Employing Lessons from Traditional Water Tank Spaces to Enhance the Spatial Vitality of Contemporary Public Spaces: Insights from the Temple Tanks of Madurai, India.

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Abstract

It is well known that the lack of appropriate urban design and planning strategies has resulted in the degradation of the urban environment. Subsequently, it has also affected the quality of urban life. As cities evolve, rediscovery of both the formal and informal public spaces therefore becomes essential. Public spaces adjacent to traditional urban water bodies, such as temple tanks serve as a crucial interface between water and land, reflecting the characteristics and images of cities. In this context, this study investigates users' perceptions and affinity towards these water-based public spaces of Madurai, Tamilnadu, India with a particular focus on temple tanks with a cultural setting.

In this study, a mixed method approach was adopted to assess spatial vitality. This included photo documentation, a questionnaire survey, and mapping of behavioral patterns and activities within the selected case study area. The study also examined the relationship between user behavior and various physical and cultural attributes of temple tanks.

The findings reveal that water serve as a significant pull factor in public space design, contributing to people's engagement. The presence of water enhances the microclimate and creates a comfortable environment in the dense urban context of Madurai. In addition, attributes such as visual images, scale, public realm, and commercial activities contribute to the spatial vitality of these public spaces. The study identifies key attributes of a public space that contribute to the creation of a successful public space in culturally rich tropical urban areas.

Keywords: Diversity, Social Behaviour, Spatial Attributes, Temple Tanks, User Perception.

Introduction

India, an age-old civilization known for its rich tradition of public spaces, historically supported both formal and informal gatherings, facilitating social, cultural, and religious

activities. Traditionally, public spaces in Indian cities were vibrant hubs for community interaction, often blending social, cultural, religious, and ecological functions. Among these, water-based sanctum ponds or temple tanks, stand out as iconic features of the urban landscapes. These spaces, intricately woven into the socio-religious fabric of the Indian society served as the venues for rituals, communal gatherings and festivals, while also addressing critical needs such as water conservation and urban cooling. However, with rapid urbanization, modernization, and changing lifestyles, the prominence and vitality of such traditional spaces have diminished, raising concerns about their preservation and adaptation in contemporary urban contexts.

In contemporary Indian cities, the need to reimagine and revitalize public spaces has become increasingly important. As cities expand and densify, urban open spaces are increasingly viewed as an essential element in improving the quality of life for the urban residents. Public spaces play a crucial role in enhancing urban livability by providing opportunities for social engagement, recreation, and cultural exchange. This has pressed urban planners and designers to seek ways to restore the spatial vitality of traditional spaces, like temple tanks, while also addressing the needs of modern urban environments.

This study examines the potential of traditional water-based public spaces, specifically temple tanks in Madurai, Tamil Nadu by exploring the concept of spatial vitality and its relevance to contemporary public space design. Temple tanks, which traditionally functioned as a communal and ecological hub, offer lessons in inclusiveness, environmental sustainability and cultural vibrancy. By investigating users' perceptions and behavioral patterns, this study aims to explore the socio-spatial value and spatiotemporal nature of public spaces to identify determinants of spatial vitality. Further, it focuses on how the vitality of traditional water tanks in Madurai can guide the design of contemporary urban public spaces in India. The objectives of the study are:

- To assess users' perceptions of traditional water-based public spaces, particularly temple tanks in Madurai.
- To identify the morphological and spatial characteristics that enhances spatial vitality.
- To explore the relationship between user behavior, spatial vitality, and the physical environment in temple tanks.
- To propose design strategies for improving the vitality of public spaces based on the findings.

Theoretical Framework

This study employs theoretical perspectives related to the role of public realms as dynamic spaces influenced by spatial, temporal, and cultural factors. It engages theoretical ideas related to design elements such as scale, accessibility, and active edges significantly contributing to fostering user engagement and enhancing the sense of place within these spaces.

Understanding Public Space and Public Realm

Public spaces are critical elements of urban environments, facilitating social interaction, cultural exchange, and ecological functions. However, the term "public space" is broad, encompassing a variety of spaces, from streets to parks and plazas, each serving different functions depending on the context. Bedimo-Rung et al. (2005), Bertram and Rehdanz (2015), Chen et al. (2016), and Sugiyama et al. (2010) argue that public spaces, serving as the "lungs" of cities, are essential for social, recreational, and economic activities, supporting urban life and benefiting residents. Dallimer et al. (2014), Kaczynski and Henderson (2008) and Kaplan (1989) suggest that urban open spaces offer significant advantages, including mitigating issues like air and water pollution, heat stress, noise, and flooding, while also enhancing health and well-being through accessible green spaces. A vibrant urban public space is seen as safer, more inviting and desirable, offering more opportunities for social activities and cultural exchange. Jalaladdini and Oktay (2012) and Jian et al. (2020) emphasize that effective placemaking processes are instrumental in

enhancing the social and cultural relevance of public spaces, solidifying their role as integral components of community life. Xia et al. (2020) assert that the social construction of space arises from the assembly of individuals within a specific place and time, shaped significantly by the spatial morphology.

According to Gehl (2011), if we start observing city life and the interaction with the physical environment, even the most mundane street corner or an ordinary public place looks to be the most exciting spot. In this context, it is necessary to differentiate public space from the public realm. Pioneers have discussed that public realms are social, and are not just physical territories. The existence and nature of a public realm within a physical space is not determined by fixed cultural or legal designations; instead, it is shaped by the interactions and perceptions of the people who use it. However, whether a space is perceived as private, public, or parochial depends on social and contextual factors rather than immutable classifications.

Indeed, inthis context, Lofland (1998) argues that the proportions and densities of relationship types in public spaces are fluid, constantly shifting in response to various social dynamics. The public realm is hence a subset within the larger public space boundary where the intensity of activities and density of people are much higher as compared at various locations within the same public space. The volume and the area of this subset (public realm) can be as small as one corner or as equal to its larger unit (public space) depending upon the intensity of activity and density of people present and it may or may not be confined to a particular location within the public space. Public realm volume hence can be considered as a resultant volume due to people's behavior within a public space at a given particular time.

Temporal Qualities and Behavioural Settings in the Public Realm

To reveal the potential of the public realm in improving temporal quality of a space, it is necessary to understand how people utilize and experience a space. According to ecological psychologists Barker who coined the phrase in the 1960s and later expanded by Lang (1987), public spaces are understood through their behavioural settings. Places are temporal settings, and these settings consist of standard or re-occurring behaviour patterns, which may be different for different people at different times of the day, week, or year. This pattern could also be reoccurring at a certain pattern daily or yearly during the festivals or celebrations. Everyday activities such as walking, informal gatherings and social practices all create a pattern together that constitutes the temporal nature of a place. The time a user takes to stay or walk in a place says how good a public place is physically or psychologically. In fact, how fast people walk in a place depends upon the weather, age, mobility and errands; whether the person is alone or walks in a group. Jalaladdini and Oktay (2012) observe that lonely individuals walk faster than those in groups, while men tend to walk faster than women or teenagers. Thus, public spaces are not static; they are dynamic systems where human behaviour interacts with the physical environment.

Spatial Vitality and its Determinants

The concept of spatial vitality refers to how well a public space supports a variety of activities and social interactions, making it an active, vibrant place. Mass (1984) defined spatial vitality as a synergic result of coexisting heterogeneous pedestrian population and economic and entertainment opportunities. According to Montgomery (1998), vitality in urban spaces is marked by the presence of people at different times of the day, the frequency of social and cultural events, and the variety of uses for the space. Jacobs (1992) and Lynch (1981) contend that vital public spaces foster social interaction, stimulate economic activity, and instill a sense of security, all of which contribute to the overall livability of a city. Jacobs (1992), Khalili and Fallah (2018), Liu et al. (2017), Mu et al. (2021) and Xu et al. (2018) emphasize that the regenerative capacity of urban open spaces, along with their role in promoting vitality, services, and ecological outcomes, remains a key focus for researchers and planners. Urban vitality is a crucial characteristic since it lowers crime, promotes the viability of commercial endeavors, increases passive enjoyment of the area through people-watching,

fosters social contact, and also offers chances for cross-cultural interchange. Jennings and Bamkole (2019) and Xia et al. (2020) define "spatial vitality" as the use and activity intensity of urban public spaces, such as waterfronts, parks, and streets.

Rashid et al. (2021) find that regions with organized socio-spatial structures and more residential land use show higher spatial vitality, which supports greater female presence. Furthermore, many studies have presented the positive relation between spatial vitality and high-density areas. These findings imply that proximity to these public spaces in high density locations increases contact and, hence, the possibility for innovation. Based on the literature reviews, two categories of determinants to measure spatial vitality:

Environmental determinant (Physical and ambient characterization of public space controlling human actions) and social determinant (limitation in human behavior because of restrictions offered by the spatial structure of public space concerning prevailing social construct), can be extracted to develop the conceptual framework as shown in Fig 1. One of the key arguments for this study that enforces the social determinant lens is the impact of culture or religion-specific visual images of traditional public spaces on spatial vitality. Spatial vitality of a public space is thus a performance criterion of a spatial structure based on its ability to achieve equitable socio-cultural impact.

Such socio-cultural impact can be evaluated using factors that include equity and diversity, concentration, accessibility, and livability. To evaluate human behavior within a designed or designated public space, it is important to discuss the observation in comparison to the contextual socio-cultural environment. Studies by Fang (2021) have analyzed spatial characterization of urban vitality and proved the direct correlation of diversity and accessibility to urban vitality.

Işiklar (2017) has concluded aspects of vitality as a result of measured liveability factors. Kang (2020) has also presented diversity as factors related to space, time and activities and has evaluated them as essential components of urban vitality. Thus, these chosen factors of socio-cultural environment become appropriate for the study. However, since the focus of this study is based on a religiously exclusive traditional public space, it is imperative to include the factor of equity to diversity. Equity in public places evaluates the religious and cultural inclusivity of the demographics at a particular time of observation.

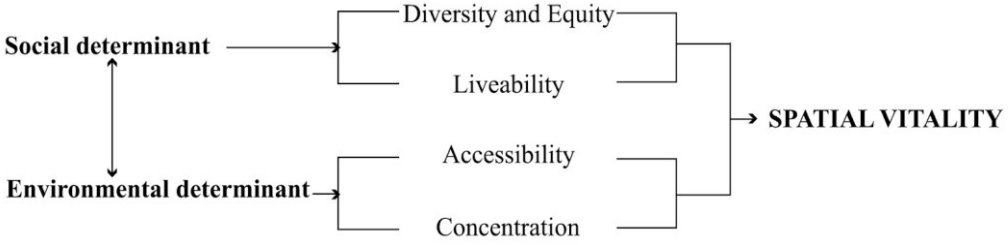

Fig. 1: Conceptual Framework
Source: Author

These key concepts such as public space and the public realm emphasize how spatial vitality is influenced by temporal qualities, behavioral settings, and design elements.

Background: Spatial Vitality of Temple Tanks in Urban India

The spatial vitality of traditional water tanks, particularly temple tanks, plays a significant role in shaping urban public spaces in India. These historical water bodies have not only served as functional reservoirs but have also been integral to the social, cultural, and ecological fabric of urban communities.

With the increasing urbanization of Indian cities, understanding how these spaces contribute to the vitality of public realms has gained importance. In fact, there exists a dynamic relationship between spatial vitality and traditional water tanks and performs a role as public spaces within the urban Indian context. The factors that influence their vitality,

include morphology, cultural significance, and ecological benefits and can provide great insights into how these ancient spaces can inform contemporary urban design.

Linking Spatial Vitality with Traditional Water Tanks in India

In the context of this study, traditional water tanks, specifically temple tanks in Madurai serve as the focal point for examining spatial vitality. These temple tanks historically functioned as central public spaces in South Indian cities, providing a setting for both religious rituals and everyday social interactions. The spatial vitality of these tanks is deeply rooted in their physical form and socio-cultural significance. Traditionally, they served as inclusive gathering spaces, welcoming people from diverse backgrounds during festivals, religious ceremonies, and daily activities. Their centrality within the city's spatial and cultural fabric has made them crucial hubs of social and economic activities. However, with modernization and rapid urbanization, the role of these tanks has diminished. Many have been neglected, while others have lost their cultural and ecological significance. This shift has diminished the spatial vitality of these areas, highlighting the importance of exploring their potential to be revitalized as contemporary public spaces.

Evaluating the Spatial Vitality of Temple Tanks

In evaluating the spatial vitality of temple tanks, this study focuses on the following:

- Inclusiveness: The degree to which temple tanks can serve as an inclusive public space, welcoming people from different social, religious, and cultural backgrounds. Given the religious significance of these tanks, inclusiveness becomes a critical measure of vitality.
- Aggregation Density: This refers to the concentration of people in and around the temple tanks at different times of the day or year. A higher aggregation density typically indicates a more vibrant public space, as it suggests that the space is actively used by a wide variety of people for different purposes.
- Use Intensity: This refers to the range and diversity of activities that take place in the space. A public space with high use intensity is one that supports a variety of activities, from passive uses like sitting and people-watching to more active uses like social gatherings, festivals, or religious ceremonies.

By studying these factors, this research ascertains how temple tanks, as traditional public spaces, can inform the design of more inclusive and vibrant contemporary public spaces in Indian cities.

The Role of Morphology in Spatial Vitality

The morphological characteristics of public spaces, including the layout, shape, and scale, also have a significant impact on spatial vitality. Temple tanks are usually characterized by their large, open water bodies surrounded by steps, pavilions, and sometimes greenery, creating a multi-functional space that can be used for different activities. This morphology supports flexibility in use, allowing the space to adapt to various social and environmental conditions. In contemporary urban design, this flexibility is a crucial feature for enhancing spatial vitality. Gehl (2011) emphasizes that public spaces capable of accommodating diverse activities and adapting to changing user needs are more effective in fostering social interactions and engagement.

Cultural and Ecological Value of Temple Tanks

Temple tanks not only serve social functions but also offer ecological benefits. They contribute to water management, regulate micro-climates, and enhance urban biodiversity. This makes them unique compared to other types of urban public spaces, such as plazas or parks. In the context of sustainable urbanization, the ecological psychology framework is relevant, as it helps understand how people interact with and perceive these water-based

public spaces. The concept of behavior setting plays a crucial role here, as the activities performed around these tanks are closely tied to the ecological functions of the water bodies.

The cultural significance of temple tanks further enhances their potential as vibrant public spaces. Religious festivals, rituals, and community events create temporal vitality, where the space becomes highly active during specific times of the year. This temporal dimension adds complexity to the spatial vitality of the temple tanks, as the vibrancy of the space may vary significantly between daily use and festival periods.

Temple Tanks as Public Spaces in Urban Indian Context

A layout of a temple always includes a tank–a tank revered and dedicated to God in almost every South Indian village, and there are also several in Indian towns and cities. To drink, one has to wash one's hands and feet before entering the temple. Occasionally to irrigate temple grounds, one would utilize water from the temple tank. In the Tamil month of "Maasi," worshippers disperse throughout 10 days. Through the main processional streets, the deity is carried in procession. Numerous devotees are attracted to other festivals and auspicious days throughout the year, particularly in the Tamil months of "Aypasi" and "Maasi." Hence, thousands of devotees from far and near congregate to these sanctum ponds to have their holy dip. Some of the sanctum ponds outside the temple are the ones at the Teppakulam Mariamman Temple at Madurai, Parthasarathi temple at Thiruvallikeni and the Kapaliswara temple at Mylapore. They were recognized as a valuable source of sustenance, irrigation, agriculture, water supply for men and cattle for several decades. Respect for water in general and temple tanks are an inborn cultural trait of the South Indian people.

The temple tanks are revered and held in high regard. The celebrations connected to the harvest are always celebrated at the same time. At the same time, the most crucial resource for an agricultural society is water. Therefore, worshiping water is fundamental to Indian culture. The significance of water in people's life is represented by the Sacred Tanks in this context. It is also a familiar scene in certain temples (eg. Meenakshi Amman Temple, Madurai) to see people spend their evenings sitting on the steps of the tank enjoying the cool breeze and listening to discourses or musical performances.

A few important festivals center on the temple tank like the Teppotsavam and the Theerthavari. The Teppotsavam or float festival takes place in all the major temples of Tamilnadu, usually in the Tamil month of Maasi. The principle procession deity (utsava vigraham) is placed in an ornamental wooden mandapa which floats around the tank several times. Devotees congregate all around the steps to watch and worship the deity.

In the center of the major temple tanks, there is a pillar mandapam called neerazhi mandapam. Sometimes the deity would be placed in the center of the mandapa, Vedic chanting and musical (Nadaswaram) performances would take place. Some of the famous teppakulam are at Trichy, Madurai (Vandiyur Teppakulam), Thanjavur, Kanchipuram, Tiruvarur, Mannarkudi etc. Theerthavari is the concluding festival on the tenth and the last day of the annual Brahmotsavam. The deity is given a ceremonial bath. All the devotees also take bath on the occasion; eg. Theerthavari festival for Lord Srinivasa in the Swami Pushkarini tank is famous.

With rapid urbanization in almost all traditional cities and towns of South India, religious sanctums have largely adapted functions other than religious activities. Though these traditional religious public spaces host commercial activities that are greatly dependent on the footfall of cultural orientation, they also attract people for recreation. Hence, these spaces positively contribute to the demand for public spaces due to urbanization in such dense traditional cities. Studies have proven this phenomenon of functional changes of temple tanks in relation to the change in its surrounding land use (Srirangam and Forsyth, 2012). These spaces can hence be classified as water-based traditional urban open spaces that are timeless - Ephemerals owing to their unchanged visual image and changing functional attributes (Prosperi, 2012).

The crucial role of temple tanks in urban Indian contexts is undeniable. It emphasizes their spatial vitality, morphology, and cultural and ecological significance. Unarguably, these

traditional spaces continue to shape public life, offering valuable insights for contemporary urban design and planning.

Research Methodology

The research adopts a mixed-method approach, incorporating case studies to explore users' perceptions and their affinity towards temple tanks as urban open spaces in Madurai, India. One key indicator of quality of life is the presence of other people, whose interactions contribute to the vibrancy of urban spaces and offer insight into the social dynamics of these areas (Gehl and Svarre, 2013). This study employs a methodology, as outlined in the Fig. 2.

In order to assess the spatial vitality of the public realm, it is essential to understand how people engage with the space to meet their needs. To systematically capture these interactions, the study poses fundamental questions: who uses the space, what activities are occurring, and where are these interactions taking place? The field study utilizes several techniques, including questionnaire surveys, mapping of behavioral patterns and activities, footfall counting and tracing, and photo documentation. These methods provide a comprehensive understanding of the spatial dynamics and social interactions within the temple tank spaces.

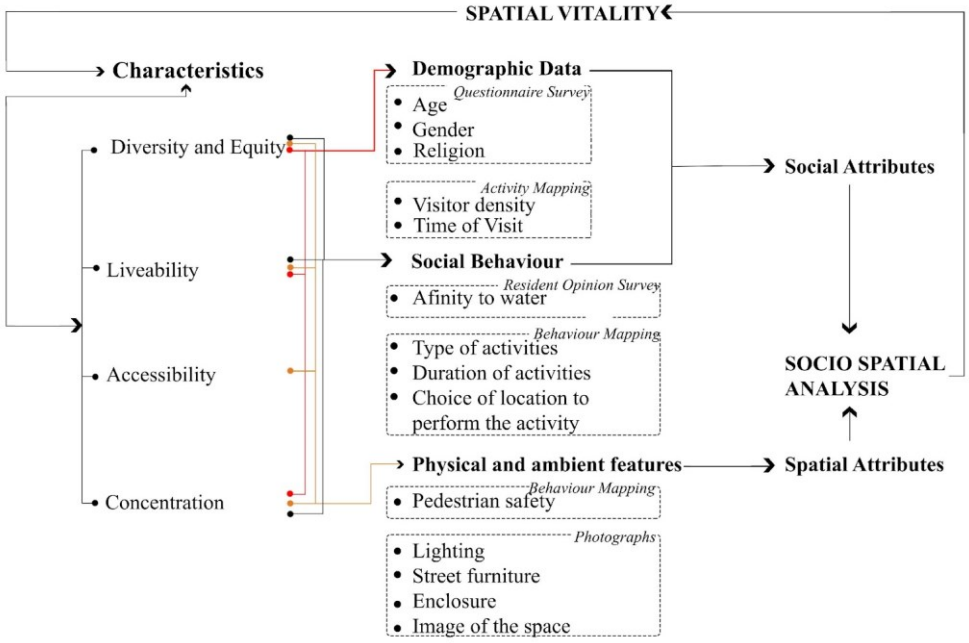

Fig. 2: Methodology Flow chart
Source: Author

Introduction to Case study

One of the oldest continuously inhabited towns in the world, Madurai is a temple city in the South Indian state of Tamil Nadu. For more than 2000 years, it has served as a significant cultural hub. Madurai's population is rapidly increasing, causing considerable stress and the transformation of various open spaces into built environments.

Since the study emphasizes the spatial vitality of a water-based traditional urban open space located in Madurai, it becomes critical to understand the affinity of the people to such open spaces within the wider category of recreational spaces available in the city. First, an online questionnaire survey was conducted to evaluate the affinity of people toward a water-based open space. The survey recorded over 250 responses. The results of the survey, shown in Fig. 3, concluded that water bodies such as huge temple tanks in cities are one of the most important leisure elements that draw people for relaxation. Further, it revealed that people had more affinity towards water as it had dynamic characteristics throughout the day and across

various seasons (Herzog, 1985, Kaplan, 1989). It also acted as a major breathing space for the urban dwellers.

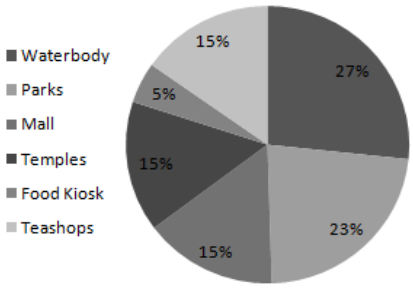

Fig. 3: Affinity of people toward water-based urban open space: Results obtained from the questionnaire survey
Source: Author

Water Bodies in Madurai were mapped as shown in Fig. 4. Madurai city has 10 temple tanks (Centre for Urban Water Resources, 2018) and Vandiyur teppakulam is found to be the largest temple tank in south India. It was created at the site where the sand was excavated for the construction of Thirumalai Nayakar Mahal, Madurai, a palace for the Nayak king who ruled Madurai from 1623 to 1659.

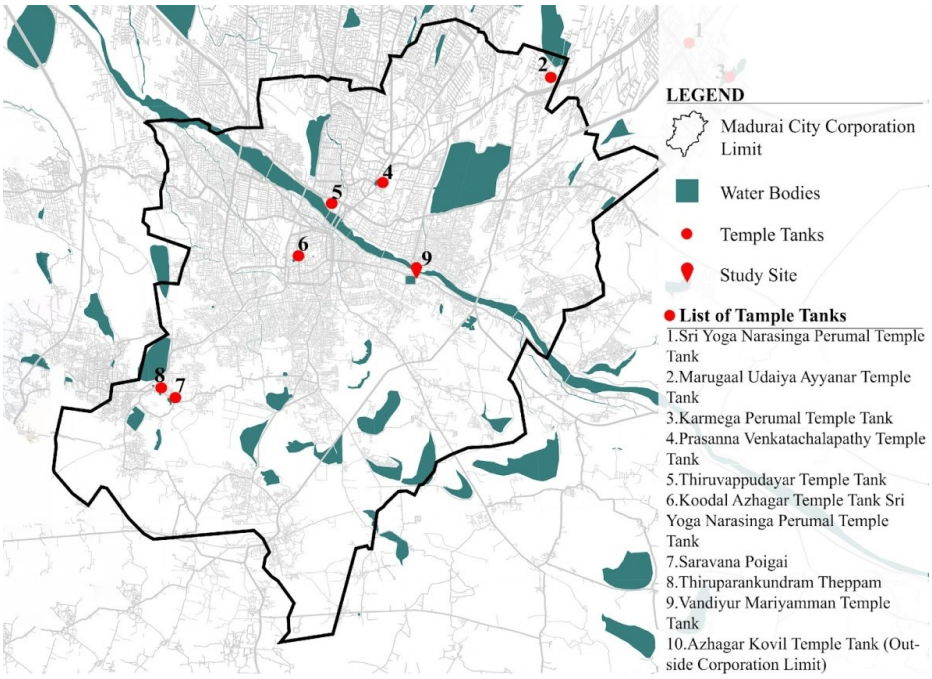

Fig. 4: Map showing the location of various water bodies at Madurai.
Source: Author

Vandiyur Mariamman teppakulam spans 305m x 285m with 12 padithurai or stepped seaters, as shown in Fig. 5 (3 padithurai on each side). Some of the major landmarks found along the road abutting the Teppakulam are Thiagarajar College of Arts & Science and Mariamman temple towards the north, Meenakshi Sundareswarar Girls Higher Secondary School towards the west, and Sourashtra club towards the east. The identified case study has a steady stream of visitors with an established built environment. This place attains its livelier aura during the teppotsavam or float festival that happens during the month of January or February. The recreation facility was inaugurated after the Madurai Corporation filled Theppakulam with Vaigai water. The recreation facility included boating activity. The built

fabric and land use around this theppakulam transformed considerably with urbanization. However, the visual image of Vandiyur Mariamman thepakkulam remains timeless. Hence Vandiyur Mariamman thepakkulam becomes an ideal case study for this research.

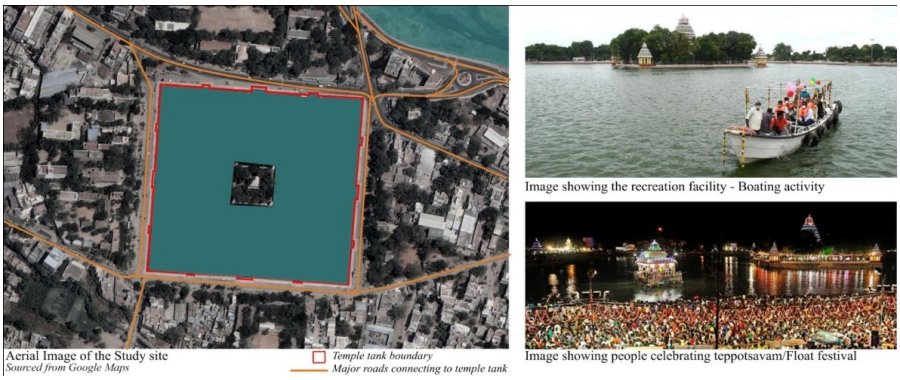

Fig. 5: Identified study site Vandiyur Mariyamman Teppakulam
Source: Author

Data Acquisition and Processing

The study is carried out to explore the relationship between human behavior (usage patterns of public spaces based on social behavior) and the physical environment. The four qualitative characteristics of spatial vitality diversity and equity; liveability; accessibility and concentration are assessed and documented using various data mapping techniques. Data required for the study were broadly considered under three sets: 1. Demographic data (age, gender, religion, visitor density, time of visit), 2. Social behaviour (type of activities, duration of activities, choice of location to perform the activity within the case study area), and 3. Physical and ambient features (lighting, pedestrian safety, street furniture, enclosure, and image of the space).

Counting and Tracing Footfall

To record the required demographic data and social behaviour within the case study, a manual counting and tracing of footfall was carried out along with the questionnaire survey. Counting, as the name implies; is generally the counting of people performing certain tasks over a period at regular intervals. Thus, by referring to the previous researchers, user characteristics such as age, gender, and activity were recorded by counting.

Mapping of Behavioral Patterns and Activities

Manual plotting of activities was carried out asceri the types of activities performed within the site. The activities that were observed on the site are classified under four major categories, namely: 1. Health-related activities like jogging, walking, exercise, and cycling, 2. people-watching, chatting, standing, sitting, idling, and other socially interactive group activities, 3. recreational activities like fishing, children's playing, boating, and 4. commercial activities such as food vending and fabric dyeing. The site gets activated based on the working hours of the surrounding land uses. Hence, the activities of the visitors were observed on weekdays and weekends from 6.00am to 9.00am, 12.00pm to 3.00pm, and 6.00pm to 9.00pm.

Behavioral mapping maps observed people's movements and choice of activity to find the most preferred zones in contradiction to the least used zone. This may vary among different groups of users and, more importantly, age groups. The output of the same is represented in the form of an activity matrix. These matrixes are further substantiated through photo documentation. The physical and ambient features that needed to be correlated to the findings are drafted manually and are embedded in the base map used for behavior and activity mapping. The photo documentation of the study site also becomes a vital source to access the traditional and religion-specific image of the place. Further, the diversity of age

groups was quantified using the Simpson Diversity Index (D_SIDI) and Shannon Diversity Index (D_SHDI) (Morris et al., 2014).

Photo Documentation

Photo documentation serves as a crucial resource for accessing the traditional and religion-specific imagery of the place. This visual record complements the findings from the field study and enhances the understanding of the site characteristics.

Questionnaire survey

An online and on-site questionnaire survey was conducted to substantiate the findings derived through observations on the site. The questionnaire enabled the participants to rate their preferences, attitudes, and satisfaction level with the physical elements present and specific issues to be addressed related to the physical environment, functions, and the activities involved. Both comfort and perceptual understanding of public space are highly subjective. Hence, a questionnaire survey with a sample size of 250 through random sampling becomes a source of reliable findings. The respondents were asked to rank their preferences for visiting vandiyur teppakulam with respect to physical environment, functions and the activities involved. The answers are given on a Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree) and 1 (Highly Dissatisfied) to 7 (Highly Satisfied). The statistical analysis was carried out using SPSS software (https://www.ibm.com/in-en/analytics/spss-statistics-software). First, the accuracy of the information identifying the various ways in which users assess the environment was examined using Cronbach's Alpha analysis. Secondly, the Exploratory Factor Analysis (EFA) method helped in identifying whether the components that were identified had a hidden relationship. Cronbach's Alpha analysis as given in Table 1, demonstrates that the data are adequately reliable, with a reliability of 0.778; therefore, the discovered variables further could be used for KMO and Bartlett reliability tests (EFA). According to Table 2, the KMO and Bartlett result for EFA reveals an adequate value of 0.803 ($0.5 < KMO < 1$) and sig.= 0.000 <0.05, indicating that the gathered data is suitable for further investigation. The spatial vitality of a public place is found to be influenced by the first four component elements, as shown in Table 3, which accounts for 60% of the total variance. The rotated component matrix divides the components into four categories, as shown in Table 4, based on how each aspect is loaded into the matrix: protection, comfort, accessibility, and aesthetics.

Table 1: Cronbach's Alpha analysis

Cronbach's Alpha	Number of Items
0.778	12

Table 2: KMO and Bartlett's test results
Source: Author

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.803
Bartlett's Test of Sphericity	Approx. Chi-Square	486.058
	Df	66
	Sig.	<.001

Table 3: Total Variance Explained
Source: Author

Total Variance Explained									
Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% Of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.087	25.726	25.726	3.087	25.726	25.726	2.093	17.440	17.440
2	1.470	12.252	37.977	1.470	12.252	37.977	1.986	14.832	32.272
3	1.390	10.572	49.787	1.390	10.572	49.787	1.797	16.338	46.017
4	1.051	8.758	59.837	1.051	8.758	59.837	1.421	11.838	59.837
5	0.921	7.675	64.512						
6	0.857	7.140	71.653						
7	0.770	6.420	78.073						
8	0.693	5.777	83.850						
9	0.604	5.033	88.882						
10	0.538	4.481	93.364						
11	0.450	3.750	97.114						
12	0.346	2.886	100.000						

Table 4: Rotated Component Matrixes
Source: Author

Factors	Components	Item Description	Rotated loading	% of Variance	Eigen Value
I	Protection	Crowded	.793	25.726	3.087
		Safety	.671		
		Cleanliness	.670		
		Well Maintained footpaths	.615		
II	Comfort	Seating facilities	.726	12.252	1.470
		Adequate lighting	.692		
		Availability of food	.645		
		Health related activities	.608		
III	Accessibility	Parking facilities	.683	10.572	1.390
		Convenient transportation	.477		
IV	Aesthetics	Scenic view	.708	8.758	1.051
		Trees	.562		

5. Findings

Equity and Diversity

In the case study, equity and diversity is established in terms of gender, age groups and groups of people engaged in social activities from the onsite observation. Figs. 6a and 6b show the gender and diversity of the age group of total visitors of the open spaces. The study found that people did most activities in a group, like family or friends both accounting for more than 80% of the total visitors. They were found to be engaged in social interaction activities as shown in the Fig. 6c Vandiyur Mariamman teppakulam derives its name from the location and its association with the temple present in its North. The physical setting of this public space also reflects certain visual clues that represent one particular religion. For example, the red and white colours painted on the ledges of the padithurai reflect the ambiance of a Hindu religious space. However, this water-based public space is observed to

engage people from religious beliefs apart from Hinduism also. This observation can be substantiated by the results from the questionnaire survey which established that almost 14 percent of the respondents are Christians and Muslims as shown in the Fig. 6d. The questionnaire survey and activity mapping also established the fact that almost 60 percent of the respondents come to this space for recreational and leisure activities rather than for religious activities as shown in Fig. 6e. This public place established variety and equity in its population mix despite holding a symbol of a specific socioeconomic classification that might have adverse consequences on the visual-artistic trends in urban architecture.

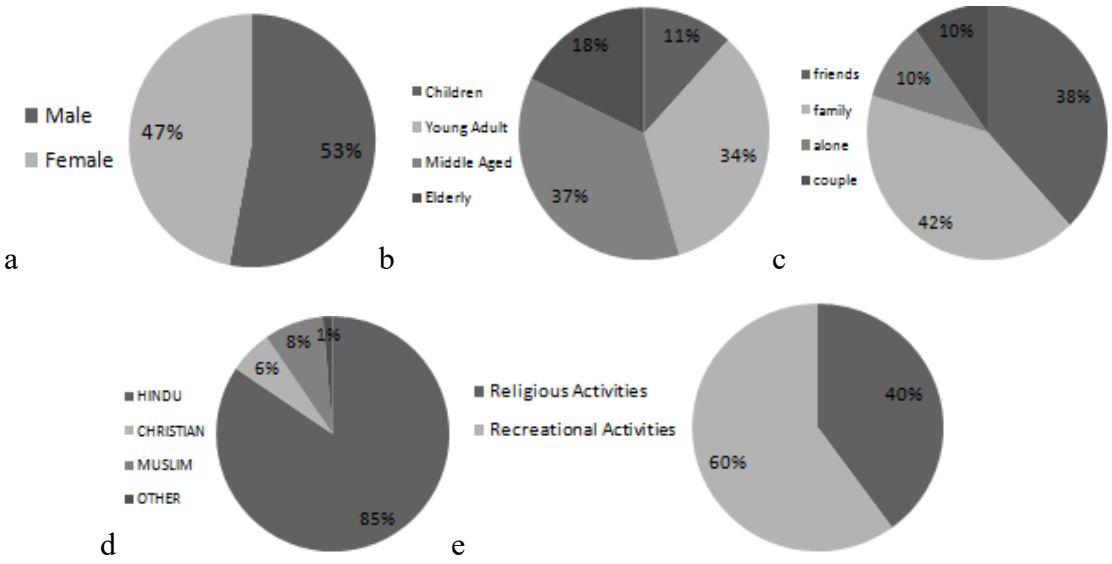

Fig. 6: Demographic data based on a. Gender, b. Age Group, c. Types of user groups, d. Religion, e. Purpose of visit
Source: Author

Further, Fig. 7 shows there exist D_SHDI of 1.3 and D_SIDI of 0.72 for the weekend and D_SHDI of 1.26 and D_SIDI of 0.7 for the weekdays. The Shannon's Evenness for this public space is represented in Fig. 8. The evenness values in all zones are almost similar with values ranging between 0.65 to 1.57 in weekdays and 0.64 to 0.95 in weekends. Such values of diversity and evenness in this public space prove that Vandiyur Mariamman Teppakulam's spatial vitality is noteworthy.

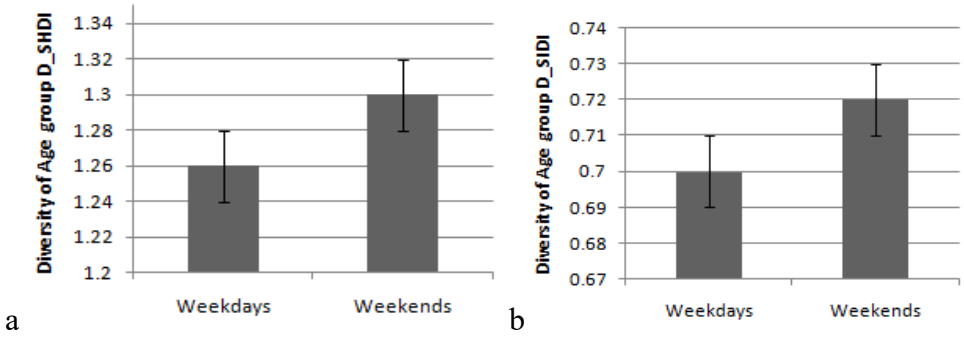

Fig. 7: Diversity of Age group in Vandiyur teppakulam on weekdays and weekends,
a. Shannon Diversity Index, b. Simpson Diversity Index
Source: Author

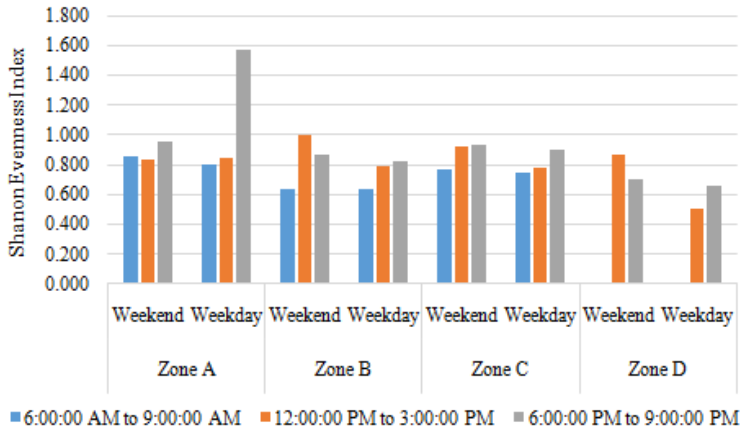

Fig. 8: Population Distribution: Shannon Evenness
Source: Author

As stated earlier, the teppakulam is one of the largest water bodies present in the city; the visual dominance of the religious clues in this public space was diminished because of its larger enclosure volume (Fig. 9). Hence the physical dimension of such public space with a religious structure as a focal element needed to have a considerably larger enclosure to increase the diversity in the demographic mix and impart a sense of belonging and equity to people from all religious and cultural beliefs.

The study reveals that Vandiyur Mariamman Teppakulam, while symbolically representing Hinduism through its physical attributes, serves as an inclusive public space that fosters social interaction among diverse groups, with over 60% of visitors engaging in recreational activities and nearly 14% identifying as Christians or Muslims, thus highlighting its role in promoting equity and diversity despite its religious connotations.

Fig. 9: Enclosure and diminished visual dominance
Source: Author

Liveability

The liveability of open space can be evaluated based on Jan Gehl's 12 quality criteria that were organized into three sections namely protection, comfort, and aesthetics. Vandiyur Mariamman teppakulam's public realm expands to 10m along the circumference of the water tank (Fig. 10). Pedestrian safety in this public space is enhanced with padithurai on its one edge and the parking lane on the other buffering its realm from vehicular circulation. Since most of the food kiosks and activity areas are positioned within this public realm, the need to cross the road is also reduced. The presence of active land use around the water tank natural surveillance and is more defensible. The presence of water in the temple tank is considered a getaway and luxury by the visitors as not all possible public spaces in the city are provided with such huge water-based infrastructure. In addition to serving as a visual component it also creates a comfortable microclimate for the intended users. It provides aesthetic appeal and offers a comfortable environment for the occupants. Hence water becomes one of the major reasons for the visitors to choose and rank the comfort of the space in higher order despite the absence of sidewalk or street lighting in certain cross-sections of the space. Since the space is more active between 6:00 am to 9:00 am and 7.00 pm to 10.00 pm (Fig. 11) the visitors expressed less discomfort with the absence of trees and other shading elements. Since the

volume of the public realm is limited to an extent of 10m from the water tank it increases the sense of place by providing a human-scale enclosure. Also, the presence of water and night lighting in the central mandapa, temple tower and active street life increases the aesthetic value of this public space without dominating its religious orientation.

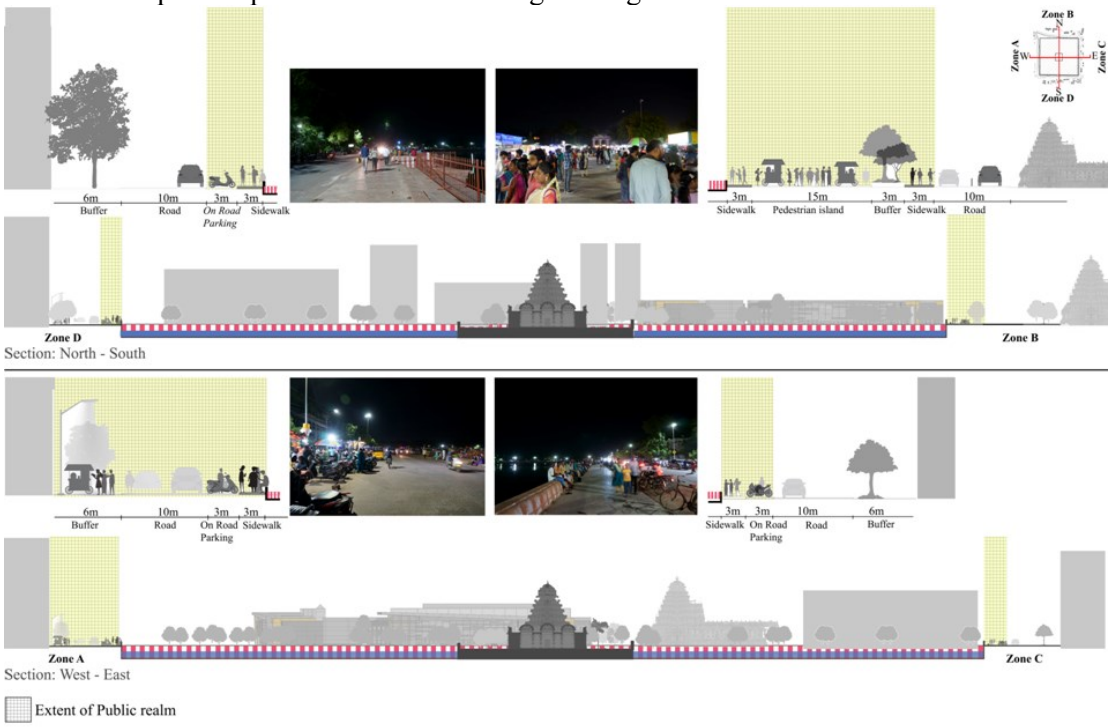

Fig. 10: Extent of the public realm
Source: Author

The results obtained by rotated component matrix as given in Table 4 reveals that user satisfaction is found to be affected by four factor components named as protection, comfort, accessibility and aesthetics. According on user satisfaction in the Madurai context, this order can be understood. The result reveals that protection (crowded, safety, cleanliness, and well-maintained footpaths) plays an important role and it has to be given first priority, secondly the comfort (seating facilities, adequate lighting, availability of food, and health related activities) followed by accessibility (parking facilities and convenient transportation) and the aesthetics (scenic view and trees) in order to enhance the spatial vitality of a space. Thus it indicates that user satisfaction in Madurai's public spaces is significantly influenced by protection, comfort, accessibility, and aesthetics, with protection being the top priority; this underscores that enhancing these factors not only improves spatial vitality but also contributes to the overall livability of the urban environment.

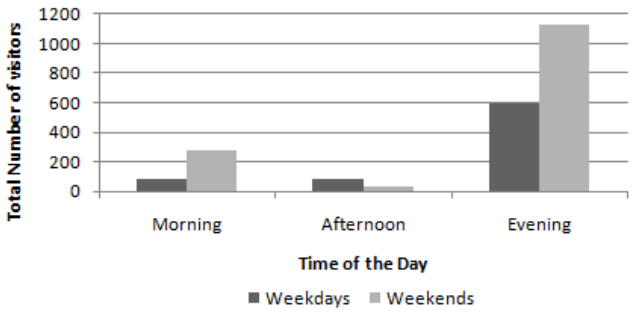

Fig. 11: Visitor count at various time frames during weekdays and weekends
Source: Author

Accessibility

Studies show that the degree of publicity in a public space can be identified through three things: Accessibility, Actors, and Activities. Based on these three factors, the degree of publicness depends on three indicators such as the following. Accessibility affects how freely the public space can be accessed by the public transport and without any physical barriers (compound walls, restrictions in time). Actors include the public who are in the space, it includes elimination of various restrictions limiting the participation of people belonging to various neighbourhoods, communities, and sectors. The third factor is the extent to which it can serve the public interest by incorporating activities that attract various age group. (Akkar, 2008). Vandiyur marriamman thepakkulam is not bounded by a compound wall and does not have any time restrictions hence it is more approachable. This public space lies almost in the center of the city and hence has more vehicular connectivity and public transport facility. Also, with more tourist attraction to this public space there is an increase in the paratransit in this zone. The questionnaire survey revealed that around 55% of visitors reach this space more through cycle and walking (Fig. 12a).

It also shows that around 45% of the visitors reach this space through four-wheeler and public transportation. This shows that the user category visiting the space includes people from various parts of the city apart from neighbours. This establishes that this public space is not only restricted to a few residents of the nearby neighbourhoods but is an important public asset that serves a larger group at the city level. The questionnaire survey also revealed that people quoted the activities present in this public space to be more engaging, attractive and in most case a major reason to visit the space. Fig. 12b proves that more accessibility to this public space has increased the frequency of visit by the visitors considerably and has been evidently noticed from the results of the questionnaire survey. Thus it indicates that Vandiyur Mariamman Teppakulam's high accessibility, marked by absence of physical barriers and its central location, attracts diverse visitors and engaging activities, enhancing its role as a vital public asset in the city.

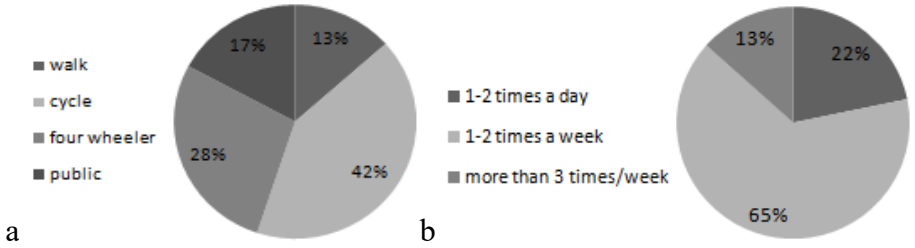

Fig. 12: Demographic data based on a. mode of travel, b. frequency of visit
Source: Author

Concentration

Vandiyur Mariamman teppakulam is observed to host various types of activities including walking, cycling, people watching, cloth dying, food kiosks, and kids playing that are suitable for various age groups of visitors. However, the place occupied by various user groups to perform their intended activities within the observed public realm differs according to the physical and ambient environment offered by the space. The behaviour and activity mapping done at site reveals that zones abutting active street life had predominantly more seating than the ones that were dormant and less active. This observation can be substantiated by the Shannon's evenness (Fig. 8) where zones which was abutting the residential zones (Zone D) had the least evenness value (0.00 in morning peak hour and 0.65 in evening peak hour) as compared to other zones. The map also revealed that the health-related activities like walking, jogging, exercising, and kids playing considerably reduced as the footfall increased through the day (Fig. 13). Fig. 14 demonstrates that weekends had a larger number of visitors than weekdays. The visitors mostly included young adults and middle-aged adults, accounting for more than 60% of the total visitors (Fig. 6b).

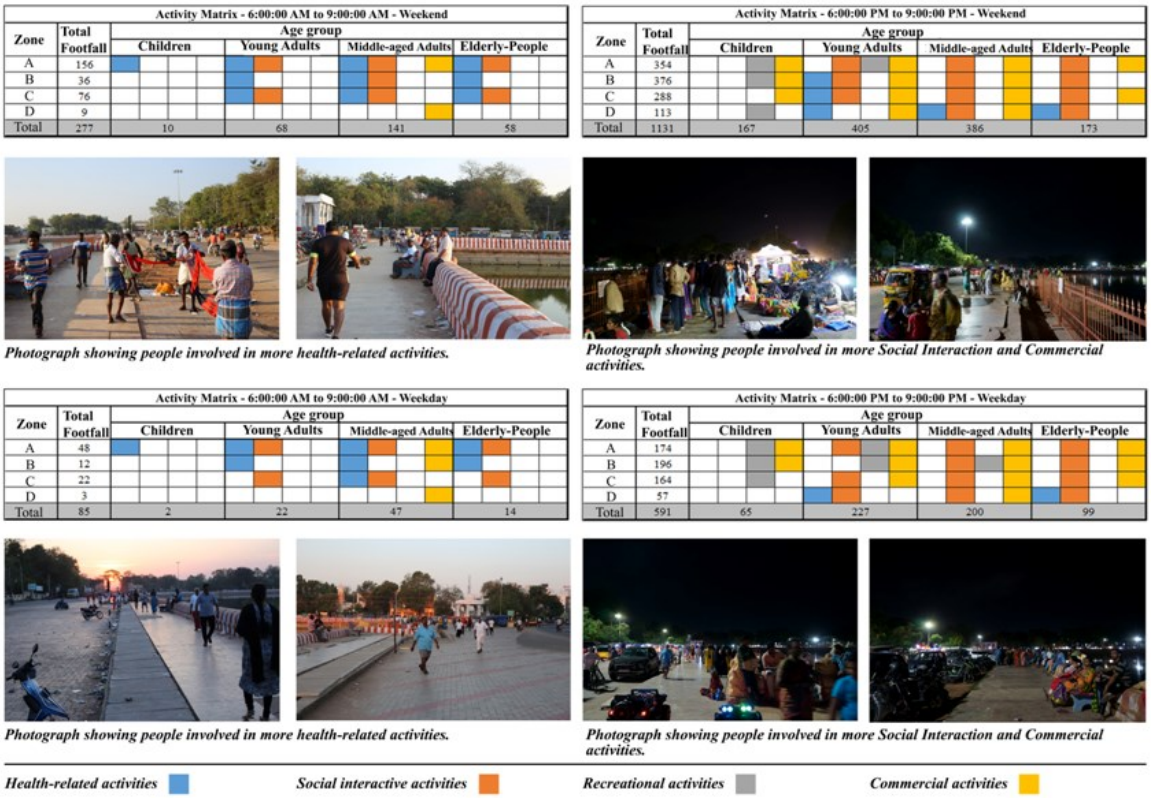

Fig. 13: Activity Matrix: Types of activities performed by various user groups across Vandiyur Teppakulam
Source: Author

The counting & tracing of footfall also revealed that during both weekdays and weekends the presence of food kiosks is one of the major reasons for stark difference in footfall count. However, it is to be noted that the increased pedestrian safety and other features of comfort acted complementary to the presence of food kiosks. It was observed from Fig. 15 that most of the visitors prefer to sit either on the ledge, sidewalks and steps/ padithurai or on the ground beside the ledge. It was quoted by the visitors that they prefer such informal seating than the formal benches. It also allowed them to organise according to their group size. They help to demarcate the zones based on turf, ensuring a sense of privacy as well as flexibility.

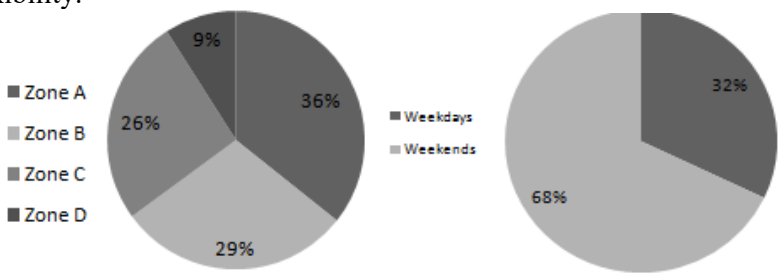

Fig. 14: Footfall at vandiyur teppakulam during weekdays and weekends
Source: Author

Fig. 15: Mapping and Quantification of Seating Preferences
Source: Author

6. Conclusion

Vandiyur Mariamman Teppakulam is one of the largest and the most preferred traditional public spaces in Madurai city, Tamil Nadu, India. This study aimed to assess the spatial vitality of this space by analysing the four characteristics including equity and diversity, concentration, accessibility, and liveability. Preliminary investigation for the study reflected that most of the visitors established greater affinity to water. And thus, water is found as a physical entity and had become a major pull factor in public space design specifically in a high-density development, tropical city. It provides the intended users with a pleasant microclimate in addition to acting as a visual component.

The results of this study discussed the physical attributes in the design of such traditional public spaces that enabled higher spatial vitality. The study revealed that the larger enclosure volume is an important attribute that manages to offset the religious and cultural perceptions of such traditional public space and thus aiding in increased diversity. However, the volume of public realm within the public space enclosure is defined by active edges such as the row of street hawkers, food kiosk, stepped seaters or the padithurai, active pavements, etc., rather than the mere building edge. Hence it is important to differentiate the public realm volume and public space enclosure while qualitatively analyzing the scale and sense of place for such public space. The study also concluded that increasing the availability of various transportation modes to a public space increased the frequency of visit and hence making it more approachable. This also enabled to increase the degree of publicness of a public space by enabling people from different parts of the city to reach through their preferred mode of travel. Natural surveillance has been one of the important characteristics that increased the defensibility of such public spaces. This study also established that the zones abutting a street were more preferred by the visitors to perform their activities. Hence it becomes imperative to equally distribute the activities planned within the public space to achieve an even population distribution amongst all zones of the public space designed. This also proves that an unhindered visual axis is vital for a defensible public space. The results evidently portrayed

that as the footfall increased and as the commercial activities commenced the health-related activities such as walking, jogging, exercising, and kids playing reduced as compared to more passive activities like sitting, eating, people watching, etc. Therefore, the presence of commercial activities is found as a key physical entity to be planned in a public space in order to increase its spatial vitality. However, the presence of increased pedestrian safety and other features of comfort acted complementary to the presence of such commercial activities. The observations in this study revealed that the visitors preferred to sit on the ledges, padithurai and on ground more than the stone benches provided in the public realm. Hence, the study also revealed that it is important to investigate how people choose to engage within a public space before designing the type of seaters provided. Following are the specific design strategies evolved for optimizing public space engagement and accessibility

- Larger enclosures support diverse activities and enhance spatial vitality.
- Features like hawkers, kiosks, and seating areas to be incorporated to create vibrant public realms.
- Clearly separate active spaces from physical boundaries to define a sense of place.
- Offer multiple transportation options to improve accessibility and encourage frequent visits.
- Ensure visibility across spaces to enhance safety and encourage public use.
- Balance activity zones to avoid overcrowding and ensure even use across the space.
- Integrate commercial spaces to increase footfall while maintaining room for physical activities.
- Provide seating options that align with user preferences, such as ledges and informal seating.
- Incorporate features that ensure pedestrian safety and comfort to enhance space usability.

The conclusive findings of this study therefore essentially outline the ability of certain designed attributes including visual image, scale, volume of public realm, presence of commercial activities, etc, to help in improving the spatial vitality of a public space. These results may be crucial in helping architects and urban designers in south Indian cities and other Indian cities with similar urban settings construct viable urban open spaces.

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