampore (Danish), Chinsura (Dutch), and Chandannagar (French). Together, these towns formed a significant commercial and cultural corridor in Bengal (Ivermee R., 2020).

Chandannagar was established in 1690 and fortified with the construction of Fort d'Orléans in 1700 (Sen S. N., 2012). Initially, it held limited commercial importance. This changed with the arrival of Governor Joseph François Dupleix in 1730, under whose leadership the settlement rapidly developed into a major trading centre (Sen S. N., 2012). Its hinterland became a key supplier of textiles to Pondicherry, supported by bullion from Paris (Ray, p. 53). These trade networks connected Chandannagar with Pondicherry and France, reshaping both its economy and social structure, while French language, customs, and cultural practices increasingly influenced local Bengali life.

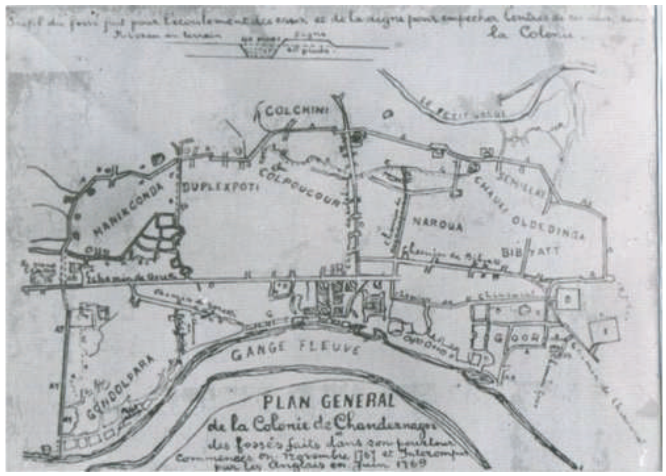


Fig.1 *Archival map of Chandannagar. Source: https://www.tumblr.com/greenjaydeep/31525275766/chandannagar-chandernagor-the-french-connection?redirect_to=%2Fgreenjaydeep%2F31525275766%2Fchandannagar-chandernagor-the-french-connection&source=blog_view*

Administratively subordinate to Pondicherry, Chandannagar's prosperity was disrupted following the Battle of Plassey in 1757. Lord Clive demolished Fort d'Orléans, and the settlement was captured by the British during the Seven Years' War, marking the beginning of its decline (Sen S. N., 2012). Although open trade had characterized the early eighteenth century, limited interaction with Asian merchants weakened the long-term prospects of French commerce in Bengal (Mukherjee R., 2015, p. 201).

The Treaty of Paris (1763) briefly restored French trading rights, allowing commerce in silk, cotton goods, opium, and saltpetre to resume (The French in India, 1768–1816, p. 82). However, British interference continued to restrict French economic activities. By the 1770s, Chandannagar had lost much of its earlier prominence. Comte de Modave described it in 1774 as a town of ruins, deserted streets, and profound silence (The French in India, 1768–1816). Although the Treaty of Versailles returned Chandannagar to French control, strict limitations were imposed, prohibiting fortifications and military presence, and reducing the settlement to a purely commercial role (Sen S. N., 2012).

By the nineteenth century, Chandannagar had become politically charged. In 1790, its residents demanded autonomy and rejected governance from Pondicherry (Sen S. N., 2012). Its relatively liberal environment enabled it to emerge as a refuge for political dissidents and revolutionaries organizing against British rule (Samanta, 1995, p. 338). In response, the British implemented strict surveillance measures under the Foreigners' Act in 1911 to suppress anarchist activities (Sen S. N., 2012). Despite these controls, Chandannagar continued to function as a centre of anticolonial resistance.

Thus, Chandannagar's social, cultural, and political histories remain deeply intertwined. From a French trading post to a hub of revolutionary activity, it became a space where diverse forces interacted, adapted, and resisted colonial dominance.

2. Evolution of Chandannagar

The evolution of Chandannagar has been traced through the construction of a chronological timeline derived from a systematic analysis of historical sources. This included archival cartography, official colonial records, and existing scholarly literature, which together provided a layered understanding of the town's spatial, political, and socio-economic transformations. These sources were critically examined to identify key phases of growth, decline, and restructuring, enabling the mapping of both continuity and rupture in the town's urban form.

To supplement documentary evidence, commentaries and oral narratives obtained through interviews with long-term residents were incorporated. This helped bridge gaps in the archival record and offered insights into lived experiences, local perceptions, and everyday spatial practices that are often absent from formal historical accounts. The integration of these perspectives ensured that the timeline reflects not only administrative and political shifts but also social and cultural changes embedded in the urban landscape.

The maps presented in this study visually articulate these transitions, illustrating changes in land use, settlement patterns, infrastructural networks, and architectural distribution across different periods. Rather than functioning as mere illustrations, these cartographic representations serve as analytical tools that reveal how historical events, colonial policies, and economic shifts shaped Chandannagar's spatial morphology over time. Together, the timeline and maps provide a structured framework for understanding the town's layered evolution and its contemporary urban character.

Fig.2 *Plan of Chandannagar 1722*
Source: Author

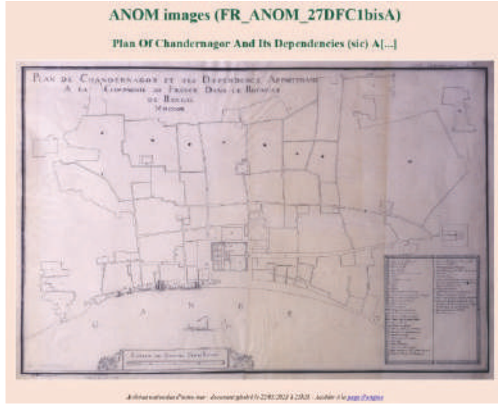


Fig.3 *Archival Map of Chandannagar, 1722*
Source: ANOM Archives

Fig.4 *Plan of Chandannagar, 1762.*
Source: Author

Fig.5 *Archival Map of Chandannagar, 1762.*
Source: ANOM Archives

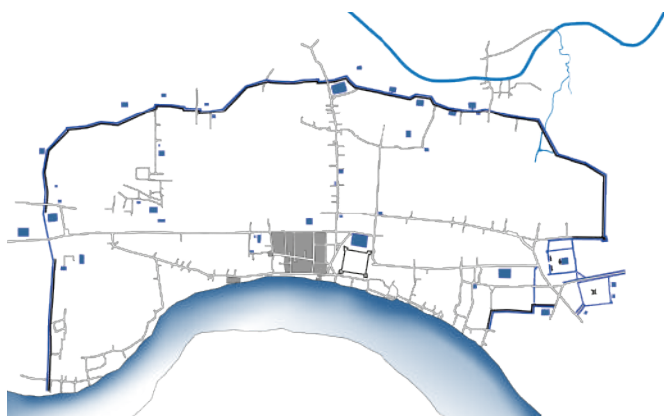


Fig.6 *Plan of Chandannagar, 1769*
Source: Author

Fig.7 *Archival Map of Chandannagar, 1769*
Source: ANOM Archives

Fig.8 *Plan of Chandannagar, 1852*
Source: Author

Fig.9 *Archival Map of Chandannagar, 1852*
Source: ANOM Archives

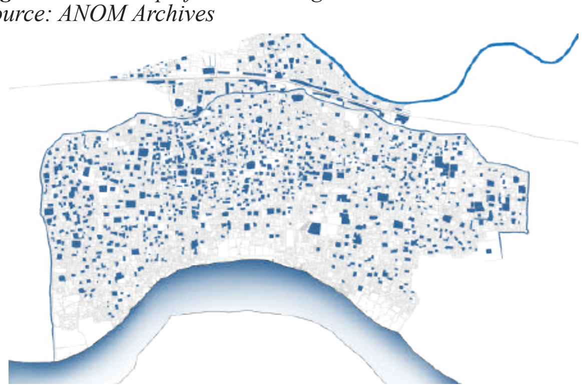


Fig.10 *Plan of Chandannagar, 2022.*
Source: Auth

3. Timeline of Urban Evolution

3.1. Seventeenth Century: Emergence of French Presence

1650: Chandannagar originated as a temple-centred rural settlement characterized by clusters of mud houses interspersed with extensive agricultural fields and orchards. The spatial structure reflected a typical agrarian village morphology.
1673: The French East India Company, seeking a strategic foothold in Bengal's trade network, negotiated with the Mughal Subahdar of Bengal to establish a trading post in the village of Farasdanga along the Hooghly River.
1688: A permanent French settlement was formally established. Its advantageous riverine location facilitated trade and attracted merchants, artisans, and traders, resulting in a notable increase in population and the gradual transformation of the settlement into a commercial node.

3.2. Eighteenth Century: Early Colonial Urbanization

1730–1750s: Chandannagar experienced significant urban expansion, emerging as an important trading centre. This phase witnessed the construction of warehouses, administrative buildings, and residential quarters for French officials as well as Indian merchants, indicating an increasingly organized urban fabric.
1757: The Battle of Plassey marked a major disruption in the town's development. Large portions of Chandannagar's infrastructure, including docks and trading establishments, were destroyed during conflict with the British East India Company. This event initiated a prolonged phase of economic and urban decline.
1763: The Treaty of Paris temporarily restored Chandannagar to French control. Although gradual recovery followed, the settlement never regained its earlier commercial prominence, and its urban landscape remained shaped by the consequences of earlier destruction.

3.3 Nineteenth Century: Urban and Cultural Renaissance

1816: A renewed phase of urban development began, marked by the emergence of a hybrid architectural vocabulary combining French and Indian influences. The construction of state mansions, churches, and educational institutions significantly altered the town's historic skyline.
Early–mid nineteenth century: Chandannagar evolved into an important centre for education and cultural exchange. Its streetscape increasingly reflected a distinctive cultural synthesis, with colonial-era buildings coexisting alongside traditional Bengali domestic architecture.
1850s: This period marked Chandannagar's transformation into a more structured and formally planned urban settlement. Improvements in infrastructure—such as roads, public spaces, and administrative complexes—contributed to the town's emerging civic identity. Concurrently, new ideas in art, literature, and education enriched the social life of the settlement and enhanced its cultural vibrancy.

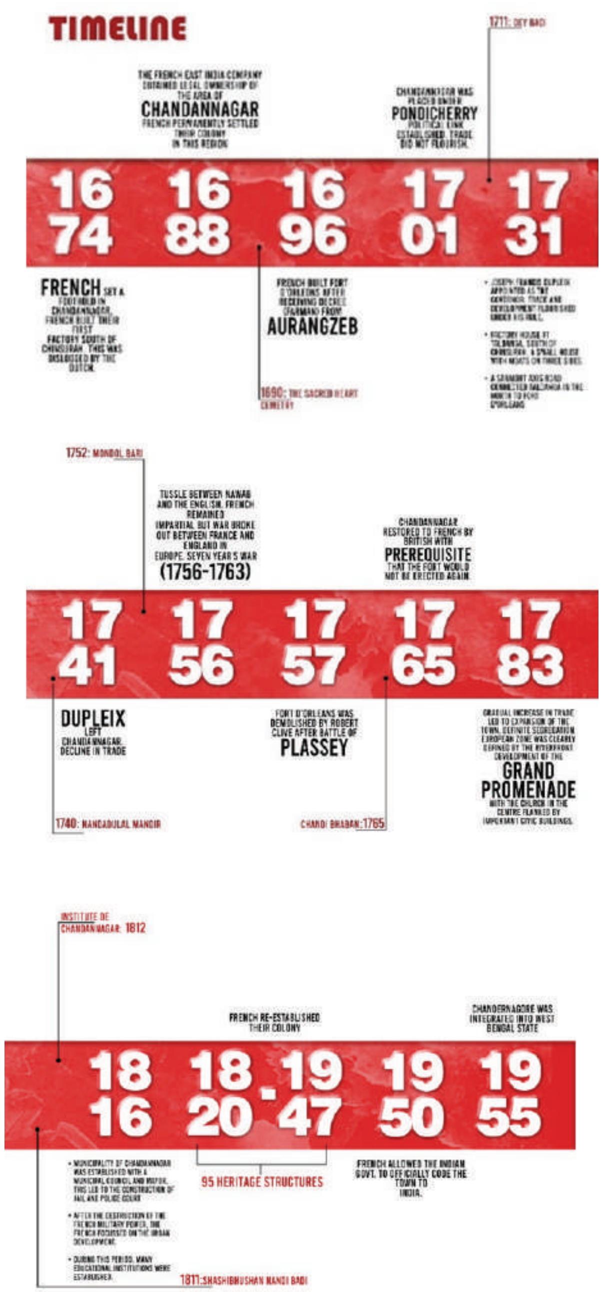


Fig.11 *Timeline showing the historical events overlapped with the year of construction of heritage structures.*
Source: Author

4. Influence of French Colonial Rule on Urban Development

Chandannagar derives its name from the crescent-shaped bend of the Hooghly River, with chand meaning moon and nagore meaning city in Bengali (Saha, 2016). The town was established by the French across three pre-existing rural settlements—Borkishonpur, Khalisani, and Gondalpara—whose agrarian character was gradually transformed under colonial administration (Banerjee, A Tale of Two Cities Under Colonial Rule: Chandernagore and Calcutta, p. 2012).

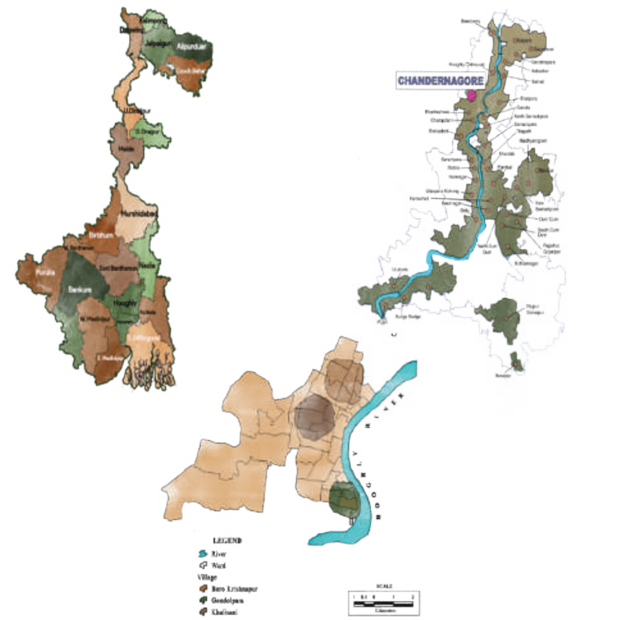


Fig.12 *Diagrammatic representation of the location and establishment of the town of Chandannagar.*
Source: Author

Originally a temple-centred settlement, Chandannagar began to urbanize during the Muslim period, but it was French colonial intervention that consolidated it into a distinct urban entity (Subhendu Ghosh, 2018). French colonization was primarily oriented toward administrative control and mercantile activity, resulting in the construction of civic and commercial institutions such as post offices, banks, and administrative buildings. These colonial spatial and socio-cultural formations differed significantly from the indigenous villages that preceded them (Sen S., 2010).

As a consequence, colonial settlements often developed as dual systems: a newly imposed European urban order coexisting alongside older indigenous patterns, with limited architectural and social integration but considerable physical proximity (Abu-Lughod, 1965). Chandannagar exhibits many of the defining characteristics of colonial towns, including functional zoning, geometric planning principles, racial and social segregation, the establishment of specialized administrative districts, and the development of extensive road networks (Osmani, 2004). The town's broad avenues, detached residential bungalows with front lawns and rear gardens, and tree-lined streets—featuring species such as mahogany and rain trees—testify to this colonial planning logic and contributed to the formation of distinctive residential neighbourhoods.

French administrators also expressed an interest in the integrated development of surrounding villages. Initially, traders gradually assumed administrative control, adopting what has been described as a relatively empathetic approach toward local communities. Their occupation of the Hooghly riverbank in 1673 marked the beginning of Chandannagar's architectural transformation. Legal ownership of the region was secured by the French East India Company, which established a permanent colony in 1688 (Anubrata Mondal, 2018).

Although Calcutta expanded at a much faster rate, Chandannagar developed a distinctive identity. Eighteenth-century accounts describe it as a visually refined settlement, containing several well-built houses and a church, and serving as a preferred retreat for European elites. Over time, however, French interest in retaining Indian settlements waned. In 1824, a treaty signed in London between the British government and the Netherlands resulted in Dutch settlements being ceded to England, after which Chandannagar came under European control from 1825.

Even after the abrupt end of Dutch authority, many Dutch residents remained in Chandannagar. Under British control, however, the town lost much of its former grandeur, becoming primarily a military depot. The former Dutch quarter fell into decline, characterized by abandonment and ruin (Fenton, 1901).

5. Conclusion

This study has traced the historical and spatial evolution of Chandannagar to demonstrate how colonial governance, mercantile networks, and shifting political circumstances shaped its distinctive urban form. From its origins as a rural, temple-centred settlement to its transformation into a French colonial trading town and later a centre of political resistance, Chandannagar emerged through layered processes of adaptation, negotiation, and contestation. Rather than representing a simple narrative of colonial imposition, its urban morphology reflects a complex interplay between European planning ideals and pre-existing indigenous spatial practices.

The paper has shown that French colonial intervention introduced new typologies of governance, commerce, and residence, visible in the town's administrative districts, street networks, and bungalow-based neighbourhoods. At the same time, older settlement patterns persisted, creating a dual urban structure in which colonial and indigenous systems coexisted with limited integration but close physical proximity. This hybridity challenges binary interpretations of colonial cities as either imposed or organic, instead revealing Chandannagar as a product of continuous spatial negotiation.

By employing a chronological framework supported by cartographic analysis and oral narratives, this research underscores the importance of visual and lived histories in understanding urban transformation. The maps used in this study function not merely as illustrative tools but as analytical devices that reveal shifts in land use, circulation, and architectural distribution over time. Such an approach allows for a more nuanced reading of colonial towns as dynamic landscapes rather than static historical artefacts.

Ultimately, Chandannagar's significance lies in its ability to embody the entanglements of colonial ambition, local agency, and political resistance within a single urban fabric. Its layered spatial character offers valuable insights into broader debates on colonial urbanism, cultural exchange, and the long-term legacies of European settlements in South Asia. Recognizing these complexities is crucial not only for historical scholarship but also for contemporary heritage discourse, where issues of preservation, identity, and representation remain deeply intertwined.

6. References

Abu-Lughod, J. (1965, July). Tale of Two Cities: the Origins of Modern Cairo. Comparative Studies in Society and History , Volume 7 , Issue 4, 429 - 457.

Anubrata Mondal, D. K. (2018). A study on the Energy Efficient Interior Lighting System of a Heritage Building. International Journal of Engineering and Technology Science and Researc, Volume 5, Issue 1, 1071-1082.

Banerjee, S. (n.d.). A Tale of Two Cities Under Colonial Rule: Chandernagore and Calcutta. Retrieved July 27, 2019, from www.iicdelhi.nic.in: http://www.iicdelhi.nic.in/ContentAttachments/Publications/DiaryFiles/283210August292012_IIC%20Occasional%20Publication%2039.pdf

Fenton, E. (1901). The Journal of Mrs. Fenton, 1826-1830.

INTACH. (1988). Evolution of the Euro- Indian Urbanism on the West Bank of the Ganga in Bengal: Consequences on Physical Form, Issues in Conservation. INTACH-GREHA.

Ivermee, R. (2017). Association of Asian Studies. Retrieved August 5, 2020, www.asianstudies.org:https://www.asianstudies.org/publications/eaa/archives/the-hooghly-river-a-sacred-and-secular-waterway/

Ivermee, R. (2020). Hooghly: The Global History of a River. Oxford University Press.

Mukherjee, R. (n.d.). Life and Trade in the Indian Ocean World from Eighteenth Century Chandernagor. Senshu University Institute of Humanities Monthly Bulletin, 1-9.

Osmani, K. H. (2004). The spatial development and urban transformation of colonial and postcolonial Algiers. In Y. Elsheshtawy, Planning Middle Eastern Cities: An Urban Kaleidoscope (pp. 29-55). London.

Rahman,M. (2025), Tracing the European Architectural Footprints and Transformations on the French Town of Chandannagar, West Bengal. PhD Thesis.
http://hdl.handle.net/10603/663073

Ray, A. (n.d.). French Views on Mughal State: Mid 17th to Early 18th centuary.

Samanta, A. (1995). Terrorism in Bengal: A Collection of Documents on Terrorist Activities from 1905 to 1939, Volume 1. West Bengal: Government of West Bengal.

Sen, S. (2010). Between Dominance, Dependence, Negotiation, and Compromise: European Architecture and Urban Planning Practices in Colonial India. Journal of Planning History, Vol9, Issue 4, 203-231.

Sen, S. N. (2012). Chandanagore, From Bondange to freedom. Prime Books.

The French in India, 1768-1816. (n.d.). Pondicherry Archives.

The French in India, 1768-1816. (n.d.). Ministiere des Colonies, p. 82.

Understanding Vertical Greenery Systems and Their Applications in Architecture

Irfan Haider Khan
Department of Architecture, Jamia Millia Islamia, New Delhi, Central Public Works Department,
Ministry of Housing and Urban Affairs, Govt. of India,
irfan.haider@gov.in

***Abstract* - Vertical greenery systems refer to architectural interventions in which vegetation is integrated onto vertical surfaces of buildings and urban structures. In response to increasing urban density, limited ground-level green space, and rising environmental pressures, such systems have gained attention as a means of incorporating nature into the built environment. This paper presents a structured overview of vertical greenery systems, clarifying their conceptual basis, historical evolution, and principal typologies, including green facades and living walls. It examines how these systems are applied in architecture at multiple scales, ranging from building envelopes and interior spaces to dense urban contexts. Drawing on peer-reviewed literature and representative built examples, the paper discusses the environmental, spatial, and experiential roles of vertical greenery systems, while also acknowledging practical considerations related to cost, technical integration, and maintenance. By synthesizing current knowledge, the study aims to provide a clear and accessible reference for understanding vertical greenery systems as architectural strategies rather than purely aesthetic features.**

***Index Terms* -** *vertical greenery systems, green façades, living walls, sustainable architecture, building envelopes, urban greening.*

1. INTRODUCTION

Buildings consume vast amounts of energy for cooling and intensify urban heat islands (UHIs) through bare, sun-exposed surfaces, particularly in rapidly urbanizing cities with warm or composite climates (IPCC, 2023). While active design strategies like high-efficiency HVAC systems, renewable energy integration such as solar panels, and smart building automation have gained increasing traction to mitigate climate change impacts, research underscores the vital role of nature-based solutions, green infrastructure, and passive design strategies in accelerating decarbonisation and resilience efforts (Maghami, Maghoul, Thang, & Sundaram, 2025). With increasing densities and reduced green open spaces at ground level, the focus has now shifted to exploring the potential of greening building surfaces and integrating nature within the buildings. Vertical greenery systems (VGS), defined as any vertical surface in the built environment either partially or completely covered with vegetation, offer a direct intervention by converting heat-absorbing walls into shaded, evaporatively cooling surfaces that improve thermal comfort and energy efficiency.

Fig.1. Historical progression of vertical greenery systems. (a) Spontaneous growth of mosses and lichens on masonry walls at Reis Magos Fort, Goa, India (Image: Author); (b) Ivy covering the Front Quad of Lincoln College, Oxford, where climbing plants have been recorded since the 1860s (Image credit: Rémi Mathis, Wikimedia Commons, licensed under CCBY-SA 3.0); (c) Stanley Hart White's 1938 "botanical bricks" patent drawings (US Patent No.2,113,523, public domain); (d) Living walls designed by Patrick Blanc inside the Changi International Airport, Singapore (Image: Author).

The concept of vertical greenery on buildings has existed for more than a century as is evident from historical examples such as Hanging Gardens of Babylon, however structured research on VGS has only emerged in recent decades. Although often presented as a contemporary feature of sustainable or high-tech architecture, the basic idea of using plants on facades has older roots in everyday practice and early technical experiments. Earlier examples include ivy-covered walls and courtyard buildings in the UK where climbing plants were used informally to provide shade, soften hard surfaces, and improve comfort, even if these effects were not measured scientifically (Fig. 1(b)). The first clear step toward modern VGS came with Stanley Hart White's 1938 patent for modular "botanical bricks" (Fig. 1(c)), which introduced the concept of an engineered, vegetation-bearing wall system, and was later advanced by Patrick Blanc's murvégétal (hydroponic living walls) from the late 1980s, which made large, continuous planted facades technically and visually feasible at an architectural scale (Fig. 1(d)).

The literature indicates that VGS offer a broad range of benefits, ranging from biodiversity conservation and acoustic dampening to building envelope longevity and improved air quality (Ghazalli, Brack, Bai, & Said, 2019). Although aesthetics remains the primary driving factor for VGS, recent research explores their application as a measure to address UHI and climate change related challenges in high density cities. Recent bibliometric analyses indicate a surge in research focusing on the engineering and environmental benefits of VGS, yet a rigorous distinction between system typologies and a critical assessment of their life-cycle costs remains essential for widespread adoption.

1.1. VERTICAL GREENERY SYSTEMS: NOMENCLATURE AND TYPOLOGIES

Unlike green roofs, the classification of which is mostly standard (intensive and extensive green roofs), the terminology used to describe VGS is highly varied, with terms such as "green facades", "living walls", "vertical gardens", "vegetated walls", and "vegetated mats" often used interchangeably, despite important technical distinctions. Terminologies used by VGS suppliers for their patented systems present further complications (Radić, Dodig, & Auer, 2019). This inconsistency in nomenclature complicates comparative evaluations and knowledge synthesis. To address this issue, Khan & Munawer (2024a) proposed a clear typological distinction between green facades and living walls (Fig. 2).

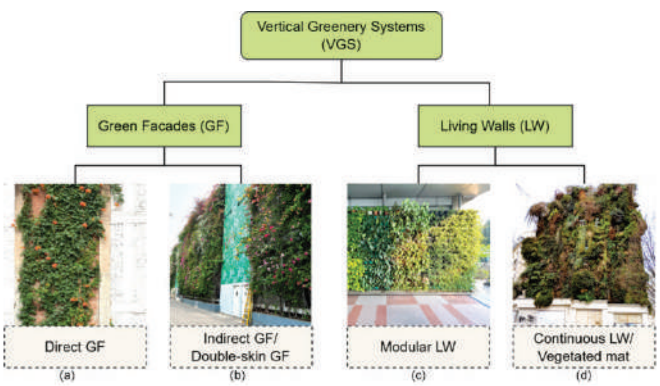


Fig.2. *Proposed classification of vertical greenery systems. Adapted from Khan & Munawer (2024a).*

Green facades are typically characterized by climbing plants that either attach directly to the building surface (direct green facades) (Fig. 2(a)) or grow on supportive structures, such as trellises, wire meshes, or frames (indirect green facades) (Fig. 2(b)). These systems are generally straightforward and are often selected for their affordability and minimal maintenance requirements. In contrast, living walls are more sophisticated, comprising pre-planted modules (modular living walls) (Fig. 2(c)) or hydroponic systems, which are often equipped with advanced irrigation and drainage systems (continuous living walls) (Fig. 2(d)). These setups are designed to provide greater flexibility in plant selection and to improve environmental performance. Therefore, the appropriate selection of typologies and their components have a direct impact on VGS performance.

The term 'vertical greenery system' has been used in this paper as an umbrella term that covers all types of facade-greening systems. The subsequent discussions in this article refer to this nomenclature, moving beyond simple aesthetics to evaluate the functional performance of these systems.

2. BENEFITS OF VERTICAL GREENERY SYSTEMS

The integration of VGS into the built environment provides a multi-dimensional array of benefits that address ecological, social, and economic imperatives (Fig. 3).

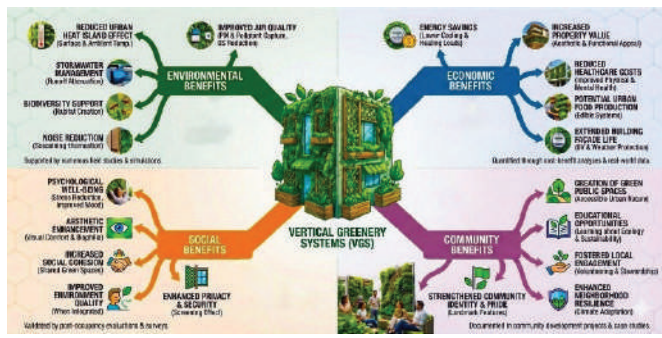


Fig.3. *A conceptual framework illustrating the benefits of Vertical Greenery Systems (VGS), encompassing environmental, economic, and social-community well-being impacts. Sources: Ghazalli et al. (2019); Gunn et al. (2022); Khan & Munawer (2025); Wang et al. (2022).*

2.1 ENVIRONMENTAL BENEFITS

VGS acts as a high-performance "second skin" for buildings. The most significant environmental contribution is the mitigation of the UHI effect. Through evapotranspiration and shading, VGS can reduce exterior wall surface temperatures by as much as 12°C to 20°C in warm climates, subsequently lowering ambient air temperatures (Khan & Munawer, 2024a; Su et al., 2024). Furthermore, VGS serves as a bio-filter; the foliage traps particulate matter (PM10 and PM2.5) and absorbs gaseous pollutants such as CO2 and NOx, significantly improving localized air quality (Ysebaert, Koch, Samson, & Denys, 2021). From a hydrological perspective, modular living walls contribute to stormwater management by attenuating runoff through substrate absorption, reducing peak flow by up to 60-90% for small-scale rain events (Masi et al., 2016; Moravej, Swinbourne, Hall, & Kenway, 2025).

2.2 ECONOMIC AND ENERGY PERFORMANCE

The thermal buffer provided by VGS translates directly into energy savings. By reducing the cooling load in summer and providing an extra layer of insulation in winter, VGS can reduce building energy consumption by 5% to 30%, depending on the system typology and climate (Su et al., 2024). Additionally, VGS protects the building envelope from UV radiation and thermal expansion/contraction cycles, potentially doubling the lifespan of the facade materials. In the real estate market, "biophilic" buildings often command higher property values and faster lease-up rates due to their aesthetic appeal and perceived wellness benefits (Jayakody, Weerasinghe, Jayasinghe, &Halwatura, 2023; Khan & Munawer, 2024b; Teotónio, Silva, & Cruz, 2021).

2.3 SOCIAL AND PSYCHOLOGICAL BENEFITS

The human-centric benefits of VGS are rooted in the Biophilia Hypothesis. Studies have consistently shown that visibility of greenery in dense urban settings reduces cortisol levels, lowers blood pressure, and improves cognitive performance (Xing et al., 2025). In workplace environments, VGS can lead to increased productivity and reduced absenteeism (Elsadek, Liu, & Lian, 2019; Hollands &Korjenic, 2021; Ling & Chiang, 2018). Furthermore, VGS provides acoustic dampening; the substrate and foliage combined can reduce noise reflection by up to 10 dB, creating quieter, more liveable urban pockets (Oquendo-Di Cosola, Olivieri, & Ruiz-García, 2022).

3. BARRIERS TO WIDESPREAD IMPLEMENTATION

Despite the documented advantages, VGS adoption faces several critical challenges that vary across geographic and economic contexts (Fig. 4).

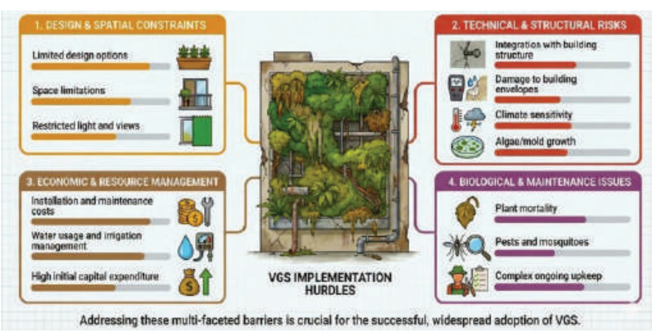


Fig.4. *A systematic classification of the multi-faceted barriers to Vertical Greenery System (VGS) implementation, highlighting the structural, economic, and biological hurdles that impact widespread urban adoption. Sources: Conejos et al. (2019); Khan & Munawer (2024a, 2025); Olusoga&Adegun (2022).*

3.1 HIGH INITIAL AND MAINTENANCE COSTS

The capital expenditure for VGS, particularly continuous and modular living wall systems, and remains high compared to traditional facade treatments. Beyond installation, the "life-cycle cost" is a major deterrent. VGS requires specialized maintenance, including regular pruning, nutrient monitoring, and irrigation system checks. Unlike green facades, which are relatively self-sustaining, high-tech living walls can fail rapidly if the automated irrigation system malfunctions (Khan & Munawer, 2024b).

3.2 TECHNICAL AND STRUCTURAL CONSTRAINTS

The weight of the growing medium and the water-saturated plants adds significant dead load to the building structure (often exceeding 50–100 kg/m² for modular systems). Issues of moisture penetration and root damage to the primary building skin are frequent concerns for stakeholders (Khan & Munawer, 2025). Furthermore, plant selection is a complex technical challenge; species must be resilient to high wind loads and varying solar exposure on different building orientations (Conejos et al., 2019).

3.3 POLICY AND PERCEPTUAL BARRIERS

Many municipal building codes and fire safety regulations lack specific frameworks for VGS. Concerns regarding the flammability of dried vegetation or plastic modules can delay approvals. Additionally, there is a "knowledge gap" among developers and facility managers who may perceive VGS as a high-risk aesthetic luxury rather than a functional infrastructure(Hui, Jim, & Tian, 2022; Tsantopoulos, Varras, Chiotelli, Fotia, &Batou, 2018).

Despite the structural, economic, and regulatory challenges outlined above, evidence from realised projects suggests that these barriers are not uniform and are strongly shaped by system typology, climatic context, and design intent. In practice, several built examples demonstrate that costs, technical risks, and maintenance demands can be mitigated through context-specific design choices, appropriate plant selection, and early integration of vertical greenery into the architectural and service strategies. To move from generalized constraints to applied understanding, the following case studies examine how different VGS typologies have been implemented across varied climates and building types, highlighting both their performance outcomes and the trade-offs involved.

4. CASE STUDIES AND PERFORMANCE ANALYSIS

To validate the theoretical benefits, the following case studies examine the application of vertical greenery systems across different climates, building types, and system configurations. They are used to illustrate how design choices and contextual conditions shape performance, feasibility, and operational outcomes in practice.

4.1 CAIXAFORUM, MADRID

The CaixaForum Madrid, designed by Herzog & de Meuron with a vertical garden by Patrick Blanc, is a seminal example of a continuous hydroponic living wall (murvégétal) applied in a dense urban retrofit. Completed in 2007–2008, the intervention transformed a former electrical power station into a cultural centre, with the vegetated wall functioning as both a visual buffer and a microclimatic modifier for the adjacent public plaza along the Paseo del Prado.

The living wall covers approximately 460 m² and accommodates 15,000–17,000 plants. It is attached to a blank wall of an adjacent building, rather than the museum envelope, allowing extensive greening without structural intervention to the heritage fabric. The system employs Blanc's hydroponic assembly comprising a steel subframe, a waterproof PVC layer, dual layers of inert polyamide felt, and a dense planting layer. An air cavity between the wall and the masonry provides moisture protection and contributes to thermal and acoustic buffering (WGIN, 2021). Madrid's Mediterranean climate, marked by extreme summer heat and winter frost, necessitated a highly resilient planting palette. Approximately 250–300 species are used, prioritising high leaf area index (LAI) and stress tolerance. Planting follows a vertical zonation aligned with microclimatic gradients, with shade-tolerant species at lower levels and sun- and wind-resistant taxa at upper zones.

Fig.5. *CaixaForum Madrid. Continuous hydroponic living wall applied as an urban vertical greenery system adjacent to a cultural building. Image credits: Wikimedia Commons, licensed under Creative Commons (CC BY-SA).*

Monitoring of comparable living wall systems in Madrid indicates external surface temperature reductions of approximately 8–15.5 °C during peak summer conditions, driven by combined shading, evapotranspiration, and air-cavity buffering (de Jesus, Lourenço, Arce, & Macias, 2017). Simulation studies for similar contexts suggest cooling energy demand reductions of roughly 33–50%, although building-specific energy data remain unavailable. Acoustic studies further report improved sound absorption in dense urban settings (Oquendo-Di Cosola et al., 2022).

Despite its performance, the system is technologically intensive. The absence of soil storage makes it highly dependent on uninterrupted irrigation and precise nutrient dosing, while ongoing horticultural management is required to control species dominance and maintain long-term visual and ecological performance.

4.2 ONE CENTRAL PARK, SYDNEY

One Central Park (OCP), completed in 2013–2014 and designed by Ateliers Jean Nouvel with PTW Architects and Patrick Blanc, represents a large-scale integration of vertical greenery within a high-rise residential development. Unlike applied or retrofitted systems, greenery at OCP forms a core component of the building's environmental and architectural strategy.

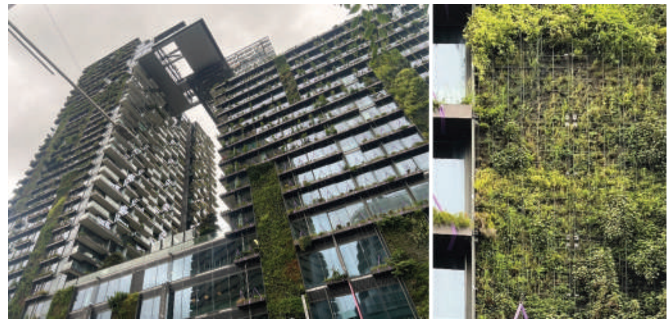


Fig.6. *One Central Park, Sydney. Hybrid vertical greenery system combining hydroponic living walls and balcony-based green facades integrated into a high-rise residential complex.*
Image source: Author.

The project incorporates approximately 1,200 m² of hydroponic living walls alongside nearly 5 km of linear slab-edge planters, creating a hybrid system combining living walls with soil-based green facades. A distinctive heliostat system redirects sunlight into shaded zones, ensuring adequate photosynthetically active radiation for vegetation within a dense urban canyon (Nouvel & Beissel, 2014).

Plant selection includes approximately 350 species, of which 250 are native Australian taxa, chosen for wind tolerance and drought resistance in response to high-altitude exposure. Balcony planters support trailing and climbing species trained on stainless-steel cables, forming a dynamic vegetated veil.

A key innovation is the on-site blackwater recycling system, which treats wastewater for irrigation, creating a closed-loop water cycle and reducing reliance on potable water. The vegetated facade system functions as a dynamic shading device, with studies estimating cooling load reductions of up to 20% through solar interception (CRC for Water Sensitive Cities, 2019). The "green veil" of the balcony planters functions as a dynamic shading device. Unlike fixed metal louvers, the plants grow and change density. Research estimates this foliage reduces the cooling energy load by up to 20% by intercepting direct solar radiation before it hits the high-performance glazing (Nouvel & Beissel, 2014).

Economically, the integration of greenery contributed to rapid apartment sales, premium pricing, and a 5-Star Green Star rating, demonstrating that high-density residential development and extensive vertical greenery can coexist when integrated at the design stage (CRC for Water Sensitive Cities, 2019; Nouvel & Beissel, 2014).

4.3 MFO PARK, ZURICH

MFO Park (Maschinenfabrik Oerlikon) in Zurich exemplifies a pure green facade typology, distinct from building-attached living walls. Rather than enclosing space, the project defines a three-dimensional green volume through a steel framework colonised entirely by climbers rooted in the ground.

Fig.7. MFO Park, Zurich. Soil-based green facade formed by climbers on a steel trellis structure. Image credits: Wikimedia Commons, licensed under Creative Commons (CC BY-SA).

Located in Neu Oerlikon, a redeveloped industrial district, MFO Park mimics the volume of the former factory halls that stood there. The structure consists of a double-walled steel trellis framework, open to the sky. Circulation elements are embedded within the interstitial zone between mesh layers, allowing users to inhabit the thickness of the green facade itself. Climbing plants, including vines, wisteria, and clematis, progressively colonise the structure without reliance on hydroponics or artificial substrates, demonstrating the long-term spatial potential of soil-based systems (Hoory, 2017).

In summer, deciduous climbers form a dense canopy that provides shading and cooling through evapotranspiration. Studies of comparable ventilated green facades indicate air temperature reductions of up to 8 °C within shaded cavities relative to exposed conditions. In winter, leaf drop allows solar penetration, enabling passive seasonal adaptation (Lin, Chokhachian, Musso, & Xiao, 2022).

Beyond microclimatic moderation, MFO Park functions as a social condenser, accommodating performances, recreation, and everyday urban use. The project illustrates how green facades can generate inhabitable outdoor rooms, extending VGS application beyond envelope modification to urban spatial production.

4.4 OASIA HOTEL DOWNTOWN, SINGAPORE

The Oasia Hotel Downtown, designed by WOHA, represents a prototype for tropical high-density urbanism, rejecting the sealed glass tower in favour of a porous, vegetated building form adapted to hot-humid climates.

The tower is wrapped in a red aluminium mesh that acts as a trellis for 21 species of creepers, creating a continuous "vegetated cloak". The building achieves a Green Plot Ratio of approximately 1,100%, effectively compensating for the limited ground-level greenery in Singapore's central business district (Goh, 2022). Large, open-sided sky gardens and breezeways are distributed vertically, enabling cross-ventilation and reducing reliance on mechanical cooling in common areas.

Thermographic assessments cited by the project team indicate that the vegetated facade can be up to 25 °C cooler than adjacent glass curtain wall surfaces under peak solar exposure (Wong, Hassell, & Phua, 2018).

Fig.8. Oasia Hotel Downtown, Singapore (WOHA Architects). A climber-based vertical greenery system envelops the tower, functioning as a vegetated shading skin adapted to a high-density, hot-humid urban context. Image credits: Wikimedia Commons, licensed under Creative Commons (CC BY-SA).

The mesh-and-vegetation system functions as a second skin, shading the primary envelope and reducing solar heat gain to air-conditioned spaces. Unlike highly manicured living walls, the facade is designed to evolve over time, with species competition producing a heterogeneous and adaptive vegetated surface.

5. CONCLUSION

Vertical greenery systems (VGS) encompass a range of configurations, from climber-based green facades to modular and hydroponic living walls, each offering distinct mechanisms for environmental interaction and spatial expression. Within architecture, VGS serve as envelope modifiers that can influence surface microclimates, as spatial devices that enrich occupant experience, and as urban greening strategies that respond to density and land constraints. The literature underscores that the realized benefits of VGS are contingent on system typology, climatic context, and integration with architectural and structural design, rather than arising automatically from the presence of vegetation alone. By synthesising typological clarification, documented applications, and peer-reviewed evidence, this study positions vertical greenery as a purposeful design strategy that extends beyond aesthetics to engage environmental performance and spatial quality. Continued empirical investigation and context-sensitive design practice will further refine understanding of how VGS contribute to sustainable and human-centred architecture.

6. REFERENCES

Conejos, S., Chew, M. Y. L., &Azril, F. H. Bin. (2019). Green maintainability assessment of high-rise vertical greenery systems. Facilities, 37(13–14), 1008–1047.

CRC for Water Sensitive Cities.(2019). One Central Park Green Walls. Sydney, NSW.

Elsadek, M., Liu, B., &Lian, Z. (2019). Green façades: Their contribution to stress recovery and well-being in high-density cities. Urban Forestry and Urban Greening, 46.

Ghazalli, A. J., Brack, C., Bai, X., & Said, I. (2019). Physical and Non-Physical Benefits of Vertical Greenery Systems: A Review. Journal of Urban Technology, 26(4), 53–78.

Goh, A. (2022, June 9). Inside Singapore's famous "living tower," a 620-foot hotel that's covered in red mesh and is being intentionally overrun with greenery.Business Insider. Retrieved January 9, 2026, from https://www.businessinsider.com/oasia-hotel-downtown-singapore-green-living-tower-2022-6

Gunawardena, K. (2021, July). Vertical greening in urban built environments.Peterhouse, University of Cambridge.

Gunn, C., Vahdati, M., &Shahrestani, M. (2022). Green walls in schools - The potential well-being benefits. Building and Environment, 224.

Hollands, J., &Korjenic, A. (2021). Indirect economic effects of vertical indoor green in the context of reduced sick leave in offices. Sustainability (Switzerland), 13(4), 1–19.

Hoory, L. (2017, January 5). MFO-Park in Zurich Is Changing the Paradigm of Public Greenspace. Garden Collage Magazine. Retrieved January 9, 2026, from https://gardencollage.com/change/sustainability/mfo-park-zurich-changing-paradigm-public-greenspace/

Hui, L. C., Jim, C. Y., &Tian, Y. (2022). Public views on green roofs and green walls in two major Asian cities and implications for promotion policy. Urban Forestry and Urban Greening, 70.

IPCC. (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. (Core Writing Team, H. Lee, & J. Romero, Eds.). Geneva, Switzerland: IPCC. Retrieved from https://www.ipcc.ch/report/ar6/syr/

Jayakody, G. D. C., Weerasinghe, K. G. N. H., Jayasinghe, G. Y., &Halwatura, R. U. (2023). Economical sustainability of vertical greeneries in tropical climate.Energy and Buildings, 299.

de Jesus, M. P., Lourenço, J. M., Arce, R. M., & Macias, M. (2017, July 1). Green façades and in situ measurements of outdoor building thermal behaviour.Building and Environment.

Khan, I. H., &Munawer, T. (2024a). Vertical Greenery Systems: A Review of Thermal Performance. Transactions of the Indian National Academy of Engineering, 9(1), 25–44.

Khan, I. H., &Munawer, T. (2024b).A Systematic Review of Economic Sustainability of Vertical Greenery Systems for Buildings. Construction Economics and Building, 24(1/2), 119–143.

Khan, I. H., &Munawer, T. (2025). Benefits and barriers of vertical greenery systems in Delhi: Evaluating design professionals' perceptions. Discover Environment, 3(1).

Lin, H., Chokhachian, A., Musso, F., & Xiao, Y. (2022). Effects of the Green Façade on Thermal Comfort in the Transitional Spaces: Field Measurements in Munich, Germany. Conference Proceedings of 5th International Conference on Countermeasures to Urban Heat Islands (IC2UHI) 2019 (pp. 550–559).

Ling, T. Y., & Chiang, Y. C. (2018). Well-being, health and urban coherence-advancing vertical greening approach toward resilience: A design practice consideration. Journal of Cleaner Production, 182, 187–197.

Maghami, M. R., Maghoul, A., Thang, K. F., &Sundaram, S. (2025). Net zero energy buildings: An overview of passive and active designs. Energy Reports, 14, 1327–1348.

Masi, F., Bresciani, R., Rizzo, A., Edathoot, A., Patwardhan, N., Panse, D., &Langergraber, G. (2016). Green walls for greywater treatment and recycling in dense urban areas: a case-study in Pune. Journal of Water, Sanitation and Hygiene for Development, 6(2), 342–347.

Moravej, M., Swinbourne, C., Hall, R., &Kenway, S. (2025). Vertical green systems (VGSs) and on-site storage for stormwater management.Water Research, 281.

Nouvel, J., & Beissel, B. (2014). Case Study: One Central Park, Sydney. CTBUH Journal, (IV), 12–18.

Olusoga, O., &Adegun, O. (2022). Professionals' perception studies of vertical greening systems in Lagos, Nigeria. International Journal of Building Pathology and Adaptation.

Oquendo-Di Cosola, V., Olivieri, F., & Ruiz-García, L. (2022, July 1). A systematic review of the impact of green walls on urban comfort: temperature reduction and noise attenuation. Renewable and Sustainable Energy Reviews.

Radić, M., Dodig, M. B., & Auer, T. (2019).Green facades and living walls-A review establishing the classification of construction types and mapping the benefits.Sustainability (Switzerland), 11(17).

Su, M., Jie, P., Li, P., Yang, F., Huang, Z., & Shi, X. (2024). A review on the mechanisms behind thermal effect of building vertical greenery systems (VGS): methodology, performance and impact factors. Energy and Buildings, 303, 113785.

Teotónio, I., Silva, C. M., & Cruz, C. O. (2021). Economics of green roofs and green walls: A literature review. Sustainable Cities and Society, 69, 102781.

Tsantopoulos, G., Varras, G., Chiotelli, E., Fotia, K., &Batou, M. (2018). Public perceptions and attitudes toward green infrastructure on buildings: The case of the metropolitan area of Athens, Greece. Urban Forestry and Urban Greening, 34, 181–195.

Wang, P., Wong, Y. H., Tan, C. Y., Li, S., & Chong, W. T. (2022). Vertical Greening Systems: Technological Benefits, Progresses and Prospects. Sustainability, 14(20), 12997.

WGIN. (2021, March 4). Caixa Forum Museum vertical garden. World Green Infrastructure Network (WGIN). Retrieved January 9, 2026, from https://worldgreeninfrastructurenetwork.org/caixa-forum-museum-vertical-garden/

Wong, M. S., Hassell, R., &Phua, H. W. (2018).A Tall Prototype for the Tropics Oasia Hotel Downtown, Singapore. CTBUH Journal, (III), 12–19.

Xing, Y., Stevenson, N., Thomas, C., Hardy, A., Knight, A., Heym, N., & Sumich, A. (2025). Exploring biophilic building designs to promote wellbeing and stimulate inspiration. PLOS One, 20(3), e0317372.

Ysebaert, T., Koch, K., Samson, R., & Denys, S. (2021, April 1). Green walls for mitigating urban particulate matter pollution—A review.Urban Forestry and Urban Greening.

Innovative Design Strategies for Photovoltaic Facade Implementation in India

Dr. Mariam Ahmad,
Assistant Professor, D/O Architecture, Jamia Millia Islamia, New Delhi-110025
mahmad7@jmi.ac.in

***Abstract* - The article titled "Innovative Design Strategies for Photovoltaic Facade Implementation in India" addresses the critical barriers hindering the widespread adoption of photovoltaic facades despite their multiple benefits and alignment with sustainability goals and energy efficiency. The study aims to comprehensively identify these challenges, which encompass technical, economic, regulatory, and social factors specific to the Indian context. Building on this analysis, the paper proposes innovative design strategies tailored to overcome these obstacles, facilitating effective integration of photovoltaic facades into buildings. By focusing on context-sensitive solutions, the paper advances pathways for enhancing renewable energy uptake in India's built environment, supporting national sustainability and energy efficiency objectives. This work contributes to the discourse on sustainable architecture by offering practical recommendations for optimizing photovoltaic facade implementation within India's unique environmental and socio-economic landscape.**

***Index Terms* -** *Photovoltaic Facade, Thin Film, Energy Efficient, Sustainable.*

1. INTRODUCTION

The global energy crisis exacerbated by rapidly rising demand in India—driven in large part by the construction industry—highlights the urgent need for renewable energy systems (RES). Traditionally, energy requirements have relied heavily on non-renewable sources such as coal and natural gas, risking the depletion of these resources within the next century. To maintain ecological balance, alternative energy solutions are crucial. India's geographic advantage of high solar insulation presents significant potential for photovoltaic (PV) technologies. Although PV systems have been applied as add-ons (e.g., on roofs and sunshades), their widespread adoption in construction remains limited due to increased costs and lack of integration into building design.

Architectural integration, or 'Architectural Inerrability', involves embedding PV panels into the building envelope itself, replacing conventional materials and ensuring the façade meets both energy generation and building performance requirements (thermal comfort, structural integrity, aesthetics, etc.). The challenge lies in balancing these dual functions without compromising either. The research proposes a design framework for PV façades that facilitates this integration, particularly in high-rise urban environments where roof and ground space are constrained. By utilizing the large uninterrupted surface area of façades, buildings can efficiently generate energy while maintaining their primary envelope functions. The study aims to identify barriers to such adoption, assess the feasibility of façade-integrated PV (FiPV), and evaluate the impact of such frameworks on technology uptake in the construction sector.

The resolution of conflict between the optimum functioning of the photovoltaic system as energy generator and functioning as the skin of the building is only possiblethrough architectural integration. Architectural integration can be stated as the process of incorporating the photovoltaic panels, modules, glasses, tiles as the skin of the building.Implying, the primary function of the photovoltaic system is not only energy generation, but at the same time fulfilling all the prerequisites of a building envelope. Architectural integration can be achieved, by following a systematic process, which identifies, and defines strategies for the proper integration of photovoltaic system within the building, primarilyfocusing on building façade. The paper focuses on generating a systematic process of achievingarchitectural inerrability of the photovoltaic system in the building facade.

According to (Ahmad & Zia, (2022, January).)Achieving a balance between the photovoltaic system's efficiency as an energy generator and its role as the building's exterior can be accomplished through architectural integration. This process involves incorporating photovoltaic elements—such as panels, modules, and glass—directly into the building's envelope. Thus, these elements fulfil both energy generation and essential envelope functions. Architectural integration requires a systematic approach that identifies strategies for seamless incorporation of photovoltaic systems, particularly on façades. This paper aims to establish such a process, focusing on achieving effective integration of photovoltaictechnology within building façades for optimal performance and sustainability. (Ahmad & Zia, (2022, January).)

Designing a photovoltaic façade requires not only technical understanding but also awareness of the challenges in integrating this technology and the concerns of designers. Acceptance of such technology depends on its practical use, learning, and application. It is crucial to identify barriers that hinder adoption, which may arise from the product, the system, or the design process, as well as stakeholder apprehensions. Ahmad & Zia (2022) categorized these barriers into three types: product and system-related, design process-related, and those impacting stakeholders. Table 1 summarizes these barrier categories identified in their research. (Ahmad & Zia, Design Strategies for Façade integrated Photovoltaic Technology (FiPV)., 2022)

TABLE 2:

Categorisation of barriers. Source:(Ahmad & Zia, 2022)

CATEGORY I (Barriers in the Photovoltaic product)	CATEGORY II (Barriers in the photovoltaic façade design)	CATEGORY III (Barriers affecting different stakeholders)
Type of photovoltaic technology (multi/mono-crystalline technology vs thinfilm technology).	lack of knowledge of the architect/façade designer.	Economic non-feasibility.
Reduced efficiency with 90° tilt angle.	Non-availability of codes for integrating photovoltaic system with local bye-laws.	Operating and managing the photovoltaic system.
Non-availability of suitable photovoltaic product	Non-availability of suitable photovoltaic product	Non-availability of suitable photovoltaic product
Photovoltaic façade's visual and optical properties.	Photovoltaic façade's visual and optical properties.	Photovoltaic façade's visual and optical properties.
Non-availability of proper tools for designing photovoltaic façade.	Non-availability of proper tools for designing photovoltaic façade.	Lack of client's interest.
	Structural and mechanical integrity.	
	Lack of skilled workforce.	
	Climatic responsiveness of photovoltaic façade	

2. STRATEGY FOR DESIGNING A PHOTOVOLTAIC FACADE

The development of a design strategy for photovoltaic façades centres on providing solutions to barriers that have a direct impact on their successful integration. The proposed solution aims to transform these barriers into enablers, thereby streamlining the process and minimizing the inherent conflict between the dual roles of photovoltaic façades—as energy generators and as the protective skin of buildings. The primary objective of formulating this design strategy is to eliminate hindrances in the design process, empower architects and designers with a simplified and efficient methodology, and significantly reduce, if not completely resolve, the tension between the photovoltaicsystem's energy-generating function and its function as building envelope. The initial step involves identifying the key barriers to integration, followed by a thorough understanding of the conflict that arises when photovoltaic systems are expected to perform both roles simultaneously. Managing this conflict is crucial for achieving both high efficiency and sustainability in façade design.(Ahmad & Zia, 2022)

A building façade must meet several requirements including facilitating a connection between the interior and exterior, providing adequate day lighting, ensuring thermal comfort, and maintaining structural and mechanical integrity. It is essential that the adoption of photovoltaic technology on façades does not compromise its primary role of energy generation. The apprehension regarding this stems from the typical installation angle of photovoltaic panels—when mounted vertically at a 90° tilt, panel efficiency drops. Moreover, façades often receive diffused rather than direct sunlight, further affecting energy output. Therefore, the design strategy must address these technical challenges to maximize performance.(Ahmad & Zia, 2022).

Architects and façade designers face the complex task of understanding photovoltaic technology and integrating it seamlessly within the building envelope. The overarching goal of the proposed strategy is to simplify this process, reduce technological complexity, and effectively manage the identified conflicts. The process is structured as a streamlined sequence of four key steps, as depicted in Figure 1.(Ahmad & Zia, 2022).

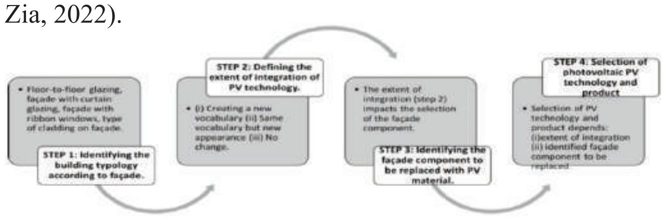


Figure 1. Steps of design strategy

Table 2 describes the process of designing a FiPV as has been described by (Ahmad & Zia, Design Strategies for Façade integrated Photovoltaic Technology (FiPV)., 2022)

TABLE 2:

Design Strategy Of Generating A Photovoltaic Façade

	DESIGN PARAMETERS	DESCRIPTION
STEP - 1	FAÇADE TYPOLOGY OF IDENTIFIED COMMERCIAL BUILDING:	a) Defining the architectural typology. As is described in detail in chapter 3, section 3.1 and 3.2, the prevalent commercial building was categorised into three typologies: ***TYPOLOGY-I:*** Curtain wall system having aluminium composite panel cladding with ribbon windows. ***TYPOLOGY-II***: Floor-to-floor glazing, with a façade of exposed brick work. ***TYPOLOGY III:*** Aluminium composite panel clad facade with floor-to-floor glazing. b) The façade typology would be an important determinant of the possibility of the extent of architectural integration. c) According to the typology of the building the façade component to be replaced would be identified.
STEP - 2	EXTENT OF APPLICATION OF THE PHOTOVOLTAIC PANEL/GLASS ON THE BUILDING FAÇADE:	Defined the extent of transformation of architectural vocabulary (for the new generated variant). Step 1 would be the reference point for identifying the extent of integration possible. This step would determine the architectural vocabulary of the designed building façade.
		Three levels of integration were possible, depending upon intent of designing the façade: **NEW ARCHITECTURAL VOCABULARY**: • The designed building façade would have a different architectural vocabulary, achieved by the application of photovoltaic panels/glass with different granularity (colour and texture). • Integration of the photovoltaic glass/panel would be in different angles, or a combination of solar glass/panel with conventional building material could be used. **NEW APPEARANCE MAINTAINING THE OVERALL VOCABULARY**: • Designed façade would have the same architectural vocabulary. Hence the photovoltaic glass/panel integrated would be having the similar granularity (colour and texture). • Achieved by using a combination of solar glass/panel with façade glass, aluminium composite panel, or exposed brick masonry. **MINIMUM INTERVENTION, SAME VOCABULARY**: • The façade designed would be using photovoltaic panel/glass of same granularity, size, and modularity. • It could be done by replacing the glass of fenestrations with solar glass or replacing the cladding material with solar panels of same granularity.
STEP 3	IDENTIFICATION OF FAÇADE COMPONENT FOR PHOTOVOLTAIC INTEGRATION:	a) Feasible façade components as identified (survey and literature review), would be the components with highest feasibility of achieving architectural integration and allowing photovoltaic panel/glass to efficiently act as an envelope material without compromising its energy generation potential. b) The integrational façade components would be decided based on façade typology: 1. Façade with curtain glazing, would provide an opportunity to design with a translucent/transparent photovoltaic curtain walling. 2. Façade with panelling of aluminium composite panels, provides an opportunity to create a vocabulary with high efficiency opaque photovoltaic panels. 3. Windows on the south side could be provided with translucent solar pv glass. 4. Combination of glass and photovoltaic glass, where possible, allowing the integration of high efficiency opaque glasses. c) Components with highest feasibility of application/integration of photovoltaic component identified (through surveys, literature study): a) Window glass. b) Curtain glazing. c) Floor to floor glazing. d) Sunshades. e) Panels between glass on the façade. f) Railings (panels between balustrade), walls (covering the fire exits and lift wells). g) Spandrel areas or areas between floor-to-floor glazing.

	SELECTION OF FAÇADE COMPONENT WITH RESPECT TO SELECTED THIN FILM PHOTOVOLTAIC TECHNOLOGY AND VICE-VERSA.	a) A-Si thin film photovoltaic panels could be produced as transparent panels, efficiently and optimally integrated as curtain glazing, window glass. 1. The transparency achieved with A-Si technology varies (Visible transparency =30%, 20%, 10%, 0%). Panels with visible transparency of 20%-30% could be
		integrated as or in combination with window glass and curtain glazing. 2. Panels with visible transparency of 0% and 10% could be integrated as cladding materials, spandrel glass, panels between windows, staircase, and lift walls (in case of end cores). b) CIGS/CIS are produced as opaque panels, but in varied colours, could be integrated as cladding materials replacing the conventional ones. Also provided in combination with curtain glazing.
STEP-4	**HEAT DISSIPATION METHOD FOR FAÇADE APPLICATION:**	a) Analysis (literature and survey) indicated the preferred method of heat dissipation was Naturally ventilated cavity (NVC). b) With the application of NVC, daylight admission within building interior would be possible, if transparent photovoltaic panels/glass would be used.
	CHOICE OF PHOTOVOLTAICS THIN FILM TECHNOLOGY:	a) Amorphous silicon, CIS (cadmium indium diselenide)/CIGS (cadmium indium gallium diselenide) thin film technology had been favoured over Mono/poly-Crystalline silicon, because of higher potential of customization, transparency without affecting efficiency. b) CIGS/CIS, A-Si, and CDTe photovoltaic panels and glass could be produced in different colours and sizes. At the same time the thin film technology created with the amorphous silicon pv cells, had far efficient performance in diffused light as well as at a tilt of 90° as compared with crystalline silicon technology.
	SELECTION OF PV PANEL:	a) Use of thin-film CIGS, frameless glass-glass module, for curtain-walling technique. b) Use of Amorphous silicon PV glass which are available in 2456 x 1245 sqmm, also available in other non-standard sizes, for curtain glazing and cladding material. c) Amorphous Silicon PV glass is manufactured in different sizes, and all the different sizes are available in varied transparency levels (V_{Trans}=0%,10%, 20%, 30).
	PV PANEL CUSTOMIZATION: I. PANEL SHAPE AND SIZE II. GRANULARITY: TRANSPARENCY III. POSITION AND INCLINATION	a) The shape and size of the photovoltaic panel/glass would be rectangular, as it would be efficient and easily adaptable to majority of façades, and easier to expedite in case customization is required in terms of size. b) Granularity as expressed in terms of texture, colour, and transparency, would be like conventional building envelope materials, so it becomes easier to adapt. The texture would be smooth and planar, and transparency would depend on the application component. c) The amorphous silicon modules are available in four transparencies: No Transparency, Low Transparency, Medium Transparency and High Transparency. The efficiency or the energy output changes (reduces), with increasing transparency. d) Mounting of panels would be parallel to the façade. If the façade geometry works out then may be a combination of opaque photovoltaic panel, inclined to the sky and glass inclined to the ground could be designed.
	MOUNTING OF PV PANELS ON THE FAÇADE	1. There are different solutions available for the mounting of pv panels on the façade. For example, seamless glass to glass module joining is available. 2. Availability of cladding with Aluminium profile (Mullion, transom), with the help of screws and fastener. 3. Mounting of solar glass/panel as louvers/sunshades is possible with the help of fasteners, aluminium clips, and screws/brackets.
	PV PANEL CROSS SECTION/ CROSS-SECTION OF THE FACADE	1. The pv panels cross-section chosen should be similar to the cross-section of the façade component it is replacing, to have least impact on the building footprint. 2. Also, the structural system and mounting system should be simple, durable, and efficient, to have maximum possible integrability.

Source: (Ahmad & Zia, Design Strategies for Façade integrated Photovoltaic Technology (FiPV), 2022)

3. APPROACH TO DESIGNING AND INTEGRATING PHOTOVOLTAIC FAÇADES IN ARCHITECTURE

The framework is a methodology for designing and integrating photovoltaic façades, consisting of three sequentially connected processes (see figure 1).

STEP ONE: Involves identifying three commercial building typologies: (i) curtain wall façades with aluminum composite panels and ribbon windows, (ii) exposed brickwork façades with floor-to-floor glazing, and (iii) aluminium composite panel façades with floor-to-floor glazing (Sandak et al., 2019; Singh et al., 2018).

STEP TWO: This phase develops design strategies by first identifying barriers (inhibitors, issues, concerns) and then selecting suitable solar panels. Barriers are analyzed for their impact and inform proactive design parameters. The chosen photovoltaic technology must function as both building skin and energy generator without compromise. Thin-film technology, especially CIGS panels, is preferred due to its efficiency (20%-22.9%) in diffused light, lightweight, color options, and minimal impact from temperature, making it highly suitable for façades (Nguyen et al., 2019).(Ahmad & Zia, 2022)

STEP THREE: involves generating façade-integrated photovoltaic systems for the identified building typologies using strategies from step two. Design variants are simulated in selected cities using software such as PV*Sol, PVSyst, or RETScreen Expert to evaluate energy generation potential. Assessment focuses on energy available at the grid and system performance ratio. Simulation determines the most efficient system based on azimuth, tilt, and city, and compares the new photovoltaic façade's performance and energy consumption to the base-case building, aiding in identifying efficiency and economic feasibility (Ahmad & Zia, 2022).

4. CONCLUSION

The studies by Nagyn et al. (2016), Nguyen, Sang, Vu, and Le (2019), Saretta, Caputo, and Frontini (2019), and Zhang et al. (2018) have primarily focused on the renovation of existing buildings through the application of photovoltaic panels, either as retrofit solutions or as supplementary components to the building envelope. However, to realize an optimally functioning and efficient photovoltaic façade, it is essential to gain a comprehensive understanding of how photovoltaic materials can be seamlessly integrated into the architectural fabric of a building.

Achieving successful architectural integration of photovoltaic façades necessitates a clear grasp of the design process and the factors influencing it. This study systematically identifies and analyses the barriers that may arise during the integration process, evaluating their impact on the design. Building upon this analysis, a structured framework has been developed to facilitate the adoption of façade-integrated photovoltaic technology (FiPV) in commercial buildings. The framework offers a streamlined and sequential approach for designing a photovoltaic façade, ensuring efficient integration of photovoltaic materials with the existing building façade.

The proposed framework enables designers to simulate a variety of design alternatives using tools such as PVSyst, RETScreen Expert, or PV*Sol, depending on the available expertise and skill sets. Through simulation, designers can make informed decisions by assessing key parameters including energy generation, visual and aesthetic qualities, and economic viability. The implementation of this framework and its associated design strategy empowers architects and façade designers to incorporate renewable energy systems within the building envelope, thereby promoting the creation of energy-efficient and sustainable building systems.

Ultimately, the developed framework supports the global movement towards the construction of net zero energy buildings, positioning itself as a practical tool for achieving sustainable architectural outcomes.

5. REFERENCES

Saretta , E., Caputo, P., &Frontini, F. (2019). A review study about energy renovation of building facades with BIPV inurban environment. Sustainable Cities and Societies, 343-355.

Ahmad, M., & Zia, H. (2022, January). Architectural integration of photovoltaics in the building façade: a framework forarchitects' design process. Int. J. Renewable Energy Technology, 13, 84-100. Inderscience.

Ahmad, M., & Zia, H. (2022). Design Strategies for Façade integrated Photovoltaic Technology (FiPV). ICCAUA2022 Conference full paper proceedings book, Alanya HEP University, Alanya, Turkey (pp. 173-180).Alanya: Alanya HEP University.

Akinwale, Y. O., Ilevbare, O. E., &Ogundari, I. O. (2015).Utilising renewable energy technologies for electricity.International Journal of Renewable Energy Technology, 6(3). doi:10.1504/IJRET.2015.070149

Gholami, H., &Rostvik, H. N. (2020, August 1). Economic analysis of BIPV systems as a building envelope material forbuilding skins in Europe. Energy 204.

Gholami, H., Rostovik, H. N., & Muller, D. (2019). Holistic economic analysis of building integrated photovoltaics (BIPV)system: Case studies evaluation. Energy and Building (203).

Khan, N., Abas, N., &Kalair, A. (2015).Earthy, solaris and atmospheric energy sources.International Journal ofRenewable Energy Technology, 6(1). doi:10.1504/IJRET.2015.067515

Nagyn, Z., Svatozarevic, B., Jayathissa, P., Begle, M., Hofer, J., Lydon, G., Schlueter, A. (2016). ADAPTIVE SOLARFACADES: FROM CONCONCEPTS TO PROTOTYPES. Frontiers of Architectural Research, 5(2), 143-156.

Nguyen, L. D., Sang, N. D., Vu, N. H., & Le, N. L. (2019). Facade Integrated Photovoltaic Systems: Potential Applicationfor commercial building in Vietnam. International Conference on System Science and Engineering (ICSSE) 2019.Dong Hoi City, QuangBinh Province, Vietnam.

Sandak, A., Sandak, J., Marcin, B., &Kutnar, A. (2019).State of the Art in Building Façades.In A. Sandak, J. Sandak, B.Marcin, & A. Kutnar, Bio-based building skin (pp. 1-26).

Singh, R., Ravache, B., &Sartor, D. (2018).Building Innovation: A Guide for High-Performance Energy Efficient Buildingsin India.Lawrence Berkley National Laboratory. Energy Technologies Area, Berkley Lab.
Retrieved fromhttps://escholarship.org/content/qt6tp8264b/qt6tp8264b.pdf

Zhanga, X., Lovati, M., Vigna, I., Widén, J., Han, M., Gal, C., &Feng, T. (2018, November).A review of urban energysystems at building cluster level incorporating renewable-energy-source (RES) envelope solutions.AppliedEnergy, 230(SI), 1034-1056.

From Concrete to Green: Building Sustainable Cities for the Future

Dr. Ayla Khan,
Associate Professor, Department of Architecture, Jamia Millia Islamia, New Delhi,
akhan3@jmi.ac.in

***Abstract* - - Rapid and unplanned urbanization has led to sprawling cities that are increasingly vulnerable to climate change impacts such as flooding, droughts, and heat waves. This growth has strained housing, transportation, and basic urban services, while contributing to air pollution, environmental degradation, and declining public health.**

A sustainable city is defined as one that balances environmental protection, economic growth, and social equity while remaining resilient to environmental risks. Sustainable cities prioritize efficient resource use, reduced emissions, inclusive planning, accessible public transport, and green spaces that enhance quality of life. Cities play a crucial role in achieving global sustainability goals through eco-friendly infrastructure, renewable energy adoption, and climate-resilient development.

Key recommendations include nature-based solutions such as urban farming, renewable energy systems, green roofs, sustainable drainage, pedestrian-friendly transport, zero-emission vehicles, circular economy practices, xeriscaping, and sustainable architecture. Together, these measures can reduce environmental impacts, enhance resilience, and create healthier, more inclusive urban environments for present and future generations.

***Index Terms* -** *Vertical Greenery Systems, Green Façades, Living Walls, Sustainable Architecture, Building Envelopes, Urban Greening.*

1. INTRODUCTION

Cities and their current scenario: Rapid and unplanned urbanization is leading to urban sprawl that has made cities highly vulnerable to climate change induced flooding, droughts, and heat waves. Urban sprawl is further resulting in inadequate housing and transportation systems. inadequate transportation infrastructure has led to air pollution that affects the health and well-being of the urban population .Cities face institutional, political, and financial constraints, have ineffective and uncoordinated national policies and processes, lack integrated planning, do not properly engage stakeholders, and struggle to mobilize finance.Short-term and uncoordinated responses to rapid urbanization through additional infrastructure, excessive land use, and ground water extraction, energy-intensive cooling and other resource intensive measures havecaused environmental degradation and made natural resources vulnerable.

The United Nations Environment Programme calls out that most cities today are struggling with environmental degradation, traffic congestion, and inadequate urban infrastructure, in addition to a lack of basic services, such as water supply, sanitation, and waste management. A sustainable city should promote economic growth and meet the basic needs of its inhabitants, while creating sustainable living conditions for all. Ideally, a sustainable city is one that creates an enduring way of life across the four domains of ecology, economics, politics and culture.

Fig.1 *Gujarat International Finance Tec-City*
Source: By Gujarat in-During visit to Gift One, https://commons.wikimedia.org/w/index.php?curid=25183611

2. THE MEANING OF A SUSTAINABLE CITY

In the urban context, the United Nations Sustainable City Program defined the 'sustainable city' as one that is able to retain the supply of natural resources while achieving economic, physical, and social progress, and remain safe against environmental risks that could undermine development. For Arctic cities, along with others, climate change presents a significant.

The sustainable city, eco-city, or green city is a city designed with consideration for social, economic, environmental impact (commonly referred to as the triple bottom line), and resilient habitat for existing populations, without compromising the ability of future generations to experience the same. The UN Sustainable Development Goal 11 defines sustainable cities as those that are dedicated to achieving green sustainability, social sustainability and economic sustainability. They are committed to doing so by enabling opportunities for all through a design focused on inclusivity as well as maintaining a sustainable economic growth. The focus also includes minimizing required inputs of energy, water, and food, and drastically reducing waste, output of heat, air pollution – CO2, methane, and water pollution.

3. THE PRESENT STATISTICS FOR CITIES

Cities occupy just 3 percent of the Earth's land but account for 60 to 80 percent of energy consumption and at least 70 percent of carbon emissions (greenhouse gas emissions), generate huge amounts of waste and pollution, and are rapidly encroaching into natural habitats. Urban sprawl is leading to poor living conditions, making cities highly vulnerable to climate change, and threatening the biodiversity surrounding cities.

Fig.2 *Auroville, Sri Aurobindo Ashram in Viluppuramdistrict, Tamil Nadu.*
Source:By KalkiRaj ,
https://commons.wikimedia.org/w/index.php?curid=152138575

While cities contribute to global economic growth, they are also drivers of environmental degradation. With rapidly growingcities, the urban population is projected to grow from 4.4 to 6.7 billion people by 2050. And by 2030, it is estimated that cities will expand to cover an additional 290,000 km2 of natural habitat, particularly in the tropical forests of Africa and Asia, which are amongst the most bio diverse places on Earth.

As centres of consumption and production, cities have negative impacts on nature far beyond urban areas. Although they cover only 2-3% of land, cities account for 75% of natural resource consumption, up to 80% of energy consumption, 70% of greenhouse gas emissions, and 50% of waste production. Today, 55 percent of the world is estimated to be living in urban areas and the United Nations estimates that by the year 2050, that number will rise to 70 percent.Environmental footprints of cities are quite alarming and can threaten the natural resources required to sustain the economic development and poverty alleviation rates.Cities can be key to achieving global environmental and sustainability goals. Cities are drivers of progress but can also be places for catastrophe and environmental degradation. Implementing eco-friendly infrastructure, promoting renewable energy sources, and adopting green technologies are crucial steps cities can take to mitigate their environmental impact.Making small efforts towardsInclusive planning of cities – involves that approach in planning that upholds benefit of urban spaces, services, infrastructure, safety for all its users. This approach transforms city planning from car-centric models to human-centric ones, ensuring everyone has the right to participate fully in urban life.

Fig.3 *Copenhagen, Denmark, seen from the top of St. Nicolas' Church.*
Source:By MikHartwell
https://commons.wikimedia.org/w/index.php?curid=13321835

While cities contribute to global economic growth, they are also drivers of environmental degradation. With rapidly growingcities, the urban population is projected to grow from 4.4 to 6.7 billion people by 2050. And by 2030, it is estimated that cities will expand to cover an additional 290,000 km2 of natural habitat, particularly in the tropical forests of Africa and Asia, which are amongst the most bio diverse places on Earth.

As centres of consumption and production, cities have negative impacts on nature far beyond urban areas. Although they cover only 2-3% of land, cities account for 75% of natural resource consumption, up to 80% of energy consumption, 70% of greenhouse gas emissions, and 50% of waste production. Today, 55 percent of the world is estimated to be living in urban areas and the United Nations estimates that by the year 2050, that number will rise to 70 percent.Environmental footprints of cities are quite alarming and can threaten the natural resources required to sustain the economic development and poverty alleviation rates.Cities can be key to achieving global environmental and sustainability goals. Cities are drivers of progress but can also be places for catastrophe and environmental degradation. Implementing eco-friendly infrastructure, promoting renewable energy sources, and adopting green technologies are crucial steps cities can take to mitigate their environmental impact.Making small efforts towardsInclusive planning of cities – involves that approach in planning that upholds benefit of urban spaces, services, infrastructure, safety for all its users. This approach transforms city planning from car-centric models to human-centric ones, ensuring everyone has the right to participate fully in urban life.

Accessible public transportation – refers to public transport such as buses, metros, trains usable across all age groups, elderly, people with disabilities and bearing capacity for office rush hours. This can be achieved through implementing low floor transport systems, providing ramps where necessary, audio-visual information systems and assistive technology.

Providing green spaces – urban green spaces help in fostering social cohesion and provide environmental benefits. Improves mental and physical health that helps enhance the quality of life where all residents can thrive.

Address issues through community engagement. Sustainable urban development involves implementing climate-resilient infrastructure, adopting low-carbon technologies, and developing strategies to cope with extreme weather events.

4. RECOMMENDATIONS FOR NATURE-BASED SOLUTIONS FOR URBAN SUSTAINABILITY

Different agricultural systems such as agricultural plots within the city (suburbs or centre). This reduces the distance food has to travel from field to fork. Producing or growing food in a city or other heavily populated areas is known as ‘urban farming’. It refers to agricultural practices in urban and their peri-urban areas. It increases the availability of food for people in need by supporting and encouraging the establishment of gardens on unused land and space.

Renewable energy sources, such as wind turbines, solar panels, or bio-gas created from sewage to reduce and manage pollution.

Various methods to reduce the need for air conditioning (a massive energy demand), such as planting trees and lightening surface colours, natural ventilation systems, an increase in water features, and green spaces equalling at least 20% of the city's surface. These measures counter the "heat island effect" caused by an abundance of tarmac and asphalt, which can make urban areas several degrees warmer than surrounding rural areas.

Fig.4 *Curitiba - State of Paraná, Brazil.*
Source : By enioprado,
https://commons.wikimedia.org/w/index.php?curid=59452091

Green roofs alter the surface energy balance and can help mitigate the urban heat island effect. Improved public transport and an increase inpedestrianization to reduce car emissions. This requires a radically different approach to city planning, with integrated business, industrial, and residential zones.

Optimal building density to make public transport viable but avoid the creation of urban heat islands.Green roofs alter the surface energy balance and can help mitigate the urban heat island effect. Incorporating eco roofs or green roofs in your design will help with air quality, climate and water runoff.

A zero-emission vehicle, or ZEV, is a vehicle that does not emit exhaust gas or other pollutants from the on-board source of power.Sustainable drainage systems are a collection of water management practices that aim to align modern drainage systems with natural water processes and are part of a larger green infrastructure strategy.Xeriscaping is the process of landscaping, or gardening that reduces or eliminates the need for irrigation. It is promoted in regions that do not have accessible, plentiful, or reliable supplies of fresh watercircular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. The three principles required for the transformation to a circular economy are: eliminating waste and pollution, circulating products and materials, and the regeneration of nature.

A commitment to sustainable architecture encompasses all phases of building including the planning, building, and restructuring. Sustainable Site Initiative is used by landscape architects, designers, engineers, architects, developers, policy-makers and others to align land development and management with innovative sustainable design.

5. CONCLUSION

Building sustainable cities for the future is no longer a choice but a global necessity. Cities, while being engines of growth and innovation, are also major contributors to energy consumption, greenhouse gas emissions, and resource depletion. Addressing these challenges requires a fundamental shift in how cities are planned, designed, and managed. Sustainable cities must integrate environmental responsibility, social equity, and economic viability. This includes adopting inclusive and human-centric planning, improving access to public transportation, increasing green and open spaces, and ensuring access to basic services for all residents. Nature-based solutions, renewable energy, sustainable architecture, and circular economy practices can significantly reduce environmental impacts while enhancing resilience to climate risks such as heat waves, flooding, and water scarcity. Few cities across the globe have been the torch bearers for sustainability. Like, Copenhagen has made remarkable strides in becoming a carbon-neutral city through extensive investment in renewable energy and sustainable transportation.Curitiba, in Brazil, is renowned for its innovative urban planning, emphasizing public transportation and green spaces.

India is working on Gujarat International Finance Tec-City or GIFT which is an under-construction world-class city in the Indian state of Gujarat. It will come up on 500 acres (2.0 km2) land. It is a central business district in Ahmadabad. It is India's first operational Greenfield smart city and international financial services center, which the Government of Gujarat promoted first of its kind fully Sustainable City. Another example is the capital city of the north-eastern Indian state of Tripura;Agartala sits along the Howrah River. The project called Agartala Smart City Limited (ASCL) is looking to reshape the riverfront – as well as the identity – of the city. It seeks to not only strengthen the embankments and build a responsible waste management system, but also sustain the biodiversity fostered by the river and build organic gardens. These gardens will further generate employment for the locals, especially women while preserving the area's natural environment. A living example is that of Auroville, founded in 1968 with the intention of realizing human unity, and is now home to approximately 2,000 individuals from over 45 nations around the world. Its focus is its vibrant community culture and its expertise in renewable energy systems, habitat restoration, ecology skills, mindfulness practices, and holistic education. These case studies serve as inspiration and models for other cities aspiring to integrate sustainability into their development agendas.

6. REFERENCES

Ibri, S. E. (2017). Smart Sustainable Cities of the Future. Norway: Springer.

Bibri, S.E., Krogstie, J. Generating a vision for smart sustainable cities of the future: a scholarly backcasting approach. Eur J Futures Res 7, 5 (2019)

Cohen, S. (2018). The Sustainable City. New York: Columbia University Press.

Khare, A. T. (2025). Sustainable and Smart Cities, Governance, Economy and Society. New York: Routledge,Taylor and Francis Group.

Monga, P. K. (2016). Sustainable Cities Hubs of Innovation, Low Carbon, Industrialization and Climate Action . Vienna: United Nations Industrial Development Organisation.

United Nations. (2025). Goal 11: Make cities inclusive, safe, resilient and sustainable. Retrieved from Sustainable DevelopmentGoals:https://www.un.org/sustainabledevelopment/cities

The Role of Teacher-Student Relationship on Students' Performance in Architectural Thesis

Ar. Neha Bhardwaj, Assistant Professor, Galgotias University, neha.bhardwaj@galgotiasuniversity.edu.in
Dr. Mohammad Amir Khan, Assistant Professor, D/O Architecture, Jamia Millia Islamia, New Delhi-110025
mkhan8@jmi.ac.in

***Abstract* - The architectural design thesis is a significant academic endeavor that serves as a culmination of a student's educational journey in architecture. It requires a deep understanding of architectural principles, creative problem-solving skills, and rigorous research. This research paper explores the impact of teacher-student relationships on student performance in an architectural thesis. It delves into various dimensions such as communication, motivation, engagement, and accessibility, which play crucial roles in shaping student outcomes. Through a thorough analysis of existing literature and empirical survey data, a conceptual framework is proposed to enhance mentorship effectiveness. The findings highlight that structured mentoring and consistent engagement are essential for fostering student success, thereby reinforcing the importance of a strong mentor-mentee relationship in architectural education.**

***Index Terms* -** *Architectural thesis, Teacher-student relationship, Mentorship, Student performance, Architecture Pedagogy*

1. INTRODUCTION

The final-year architectural thesis is a pivotal phase in an architecture student's academic career, representing the synthesis of five years of learning and development. It challenges students to apply their acquired knowledge, skills, and creativity to a self-directed project that contributes to the broader architectural discourse. The role of a mentor in this process is indispensable, guiding students through the complexities of research, design development, and project execution. A strong and supportive teacher-student relationship fosters an environment conducive to learning, motivation, and critical thinking. Conversely, a lack of proper mentorship can lead to confusion, stress, and diminished student performance. This paper seeks to analyse the effectiveness of teacher-student relationships in architectural thesis projects by identifying key mentorship attributes, assessing their impact on student performance, and proposing strategies to optimize this academic engagement.

2. OBJECTIVE OF THE RESEARCH

This research aims to explore the effectiveness of the role of the mentor-mentee relationship on the Student's performance during the architecture thesis.

The research has two objectives:

1. Identify the type of relationship developed between Mentor Mentees during the thesis Project. (The Relationship will be identified based on i.e. Communication [Sociological Impact], Student Motivation [Psychological Impact], Student Response and understanding on discussions or feedbacks [Teaching Strategy] Students Evaluation Result [Student Performance])
2. Create a basic framework that can help in creating a positive relationship between mentor and mentees. (The framework will cover above mentioned factors to create better planning for the upcoming thesis project) .

The specific objectives include analysing the key factors that contribute to effective mentorship, evaluating the frequency and quality of student-teacher interactions, and developing a structured framework to improve student outcomes through enhanced engagement and guidance. By investigating these aspects, the study seeks to offer valuable insights into fostering a more productive academic experience for architecture students.

3. RESEARCH QUESTIONS

The study aims to address the following research questions:

1) What are the key attributes of a positive teacher-student relationship in the context of an architectural thesis?
2) How does the frequency and nature of student-teacher interactions influence thesis performance?
3) What strategies can be implemented to enhance student motivation and minimize stress during the thesis process?

4. THEORETICAL FRAMEWORK

The theoretical foundation of this research is based on the dynamics of teacher-student relationships in architectural thesis education, emphasizing the role of mentorship, active learning, and professional preparation. The architecture thesis serves as a platform where students consolidate their learning, demonstrate their research and design skills, and explore their academic and professional interests. The interaction between students and mentors plays a crucial role in guiding students through this journey, impacting their motivation, stress levels, and overall performance (Hudson, 2013; Davis & Jones, 2020).

The student, as an active learner, is responsible for selecting the research topic, structuring the study, and carrying out the work, while the mentor serves as a facilitator. This mentor-mentee relationship ensures that students receive the necessary guidance, constructive feedback, and professional insights required to complete their thesis successfully. Mick Healey (2013) emphasizes that the dissertation process fosters research training, enhances employability, promotes teaching-research integration, and empowers students in their academic journey.

The student's role in the architectural thesis extends beyond research and design; it involves the ability to critically engage with contemporary architectural debates, understand social responsibilities, and envision the future of architecture. The University of Lincoln's 'Student as Producer' model highlights key attributes of student learning, including discovery, digital scholarship, learning environments, assessment through community-based learning, and the development of professional skills. This framework supports the notion that students benefit the most when they are actively engaged in knowledge production rather than passive recipients of instruction (Davis & Jones, 2020).

Similarly, the teacher's role extends beyond conventional instruction to mentoring and guiding students through the various stages of research and design. Effective mentorship involves helping students set their academic and career goals, identifying their strengths and weaknesses, offering structured feedback, and fostering a positive and encouraging learning environment. (Hudson, 2013; Harvard Handbook on Mentoring)Teachers also assist students in recognizing the real-world implications of their projects, ensuring that their thesis work aligns with professional standards and societal needs(Allu, 2015).

The student-teacher relationship in the architectural thesis is a collaborative process where mutual respect, trust, and effective communication contribute to the student's success. A strong mentoring relationship ensures that students can navigate challenges, refine their research skills, and develop confidence in their work(Hudson, 2013; Hobson & Maxwell, 2020). Features such as regular interaction, clear goal setting, accessibility of mentors, and constructive feedback loops define successful mentorship. When these elements are present, students are more likely to remain motivated, engaged, and perform well in their thesis.

This theoretical framework establishes the importance of mentorship, student agency, and professional development in architectural thesis education. By fostering a supportive and interactive mentor-mentee relationship, institutions can enhance student learning experiences, reduce stress levels, and prepare students for professional careers in architecture (National Academies of Sciences, Engineering, and Medicine, 2019). The integration of these elements creates a comprehensive and structured approach to architectural thesis education, ensuring that students not only succeed academically but also develop the necessary skills for their future professional practice.

5. METHODOLOGY OF THE RESEARCH

This research employs a quantitative research method to examine the mentor-mentee relationship in architectural thesis projects. A structured 5-minute online survey was conducted to assess students' and professors' perspectives on their thesis experiences. Given the constraints of the global pandemic, the survey method was chosen to maintain social distancing while collecting meaningful data.

The study begins by identifying the core challenges faced by students and teachers during the thesis process. These challenges include students' psychological stress, professors' mentoring tactics, and the dynamics of student-teacher interaction. To analyse these aspects, a literature review of scholarly articles and previous studies on mentor-mentee relationships in architectural education was conducted, which informed the development of the survey instrument.

Problem Identification and Approach: The research identifies three key problems:

1) The psychological state of students during their thesis period.

2) The teaching strategies employed by professors to guide students effectively.

The dynamics of an ideal mentor-mentee interaction in thesis projects.

To address these challenges, the research explores:

1) The level of stress experienced by students and their self-confidence during their thesis.

2) The most commonly used teaching techniques and potential alternatives for one-on-one instruction.

3) The characteristics of a productive student-teacher relationship and key factors that contribute to its success.

A survey was conducted among 55 thesis students, collecting their responses via Google Forms to gain insights into their experiences and perspectives on mentorship. The findings aim to propose a framework that enhances mentorship strategies for improved student outcomes in future architectural thesis projects.

Research Aim and Intent of the Questionnaire: The primary aim of the research questionnaire is to assess the nature of the mentor-mentee relationship in the thesis project. The study focuses on three major factors:

- Communication (Sociological Impact)– Evaluating the level of participation and engagement between students and mentors.
- Student Motivation (Psychological Impact)– Assessing students' motivation levels concerning their thesis and architectural discipline.
- Student Knowledge and Response to Feedback (Teaching Strategy) – Analysing teaching strategies employed by mentors and their effectiveness in facilitating student learning.

- Survey Development and Data Collection: A review of existing standardized research questionnaires was conducted to select the most appropriate instruments. While no dedicated tools for architecture mentoring exist, related scales were adapted, including:

- Perceived Stress Scale (PSS) – Measures student stress levels during their thesis.
- Science Motivation Questionnaire II (SMQ-II) – Evaluates student motivation levels.
- My Mentoring Skills inda Phillips-Jones, 2003) – Assesses the effectiveness of mentor-mentee relationships.
- Mentee/Mentor Survey (Kemis et al., 2016) – Examines student and faculty perceptions of mentorship.
- Mentorship Effectiveness Scale (Johns Hopkins University) – Evaluates mentor characteristics in professional mentorship settings.

The final questionnaire was structured to assess key psychological, sociological, and teaching-related factors. Responses were collected using Likert-scale questions to ensure measurable and comparable data.

Sampling and Data Processing The survey targeted students and faculty members from architecture institutes, focusing on individuals with first-hand experience in architectural thesis mentoring. Conducted over two weeks, the survey yielded 80 responses, ensuring a diverse and representative sample.

The collected data was cleaned and organized for analysis, ensuring consistency and eliminating incomplete responses. A quantitative analysis was performed to identify patterns in mentor-mentee interactions, student motivation levels, and satisfaction with mentorship.

6. RESULTS

Teacher Responses The survey responses from teachers were analysed across four key domains: teaching strategy, attitude, engagement, and accessibility. The findings indicate that a majority of teachers adopt a student-cantered approach, emphasizing active learning, interaction, participation, and collaboration. Discussion-based mentoring emerged as the most commonly utilized strategy, allowing personalized feedback and direct engagement with students.

Teachers generally exhibited a positive attitude toward student performance and demonstrated flexibility in accommodating students' needs. They perceived their role as facilitators rather than authoritative figures, fostering a supportive academic environment. However, accessibility challenges were noted, with some teachers unable to maintain regular meetings with students, particularly in an online learning context. Despite these limitations, most teachers remained engaged, monitored mentee progress closely, and believed that students effectively implemented their feedback.

Student Responses Students' responses were evaluated across six domains: attitude, engagement, accessibility, stress levels, motivation, and performance. The data suggests that students who experienced strong teacher engagement and accessibility reported lower stress levels and higher academic performance. Conversely, students who perceived lower levels of engagement and accessibility exhibited increased stress and lower performance outcomes. Interestingly, certain students performed well despite experiencing high levels of stress, while others with lower stress and high motivation displayed weaker performance. Some instances of low performance were attributed to submission-related issues, indicating that external factors such as self-discipline, time management, and personal academic habits also played a crucial role in determining overall student success.

The overall findings highlight that most teachers employ discussion-based strategies and support student-cantered learning by encouraging active participation and collaboration. Teachers maintain a generally positive attitude towards student progress, remain flexible in their approaches, and see themselves as facilitators. However, accessibility remains a challenge, with some teachers unable to meet regularly with students due to online constraints. Despite this, teachers actively track student progress and encourage mentees to incorporate feedback into their work. On the student side, strong teacher engagement correlates with lower stress and improved performance, while students with less engagement tend to struggle more. The responses also indicate that performance setbacks often result from submission delays rather than mentorship gaps. While most students acknowledge their teachers' accessibility and support, thesis time remains a stressful period requiring structured interventions.

The analysis suggests that teachers prioritize student-cantered learning and act as facilitators rather than authoritative figures, ensuring a balance between guidance and independence. Accessibility and engagement are crucial to student success, but logistical challenges sometimes limit the frequency of meetings. While students benefit from engaged mentorship, self-discipline and time management also play integral roles in academic success. Ultimately, a well-structured mentor-mentee relationship enhances student performance, but additional personal and institutional support mechanisms are necessary to optimize thesis outcomes in architectural education.

7. FRAME WORK DEVELOPMENT

Conceptual Framework: The research mainly focuses on the behaviour of the teachers as well as the student during the thesis duration. After going through various models related to the mentorship program. the framework recommended here is taken from the research paper published by Robert G. Hamlin and Lesley Sage named under behavioural criteria of perceived mentoring effectiveness, An empirical study of effective and ineffective mentor and mentee behaviour within formal mentoring relationships. (Hamlin, 2011).

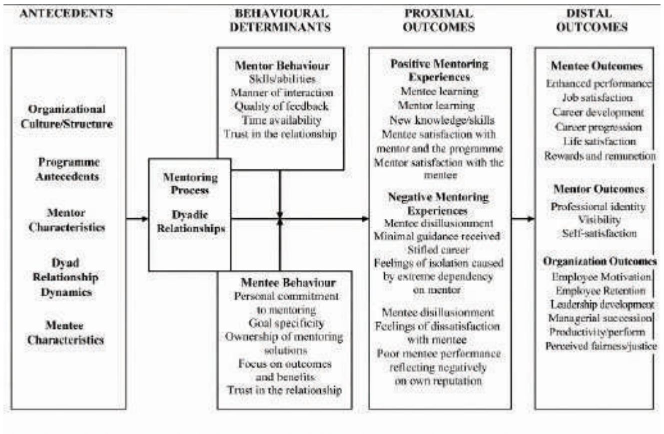


Fig.1 *Conceptual framework on Mentor-Mentee Relationship by Robert G. Hamlin and Lasley Sage (2011)*

As the above framework is defined for the education field. The important point has been identified for the research for developing a better relationship during the thesis period.

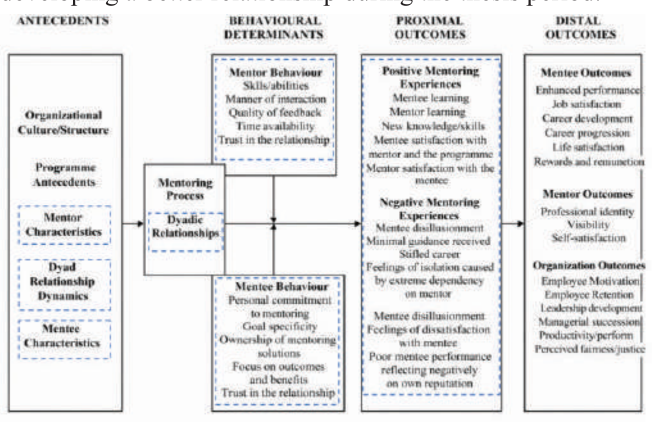


Fig.2 *Conceptual framework on Mentor-Mentee Relationship by Robert G. Hamlin and Lasley Sage (2011)*

Framework Development:The Schedule plan of the Architecture thesis adopted by Jamia Millia Islamia's faculty of Architecture and Ekistic for batch 2021-2022 was used as a reference after going through the complete procedure.

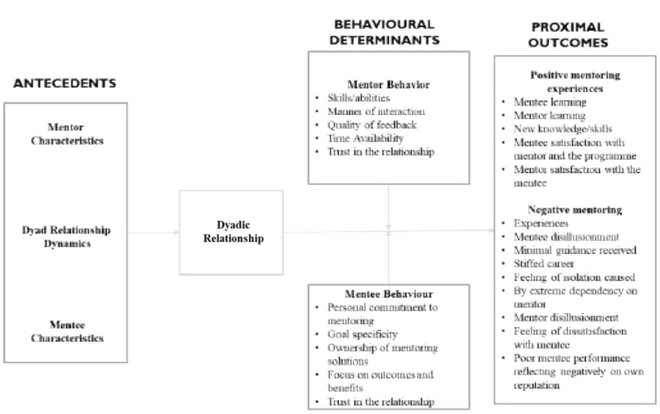
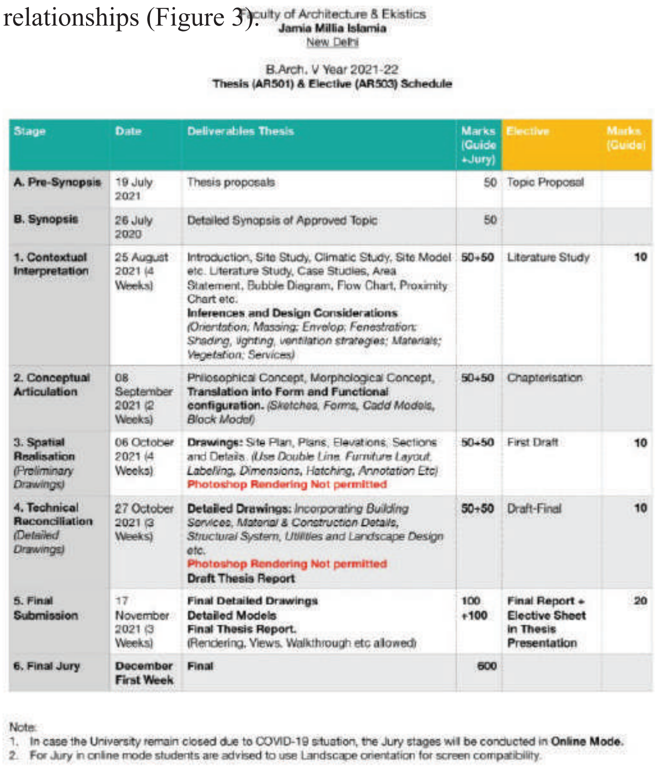


Fig.3 *Edited Conceptual framework on Mentor-Mentee Relationship by Robert G. Hamlin and Lasley Sage(2011)*

The final framework developed from the research paper published by Robert G. Hamlin and Lesley Sage(2011) named under behavioral criteria of perceived mentoring effectiveness, An empirical study of effective and ineffective mentor and mentee behavior within formal mentoring relationships (Figure 3).


Faculty of Architecture & Ekistics
Jamia Millia Islamia
New Delhi

B.Arch. V Year 2021-22
Thesis (AR501) & Elective (AR503) Schedule

Stage	Date	Deliverables Thesis	Marks (Guide +Jury)	Elective	Marks (Guide)
A. Pre-Synopsis	19 July 2021	Thesis proposals	50	Topic Proposal	
B. Synopsis	26 July 2020	Detailed Synopsis of Approved Topic	50		
1. Contextual Interpretation	25 August 2021 (4 Weeks)	Introduction, Site Study, Climatic Study, Site Model etc. Literature Study, Case Studies, Area Statement, Bubble Diagram, Flow Chart, Proximity Chart etc. **Inferences and Design Considerations** *(Orientation; Massing; Envelop; Fenestration; Shading, lighting, ventilation strategies; Materials; Vegetation; Services)*	50+50	Literature Study	10
2. Conceptual Articulation	08 September 2021 (2 Weeks)	Philosophical Concept, Morphological Concept, **Translation into Form and Functional configuration.** *(Sketches, Forms, Cadd Models, Block Model)*	50+50	Chapterisation	
3. Spatial Realisation *(Preliminary Drawings)*	06 October 2021 (4 Weeks)	**Drawings:** Site Plan, Plans, Elevations, Sections and Details. *(Use Double Line, Furniture Layout, Labeling, Dimensions, Hatching, Annotation Etc)* **Photoshop Rendering Not permitted**	50+50	First Draft	10
4. Technical Reconciliation *(Detailed Drawings)*	27 October 2021 (3 Weeks)	**Detailed Drawings:** *Incorporating Building Services, Material & Construction Details, Structural System, Utilities and Landscape Design etc.* **Photoshop Rendering Not permitted** **Draft Thesis Report**	50+50	Draft-Final	10
5. Final Submission	17 November 2021 (3 Weeks)	**Final Detailed Drawings** **Detailed Models** **Final Thesis Report.** (Rendering, Views, Walkthrough etc allowed)	100 +100	**Final Report + Elective Sheet in Thesis Presentation**	20
6. Final Jury	**December First Week**	**Final**	600		

Note:
1. In case the University remain closed due to COVID-19 situation, the Jury stages will be conducted in **Online Mode.**
2. For Jury in online mode students are advised to use Landscape orientation for screen compatibility.

Fig.4 *Schedule plan for architecture thesis 2021-22, Jamia Millia Islamia, New Delhi*

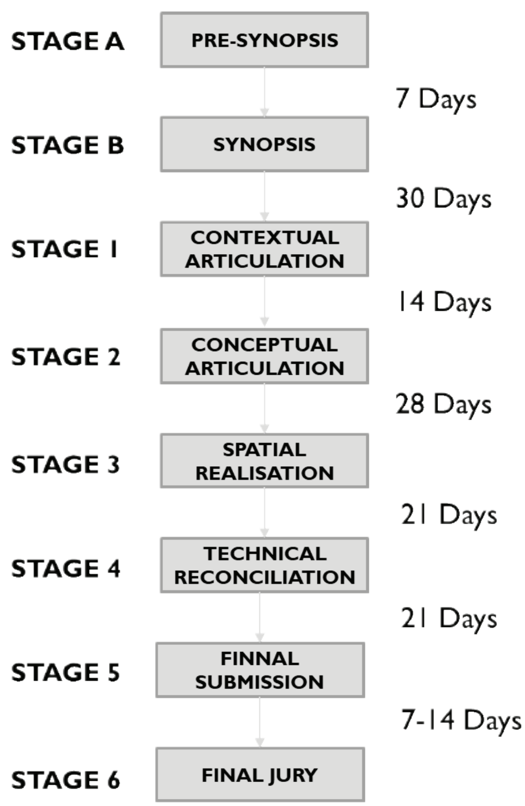


Fig.5 *Time duration among the stages*

The aforementioned phases were divided into two parts, the first of which included Stage A (Pre-Synopsis) and Stage B (Synopsis), both of which are fully reliant on students and authorities (see Figure 6). The Stage is where students are given things to work on. Even if no guide has been designated at the time, the student can speak with any faculty member about their problem. The schedule plan's second component is separated into six sections. As a result, the students were allocated to their valued guide. So here, the student-teacher relationship is important.

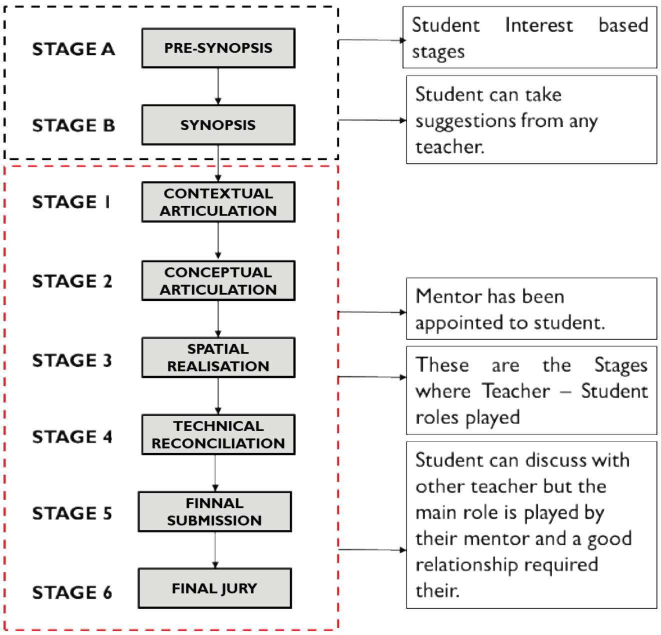


Fig.6 *Understanding of Stages*

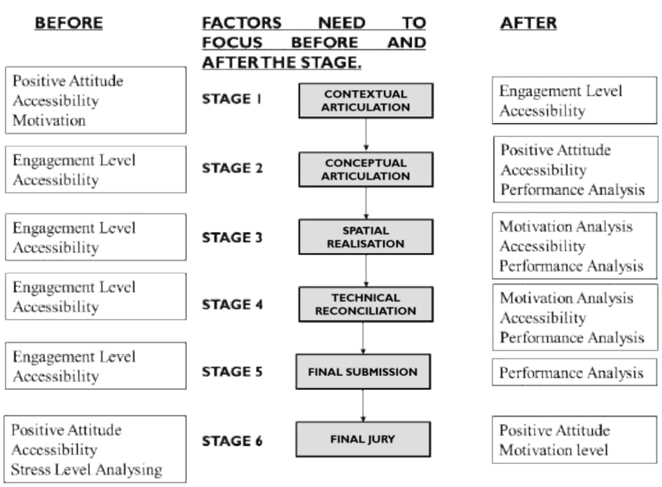


Fig.7 *Factors need to be focused on before and after the Stages*

Figure 7 illustrates how specific learner- and process-related factors need to be consciously addressed before and after each stage of an academic or design workflow. Before entering a stage, emphasis is placed on foundational aspects such as positive attitude, motivation, engagement level, accessibility, and stress management, ensuring readiness for learning and performance. Each stage—from contextual and conceptual articulation to spatial realization, technical reconciliation, final submission, and jury—represents a progressive deepening of understanding and execution. After each stage, the focus shifts toward evaluating outcomes through indicators such as engagement, performance analysis, motivation analysis, and attitude reinforcement.

It was attempted to identify the role of the student and professors before and after the thesis at each step after relating the domain to the phases. (See Figures 8 and 9)

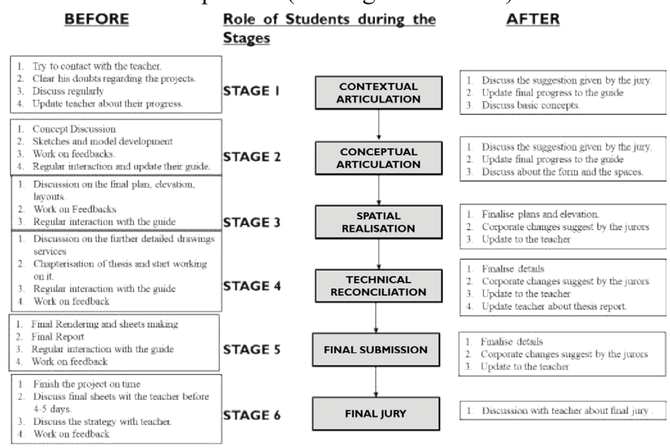


Fig.8 *Role of Students (Mentee) Before and After Thesis*

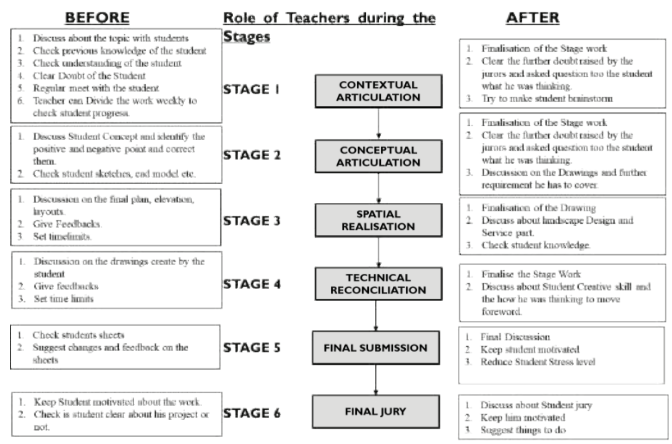


Fig.9 *Role of teachers (mentors) before and after thesis*

7.1 Final Framework:

Thereafter, efforts are made to construct a framework which intended to be useful to both professors and students during the thesis period. The framework (Figure 10) illustrates a structured and stage-wise approach to fostering a positive dyadic relationship between the mentor (teacher) and mentee (student) throughout the Architecture thesis process. Anchored in the overarching goal of developing a Constructive and trust-based student–teacher relationship, the model emphasizes coordination and engagement across all thesis stages—from contextual interpretation to the final jury. Each stage integrates three key dimensions: behavioural aspects, teaching methods, and meeting frequency. Behavioural components such as positive attitude, trust, engagement, student focus, and quality of feedback are progressively strengthened as the thesis advances. Teaching methods evolve from discussion and brainstorming in the early stages to project-based and lecture methods during technical development, ensuring conceptual clarity and skill development. Regular and structured meetings, along with weekly topic-wise planning, provide academic continuity and emotional support.

The framework highlights that sustained mentor–mentee interaction and mutual understanding lead to positive outcomes, including improved student performance, higher motivation, reduced stress, enhanced trust in mentors, conceptual clarity, meaningful learning, and overall student satisfaction with the thesis process and programme.

Ultimately, the model reinforces the idea that a positive relationship is both a process and an outcome of effective mentoring in architectural education.

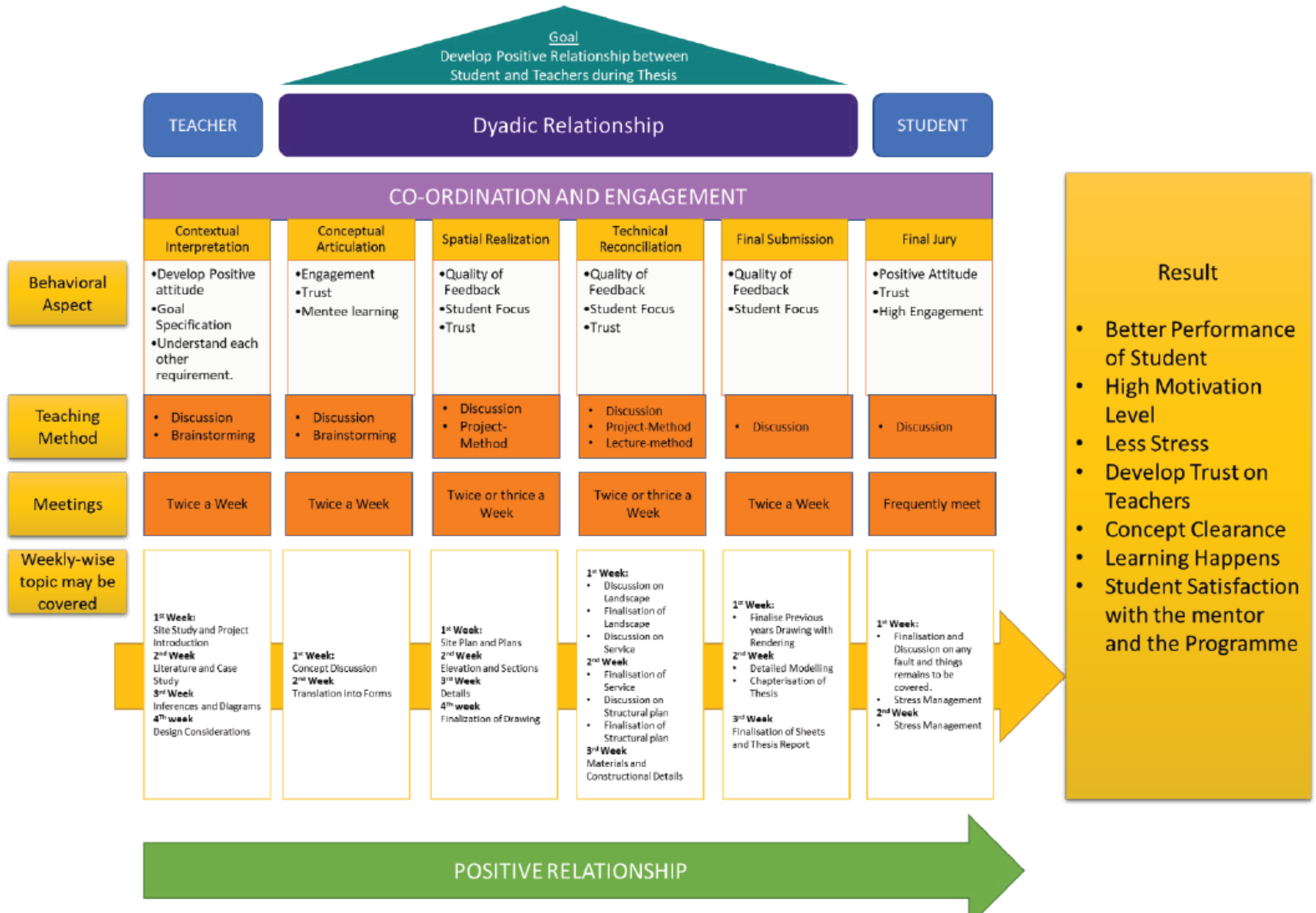


Fig.9 *Framework for creating positive relationship during architecture thesis*

7.2 RECOMMENDATIONS FOR TEACHERS

Mentoring is a dyadic process in which both the student and the teacher are involved, thus the teacher should keep the following points in mind:

- Student mentoring should be a two-way street.
- There should be a frequent meeting with updates delivered.
- Because some students don't pay attention to their instructors, it's important to urge them to engage.
- Establishing trust is essential.
- If students have any questions or concerns, they should not hesitate to approach their professors.
- The instructor must be able to work in a low-stress setting.
- To establish a stronger mentoring session, a good mentor-mentee session is essential.
- Mentees should meet with their teacher once a week, if feasible, to discuss their progress.
- Prior to submitting the thesis, a stress-reduction session should be scheduled.

8 CONCLUSION

The architectural thesis represents a critical phase in an architecture student's academic journey, significantly shaping both their professional development and their relationship with faculty mentors. A positive and well-structured mentor-mentee relationship not only provides clarity and deeper project understanding but also fosters motivation and enhances performance. This study analyzed the interaction between students and teachers based on six key domains: accessibility, engagement, teacher attitude, stress level, motivation, and performance. The findings indicate that high levels of accessibility, engagement, and a supportive teacher attitude contribute to reduced student stress, increased motivation, and improved academic performance. Conversely, limited accessibility, lack of engagement, or misalignment in expectations between students and teachers often result in heightened stress levels and suboptimal academic outcomes.

Beyond teacher involvement, student attitudes and self-discipline play a crucial role in determining success.

Some students, despite receiving high levels of support, exhibited poor performance, highlighting the need for further research into student-specific challenges. To address these concerns, the study proposed a structured framework incorporating frequent meetings, task segmentation, and weekly submissions. This approach encourages continuous student involvement, prevents last-minute stress, and facilitates effective mentorship. The proposed framework also emphasizes post-stage jury interactions, ensuring that students remain engaged throughout the semester rather than experiencing long periods of inactivity.

While the framework offers practical recommendations, its application may vary across institutions due to differences in academic structures and online learning constraints. As a pilot study conducted within a single institution, the results provide valuable insights but require further validation through broader research across multiple institutions. Future studies should explore variations in student behaviours, diverse teaching methodologies, and the impact of different mentorship models to refine and optimize student-teacher engagement strategies in architectural education.

9 REFERENCES

Allu, E. L. A., 2015. Mentoring Architectural Students in the University of Jos, Nigeria: A Case for Improving Sustainable Training and Practices. Humanities and Social Sciences Review, 1(1), pp. 357-362.

AMTA, 2021. Ten Tips for a Successful Mentor-Mentee Relationship. [Online] Available at: https://www.amtamassage.org/find-mentor/ten-tips-for-successful-mentor-mentee-relationship/ [Accessed 10 12 2021].
Anon., n.d.

Dahlberg, A. B.-W. a. M. L., 2019. The Science of Effective Mentorship IN STEMM, WASHINGTON DC: THE NATIONAL ACADEMIES PRESS.

Dixita, 2021. Mentor and Mentee: Roles, Responsibilities, and Relationships. [Online] Available at: https://matterapp.com/blog/mentor-and-mentee-roles-responsibilities-and-relationships [Accessed 10 12 2021].

Hamlin, R. G., 2011. Behavioural criteria of perceived mentoring effectiveness: An empirical study of effective and ineffective mentor andmentee behaviour within formal mentoring relationships. Journal of European Industrial Training , 35(8), pp. 752-778.

Hudson, P., 2016. Forming the Mentor-Mentee Relationship. Mentoring & Tutoring: Partnership in Learning , 24(1), p. 13.

Li, W., 2018. A Research on Undergraduate Architecture Teaching Approach Based on Integration of Architectural Design and Architectural History Teaching. Creative Education, 9(12), p. 9.

Melor Md Yunusa, W. S. W. O. N. M. I., 2011. Teacher-student relationship factor affecting motivation and academic achievement in ESL classroom. Procedia Social and Behavioral Sciences, 15(1), p. 5.

Mick Healey, A. S. J. D. L. L., 2013. Developing and enhancing undergraduate final-year projects and dissertations A National Teaching Fellowship Scheme project publication, Gloucestershire, England: Higher Education Academy.

Office for Alumni Affairs & Career Advancement, Harvard thchan, 2015. The Mentor – Mentee Relationship, BOSTON: Harvard TH. CHAN.

Shannon N. Davis, R. M. J., 2020. The Genesis, Evolution, and Influence of Undergraduate Research Mentoring Relationships. International Journal for the Scholarship of Teaching & Learning, 14(1), p. 9.

STUDENT'S WORK ARTICLES PG. 41-42

Arthshila, Shantiniketan, West Bengal

Mayesura Taiyeba,
B.arch. 2nd year student,
D/O Architecture, Jamia Millia Islamia, New Delhi-110025

Arthshila, is located in the beautiful landscapes of Shantiniketan, -West Bengal, -I'm immediately back in that winter light — soft, slanting, almost golden against the laterite earth. The visit to the complex was more than just entering a "building", more like slowly discovering a series of pauses stitched together. As an architecture student, I have found myself unconsciously analyzing every space I enter. However, in this instance, the analysis followed the experience; initially, I simply perceived it.

The scale of the building was neither monumental nor intimidating, rather it resonated with the audience. The spaces were small, almost modest. Each gallery room was planned with the intention of slowing the audience to experience the exhibit, with the physical space planning ensuring that people wouldn't rush through. The proportions forced intimacy — with the work, with the walls, with light. It felt like the architecture was quietly guiding my body, choreographing how I should move and look.

The presentation area was especially clever. It wasn't loud or overly designed, yet the arrangement made perfect sense — the seating, the orientation, the way attention naturally focused toward the display. It felt flexible, like it could host discussions, screenings, or just informal gatherings without needing transformation. It's the kind of solution we're told to design in studio but rarely see executed so effortlessly.

The designing of utilities highlighted the importance of efficient planning. The washrooms being slightly detached, accessed through a different path, made such a difference. It separated the service functions from the experiential core of the building without making them inconvenient. It kept the gallery spaces clean and uninterrupted. Even the storage being tucked away, almost hidden but aesthetically integrated, showed how carefully everything had been thought through.

Use of terracotta birds on the roof added a warm and human touch to the design. They softened the structure, making it feel rooted in Shantiniketan's craft culture rather than just contemporary architecture dropped onto the site.

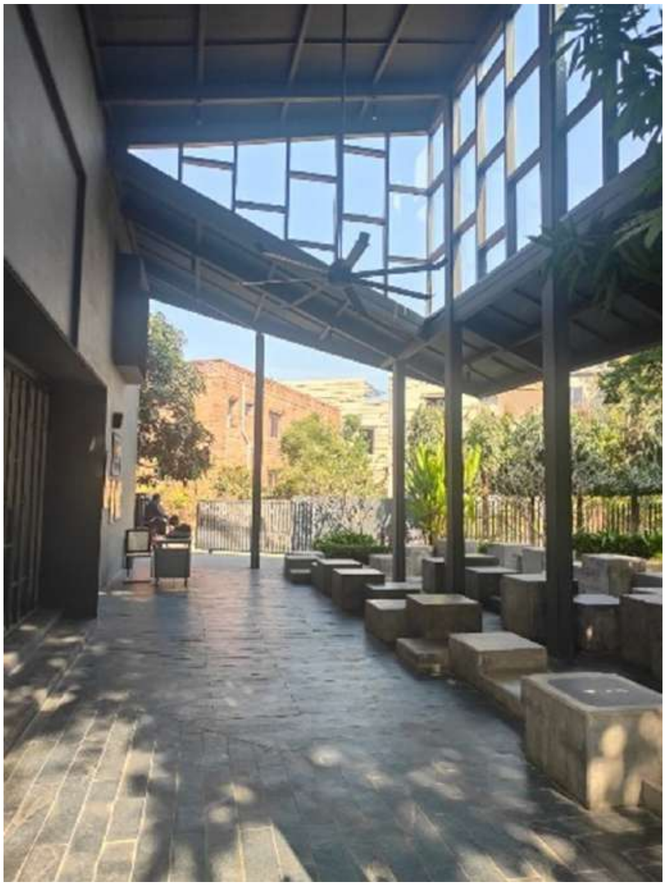


Fig.1 *Arthshila, Shantiniketan, West Bengal*
Source: Author

Walking through Arthshila felt exploratory, almost childlike. Every corner revealed something subtle. It reminded me that architecture doesn't have to be grand to be meaningful — sometimes it just needs to be attentive, quiet, and deeply considered. It's the kind of space I hope to design someday.

Chhatrapati Shivaji Maharaj Terminus

Samiya Sheikh,
B.arch. 2nd year student,
D/O Architecture, Jamia Millia Islamia, New Delhi-110025

Mumbai never really slows down. It moves in waves, with people spilling out of local trains, vendors calling out, footsteps overlapping, time always running a little faster than planned. In the middle of this constant motion, the architecture provides the pause needed.

Chhatrapati Shivaji Maharaj Terminus located within the heart of the city stands surrounded by this hustle, absorbing the noise without ever reflecting it back. While the platform is always overflowing with energy, the building remains composed and a symbol of solitude present amongst the throes of people. I watch thousands pass beneath its arches every day, each person carrying their own destination, their own worries, their own rush. And yet, above them all, the station stands unmoved.

What fills me with awe is the contrast in the design. The pointed arches, soaring dome, and turrets belong to another time, yet finding means to coexist with Mumbai's present. Trains come and go, announcements echo, and crowds surge forward, but the stone carvings remain still with animals' frozen mid-expression, patterns carefully etched by hands. The Gothic grandeur is softened by the Indian craftsmanship. In moments like these, I realize how rare it is for architecture to feel alive. CSMT doesn't compete with Mumbai's chaos, it understands it. No matter how many times I pass through, I am always in awe. Amid the rush, this architectural marvel reminds me that beauty can exist alongside chaos. Sometimes, in the busiest city, the most powerful thing is stillness.

Fig.1 *Chhatrapati Shivaji Maharaj Terminus*
Source: Author

STUDENT’S WORK
THESIS
PG. 43-48

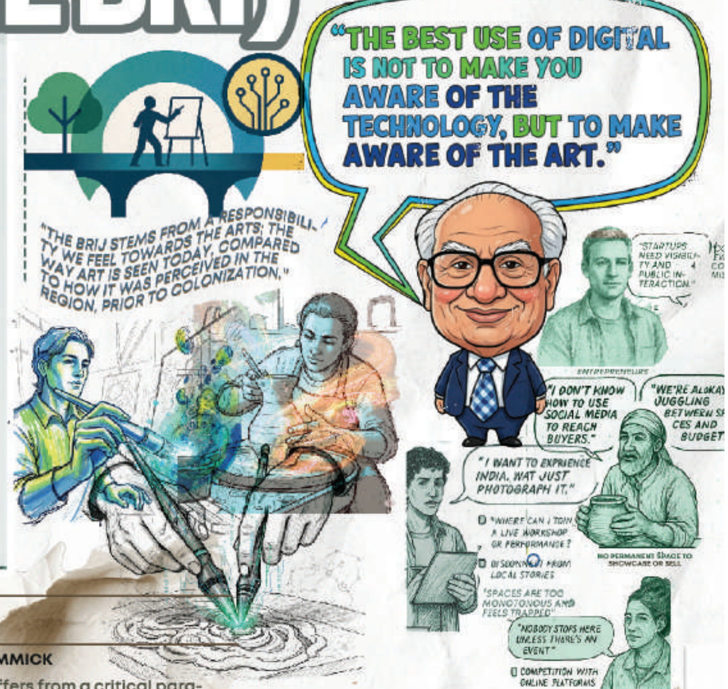
THE BRIJ

The Brij is a visionary project proposed by the Serendipity Arts Foundation, led by Mr. Sunil Kant Munjal, and designed by CP Kukreja Architects (India) in collaboration with Crab Studio (UK). It is envisioned as India's first "Live Museum"—a dynamic, immersive, and collaborative cultural space located in Vasant Kunj, New Delhi.

The project was proposed to challenge the static nature of traditional museums and to respond to the evolving ways in which people engage with art, culture, and heritage. Instead of simply preserving the past, .The name honors Mr. Brijmohan Lall Munjal, a visionary industrialist, while the concept reflects a desire to transform a former industrial site (an Aravalli quarry) into a regenerative cultural landmark that bridges history and innovation, making it a living canvas of Delhi's cultural expression.

VASANT KUNJ

The former quarry site symbolizes regeneration—transforming an industrial scar into a vibrant cultural hub. With excellent infrastructure and green potential, the site supports the vision of a dynamic, immersive "Live Museum."



CONCEPT ARTICULATION

AI AS A TOOL AND NOT A GIMMICK

Delhi's cultural landscape suffers from a critical paradox: while rich in heritage, it lacks spaces where tradition dynamically converses with technology and community. The Brij emerges as an urgent response – transforming an abandoned quarry into India's first 'living canvas' to democratize art, regenerate urban tissue, and position Delhi as a 21st-century creative capital.

Technology amplifies human creativity rather than replacing it. This vision prioritizes co-creation, where artists lead and AI assists. By treating digital tools as mediums, artists retain authorship while building responsive, interactive installations that extend the boundaries of human expression.

UNDERSTANDING THE TYPOLOGY

THE BRIJ EMBODIES A HYBRID TYPOLOGY THAT MERGES CULTURE, EDUCATION, INNOVATION, AND PUBLIC LIFE INTO A SINGLE, COHESIVE CAMPUS. RATHER THAN FUNCTIONING AS A TRADITIONAL MUSEUM OR INSTITUTION, IT OPERATES AS A MULTIDISCIPLINARY ECOSYSTEM—A PLACE TO LEARN, CREATE, PERFORM, AND ENGAGE.

EDUCATION & RESEARCH

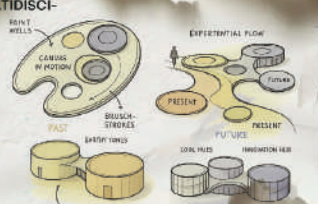
- FORMAL POSTGRAUDADE EDUCATION
- MENTERSHIPS INTERNSHIPS RESIDENCIES
- A PUBLISHING WING

MULTIDISCIPLINARY EXPERIENCES

- MUSEUM WITH INTERATIVE EXIBITITS
- AUDITORIA, ARENA AND BLACK BOX
- CULINARY SPACES
- LIBRARY AND ARCHIVE

INNOVATION & INCUBATION

- WORKSHOP AREAS, LABS STUDIOS
- INCUBATION CENTRE AND ACCELERATOR

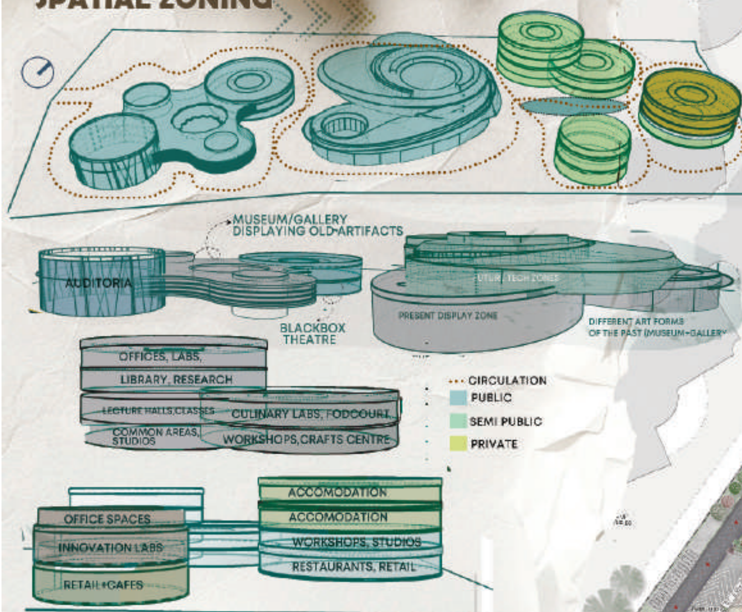


HAYA USMANI , 5TH YEAR DAY

THESIS BY : HAYA USMANI
GUIDED BY : AR. IMAAD NIZAMI

THE BRIJ

SPATIAL ZONING



The spatial flow aligns with the Axis in Time, guiding visitors chronologically from heritage to innovation.
Past galleries anchor the starting point, present-day spaces stabilize the central node, and futuristic zones rise vertically, symbolizing progress.
This upward and forward movement along the axis reflects a seamless evolution—time

Lower Levels host high-footfall public zones like workshops, craft centers, retail, and restaurants for easy accessibility and active engagement.

Mid-Levels accommodate semi-public functions such as lecture halls, studios, and innovation labs, supporting controlled access and interaction.

Upper Levels are reserved for private spaces like accommodations and research areas, ensuring privacy, quietness, and security away from the bustle.
This arrangement promotes smooth circulation, reduces conflicts between visitor and resident movement, and integrates social vibrancy at the ground while maintaining exclusivity above.

THESIS BY : HAYA USMANI
GUIDED BY : AR. IMAAD NIZAMI

NEXT GEN
CO WORKING & CO LIVING

Architecturally, a co-living–co-working thesis explores the overlap between privacy and community, solitude and collaboration. It is not about stacking beds above desks; it is about designing an ecosystem where living and working support each other without competing for attention.

What makes this hybrid typology powerful is its social intent. It responds to urban loneliness, freelance culture, young professionals, creators, and migrants—people who seek independence but value belonging. The building becomes a framework for relationships, not just a container for functions.

The spatial philosophy is rooted in choice. Residents are not forced into constant interaction, nor isolated in enclosed units. Instead, architecture creates a gradient—from intimate personal rooms to semi-private niches, shared work lounges, informal meeting corners, and vibrant community zones. Each space gently invites participation while respecting withdrawal.

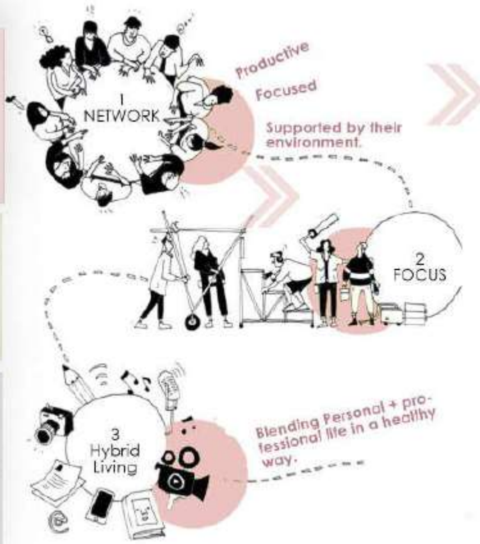
LOCATION - Noida Sector 140A, Uttar Pradesh

SITE DETAIL
SITE AREA - 46,600sqm
PERMISSIBLE FAR - 2
BUILT UP AREA - 1,39,800sqm

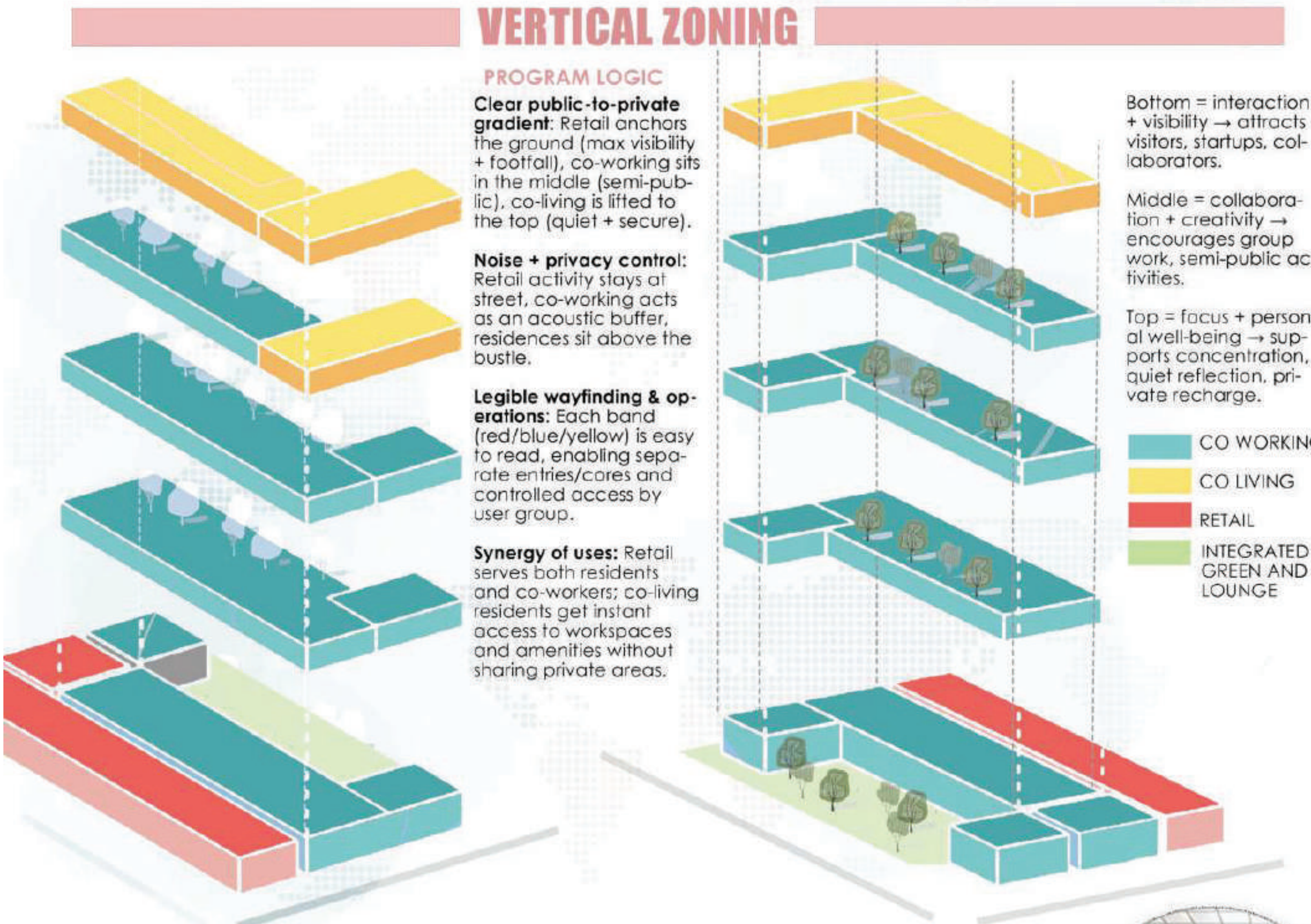
For Gen Z, work is no longer confined to fixed desks or isolated cubicles—it thrives in fluid, **co-creative environments**. They seek places where chance encounters become ideas, where a lounge doubles as a pitch room, and where a café chat feels as productive as a formal meeting. Unlike older generationss, Gen Z craves **spontaneous connections.**

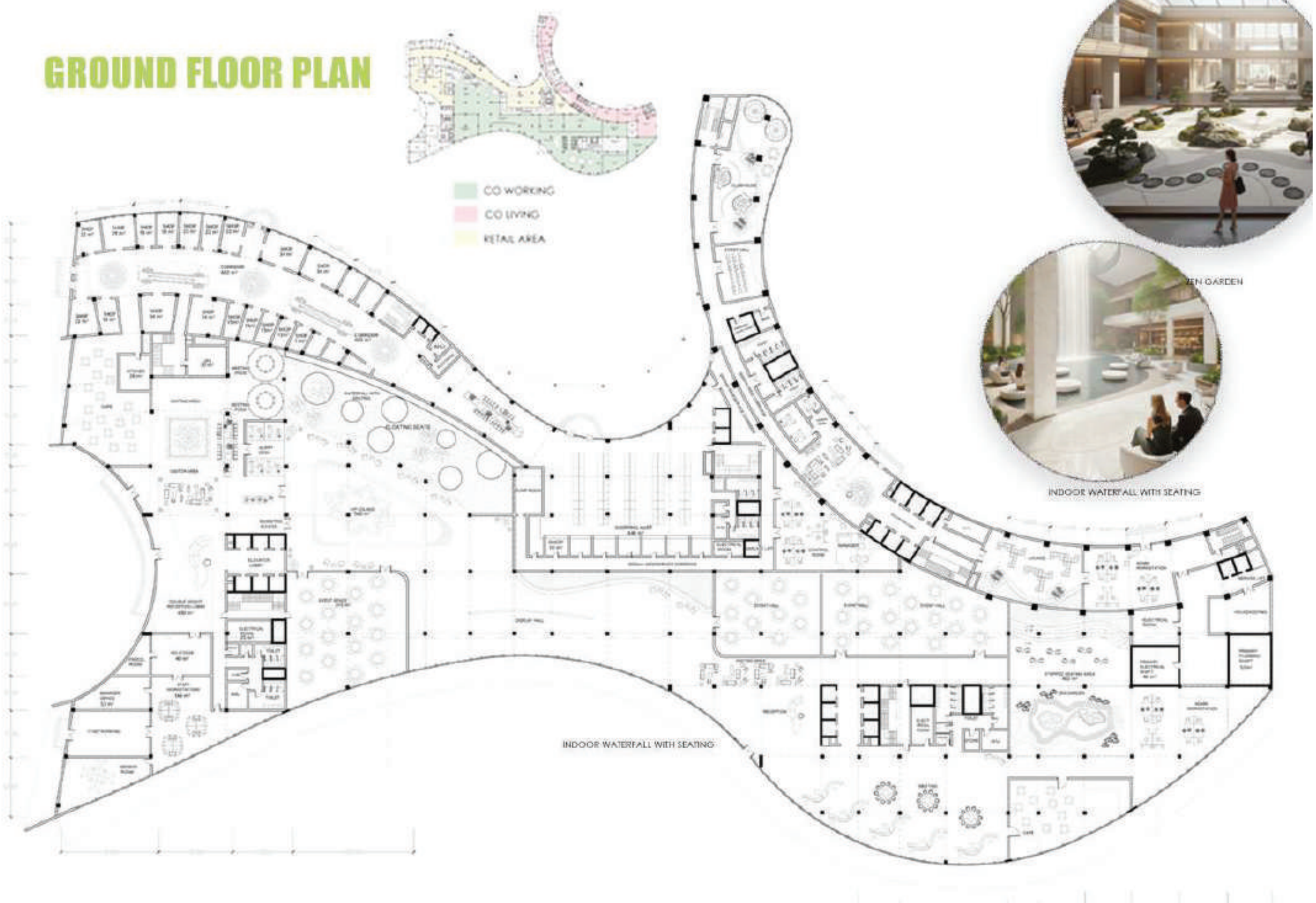
The next-gen doesn't believe in "grind culture" the way earlier generations did. For them, **mental health, focus, and balance are non-negotiables**. They want spaces that support deep work with quiet pods, soft daylight, ergonomic corners, and personalized micro-environments that adapt to their moods.

Gen Z doesn't draw hard boundaries between life and work; **they prefer hybrid, fluid lifestyles** where living, working, socializing, and learning overlap seamlessly. Harmony for them comes through biophilic integration—green terraces, indoor courtyards, natural ventilation



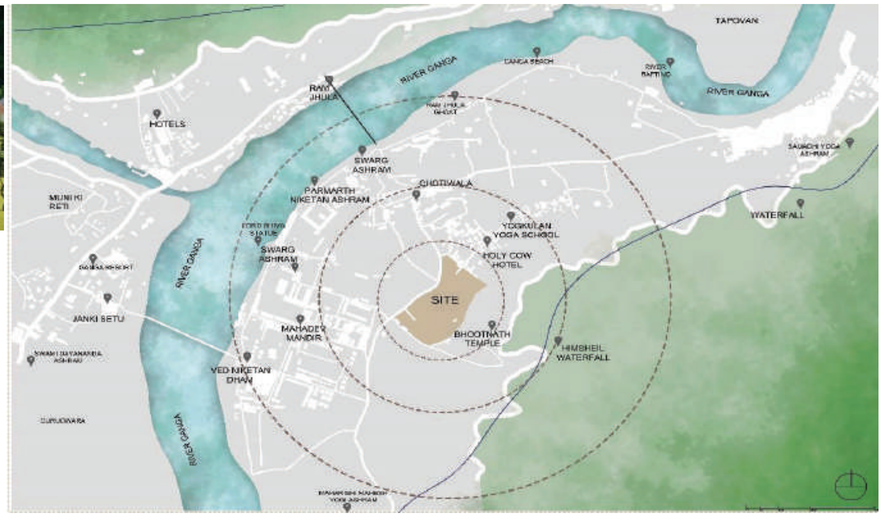
THESIS BY : BHANVI JAIN
GUIDED BY : PROF. TAIYABA MUNAWER





THESIS BY : BHANVI JAIN
GUIDED BY : PROF. TAIYABA MUNAWER

Vedic Sharnam :A JOURNEY INTO RURAL HARMONY



A Healing Retreat Rooted in Vedic Philosophy In an era dominated by speed, screens, and constant stimulation, the need for spaces that restore inner balance has become increasingly important. Vedic Sharnam is an architectural thesis that explores healing as a spatial experience—where architecture becomes a medium for mental, physical, and spiritual well-being.

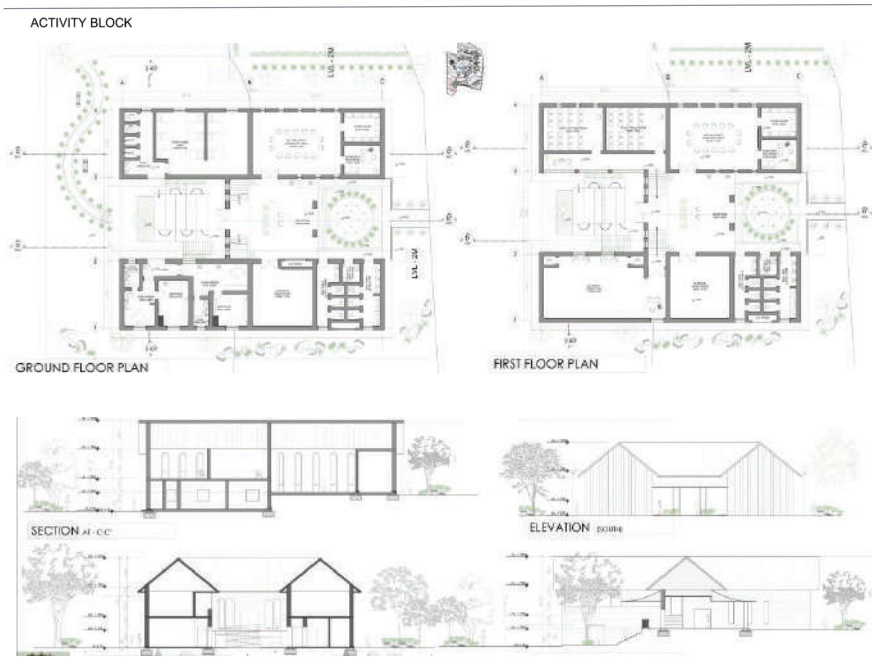
STEP 1 — Primary Axes & Core Node | STEP 2 — Secondary Axes & Influence Zones | STEP 3 — Bubble Zoning | STEP 4 — Program Hierarchy & Distribution | STEP 5 — Final Built–Landscape Form

The project is envisioned as a Vedic healing retreat, inspired by ancient Indian knowledge systems such as Yoga, Ayurveda, Vastu, and Dhyana. Rather than functioning as a recreational resort, Vedic Sharnam is designed as a restorative environment, encouraging silence, slow movement, and deep connection with nature. The planning concept is derived from Mandala geometry, a sacred spatial order symbolizing balance and energy flow. The masterplan gradually transitions from public to semi-private and finally to silent meditative

spaces, allowing users to detach from external distractions and move inward—both physically and mentally. At the heart of the campus lies the Meditation Mandapa, forming the spiritual core around which healing activities are organized.

THESIS BY : OM
GUIDED BY : AR. MOHD ZAHEER ABIDI

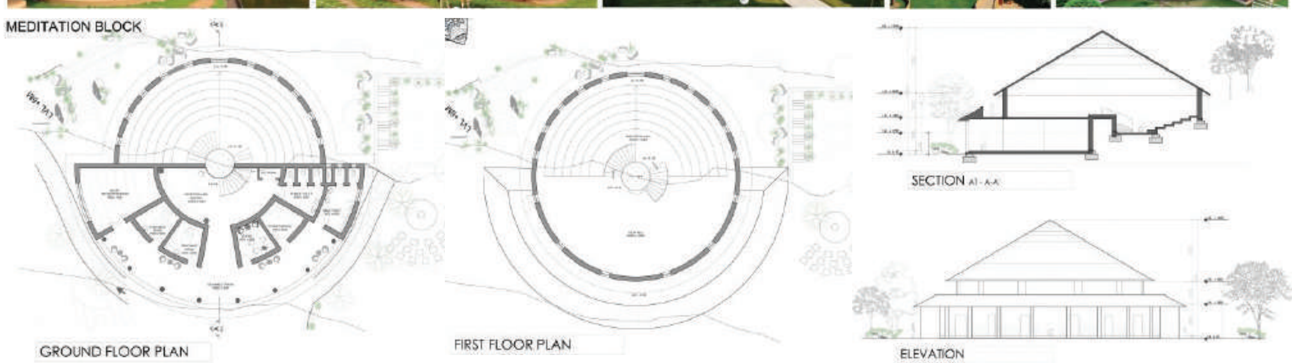
Vedic Sharnam :A JOURNEY INTO RURAL HARMONY

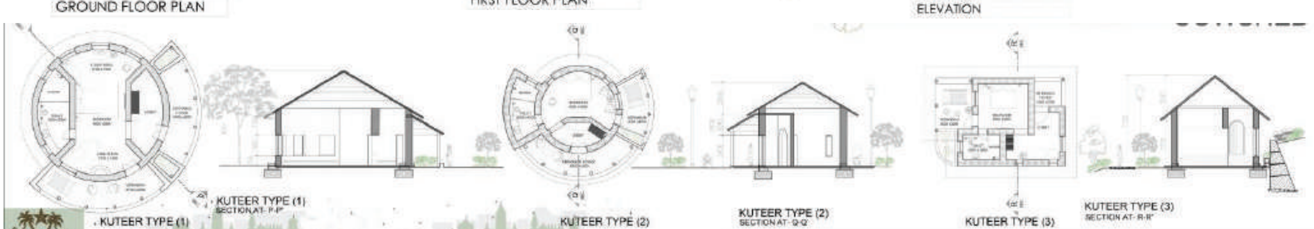


Landscape plays a crucial therapeutic role in the project. Herbal gardens, water bodies, shaded pathways, and fragrance-based planting are integrated to support ayurvedic practices and enhance sensory healing. Vehicular movement is restricted to the periphery, ensuring that the inner campus remains pedestrian-friendly, calm, and noise-free.

Materiality is kept earthy and breathable, using terracotta, lime plaster, natural stone, bamboo, and cane to create a tactile and non-toxic environment. The architectural language is intentionally minimal, allowing light, air, sound, and texture to guide the user experience rather than visual excess.

Vedic Sharnam proposes architecture not as an object, but as a process of healing—a journey that slows the body, quietens the mind, and reconnects individuals with timeless Vedic wisdom. The project ultimately aims to demonstrate how traditional knowledge systems can be meaningfully translated into contemporary architectural design to address modern lifestyle challenges





OM 5TH YEAR 21BAR024 GUIDED BY AR. MOHD ZAHEER ABIDI

THESIS BY : OM
GUIDED BY : AR. MOHD ZAHEER ABIDI

Forthcoming Issues

- Sustainable Architecture, July 2026
- Indigenous Knowledge System, Jan 2027
- Humane Habitat, July 2027

For Submissions

Category 1: Research Papers

https://forms.gle/ADHWNBTf3DL2Kju97

Category 3: Student Work

https://forms.gle/rwZTrFhiVWUHKHAt6

Category 2: Articles

https://forms.gle/xtFpgw62ZGUdUbuR9

Category 4: Cover Design

https://forms.gle/RBJkiX1co16My2ts8