International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 03 | March - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Spatial Elasticity: Designing Kinetic Urban Infrastructure for Ephemeral Socio-Cultural Hubs

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Abstract - Modern Indian cities are increasingly defined by a focus on permanent, rigid structures that fail to accommodate the moving, seasonal, and temporary nature of the country's culture. This paper introduces the concept of Spatial Elasticity, a design framework aimed at balancing static city spaces with the shifting needs of public life. The research moves beyond traditional building design to propose a Kinetic Urban Infrastructure, that is, a permanent system that allows public spaces to grow and shrink during intense cultural activities without losing their basic identity. Using a three-phase study, including a Chrono-Spatial Audit of the Kanakakkunnu Palace grounds, the research identifies a "Kinetic Skeleton" of hidden services. The study results in a design toolkit for underused city voids, showing how technical readiness can make temporary events more inclusive and environmentally friendly.

Key Words: Kinetic Urbanism, Spatial Elasticity, Ephemeral Hubs, Urban Infrastructure, Socio-Cultural, Polyvalent Space.

1. INTRODUCTION

1.1 Background

Traditional urban planning in India has mostly focused on building permanent and static structures designed for one specific purpose. While this method values long term durability, it creates a physical environment that is very different from the actual life of the Indian street. In reality, the Indian street is a space of constant movement. It is defined by a rhythmic cycle of seasonal festivals, religious rituals, and spontaneous markets that move through the city in waves. This creates a major conflict between a population that is always in motion and a built environment that is frozen in time. The current architecture often fails to respect the cultural logic of transience, leading to spaces that feel disconnected from the people they serve. Most municipal designs treat public parks and plazas as finished products rather than living platforms that need to breathe and change. This lack of flexibility means that whenever a major cultural event happens, the city has to fight against its own physical layout. Instead of supporting the event, the architecture becomes an obstacle that people have to work around.

1.2 Research Problem

When rigid public spaces are pushed to host intense cultural events, the result is often a total breakdown of local systems known as infrastructural paralysis. This leads to heavy traffic congestion, rapid physical decay of the site, and the eventual exclusion of the very cultural activities that make the city feel alive. There is currently no clear design framework to help turn unsuitable or empty urban spots into high performance cultural centers. Without adopting the concept of spatial elasticity, our public spaces will continue to exist as either empty monuments that no one uses or as broken and neglected voids that cannot handle the pressure of urban life. The ecological health of these sites is also at risk, as temporary structures are often set up in ways that damage the soil and the natural landscape. Because the infrastructure is not ready for these surges in population, the city ends up spending more money on temporary fixes that are wasteful and inefficient. This creates a cycle where cultural expression is seen as a burden on the city rather than its greatest asset.

1.3 Aim and Objectives

The main goal of this research is to create a repeatable design system for spatial elasticity. This involves developing a way for public spaces to expand and contract based on the intensity of use. The study aims to measure the elasticity gap in modern cities, which is the difference between what a space can currently handle and what the community actually needs. Another key objective is to design a modular toolkit that can transform vacant city land into active and growing hubs. This research asks how a permanent structural frame can be built to allow a regular city block to switch smoothly between quiet daily use and high energy cultural celebration. By focusing on a kinetic skeleton of services, the project aims to show that we do not need more buildings to solve urban problems. Instead, we need better systems that allow the existing landscape to perform multiple roles. The ultimate objective is to provide architects and city planners with a manual for creating resilient spaces that celebrate the transient nature of Indian public life while protecting the environment and ensuring safety for all citizens.

Mehrotra, R. (2008). The Kinetic City. Architectural Design. Bishop, P., & Williams, L. (2012). The Temporary City. Routledge. Tschumi, B. (1994). Architecture and Disjunction. MIT Press.

2. BODY OF PAPER

2.1 Theoretical Framework

This research is supported by three primary theoretical pillars that redefine the relationship between urban form and human behavior. These theories argue that the city is not a collection of static objects but a living system of events and movements.

2.1.1 The Kinetic City

The concept of the Kinetic City suggests that the urban landscape is a shifting environment shaped by human interaction rather than just permanent stone and steel structures. In the Indian context, the city exists in two layers: the static city of formal buildings and the kinetic city of festivals, street vendors, and temporary shelters. This theory argues that the kinetic layer is often more representative of the true cultural identity of the people. By viewing the city through this lens, we can see that the most successful public spaces are those that do not resist change but instead provide a stage for it to happen. Designing for the kinetic city requires a shift from building specific rooms to creating open platforms that can support a thousand different stories over time. This approach ensures that the architecture remains relevant even as the needs of the population evolve.

Mehrotra, R. (2008). The Kinetic City. Architectural Design.

2.1.2 Architecture and Disjunction

Disjunction theory proposes that there is no inherent or natural link between a space and the activity that happens within it. Architecture should therefore act as a "Kinetic Skeleton" , a permanent service base that supports a variety of unpredictable programs. Instead of designing a building to be just a museum or just a stadium, this theory suggests creating a robust frame that can handle a market one day and a religious gathering the next. In Sec. 1.2, we identified how rigid designs lead to failure; here, we see that by separating the "skeleton" (the services) from the "skin" (the temporary event), we can create high performance urban hubs. This separation allows for total creative freedom in how the space is used without compromising the safety or efficiency of the city's basic infrastructure.

Tschumi, B. (1994). Architecture and Disjunction. MIT Press.

2.1.3 Loose Space and Liquid Modernity

The theory of Loose Space promotes the idea of urban environments that are not strictly controlled or over-designed. These are "loose" spots where people are free to appropriate space for their own diverse needs, from play and protest to commerce and relaxation. This connects deeply with the idea of Liquid Modernity, which describes a world where social forms and human habits change faster than we can build permanent structures for them. Because our modern lives are so fluid, our architecture must be elastic. If we continue to build rigid, fixed-use monuments, we are essentially building ruins for the future. The goal is to bridge this elasticity gap by creating infrastructure that is technologically advanced but socially open. This ensures that the public realm remains a democratic space where every citizen has a place, regardless of the changing political or economic climate.

Stevens, Q., & Franck, K. A. (2007). Loose Space: Possibility and Diversity in Urban Life. Routledge. Bauman, Z. (2000). Liquid Modernity. Polity.

Author/Work	Core Idea	Contribution to Study	Link to Spatial Elasticity
Bernard Tschumi – *Architecture and Disjunction*	Disjunction between space & event	Supports idea of flexible, non-programmed architecture	Space adapts to unpredictable events
Rahul Mehrotra – *Kinetic City*	Temporary, event-based urbanism	Validates ephemeral socio-cultural hubs	City expands/contracts with use
Quentin Stevens & Karen Franck – *Loose Space*	Informal, user-driven space	Encourages user appropriation	Elasticity through openness & incompleteness
Peter Bishop & Lesley Williams – *Temporary City*	Value of temporary interventions	Supports pop-up, time-based infrastructure	Time-based expansion & contraction
Herman Hertzberger – *Polyvalence*	Multi-use architecture	Promotes adaptable spatial design	Flexibility without physical change
N. John Habraken – *Supports & Infill*	Permanent vs changeable layers	Defines structural system for hubs	Stable core + flexible infill
Stephen Graham & Simon Marvin – *Splintering Urbanism*	Fragmented cities	Warns against exclusive infrastructure	Elastic hubs as social connectors
Stan Allen – *Field Conditions*	City as dynamic field	Supports lightweight, modular systems	Elasticity through networks
Keller Easterling – *Extrastatecraft*	Infrastructure as an active system	Frames hubs as programmable systems	Elasticity as operational logic
Harvard Graduate School of Design – *Kumbh Mela Study*	Ephemeral mega-city	Real-world pr temporary urbar	Extreme scalability
Felipe Hernández – *Informal City*	Adaptive informal systems	Learning from bottom-up urbanism	Organic elasticity

AbdouMaliq Simone – *People as Infrastructure*	Humans as systems	Centers user-driven dynamics	Social elasticity
Ananya Roy – *Urban Informality*	Flexibility beyond rules	Enables temporary activation strategies	Regulatory Elasticity
Cedric Price – *Fun Palace*	Architecture as machine	Prototype for kinetic systems	Fully transformable space
Cedric Price – *Fun Palace*	Plug in urbanism	Supports modular expandable systems	Vertical & modular elasticity
Michael Fox & Miles Kemp – *Interactive Architecture*	Responsive environments	Enables smart kinetic systems	Real time elasticity
Robert Kronenburg – *Flexible Architecture*	Movable/adaptable structures	Technical basis for transformable design	Physical elasticity
Thomas Lommée – *OpenStructures*	Modular open system	Enables scalable design systems	Expandable/reducible architecture
William H. Whyte – *Social Life of Spaces*	Human behavior in space	Micro scale insights	User-driven elasticity
Jan Gehl – *Life Between Buildings*	Human-centered design	Ensures livability of hubs	Elasticity at human scale
Kevin Lynch – *Time & City*	Temporal perception	Adds time dimension to design	Temporal elasticity
Mike Lydon & Anthony Garcia – *Tactical Urbanism*	Temporary interventions	Hubs as prototypes	Experimental elasticity
Jeremy Till – *Architecture Depends*	Embracing uncertainty	Supports adaptable systems	Elasticity through contingency
Charles Waldheim – *Landscape Urbanism*	City as landscape system	Grounds hubs in terrain logic	Horizontal elasticity
Zygmunt Bauman – *Liquid Modernity*	Fluid modern society	Philosophical basis for flexibility	Elasticity as necessity

Table 1: Literature Reviews

2.2 Research Methodology

The methodology for this study is built on a "Skeleton-Skin-Interface" framework. This process treats the site as a living laboratory to observe how permanent infrastructure can better support temporary social events.

Concept Layer	Focus	Key Objective	Outcome / Contribution to Study
Phase 1 : The Skeleton	Establish permanent parameters of the site	Define concepts of Ephemeral Urbanism & Kinetic Architecture; analyze evolution of Kanakakkunnu Palace	Identifies fixed constraints (topography, heritage, utilities); establishes need for a strong permanent framework
Phase 2 : The Skin	Study dynamic, temporal use of space	Analyze user patterns, crowd behavior, and event-based transformations (e.g., Nishagandhi Festival)	Reveals culture of congestion, friction points, and temporal spatial shifts; defines social layer of design
Phase 3 : The Interface	Integrate permanent and ephemeral systems	Develop spatially elastic infrastructure that adapts to varying scales of use	Proposes a replicable kinetic urban toolkit enabling expansion/contraction of socio-cultural space

Table 2 : Research Methodology

2.2.1 Chrono-Spatial Audit

The first step of the research involves a Chrono-Spatial Audit (CSA). This is a specialized mapping process that tracks how a site changes over time. Instead of just looking at a site plan, the CSA records the flow of people, the appearance of temporary stalls, and the changes in noise and light levels throughout a 24 hour cycle or a 7 day festival week. By mapping these "events," we can identify exactly where the static infrastructure fails to support the moving crowd. In Fig. 1.2, we see how the patterns of movement during a festival create a completely different city than the one shown on a standard map. This data allows us to identify the "hotspots" where kinetic infrastructure is most needed to prevent the infrastructural paralysis.

2.2.2 Infrastructure Auditing

Following the mapping of human behavior, the research conducts a technical audit of the hidden service layers. This includes investigating the availability of water, electricity, and waste management systems (WMS) during peak usage times. Often, temporary events are forced to use dangerous, makeshift wiring and open drainage because the permanent site was never designed for high intensity use. This audit identifies the vulnerabilities in the current system and provides the technical basis for the design toolkit described in Sec. 6. By understanding the "invisible" needs of the site, we can design a kinetic skeleton that provides safety and efficiency without needing to build massive, permanent walls that would clutter the landscape during quiet periods.

2.2.3 Typological Translation

Following the mapping of human behavior, the research conducts a technical audit of the hidden service layers. This includes investigating the availability of water, electricity, and waste management systems (WMS) during peak usage times. Often, temporary events are forced to use dangerous, makeshift wiring and open drainage because the permanent site was never designed for high intensity use. This audit identifies the vulnerabilities in the current system and provides the technical basis for the design toolkit described in Sec. 6. By understanding the "invisible" needs of the site, we can design a kinetic skeleton that provides safety and efficiency without needing to build massive, permanent walls that would clutter the landscape during quiet periods.

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2.3 Case Study: Kanakakkunnu Palace Grounds

2.3.1 Site Context and Resting State

Kanakakkunnu Palace in Thiruvananthapuram serves as a primary example of how a historic site can function as a high performance urban lung by maintaining a balance between historical preservation and public utility. In its resting state, the site operates as a quiet public park used for walking, relaxation, and informal social gatherings, providing a necessary escape from the surrounding urban densityThe site relies heavily on its natural topography rather than heavy construction to define its various functional zones. The open meadows and wooded slopes provide a natural cooling effect for the city, acting as an ecological anchor that helps regulate the local microclimate. Because the necessary infrastructure for large gatherings is either tucked away or designed to blend into the landscape, the site does not feel like a massive, empty event venue when it is not in use. This balance is critical for achieving true spatial elasticity; it ensures the space remains valuable and accessible to the daily citizen even when no major festival is occurring, preventing the site from becoming a dead zone in the city's heart.

2.3.2 The Active State: Institutionalizing Transience

During peak periods, such as the famous Nishagandhi Dance Festival, the site undergoes a total transformation into its active state. Thousands of people descend on the grounds simultaneously, yet the site manages to host them comfortably without suffering from the typical infrastructural paralysis. This success is due to what we call a "Kinetic Skeleton" of permanent service points that are strategically placed to support mass occupancy. The open air theater, for example, is built directly into a natural hillock, which allows for perfect sightlines for the audience without the need for massive, permanent concrete stands that would ruin the park's aesthetic.We discussed the importance of infrastructure auditing; at Kanakakkunnu, the presence of latent utility connections allows for the rapid setup of professional lighting, sound systems, and temporary stalls. This readiness ensures that the transition from a quiet park to a global cultural stage is seamless and does not damage the sensitive historical or natural environment, effectively institutionalizing transience through permanent preparation.

Site	City	Spatial Character	Cultural Use / Events	Relevance to Your Study
Ramlila Maidan	New Delhi	Large open urban ground	Religious festivals, rallies, public gatherings	High-capacity event ground (elastic crowd use)
Azad Maidan	Mumbai	Central Urban Maidan	Protests, sports, political gatherings	Public + political + social overlap
Thekkinkadu Maidanam	Thrissur	Circular sacred ground	Thrissur Pooram	Public + political + social overlap
Bannimantap Parade Grounds	Bannimantap Parade Grounds	Ceremonial parade ground	Mysore Dasara events	Seasonal transformation of space
Cubbon Park	Bengaluru	Large Green Urban Park	Public events, informal gatherings	Daily + occasional event hybrid
Lalbagh Botanical Garden	Bengaluru	Botanical Garden	Flower shows, exhibitions	Controlled by large scale events
Nehru Park	New Delhi	Landscaped Park	Music festivals, cultural programs	Leisure + event layering
Mohor Kunja	Kolkata	Designed cultural park	Open-air stage, performances	Designed cultural interface
Surajkund	Faridabad	Large fair ground	Surajkund International Crafts Mela	Temporary mega cultural hub
Gandhi Maidan	Patna	Massive Central Ground	Political rallies, fairs	Large Scale crowd adaptibility
Maidan	Kolkata	One of largest urban greens	Sports, rallies, festivals	Multi-layered urban field
Garden of Five Senses	New Delhi	Thematic landscape + amphitheatre	Festivals, exhibitions,	Designed experiential

			performances	cultural space
Rock Garden	Chandigarh	Sculptural landscape	Tourism plus cultural management	Art-driven p interaction
Oval Maidan	Mumbai	Open sports ground	Recreation gatherings	Everyday + flexible usage
Shivaji Park	Mumbai	Neighborhoo park-ground	Sports + political gatherings	Hybrid civic + social space

Table 3 : Site Selection Criteria

2.4 Discussion: The Bengaluru Context

2.4.1 The Elasticity Deficit

When we apply the lessons learned from the Kerala model to a rapidly growing city like Bengaluru, we observe a significant and troubling elasticity deficit. Bengaluru has expanded at an incredible pace as a global tech hub, but its public spaces have remained rigid or have been systematically replaced by private, enclosed malls. This "mall-ification" of the city severely limits the ways in which different social groups can interact. Most municipal parks in Bengaluru operate under strict rules and fixed closing times, which prevents the kind of "loose" social appropriation found at sites like Kanakakkunnu. The total lack of kinetic infrastructure in high growth areas like the IT corridors means that any attempt at a community event often leads to total traffic gridlock and local frustration. The city has become a collection of static islands, offices, apartments, and malls with no flexible, democratic bridges between them to support a shared public life.

2.4.2 Design Response: The Third Place

To fix this disconnect, the research proposes the creation of a series of elastic hubs designed to act as a "Third Place" , a vital social space that is neither the home nor the work environment but a democratic ground for social mixing. These hubs would use the skeleton skin framework to provide a high tech backbone for local culture, specifically tailored to the needs of a diverse urban population. Instead of proposing a single, massive building, the response is a network of adaptive landscapes that can support the diverse needs of both long term local residents and the transient, migrant tech population. By integrating the utility pedestals and kinetic shading systems, these spaces can host a local farmers market in the morning and a high tech coding workshop or digital art gallery at night. This approach turns the traditional "urban void" into a productive, performative landscape that evolves in real time with the city's pulse, ensuring that the physical environment is as smart and flexible as the people living within it.

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2.4.3 The Socio-Spatial Friction in Digital Hubs

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2.4.4 Decoding the Infrastructure Deficit

Beyond the social aspect, there is a technical infrastructure deficit that hinders the city's ability to host spontaneous or cyclical events. In most Bengaluru neighborhoods, the existing utility networks for water, power, and waste management are already stretched to their limits. When a community festival or a public market is organized, the lack of a "Kinetic Skeleton" means that temporary, unsafe solutions are used. Makeshift electrical lines often hang dangerously low over streets, and open drains are used for waste disposal during mass gatherings.Infrastructure audit, these temporary fixes are not only dangerous but also economically wasteful. The city spends significant resources on setting up and tearing down temporary infrastructure that could be replaced by the permanent, latent systems. By institutionalizing these services, the city can reduce the physical and financial strain of hosting the ephemeral rituals that define its culture.

2.4.5 Adaptive Translation of the Kerala Model

To bridge the gaps identified, this research proposes an "Adaptive Translation" of the Kerala model, specifically the lessons learned from Kanakakkunnu. This does not mean copying the palace architecture, but rather translating its logic of spatial elasticity into the urban fabric of Bengaluru. This translation involves identifying underused "voids" such as neglected government land or areas under flyovers and equipping them with the modular kit-of-parts. For instance, a derelict lot in an IT park can be transformed into a high-performance hub by installing the plug-in utility pedestals and permeable surfaces discussed in Sec. 6. This allows the space to function as a quiet park during work hours

while being ready to transform into a vibrant food street or cultural stage in the evening. This strategy ensures that the city's growth is matched by a growth in its social resilience, creating a network of elastic spaces that can respond to the unpredictable rhythms of a modern metropolis.

2.5 Design Prototype: Modular Kit-of-Parts

2.5.1 Plug-in Utility Pedestals

The core of the design prototype is the Plug-in Utility Pedestal (PUP). These are permanent, weather-proof nodes installed throughout a public site. They provide safe access to electricity, high speed data, and water. As identified in Sec. 3.2, the biggest danger during temporary events is makeshift wiring. The PUP system eliminates this risk by institutionalizing the service layer. When not in use, these pedestals are flush with the ground or designed as seating, ensuring they do not clutter the "resting state" of the park. During an event, they act as the "kinetic skeleton" that supports whatever "skin" or stall is plugged into them.

2.5.2 Telescopic Shading and Kinetic Pavilions

To handle the intense Indian sun and the sudden arrival of seasonal rains, the prototype includes advanced telescopic shading systems. These are retractable, lightweight roofs that can be deployed based on the current weather conditions or the specific size of the crowd expected for an event. Unlike permanent concrete sheds or metal roofs, these kinetic structures do not block views, trap heat, or ruin the feeling of being outdoors when they are not needed. They allow the public space to "breathe" while providing high performance protection during active cultural events. This supports the primary goal of spatial elasticity by allowing the physical volume and character of the space to change instantly based on immediate community needs, making the architecture a responsive participant in public life rather than a static bystander.

2.5.3 High-Performance Surfaces

Finally, the toolkit includes a system of permeable, high performance surfaces designed to solve the common problem of site degradation. These surfaces are engineered to prevent the soil compaction and drainage issues that usually occur in heavily used city parks after a major event. By using a sophisticated grid of reinforced grass, porous stone, and structural soil materials, the ground can handle heavy foot traffic and the weight of temporary stages without losing its ability to absorb rainwater and support plant life. This ensures the long term ecological health of the site, preventing it from turning into a muddy or dusty wasteland after a festival. By making the ground itself part of the kinetic infrastructure, the urban hub becomes truly resilient and capable of recovering quickly from the stresses of high intensity public use.

2.5.4 The Digital Layer and Real-Time Management

To supplement the physical components, the research proposes a digital management layer as the final piece of the modular kit. This interface acts as the brain of the kinetic hub, using sensors integrated into the utility pedestals to monitor crowd density, energy consumption, and environmental health in real time. For a rapidly evolving city like Bengaluru, this digital layer allows site managers to adjust the deployment of telescopic shading or redirect crowd flows through mobile notifications. By using augmented reality (AR) wayfinding, the space can provide information about ephemeral events without the need for physical signboards that would clutter the park during its resting state. This integration of digital technology ensures that the spatial elasticity of the site is not just a physical capability but a smart, data-driven system that improves the efficiency and safety of the socio-cultural hub.

Fig -1: **Kanakakunnu Palace;** Image by KIOMOI TRAVEL

Fig -2: **Nishagandhi open-air auditorium;** Image by The New Indian Express

3. CONCLUSIONS

3.1 Key Findings

The research concludes that the future of Indian urbanism lies in the adoption of spatial elasticity rather than a continued reliance on static permanence. By designing a kinetic skeleton consisting of hidden services and flexible, polyvalent landscapes, we can create public spaces that are both technologically advanced and socially inclusive. The detailed study of Kanakakkunnu Palace grounds proves that architecture does not need to be a heavy, unmoving monument to be effective in the public realm. Instead, it should be a living, breathing platform that empowers the transient, moving nature of the people it serves. This approach allows the city to grow and change without the need for constant, expensive demolition and reconstruction, offering a more sustainable path for urban development in the twenty-first century.

3.2 Recommendations

It is strongly recommended that city planners and architects move away from rigid, single use zoning and instead embrace polyvalent spaces that can change roles multiple times throughout a single day. Municipal bodies should invest in the modular kit of parts mentioned in Sec. 6 to reclaim and revitalize underused government lands, abandoned industrial sites, or neglected park corners. By providing what we call a "vernacular of resilience," we can ensure that our cities remain vibrant, democratic, and fully capable of hosting the rich and unpredictable cultural life of India for generations to come. Urban design must stop trying to control how people use space and instead start providing the high performance tools that allow people to create their own vibrant city.

2.6 Future Research

Furthermore, future research should explore the integration of "Bio-Kinetic" infrastructure—systems that combine living ecological elements with mechanical adaptability. This could include responsive vertical gardens that expand for natural cooling during heat waves or bio-filters that treat waste generated during mass ephemeral events. As the world faces increasing climate instability, the need for public spaces to act as both social hubs and ecological safety nets will grow. Investigating how spatial elasticity can be used to manage urban flooding or provide emergency disaster relief will be a critical next step in ensuring that our cities are not just culturally vibrant, but also physically resilient in the face of an uncertain future.

Bauman, Z. (2000). Liquid Modernity. Polity. Mehrotra, R. (2008). The Kinetic City. Architectural Design.

ACKNOWLEDGEMENT

The completion of this research paper on Spatial Elasticity would not have been possible without the guidance and support of several individuals and institutions. I would like to express my sincere gratitude to everyone who contributed to the development and refinement of this study.

First and foremost, I extend my deepest thanks to my guide, **Prof. Chaithra K B**, Assistant Professor at the School of Architecture, CHRIST (Deemed to be University). Her insightful feedback, constant encouragement, and academic rigor were instrumental in shaping the theoretical framework and design direction of this research. Her patience in helping me navigate the complexities of kinetic urbanism and spatial elasticity is truly appreciated.

I would like to express my gratitude to **Prof. Dr. Vishnu P Prakash**, Dissertation Coordinator and Assistant Professor at the School of Architecture, for his systematic coordination and support throughout the various stages of this research process. I am also thankful to **Prof. Dr. Harshalatha A P**, Associate Professor, for her valuable academic insights and critical review which helped strengthen the quality of this manuscript.

I am grateful to the **School of Architecture, CHRIST (Deemed to be University), Bengaluru**, for providing the resources and the academic environment necessary to pursue this dissertation. The facilities and the collaborative atmosphere of the institution allowed me to explore innovative ideas beyond traditional architectural boundaries.

A special thanks goes to the authorities and staff at the **Kanakakkunnu Palace Grounds** in Thiruvananthapuram for their cooperation during my on-site research and data collection. Their assistance in understanding the operational logic of the site was vital for the case study analysis presented in this paper.

Lastly, I would like to thank my family and peers for their continuous moral support and constructive discussions throughout this journey. Their belief in my work kept me motivated to complete this research within the designated timeframe.

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BIOGRAPHIES

I am **Alen Vinayaraj**, a student architect and researcher currently pursuing a Bachelor of Architecture at the **School of Architecture, CHRIST (Deemed to be University), Bengaluru**.