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An Evaluation of a Commercial Street's Livability to Improve its Vibrancy: a Case study of Chennai City

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Abstract:

Commercial Street vibrancy is ensured through different types of activities happening throughout the day which contributes to street livability. The overall vibrancy of the street contributes to environmental quality, aesthetic appeal, safety and urban development. This paper investigates key parameters that influence livability, focusing on T Nagar in Chennai, India as a case study. It examines how physical, design, social, safety, natural, and wellness components collectively influence the livability of urban commercial streets. Through extensive literature reviews, the study systematically identifies and analyses various parameters under each component to assess their impact on street vibrancy. An on-site physical and social survey was conducted, targeting active street users across various nodes of the study area, thereby providing valuable insights into everyday use. The findings provide a checklist to evaluate livability performance in commercial streets. This paper offers guidance for urban planners, designers and policymakers in identifying strengths to improve commercial street livability.

Keywords: livability, street vibrancy, public space, diversity, built environment

1. Introduction

Livability is widely discussed in urban research and its meaning is ambiguous and varies across contexts and groups. The purpose of this study is to comprehend the vast body of evidence available about street livability and vibrancy, and to explore the theoretical background, dominant ideologies, as well as its components and parameters. Livability has been associated with social and physical determinants of safety, health, environment friendly and sustainability (Mahmoudi et al., 2015). Livability is a significant guiding principle for urban planning and policy decisions (Bosselmann et al., 1999). The idea of urban livability has recently gained prominence as a guiding principle within the context of the language of sustainability in urban policy and planning both in the majority of developed countries and to a lesser extent in the developing ones (Yoshihara et al., 2021). Liveable and shared street makes great places (Ali & Baper, 2023). They are the contributors to street vibrancy. Mehta (2013) argues that streets should bring people together, facilitate social interaction, and foster a sense of community. He emphasizes that streets as social public spaces contribute to the livability and vibrancy of cities. Streets are the social spaces in the cities connecting people and space (Press, 2013). Street

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design should be carried out in a way considering people and spaces, rather than being constrained by rigid engineering standards. This will enable to create novel solutions that meet the overarching goals of a livable street (Chen et al., 2019; Tandon & Sehgal, 2018). Streets that are well-designed are full of movement, nature, and recreation(Weber et al., 2014).

Complexity, vibrancy and variety define the Indian streets. Socio-economic, cultural and functional activities bring people of several diverse communities to different types of complex activities on Indian streets. They are commercially active with a mix of economic users ranging from street vendors and hawkers to large retailers (Tandon & Sehgal, 2018). Apart from shops of varied scales and diverse enterprises, Indian streets are a place for pedestrians of all ages, cyclists and all kinds of motorised vehicular traffic (Verma, 2022). Indian streets attract interactions by providing informal eating areas, cycling areas for children, elder interaction areas, religious activities and overnight parking for vehicles (Al-Thani et al., 2019). The multi-functional structure of the street provides a different typology of space for different age groups. The streets are used for more than just transportation, sometime become a temporary stage for political meetings, gatherings, religious observances, processions, cultural performances and other forms of social activities. Being a social space for sharing news (Khorrami et al., 2021), the streets occasionally become a site for announcements, transmitted by loudspeakers. The vibrancy of Indian streets is defined by their spatial quality, which encompasses a diverse array of elements and places. These spaces, whether intentionally designed or organically developed, are characterized by their socio-culturally rich economic activities. Safety measures that encourage public engagement, the integration of natural elements, and a sense of ownership contribute to their vibrancy. The quality and livability of Indian streets are evolving, with increasing attention paid to pedestrian safety, environmental sustainability, and accessibility. However, given the people's perception of the streets as vibrant entities based on their experiences of the past, there are still many challenges to be addressed. This study aims to explore tangible and intangible characteristics of Indian commercial streets that contribute to their livability by examining a case study of Sir Thyagaraya Road in Thyagaraya Nagar, Chennai.

2. Literature Review

Streets are transformed into mini public spaces with wider footpaths, trees, and seating (Dehghanmongabadi & Hoşkara, 2022). Streets improve livability by providing both generous footpaths and convenient destinations(Lesan & Gjerde, 2021). Streets that are more than a transportation access and includes pedestrian oriented walkways ensures livability in the neighbourhood and enriches social life (Speck, 2012). Creating a walkable network of streets also entails making it easier for people to get to places they are likely to visit (Istrate & Chen, 2022). Gehl (2006) focused on creating human-centred urban environments, he emphasizes the need for a human scale in urban design. The compact, mixed-use development patterns tend to be more conducive to livability and street vibrancy than sprawling and single-use development patterns (Ewing & Clemente, 2013). Place making involves creating places meaningful to people, and reflect the social, cultural, and historical contexts of their communities(John, 2010). Microclimate in streets can be achieved through street trees, which add different kinds of under-the-tree social and economic activities enriching environmental benefits(Mehta, 2013). The criteria for active commercial streets depend on acceptable speeds, volumes, noise levels, decrease in accidents, sidewalks and right-of-way for pedestrians (Musaab et al., 2018).

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Commercial streets have played important roles in shaping people's sense of place, as evidenced by users' dependence on them for shopping and getting around (Kang, 2016; Uzzell et al., 2002). Active ground floor uses, rows of shops, human-scaled buildings, the slow movement of vehicles, and active sidewalks are the visual aesthetics for passers-by to enjoy the space (Rosenlieb et al., 2018). The well-designed public spaces can act as "social magnets," attracting people and encouraging social interactions (Carmona, 2019). Hillier (2004) argues that streets can be designed to promote social activity. Safety of the streets can be achieved through different types of activities in the streets (Jacobs, 1961). The universal accessibility for the vulnerable groups, or marginalized groups should be considered while designing the streets (Dehghanmongabadi & Hoşkara, 2022). Jacobs (1961) argues that streets should be designed with a sense of place and history, incorporating elements such as public art, historic architecture, and local culture. Factors such as history, culture, and social dynamics of the neighbourhood has to be sensibly integrated to the physical layout of the existing infrastructure (Moughtin, 1992). In addition to fostering social contact and community involvement, well-designed public spaces can serve to create a sense of place and identity in urban environments (Shaftoe, 2008). Madanipour (1996) states that public space is a site for social interaction, cultural expression, and democratic participation. Based on these literature reviews six components comprised of 35 parameters are used to evaluate the street livability. The six components are the physical component which documents physical aspects of the streets, design components, social and safety components, natural components address the natural setting, and the wellness component reports satisfaction and happiness parameters. The components and parameters for livability assessment are shown in Table 1. along with its relevant studies.

Table 1. showing listed parameters and literature references

Components	Parameters		Descriptions	Relevant Studies
Physical	Adequate street width	P1	Wider streets allow more pedestrians, bicycles, and automobiles, reducing traffic and boosting safety. They provide space for social interactions, which improves the street's overall appearance and functionality.	(Ali & Baper, 2023; Cao et al., 2006; Ewing & Clemente, 2013; Fauzi & Aditianata, 2018; Hajrasouliha & Yin, 2015; Khavarian-Garmsir et al., 2022; King, 2013; Verma, 2022)
	Sidewalk quality	P2	Well-maintained sidewalks boost pedestrian activity, safety, and add to the street's overall appearance. Sidewalks with sufficient width and amenities can improve the pedestrian experience and make the street more appealing.	
	Street networking	P3	A well-connected street network with different routes can increase accessibility and foster	

			a sense of community by encouraging locals to engage.	
	Existing aged building	P4	Older buildings can offer character and charm to a street, enhancing its distinct identity and feeling of place.	
	Street hawkers	P5	Activating streets and help in creating safer, more lively, and inclusive environments, contributing significantly to the urban fabric.	
	Street vendors	P6	Street vendors serve to foster a sense of community and improve the social fabric of the street.	
Design	Mix use	D1	Integrating shopping, commercial, institutional, and public buildings encourages a constant flow of people throughout the day and night.	(Kinyingi et al., 2020; Lesan & Gjerde, 2021; Madanipour, 1996; Mouratidis, 2021; Rahman et al., 2015; Zamorano, 2010)
	Active mobility	D2	Walking and cycling on commercial streets encourage social, economic, and physical activities, while also providing health benefits.	
	Multiple transit	D3	Various public transportation options improve mobility, accessibility, and connectivity to surrounding neighbourhoods, facilitating easier access to commercial streets.	
	Adequate parking facilities	D4	Availability of parking draws people from different economic backgrounds also Sharing parking spaces among multiple users allows facilities to be used more efficiently.	
	Street furniture	D5	It encourages people to relax, watch activities, and enjoy their visit to commercial streets as an experience.	
	Street amenities	D6	Street amenities like interactive games, information kiosks, and historical statues can increase frequent visits to an area	
	Human scale	D7	It provides a welcoming environment for pedestrians also	

			assists in the reduction of vehicle use, thereby improving air quality and pedestrian safety.	
Social	Place attachment	SO1	Fostering memory and positive feelings tied to a location, linking social and place identity.	(John, 2010; Litman, 2012; Maricchiolo et al., 2021; Mouratidis, 2021; Zamorano, 2010)
	Street cleanliness	SO2	Clean streets ensure a positive visual impact and encourage activity. It has an indirect impact on the city's economy and human health.	
	Visual aesthetics	SO3	Avenue tree planting, appropriate trash removal, and better-organized public areas and street furniture are all ways to visualize street aesthetics.	
	Neighbourhood attachment	SO4	Neighbourhood attachment demonstrates people's connection to the built, natural, and social environments.	
	Community participation	SO5	Community involvement is ensured when members work together to find a solution to their specific issue. It encourages people to see the benefits of their participation	
	Neighbourhood activities	SO6	It boosts social capital within the neighbourhood, encourages participation and personal developments	
Safety	Street lighting	SA1	It promotes night time activities, it offers safety by artificially extending the hours of daylight.	(Appleyard & Lintell, 1972; Dovey & Pafka, 2020; Ghazi & Abaas, 2019; Hillier, 2004; Khder et al., 2016; Montgomery, 1998; Rosenlieb et al., 2018)
	Openness	SA2	Informal surveillance, visibility and sight distance contribute to the visual connection of spaces thereby improving activity.	
	Communal spaces	SA3	Communal spaces are shared spaces that promote informal activities and showcases the cultural identities of the context.	
	Traffic calming elements	SA4	Adjusting lane width, roundabouts, medians, diverters, and vertical deflections all help to slow down vehicular movements and ensure safety in commercial streets.	

	Shade and shelter	SA5	Shade allows visitors to stay outside longer, protects them from harsh weather and overexposure to the sun, and keeps streets active in all weather conditions.	
	Universal accessibility	SA6	Universal design enhances activity and public transit use by removing physical barriers for people with disabilities.	
Natural	Tree canopy activities	N1	It provides spaces for activities such as hawkers and vendors selling their goods, parking for vehicles, and shelter for people.	(Anamika & Pradeep, 2016; Appleyard & Lintell, 1972; Gaubatz, 2008; Montgomery, 1998; Weber et al., 2014; Zamorano, 2010)
	Presence of greenery	N2	It provides aesthetics, a connection to nature, positive psychological effects, and prevention of water runoff. urban greenery improves sidewalk quality and creates a comfortable environment.	
	Clean air	N3	Air quality has an immense impact on the health and well-being of the neighbourhood. Creating ecological buffers on streets ensures people's longer stay without air pollution.	
	Noise buffer	N4	Noise buffer enhances street livability by reducing noise pollution, creating a more peaceful and enjoyable environment for residents and visitors.	
Wellness	Sense of community	W1	Active streets that foster a strong sense of community among residents, workers, and visitors enhance liveliness and appeal.	(Dehghanmongabadi & Hoşkara, 2022; Do et al., 2019; Ewing & Clemente, 2013; Istrate & Chen, 2022; John, 2010; Maricchiolo et al., 2021; Mouratidis, 2021; Press, 2013)
	Social relationship	W2	A strong attachment to a place fosters community involvement, neighbourly interactions, and an active street life.	
	Sense of belonging	W3	When people have the freedom to pursue their passions and interests within the boundaries of common values, they feel a greater sense of belonging within their community	

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	Emotional attachment	W4	Personal attachment to a place, irrespective of different groups, can play a significant role in promoting street vibrancy. When individuals feel a strong emotional connection, they are more likely to engage actively in the community	
	Street attractiveness	W5	The dynamic street atmosphere captures the attention and interest of passers-by, contributing to the vibrancy of the street	
	Enjoyable street	W6	Designing streets with a focus on pedestrians creates an enjoyable experience. Also enhancing the streetscape with visually appealing elements can make the street more enjoyable	

3. Research Context and Process

The study area is located in Chennai, Tamil Nadu, at 13°02'26.7"N and 80°14'15.3"E. Sir Thyagaraya Road, as shown in Figure 1. is a bustling mixed-use commercial street situated in the heart of Chennai, Tamil Nadu, known for its vibrant and livable atmosphere, the street encompasses a dynamic blend of residential, commercial, and institutional buildings. The study area collects data from the prime nodes of Sir Thyagaraya Road, spanning from Mount Road on the east to Panagal Park on the west. The study area is renowned for its dense and diverse commercial zones, catering to a diverse range of activities and services. It serves as a central hub for both commercial and social activities, making it a sought-after destination for residents, shoppers, and businesses alike. Its strategic location in the core of Chennai adds to its prominence and accessibility. Sir Thyagaraya Road features a width of 30m with front setbacks varying from 0.6m to 3.0m. The sidewalk width measures between 3 and 11m, providing ample space for pedestrian movement across all studied nodes. The scope of the study area encompasses the key nodes, which are important focal points along the street. Surveys were conducted at these nodes to ensure coverage throughout the studied street. This ensures a comprehensive analysis of the most significant and impactful areas, providing valuable insights into the overall dynamics and liability of the commercial street.

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Fig. 1. Showing surveyed nodes at Sir Thyagaraya Road, Thyagaraya Nagar, Chennai.

Fig. 2. Top(right to left) (a). node 1 junction (b). node 2 junction (c). node 3 junction Bottom (left to right) (d). node 4 junction (e). node 5 junction (f). node 6 junction (Image by M Senthil)

The nodes of Sir Thyagaraya Road are vibrant centres of activity and trade, enriching the urban experience for locals and visitors. These streets promote economic vibrancy, community, social interaction, and cultural diversity. Each node has its own character, with a mix of businesses, street vendors, eateries, and well-known brands. Node 1 and Node 2 are particularly active, offering a dynamic environment with a variety of shops and amenities. Node 3 features a multi-level car park and serves as a central hub for the surrounding area. Node 4, near a school, is less vibrant due to its lengthy stretch alongside school walls. Node 5, with high vehicular traffic, is accentuated by star hotels and malls, attracting users from diverse economic groups. Node 6 features a mix of buildings and economy classes, adding to the area's diversity.

3.1.Process of Data Collection

The research process included the study and documentation of streets across all nodes. A questionnaire survey was conducted on the field for a period of ten weeks from July to September 2022 at different times of the day and at different nodes across the street to ensure a variety of samples. For the evaluation, a total of 360 responses were collected, near each of the six nodes contributing 60 responses. Each respondent was requested to provide feedback on 35 parameters under six components, which represent the livability parameters of the commercial streets along with basic demographic data. 360 total valid samples were collected consisting of 54.2% male and 45.8% female, out of which 29.2% were between 18-25 years, 31.1% between 26-40 years, 23.9% between 41-55 and 12.5% above 56 years. Out of the samples surveyed, 40.5% were residents of the locality who visit the place for shopping and leisure on a daily basis, 28.7% use it frequently as a thoroughfare or for work, 2.1% visit the place very rarely and some of them were from other cities as well. The survey captured a diverse range of demographics and usage patterns, providing a comprehensive understanding of the factors influencing urban livability in the study area. The analytical method employed in this study utilized a mixed-method approach, combining qualitative and quantitative methods to assess the livability of commercial streets. The process began with physical assessments to understand the characteristics of Indian streets. Data from structured surveys along with

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observations and visual assessments were collected from multiple urban nodes. To visually represent the data, bar charts were constructed to display the mean ratings of each parameter across the six nodes. This facilitated a comparative analysis to identify areas of strength and opportunities for improvement within the urban fabric. The collected survey data was analyzed using Statistical Package for Social Science (SPSS) 25.0 program to understand correlations among different parameters. Overall, the mixed-method approach employed in this study provided a comprehensive understanding of the factors influencing urban livability.

Fig. 15. Components to measure commercial street livability

4. Results and Analysis

4.1.Physical Components

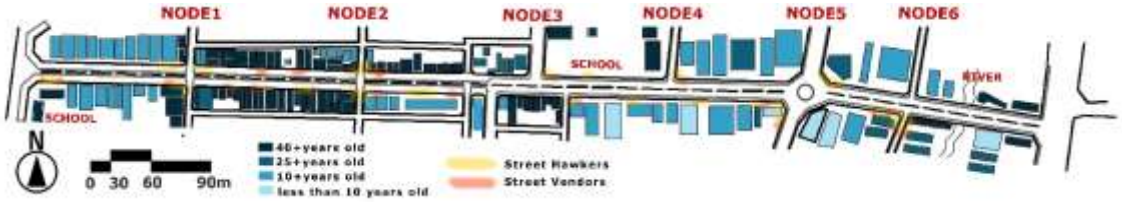

Fig. 3. Showing existing aged building, street hawkers, street vendors and sidewalk in Sir Thyagaraya Road, Thyagaraya Nagar, Chennai.

A 30-meter-wide street runs from the west to the east of the study area, featuring different types of building uses from node 1 to 6 with broader sidewalks of 9 to 10 meter from node 1 to 3 and 4m to 2.4m wide from node 4 to 6. The sidewalk enhances access to shops, promoting lively public spaces and diverse activities. The area between node 3 and 4, predominantly a school zone, experiences less foot traffic, other than school hours. Meanwhile, node 3 to 6 are undergoing new mid and high-rise development, emphasizing vehicular movement and resulting in narrower 4.5 meter sidewalks. The older buildings present in node 1 to 3 contribute to a strong sense of community, including a 50-year-old school. The newer constructions in node 3 to 6, offer modern amenities and are attractive for their extensive connectivity. Street vendors and hawkers are notably more prevalent in nodes 1 to 3, attracted by the bustling shop fronts, whereas nodes 4 to 6 with fewer hawkers due to the presence of office complexes.

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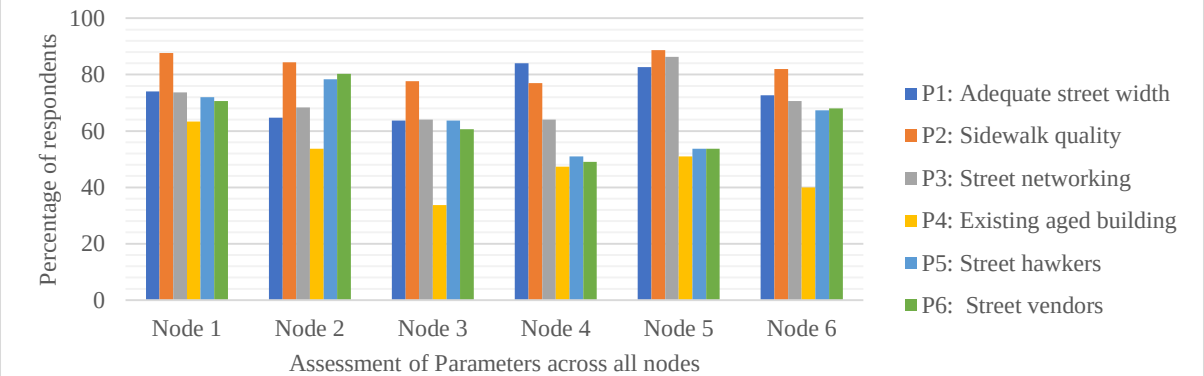

Fig. 4. Users perception of physical components (in percentage)

The analysis highlights there are several key factors that contribute to the liveliness and connectivity of the nodes. The users perceive sidewalk quality as high throughout the streets across all nodes. Node 5 emerges as a central hub with its wide streets and strong street networking, facilitating easy access and movement within the area. Node 1, 2 and 5 with their adequate street width and aged buildings, add a historical and cultural charm to the neighbourhood, enhancing its character. The presence of vibrant street life, including street hawkers and vendors, indicates a high level of pedestrian activity, making these nodes lively and engaging places. Overall, the combination of these factors makes Node 1, 2 and 5 vibrant and well-connected nodes within the urban fabric.

4.2.Design Components

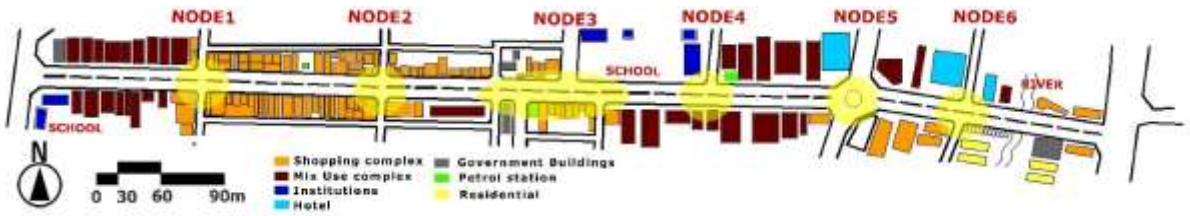

Fig. 5. Showing building use typology in Sir Thyagaraya Road, Thyagaraya Nagar, Chennai.

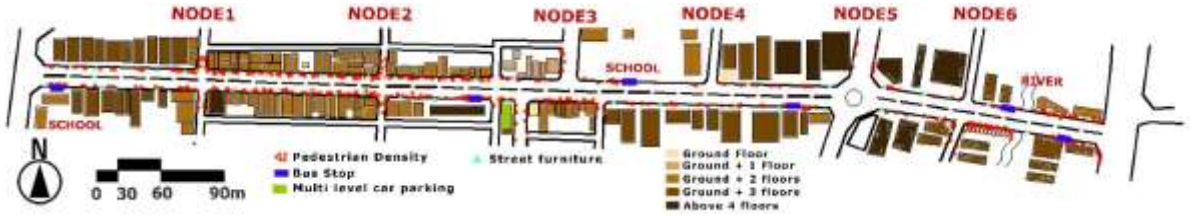

Fig. 6. Showing pedestrian density, street furniture, bus stop and multi level car parking in Sir Thyagaraya Road, Thyagaraya Nagar, Chennai.

Node 1 to 6 are lined with shopping centers, commercial establishments, and public buildings, ensuring a steady flow of pedestrians and vehicles throughout the day. Wider sidewalks from

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Node 1 to Node 3 promote walking and cycling, with an enhancement in cycling infrastructure observed from Node 3 to Node 6. These expansive walkways across all nodes encourage foot and bicycle traffic, contributing to overall health benefits. A variety of transportation options are accessible, encompassing different public transport services and amenities like auto-rickshaws and bike-sharing programs available at all nodes. Additionally, parking is conveniently distributed, featuring car parks and spaces for visitors in Node 3 to 6, as well as multi-level parking specifically at Node 3 for Node 1 and 2. Strategically placed street furniture around trees in all nodes creates inviting spaces for relaxation, allowing people to engage in conversations and enjoy their surroundings. Node 1 to 3 are enhanced with interactive installations, informational kiosks, and Node 5 is adorned with statues, enriching the space's appeal and promoting social interaction. The architecture in Node 1 to 3, with its older, low-rise buildings, emphasizes a human-scale environment that invites lingering and community bonding. Conversely, the newer, taller constructions in Node 4 to 6 introduce a different scale, which might detract from the intimate, communal atmosphere present in the earlier nodes.

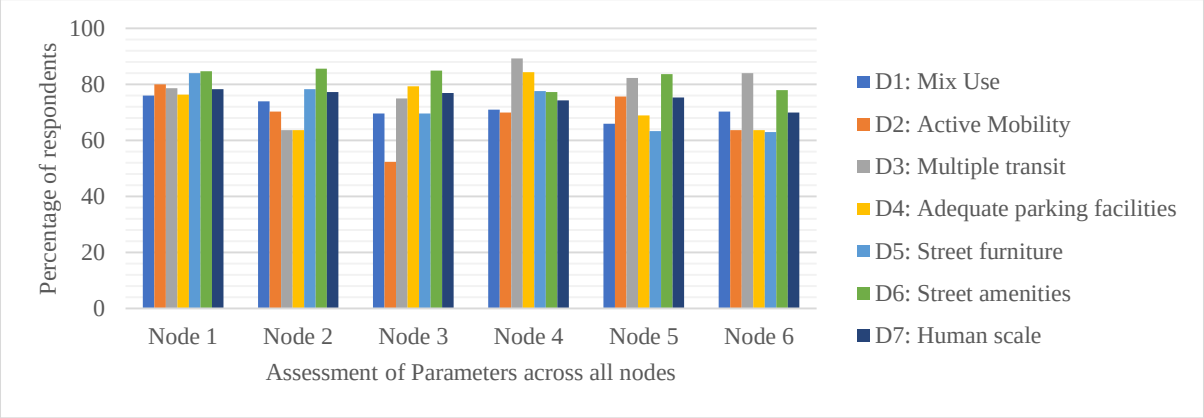

Fig. 7. Users perception of design components (in percentage)

Survey results indicate a high score for street amenities, particularly street furniture, as a significant contributor to street vibrancy across Node 1, 2, 3 and 5. Well-placed seating and urban landscape structures contribute to the aesthetic appeal and overall experience of the street. Dustbins, interactive game elements, informative kiosks, and historical statues are highly rated in these nodes, fostering a sense of belonging and enhancing the street's attractiveness. Node 4, 5 and 6 highlight multiple transit options, enhancing mobility and accessibility. Adequate parking facilities are observed in Node 3 and 4, contributing to overall convenience. Mixed-use zones in Node 1, 2 and 4 play a crucial role in activating commercial areas, integrating diverse functions and increasing land use density. The proximity of residential zones to commercial areas further enhances overall livability. Active mobility in Node 1, 4 and 5 not only encourages various activities but also promotes health benefits, contributing to community vibrancy and well-being. Node 1, 2 and 3 characterized by their human scale are particularly welcoming for pedestrians.

4.3.**Social Components**

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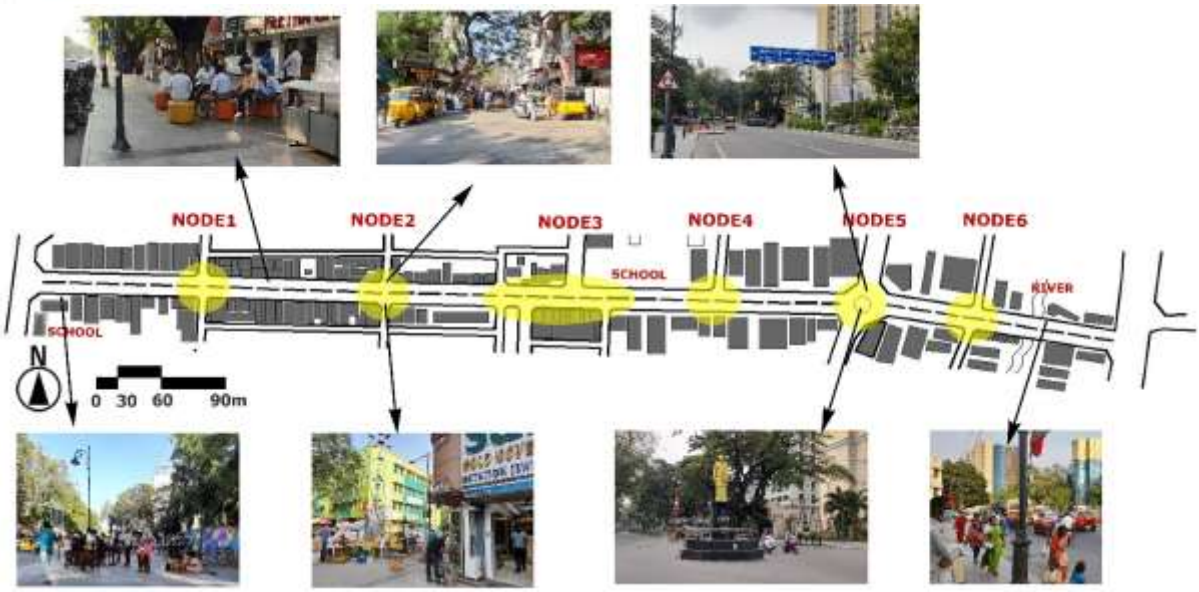

Fig. 8. Showing social activities in Sir Thyagaraya Road, Thyagaraya Nagar, Chennai.

The area under study stands out for its bustling shopping centres, particularly around Node 1, 2 and 3. A significant landmark is an over 50-year-old school situated between Node 3 and 4, which has established a profound connection with the local community. The segment extending from Node 4 to 5 is distinguished by towering office buildings and international hotels, attracting newcomers and contributing to the charm of the area. Node 6 is recognized for its convention centers and shopping malls, which attract visitors from the surrounding neighbourhood. Visually, the avenue is adorned with trees across all nodes, creating a welcoming vibe for guests. Node 1 and 2 are especially notable for their vibrant and fashionable exteriors, displaying the latest trends and inviting people to explore. The visual progression from Node 4 to 6 is characterized by recent developments, contemporary architecture, and skyscrapers, enhancing the area's aesthetic appeal. There's a strong community bond, especially in Node 1 and 2, where local ownership of small to medium-sized shops for over 50 years has fostered a sense of belonging. This enduring relationship has deepened the connection between residents and these shopping hubs, making them a favoured spot. Community involvement is vigorous, with dedicated shoppers uniting to tackle local challenges through associations. This collective effort empowers each individual to contribute to their community's growth and engage in local events. Notably, the expansive sidewalks in Node 1, 2, and 3 become stages for local talent on weekends, attracting larger audiences and boosting community interaction compared to other nodes.

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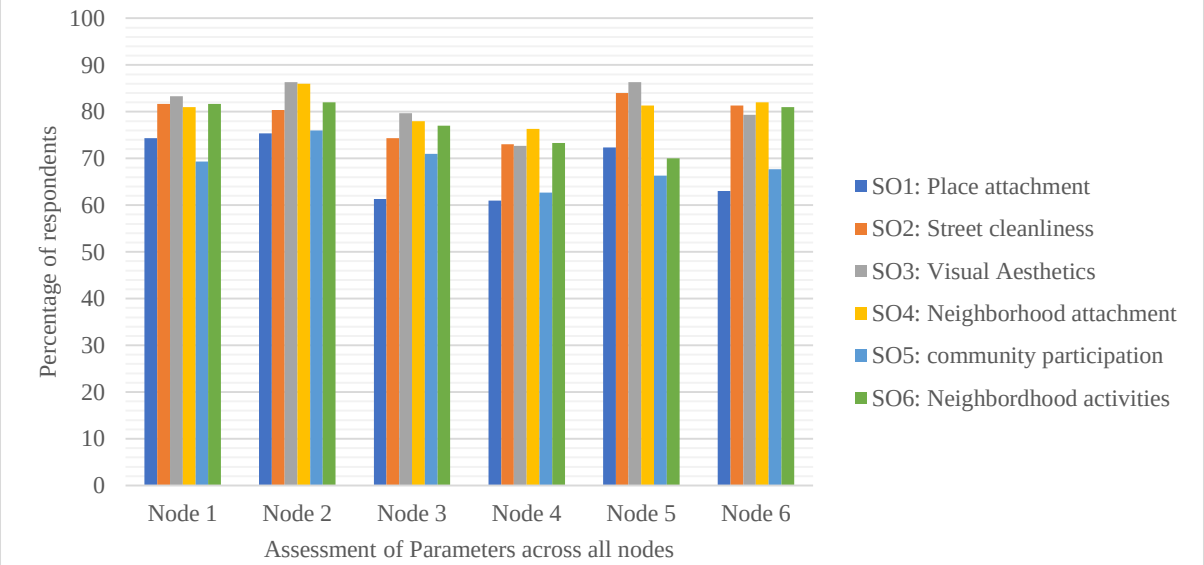

Fig. 9. Users perception of social components (in percentage)

The survey highlighted visual aesthetics to be key with respect to the social components as a choice of street vibrancy parameters by the respondents. Visual aesthetics, especially Node 1, 2 and 5 were highlighted as key components of street vibrancy by respondents. It was acknowledged that elements such as avenue tree planting, proper trash removal, well-organized public areas, and appealing street furniture played a significant role in enhancing street aesthetics. The importance of neighbourhood attachment can be seen in Node 2,5 and 6, which reflect people's connections to the built, natural, and social environments. It was understood that natural elements provide mental restoration and recreation, built elements create memories, and social elements foster community cohesion and bonding. Place attachment recognized as a powerful factor, especially in Node 1, 2 and 5, by respondents when considering street vibrancy. Street cleanliness scores high at Node 1, 2, 5 and 6 were seen as having a positive visual impact and as encouragers of activity. Community participation at the node 1, 2 and 3 were seen as a means of involving people in solving their own problems. The survey findings indicated that such involvement motivated individuals to recognize the benefits of their active engagement in their communities. Respondents recognized the positive impact of neighbourhood activities at nodes 1, 2 and 6, particularly in encouraging street performers from diverse backgrounds. These activities were seen as contributors to social capital within the neighbourhood, fostering participation and personal development.

4.4.Safety Components

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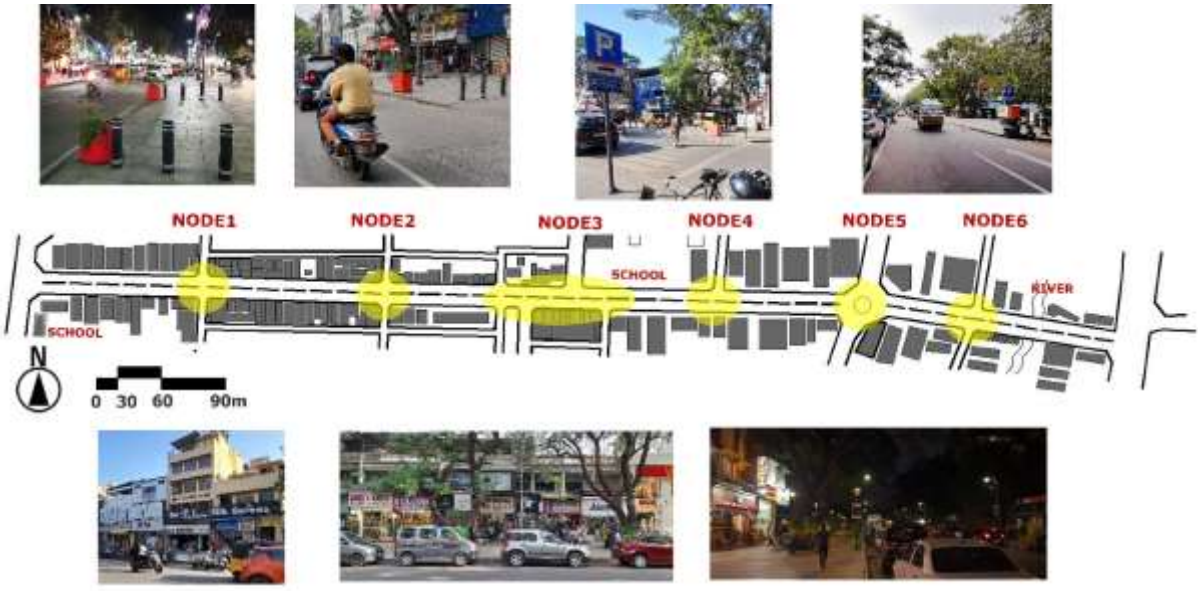

Fig. 10. Showing street lights, pedestrian crossing, parking and universal accessibility in Sir Thyagaraya Road, Thyagaraya Nagar, Chennai.

Street lights provided across all nodes, which plays a crucial role in ensuring that people can move around and engage in activities conveniently after sunset. Node 1, 2, and 3 primarily consisting of shopping complexes, feature shorter plot frontages with more transparent façades that interact with the sidewalk, facilitating pedestrian movement. From Node 3 to 4, a school compound wall designed with artworks maintain interest for sidewalk users. In contrast, Node 5 and 6, characterized by high-rise buildings, are equipped with low compound walls, offering clear views and sightlines to the road, thus contributing to a sense of safety and visual connection. Traffic calming measures are implemented across all nodes, including speed breakers and pedestrian crossings, to ensure the safety of both pedestrians and drivers. In terms of shade and shelter, tree canopies provide natural protection, enhancing comfort for pedestrians. Furthermore, all nodes emphasize universal accessibility, ensuring inclusive and accessible to individuals with physical challenges. This inclusivity facilitates the movement of disabled people across all nodes, underscoring a commitment to safety and accessibility for all community members.

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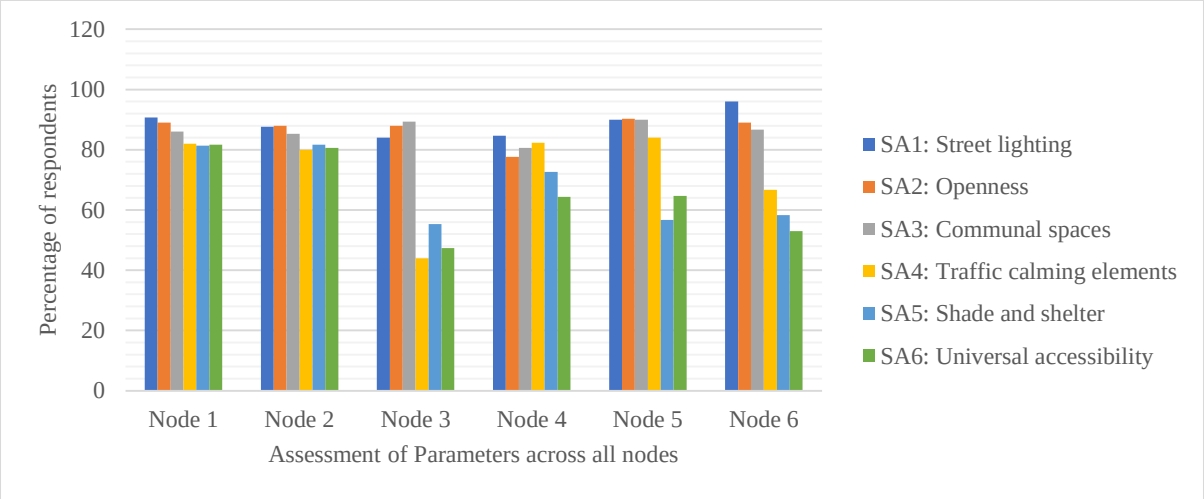

Fig. 11. Users perception of safety components (in percentage)

The result of safety components shows a high score for street lighting across all nodes as a choice of street vibrancy by the respondents. Street lights promoting night-time activities received high scores in Node 1, 2, 5 and 6, extending the hours of daylight artificially enhancing safety, improving security, and raising the overall quality of life. Openness and the visual connection to and along the street were recognized as valuable aspects of street design and were high in Node 2, 3, 5 and 6. Informal surveillance, visibility, and sight distance were understood to contribute to the visual connection of spaces, fostering safety and a sense of openness. Communal spaces, present at the Node 3, 5 and 6 were acknowledged as shared spaces that promote informal activities and showcase cultural identities with amenities and infrastructure. Traffic calming elements like lane width adjustments, roundabouts, medians, diverters, and vertical deflections, scores high at the Node 4 and 5, and were understood to slow down vehicular movement and enhancing safety. The presence of shade at the Node 1 and 2 encourages visitors to stay outside longer, protecting them from harsh weather, and facilitating street life, which were acknowledged as essential for sustaining street activity in various weather conditions. Universally accessible design consideration is high in the Nodes 1, 2 and 6, recognized as vital for creating an inclusive environment. This barrier-free environment encourages people of all ages and abilities to take a walk and move around.

4.5.Natural Components

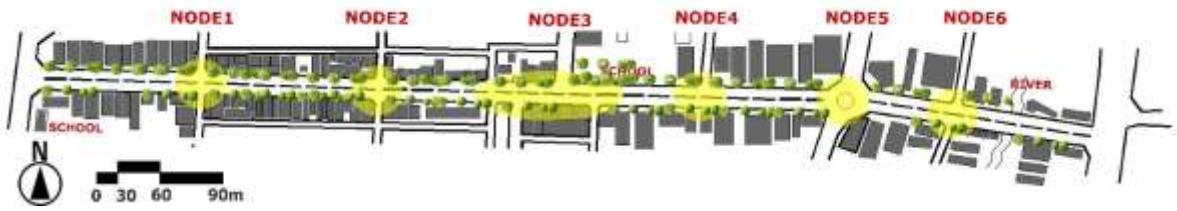

Fig. 12. Showing tree mapping in Sir Thyagaraya Road, Thyagaraya Nagar, Chennai.

Node 1, 2, and 3, there is a significant presence of tree canopies, which enhances the area's greenery and provides shade. However, Nodes 4, 5, and 6 also support with fewer tree canopies,

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with their new developments. Despite this, the tree canopies in Nodes 1, 2, and 3 are well-maintained, partly due to fewer new developments, facilitating various activities such as street hawkers and vendors selling goods under the shade of the trees. These spaces also become gathering points for people to sit, chat, and enjoy the greenery, contributing positively to their psychological well-being. The greenery is noticeable across all nodes, especially from node 4 to node 6, where planter boxes along the sidewalks and greenery in the central median of the road are prominent. The presence of tree canopies and a large number of plants in the sidewalks and medians plays a crucial role in filtering air pollution and creating cleaner air throughout the area. Additionally, these tree canopies serve as a noise buffer, helping to reduce noise pollution and create a more tranquil environment.

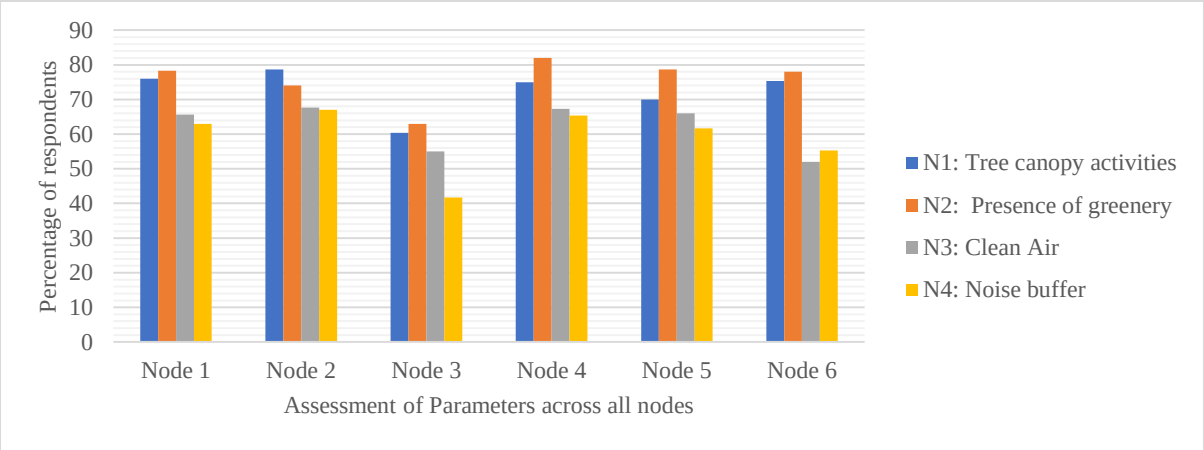

Fig. 13. Users perception of natural components (in percentage)

Presence of greenery scored high as a choice of street vibrancy by the respondents. The survey result emphasized the importance of greenery in Node 4,5 and 6, including plants in the median divider and planter boxes along sidewalks. Respondents acknowledged that the presence of greenery provided an aesthetic connection to nature in urban environments. Plants not only prevented water runoff but also had a positive psychological effect on residents, improving sidewalk quality and the overall street environment. Street trees were recognized for their role in separating sidewalks from vehicular traffic, ensuring safety, and creating a pleasant and healthy environment. They were also seen as catalysts for encouraging social interactions among residents which can be highly witnessed at the Node 1, 2, 4 and 6. The greenery in Node 1, 2, 4 and 5 contributed to improved air quality along the street. Plants filtered pollutants like carbon dioxide, nitrogen dioxide, and particulate matter. Cleaner air seen as vital for enhancing people's overall well-being and health, ultimately making the street a more livable and pleasant place to be. Trees and plants have the potential to mitigate noise pollution, positively impacting human health and well-being. This reduction in noise levels contributes to an improved quality of life and opportunities for tranquillity, which can be highly seen at the Node 2 and 4.

4.6.Wellness Components

Wellness components highlight a strong sense of community in Node 1, 2 and 3, attributed to their vibrant activity throughout the day, facilitated by the presence of both small and large shops. This constant buzz fosters a lively street environment from morning until evening. Node 3, 4 and 5, exhibit a sense of community through well-maintained roads, sidewalks, and planter

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boxes, enhancing the area's aesthetics and functionality. Social relationships are particularly strong in Node 1 and 2, largely due to the presence of long-established shops, which serve as hubs for community interaction. Node 3 acts as an interconnecting zone for surrounding neighbourhoods. Node 4, being more institutional and commercially oriented, show somewhat lesser social connectivity compared to the other areas. Conversely, Nodes 5 and 6 are noted for fostering strong social relationships, building a distinct identity through a mix of hotels, malls, and continuous shops, which contribute to the community's social fabric. The sense of belonging and freedom to engage in community activities is seen in Nodes 1, 2 and 3, where residents are encouraged to participate in and showcase their talents, enhancing local vibrancy. Despite the availability of space in Nodes 4, 5 and 6, the engagement in community activities is somewhat limited due to fewer crowds. The emotional attachment to Nodes 1 and 2 is significant, rooted in a rich history of shopping experiences and personal memories spanning more than 50 years, which deeply connect people to these places. Nodes 3 and 4 also carry an emotional significance, especially for those who have studied or worked in the area's educational institutions serving more than 50 years old, fostering a sense of connection to these locations. The newer developments in Node 5 and 6 introduce a different kind of engagement, with modern buildings and amenities offering spaces for people to spend quality time. In terms of street attraction, Node 1 is a major draw for shoppers with its mix of mid-sized and branded shops, catering to a wide economic spectrum. Node 2 stands out for its diverse range of shops, from small to large and branded, attracting a larger crowd and enriching the street with various amenities. Node 3, with its branded shops and food centres complete with parking facilities, appeals to higher-income groups. Node 4 is less attractive comparing to other nodes with its large school compound wall on one side and other side facilitate office complex. Node 5 becomes a focal point with a mall at one corner and a 24/7-star hotel offering restaurants, bars, and leisure activities, while Node 6, with its low-end shops, continuous storefronts, and convention centers, draws crowds from the surrounding neighbourhoods.

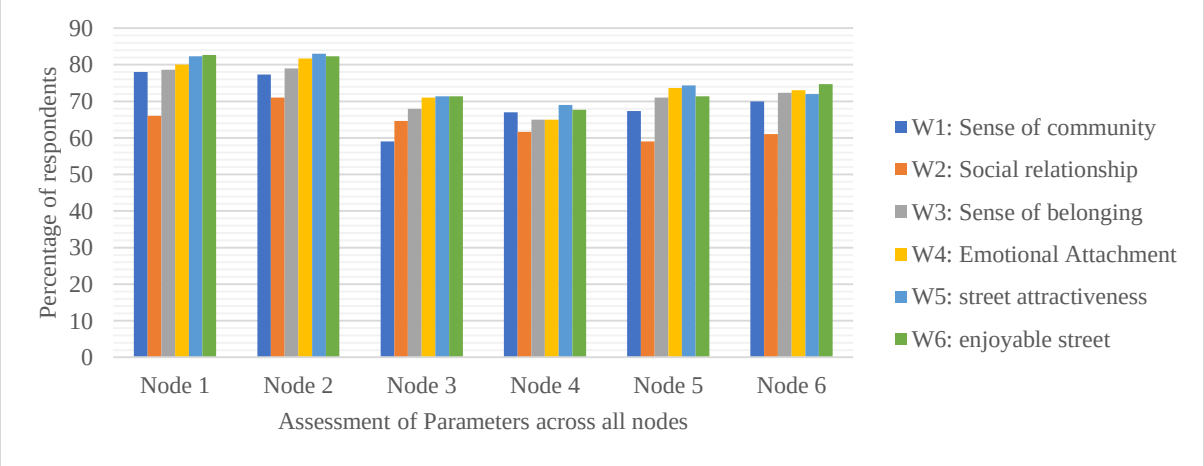

Fig. 13 Users perception of wellness components (in percentage)

5. Discussion

5.1.Physical Components

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Table 2. Correlation analysis of physical components

Physical Components		P1	P2	P3	P4	P5	P6
P1: Adequate street width	Correlation Coefficient	1.000	.341**	.405**	.142**	-.117*	0.028
	Sig. (2-tailed)		0.000	0.000	0.007	0.026	0.599
P2: Sidewalk quality	Correlation Coefficient		1.000	.429**	-0.024	0.006	0.025
	Sig. (2-tailed)			0.000	0.649	0.917	0.631
P3: Street networking	Correlation Coefficient			1.000	.172**	-0.012	0.033
	Sig. (2-tailed)				0.001	0.825	0.535
P4: Existing aged buildings	Correlation Coefficient				1.000	.311**	.444**
	Sig. (2-tailed)					0.000	0.000
P5: Street hawkers	Correlation Coefficient					1.000	.818**
	Sig. (2-tailed)						0.000
P6: Street vendors	Correlation Coefficient						1.000
	Sig. (2-tailed)						

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Adequate street width (P1) positively correlates with sidewalk quality (P2) ($r = 0.341$, $p < 0.01$), street networking (P3) ($r = 0.405$, $p < 0.01$), and existing aged buildings (P4) ($r = 0.142$, $p < 0.01$). This suggests that wider streets tend to have better sidewalk quality, more interconnected street layouts, and a higher presence of aged buildings. Sidewalk quality (P2) positively correlates with street networking (P3) ($r = 0.429$, $p < 0.01$) but does not significantly correlate with existing aged buildings (P4) ($r = -0.024$, $p > 0.05$). This indicates that better sidewalk quality is associated with more interconnected street layouts but does not necessarily relate to the presence of aged buildings. Street networking (P3) positively correlates with existing aged buildings (P4) ($r = 0.172$, $p < 0.01$). This suggests that more interconnected street layouts tend to have a higher presence of aged buildings. Street hawkers (P5) and street vendors (P6) are not included in the correlation analysis as they are not directly correlated with the other variables.

5.2.Design components

Table 3. Correlation analysis of design components

Design Components		D1	D2	D3	D4	D5	D6	D7
D1: Mix use	Correlation Coefficient	1.000	.295**	.121*	.186**	.297**	.166**	.154**
	Sig. (2-tailed)		0.000	0.021	0.000	0.000	0.002	0.003

D2: Active mobility	Correlation Coefficient	1.000	.337**	.279**	.378**	.107*	.133*
	Sig. (2-tailed)		0.000	0.000	0.000	0.042	0.011
D3: Multiple transit	Correlation Coefficient		1.000	.454**	.233**	0.055	0.097
	Sig. (2-tailed)			0.000	0.000	0.294	0.065
D4: Adequate parking facilities	Correlation Coefficient			1.000	.491**	.140**	.254**
	Sig. (2-tailed)				0.000	0.008	0.000
D5: Street furniture	Correlation Coefficient				1.000	.198**	.336**
	Sig. (2-tailed)					0.000	0.000
D6: Street amenities	Correlation Coefficient					1.000	.648**
	Sig. (2-tailed)						0.000
D7: Human scale	Correlation Coefficient						1.000
	Sig. (2-tailed)						

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Mix use (D1) positively correlates with active mobility (D2) ($r = 0.295$, $p < 0.01$), multiple transit (D3) ($r = 0.121$, $p < 0.05$), adequate parking facilities (D4) ($r = 0.186$, $p < 0.01$), street furniture (D5) ($r = 0.297$, $p < 0.01$), street amenities (D6) ($r = 0.166$, $p < 0.01$), and human scale (D7) ($r = 0.154$, $p < 0.01$). This indicates that areas with mixed-use tend to have higher levels of active mobility, access to multiple transit options, adequate parking facilities, street furniture, street amenities, and a human scale. Active mobility (D2) positively correlates with multiple transit (D3) ($r = 0.337$, $p < 0.01$), adequate parking facilities (D4) ($r = 0.279$, $p < 0.01$), street furniture (D5) ($r = 0.378$, $p < 0.01$), street amenities (D6) ($r = 0.107$, $p < 0.05$) and human scale (D7) ($r = 0.133$, $p< 0.05$). This suggests that areas with higher levels of active mobility also tend to have better access to multiple transit options, parking facilities, street furniture, amenities and human scale. Multiple transit (D3) positively correlates with adequate parking facilities (D4) ($r = 0.454$, $p < 0.01$) and street furniture (D5) ($r = 0.233$, $p < 0.01$), but not with street amenities (D6) ($r = 0.055$, $p > 0.05$) or human scale (D7) ($r = 0.097$, $p > 0.05$). This suggests that areas with multiple transit options also tend to have adequate parking facilities and street furniture, but the correlation with street amenities and human scale is not significant. Adequate parking facilities (D4) positively correlate with street furniture (D5) ($r = 0.491$, $p < 0.01$), street amenities (D6) ($r = 0.140$, $p < 0.01$) and human scale (D7) ($r = 0.254$, $p < 0.01$). This suggests that areas with adequate parking facilities also tend to have more street furniture, amenities and human scale. Street furniture (D5) positively correlates with street amenities (D6) ($r = 0.198$, $p < 0.01$) and human scale (D7) ($r = 0.336$, $p < 0.01$), indicating that areas with more street furniture also tend to have more street amenities and human scale. Street amenities (D6) correlate with human scale (D7) ($r = 0.648$, $p < 0.01$), indicating that the presence of street amenities relates to the human scale of an area.

5.3.Social components

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Table 4. Correlation analysis of social components

Social Components		SO1	SO2	SO3	SO4	SO5	SO6
SO1: Place attachment	Correlation Coefficient	1.000	.418**	.433**	.366**	.344**	.285**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000
SO2: Street cleanliness	Correlation Coefficient		1.000	.561**	.479**	.282**	.248**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000
SO3: Visual aesthetics	Correlation Coefficient			1.000	.519**	.371**	.344**
	Sig. (2-tailed)				0.000	0.000	0.000
SO4: Neighborhood attachment	Correlation Coefficient				1.000	.551**	.440**
	Sig. (2-tailed)					0.000	0.000
SO5: Community participation	Correlation Coefficient					1.000	.575**
	Sig. (2-tailed)						0.000
SO6: Neighborhood activities	Correlation Coefficient						1.000
	Sig. (2-tailed)						

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Place attachment (SO1) positively correlates with street cleanliness (SO2) ($r = 0.418$, $p < 0.01$), visual aesthetics (SO3) ($r = 0.433$, $p < 0.01$), neighbourhood attachment (SO4) ($r = 0.366$, $p < 0.01$), community participation (SO5) ($r = 0.344$, $p < 0.01$), and neighbourhood activities (SO6) ($r = 0.285$, $p < 0.01$). This suggests that individuals who have a strong attachment to a place also tend to perceive the streets as cleaner, visually appealing, have a stronger attachment to the neighbourhood, participate more in the community, and engage in more neighbourhood activities. Street cleanliness (SO2) positively correlates with visual aesthetics (SO3) ($r = 0.561$, $p < 0.01$), neighbourhood attachment (SO4) ($r = 0.479$, $p < 0.01$), community participation (SO5) ($r = 0.282$, $p < 0.01$), and neighbourhood activities (SO6) ($r = 0.248$, $p < 0.01$). This indicates that areas perceived as a cleaner also tend to be visually appealing, have stronger neighbourhood attachments, higher levels of community participation, and more neighbourhood activities. Visual aesthetics (SO3) positively correlates with neighbourhood attachment (SO4) ($r = 0.519$, $p < 0.01$), community participation (SO5) ($r = 0.371$, $p < 0.01$), and neighbourhood activities (SO6) ($r = 0.344$, $p < 0.01$). This suggests that visually appealing areas also tend to have stronger neighborhood attachments, higher levels of community participation, and more neighborhood activities. Neighbourhood attachment (SO4) positively correlates with community participation (SO5) ($r = 0.551$, $p < 0.01$) and neighbourhood activities (SO6) ($r = 0.440$, $p < 0.01$), indicating that individuals who are more attached to their neighbourhood are also more likely to participate in community activities and engage in neighbourhood activities. Community participation (SO5) positively correlates with neighbourhood activities (SO6) ($r = 0.575$, $p < 0.01$), indicating that individuals who participate more in community activities also tend to engage more in neighbourhood activities.

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5.4.Safety Components

Table 5. Correlation analysis of safety components

Safety Components		SA1	SA2	SA3	SA4	SA5	SA6
SA1: Street lighting	Correlation Coefficient	1.000	.463**	.428**	.242**	0.059	.138**
	Sig. (2-tailed)		0.000	0.000	0.000	0.266	0.009
SA2: Openness	Correlation Coefficient		1.000	.810**	.286**	.134*	.125*
	Sig. (2-tailed)			0.000	0.000	0.011	0.017
SA3: Communal spaces	Correlation Coefficient			1.000	.321**	.140**	.134*
	Sig. (2-tailed)				0.000	0.008	0.011
SA4: Traffic calming elements	Correlation Coefficient				1.000	.490**	.509**
	Sig. (2-tailed)					0.000	0.000
SA5: Shade and shelter	Correlation Coefficient					1.000	.654**
	Sig. (2-tailed)						0.000
SA6: Universal accessibility	Correlation Coefficient						1.000
	Sig. (2-tailed)						

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Street lighting (SA1) positively correlates with openness (SA2) ($r = 0.463$, $p < 0.01$), communal spaces (SA3) ($r = 0.428$, $p < 0.01$), traffic calming elements (SA4) ($r = 0.242$, $p < 0.01$), and universal accessibility (SA6) ($r = 0.138$, $p < 0.01$), but not with shade and shelter (SA5) ($r = 0.059$, $p > 0.05$). This suggests that well-lit streets tend to be more open, have more communal spaces, traffic calming elements, and universal accessibility, but the correlation between shade and shelter is not significant. SA2 (Openness) positively correlates with communal spaces (SA3) ($r = 0.810$, $p < 0.01$), indicating that areas with a sense of openness tend to have more communal spaces. SA2 (Openness) also positively correlates with traffic calming elements (SA4) ($r = 0.286$, $p < 0.01$), shade and shelter (SA5) ($r = 0.134$, $p > 0.05$) and universal accessibility (SA6) ($r = 0.125$, $p < 0.05$). Communal spaces (SA3) positively correlate with traffic calming elements (SA4) ($r = 0.321$, $p < 0.01$) and shade and shelter (SA5) ($r = 0.140$, $p < 0.01$), and universal accessibility (SA6) ($r = 0.134$, $p < 0.05$). This suggests that areas with more communal spaces also tend to have more traffic-calming elements, shade and shelter and are universally accessible. Traffic calming elements (SA4) positively correlate with shade and shelter (SA5) ($r = 0.490$, $p < 0.01$) and universal accessibility (SA6) ($r = 0.509$, $p < 0.01$) indicating that areas with more traffic calming elements are universally accessible and also tend to have more shade and shelter. Shade and shelter (SA5) do not correlate with universal accessibility (SA6) ($r = 0.654$, $p < 0.01$), indicating that the presence of shade and shelter does not necessarily relate to universal accessibility.

5.5.Natural components

Table 6. Correlation analysis of natural components

Natural Components		N1	N2	N3	N4
N1: Tree canopy activities	Correlation Coefficient	1.000	.561**	.274**	.279**
	Sig. (2-tailed)		0.000	0.000	0.000
N2: Presence of greenery	Correlation Coefficient		1.000	.230**	.275**
	Sig. (2-tailed)			0.000	0.000
N3: Clean air	Correlation Coefficient			1.000	.597**
	Sig. (2-tailed)				0.000
N4: Noise buffer	Correlation Coefficient				1.000
	Sig. (2-tailed)				

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Tree canopy activities (N1) positively correlate with the presence of greenery (N2) ($r = 0.561$, $p < 0.01$), clean air (N3) ($r = 0.274$, $p < 0.01$), and noise buffer (N4) ($r = 0.279$, $p < 0.01$). This suggests that areas with more tree canopy activities also tend to have more greenery, cleaner air, and act as a noise buffer. Presence of greenery (N2) positively correlates with clean air (N3) ($r = 0.230$, $p < 0.01$) and noise buffer (N4) ($r = 0.275$, $p < 0.01$), indicating that areas with more greenery tend to have cleaner air and act as a noise buffer. Clean air (N3) positively correlates with noise buffer (N4) ($r = 0.597$, $p < 0.01$), indicating that areas with cleaner air also tend to act as a noise buffer.

5.6.Wellness components

Table 7. Correlation analysis of wellness components

Wellness Components		W1	W2	W3	W4	W5	W6
W1: Sense of community	Correlation Coefficient	1.000	.444**	.500**	.517**	.470**	.512**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000
W2: Social relationship	Correlation Coefficient		1.000	.578**	.545**	.518**	.541**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000
W3: Sense of belonging	Correlation Coefficient			1.000	.818**	.668**	.714**
	Sig. (2-tailed)				0.000	0.000	0.000

W4: Emotional attachment	Correlation Coefficient	1.000	.788**	.801**
	Sig. (2-tailed)		0.000	0.000
W5: Street attractiveness	Correlation Coefficient		1.000	.869**
	Sig. (2-tailed)			0.000
W6: Enjoyable street	Correlation Coefficient			1.000
	Sig. (2-tailed)			

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Sense of community (W1) positively correlates with social relationship (W2) ($r = 0.444$, $p < 0.01$), sense of belonging (W3) ($r = 0.500$, $p < 0.01$), emotional attachment (W4) ($r = 0.517$, $p < 0.01$), street attractiveness (W5) ($r = 0.470$, $p < 0.01$), and enjoyable street (W6) ($r = 0.512$, $p < 0.01$). This suggests that a strong sense of community is associated with positive social relationships, a sense of belonging, emotional attachment, attractive streets, and enjoyable street experiences. Social relationship (W2) positively correlates with sense of belonging (W3) ($r = 0.578$, $p < 0.01$), emotional attachment (W4) ($r = 0.545$, $p < 0.01$), street attractiveness (W5) ($r = 0.518$, $p < 0.01$), and enjoyable street (W6) ($r = 0.541$, $p < 0.01$). This indicates that positive social relationships are associated with a strong sense of belonging, emotional attachment, attractive streets, and enjoyable street experiences. Sense of belonging (W3) positively correlates with emotional attachment (W4) ($r = 0.818$, $p < 0.01$), street attractiveness (W5) ($r = 0.668$, $p < 0.01$), and enjoyable street (W6) ($r = 0.714$, $p < 0.01$). This suggests that a strong sense of belonging is associated with higher levels of emotional attachment, perceived street attractiveness, and enjoyable street experiences. Emotional attachment (W4) positively correlates with street attractiveness (W5) ($r = 0.788$, $p < 0.01$) and enjoyable street (W6) ($r = 0.801$, $p < 0.01$), indicating that higher levels of emotional attachment are associated with streets perceived as more attractive and enjoyable. Street attractiveness (W5) positively correlates with enjoyable street (W6) ($r = 0.869$, $p < 0.01$), indicating that streets perceived as more attractive are also more enjoyable.

6. Conclusion

This study puts forth thirty-five parameters under six components (physical, design, social, safety, natural, and wellness) for analysing the livability of commercial streets. Though many researches focus on the study and analysis of livability parameters, the statistical approach towards the investigation of the diversified characteristics of commercial streets is comparatively less. There is a lack of statistical research that thoroughly investigates the diverse nature of commercial streets. This study has identified key prominent characteristics of street livability that are required for commercial streets to retain their role as central attractions by conducting a study at Sir Thyagaraya Road, Chennai. The results indicate that parameters such as sidewalks, street amenities, visual aesthetics, street lights, greenery, and street attractiveness are significant in enhancing the vibrancy of Indian commercial streets. This

paper offers a conceptual framework to assess and enhance the livability of commercial streets. Additionally, this research provides a decision-making tool for urban planning. The study undertakes a methodology to identify practical recommendations for revitalising and improving commercial streets. The research findings will be supportive to urban planners and policymakers, to develop targeted recommendations for the betterment of the livability of commercial streets like Sir Thyagaraya Road, Chennai.

7. Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used several generative Al and AI-assisted technologies in order to copyedit, proof- read or paraphrase the text. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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