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Pedalling Towards Improved Well-being.
Impact of Non-Motorised Transport Infrastructure on the Quality of Life of the Youth in Delhi

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Abstract

Rapid urbanisation and population growth in Delhi have led to a significant increase in the demand for transport infrastructure. However, a traditional adherence to car-centric development in Indian cities has contributed to escalating road injuries and degraded urban settings, exposing pedestrians and cyclists to a fatality risk of around 40 times higher than car users. To address these challenges, strategies like Non-Motorised Transport (NMT) are crucial in promoting sustainable mobility. Despite its proven effectiveness globally, the influence of NMT on the Quality of Life (QoL), especially on the youth (aged 15-29 years) in the Indian context remains unexplored. This paper investigates a recent integration of NMT infrastructure on one of Delhi's most accident-prone roads through space redistribution. The paper gathers infrastructure assessment factors and physical, social, mental and economic well-being indicators from existing literature and user perceptions on-site. Based on user perceptions, these are correlated, followed by a quantitative study of the influence of each factor on its corresponding indicator using positive responses before and after transformation. The study emphasises key factors that must be addressed while revamping public streets to enhance the health and well-being of young individuals. It suggests that layout quality and lighting significantly improve safety and comfort. Yet the design compromises safety due to a lack of city-level and neighbourhood continuity, and intersections with the high-speed road, resulting in a low rating for physical well-being. A composite well-being score is calculated to illustrate the extent of impact on QoL. Insights derived from the case of Delhi offer a practical framework for other Indian cities seeking to enhance their urban landscapes. The paper emphasises the perspectives of youth on quality well-being, shows how different design features act toward achieving a high QoL, and intends to nudge a shift toward pedestrian-friendly cities.

Keywords: well-being, quality of life, youth, non-motorised transport, Indian cities

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1. Background

In Delhi, the capital of the world's largest democracy, cyclists and pedestrians constitute an important sector of daily commuters. According to Census 2011, approximately one-third of daily commutes in Delhi happen on foot or by cycle, with 34% relying on walking (Kaur and Jain, 2020). Nearly 50% of metro users walk to or from stations, with walking being the predominant mode for 77% of urban poor commuters (Kaur and Jain, 2020). However, these pedestrians and cyclists face a fatality risk which is more than two times of motorcyclists and around 40 times higher than car users (Goel, 2023, p.1). Road accidents in Delhi increased by 17.8% between 2021 and 2022, with cyclists and pedestrians being the most affected (Crime in India, 2023, p.87; The Times of India, 2023).

As there is insufficient evidence regarding factors affecting cyclists' injury risk in Indian cities, user experiences help to cite the issues. Almost 40% of city roads lack footpaths or basic walking infrastructure (Kaur and Jain, 2020), and cyclists cite inadequate infrastructure as their primary concern (The Energy and Resources Institute, 2014, p. 93). A study by Goel (2023, p. 1) states that poor quality of roads, encroachments on footpaths, and overspeeding and honking vehicles add to cyclist vulnerability, which has led to a decline in the cycling modal share from 28% in 1954 to less than 5% in 2013 in Delhi. Ownership of cars and motorised two-wheelers has grown multiple times, affecting environmental pollution and the health of people at the same time.

Walking and cycling favour one's health; good health is the foundation of well-being and Quality of Life (QoL). Numbeo (2024) reports the QoL of Delhi as 102.34, which is comparatively lower than cities like Sydney (157), Berlin (163) and Prague (159). Unsafe mobility infrastructure, escalating traffic congestion, and accident risks are among many reasons behind Delhi's low QoL. While different contexts define QoL differently, all metrics, including the assessment tool of the Ease of Living Index (2020, p. 28) in India, rank QoL as an essential component of physical, social, and mental well-being. A safe environment and affordable transportation access promote an individual's well-being and improve QoL in Indian cities (Patil and Sharma, 2020, p.183).

Home to 1, 428.6 billion people, India has recently emerged as the world's most populous country (United Nations Population Fund, 2023). Notably, it is also one of the youngest countries globally, 27.3% of its population falls within the youth demographic (aged 15-29 years) (Ministry of Statistics and Programme Implementation, 2022, p.18). Youth play a significant role in shaping the future of a nation and a developing country, such as India, must avoid the consequences of losing its youth to dangers associated with inadequate cycle infrastructure. Therefore, it becomes essential to design urban environments that prioritise the safety and well-being of its young citizens.

2. Need of the study

India is undergoing rapid urbanisation, with a 30% decadal growth in urban areas from 2000 to 2010. This is projected to increase to 40% from 2010 to 2030 (Panda et al., 2016, p. 435), further exerting pressure on infrastructure, such as public transport, road networks, socio-economic prospects, and healthcare facilities. For a long time, India has focused on car-centric cities, with its signal-free roads and expressways over pedestrian and cyclist safety. However, this focus is beginning to shift to sustainable planning and design approaches to develop cities. One such example of enhancing the urban landscape is the recent restructuring of the busiest road in Delhi to integrate it with NMT. Pinter-Wollman, Jelić

and Wells (2018, p.1) state that modifying the built environment can impact the health and well-being of the urban population in the long run. Given the limited existing literature on the relevance of this statement in the Indian context, this study aims to assess the influence of safe cycling infrastructure on the well-being of youth, using indicators of Quality of Life (QoL) as an assessment measure.

The research sheds light on the intricacies of the interplay between demographics, urban planning, and innovative design. The analysis aims to redirect attention from vehicle-centred to pedestrian-centred cities in India. The findings are expected to guide designers in prioritising key factors for enhancing the QoL of young people while redesigning streets.

3. Methodology

As visualised in Figure 1, the study employs a systematic literature review to explore relevant international and national studies on 'public spaces', 'social sustainability', and 'quality of life'. This helps to understand concepts such as 'streets as public spaces', 'NMT as social infrastructure' and 'quality of life in Indian cities' and identify knowledge gaps and challenges. Assessment factors for quality infrastructure and indicators of QoL, derived from the review, lay the foundation for the study.

These factors and indicators are compared with the Ease of Living Index (2021, p.29). The Index captures the QoL in Indian cities through indicators such as transportation and mobility, water supply management, and solid waste management, to name a few. While the Index assesses cities based on the availability of NMT infrastructure, it lacks a thorough evaluation of streets as public spaces, NMT as social infrastructure, and its quality as perceived by users. Thus, the findings from the literature review are combined with the QoL indicators from the Ease of Living Index to evaluate the quality of NMT infrastructure.

Connections between various assessment factors for NMT and QoL indicators and their impact on youth's well-being are established through primary research grounded in on-site interactions with 96 users, structured and semi-structured interviews, and observations with ethical considerations. The stakeholders include youth aged 15 to 29, encompassing vendors, daily public transport commuters, school children, temple visitors, recreational users (for eating, observing and sitting), and residents from neighbouring areas.

Throughout the research, unforeseen delays in data collection arose due to cold weather in December and January, followed by contrasting hot days, during which the street remained deserted. Additionally, translating the urban terminologies into a local language for better user articulation was challenging.

4. Literature review

This section deconstructs the research topic into three divisions- 'streets as public spaces', 'NMT as social infrastructure, and 'QoL indicators in urban India'. Each division reviews existing literature to understand concepts and translates them to the Indian context. It ends with assessment factors and indicators extracted from the literature review for the study. These are summarised in Figure 2.

4.1. Streets as public spaces

The Charter of Public Space (2015) defines 'public spaces' as areas accessible and

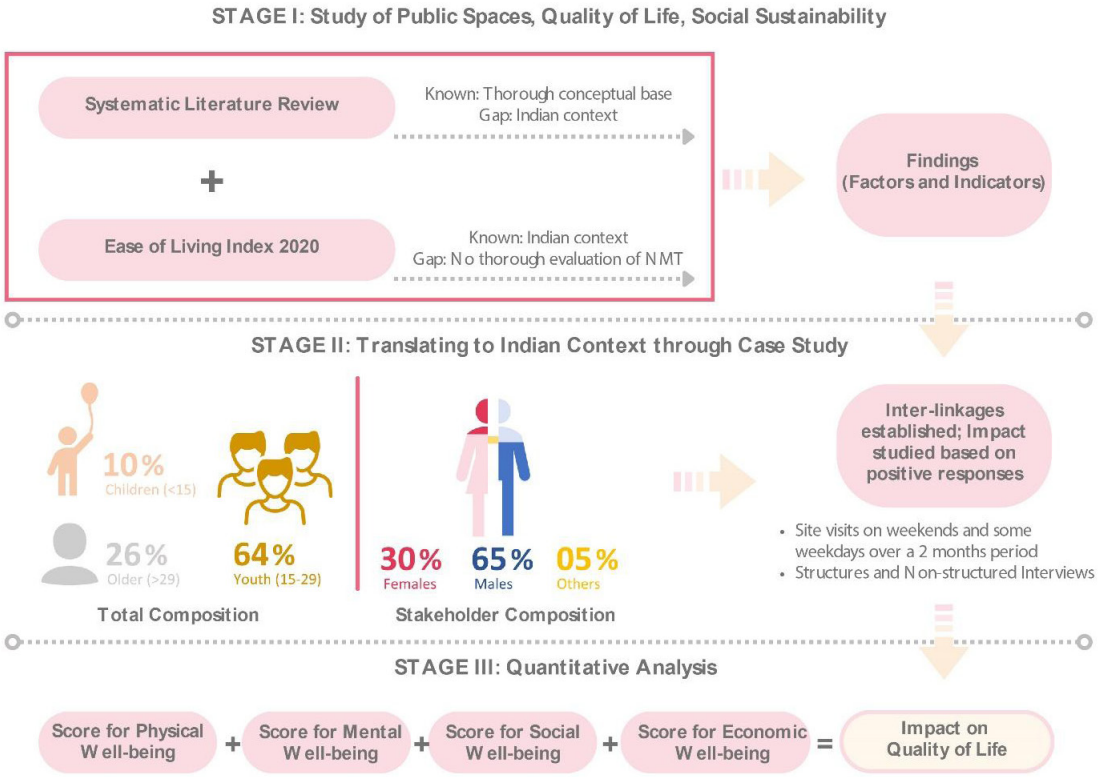


Figure 1. Study Methodology and Stakeholder Compositions Found during Field Visits. (Author, 2024)

enjoyable for all, including streets and open spaces, publicly owned or of public use. In the Indian context, the Ministry of Housing and Urban Affairs classifies public spaces into green parks, playgrounds, and forests (Mehta and Dhindaw, 2020). However, streets, often overlooked in public discourse, emerge as the most public among all spaces (Deore and Lathia, 2019, p. 138). In India, they act as dynamic spaces that serve as hubs for social interactions, economic transactions, and cultural expression within its diverse community. The United Nations (2023, p. 35) states that to achieve Sustainable Development Goal 11, i.e. Sustainable Cities and Communities, it is important to prioritise public spaces that enhance inclusion, social cohesion, and the productivity of cities (Target 11.7).
Figure 2 summarises assessment factors for quality public streets, including design parameters like land use, layout quality, public space integration, pedestrian safety, privacy, built densities, connectivity, and proximity to public transport (Ahmed, 2012, pp. 44-46), accessibility, permeability, legibility, aesthetics (Karuppannan and Sivam, 2011, p. 857). Factors like citizen engagement, adaptability, street amenities, integration of the informal economy, heritage, and local culture (Ghahramanpouri et al., 2015, p. 368) are also vital.

4.2. Non-Motorised Transport (NMT) as social infrastructure

The Brundtland Report (1987) acknowledges economic, social, and environmental sustainability as fundamental pillars. Surbeck and Hilger (2014, p. 2078) state that 'social sustainability' encompasses social, societal, and human engagement, impact, and vulnerabilities in a project. Dave (2011, p. 189) underscores the relationship between social sustainability and the built environment in developing countries. A part of that built environment is NMT infrastructure, a pivotal planning concept involving engine-free

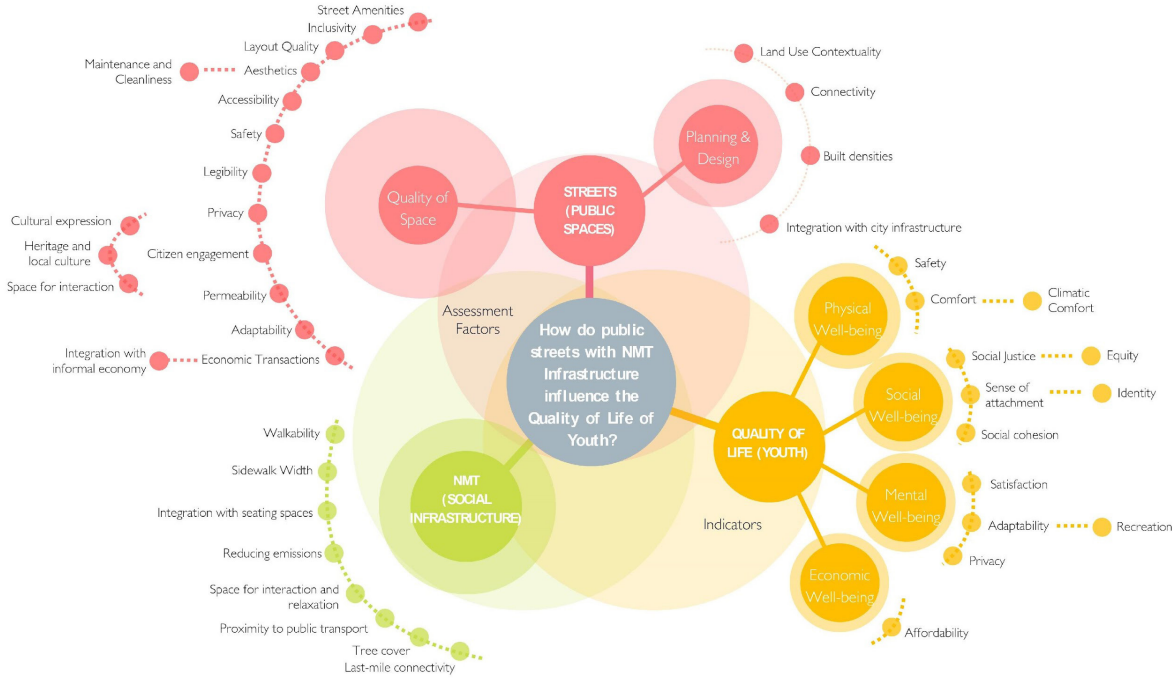


Figure 2. Assessment Factors for NMT and Indicators for Quality of Life in Cities extracted from literature review. (Author, 2024)

modes such as cycling and walking. Barton, Grant and Guise (1995, 2003) state that NMT enhances health, reduces emissions, and ensures last-mile connectivity when integrated with other transportation modes.

When public streets act as physical activity zones and spaces for social interactions, recreation, and relaxation, they contribute to individuals' physical and social well-being as social infrastructure. Despite often being neglected in urban planning, the paramount significance of NMT as social infrastructure is evident in Indian society.

Mehta (2009, p. 41) underscores the assessment factors of quality NMT as social infrastructure, emphasising walking (reduced car emissions) and specific street elements such as seating (fixed/removable/proximity to local businesses), sidewalk width, tree cover (for enhanced micro-climate), and community gathering spaces that make spaces vibrant. These factors are summarised in Figure 2.

4.3. Urban Quality of Life (QoL) and well-being of youth in urban India

Ease of Living Index (2021, p. 28) (EoLI) evaluates the 'well-being' of Indian citizens across parameters including 'QoL'. While the text uses the two terms interchangeably in some places, it considers QoL as a component of well-being. Internationally, Weingaertner and Moberg (2011, p. 122-133) define QoL as citizens' social, environmental and economic well-being. It considers well-being as a component of QoL. Since EoLI is comparatively recent and is being revised, this paper adopts the international line of thought by studying the influence of mobility on QoL as a cumulative impact on the well-being of the youth. Urban areas either promote social exclusion or encourage social sustainability and inclusion through safe public spaces (Karuppannam and Sivam, 2011, p. 849). Thus, they

should be planned to enhance physical well-being and contribute to social engagement, cultural expression, and a sense of belonging among the youth. As summarised in Figure 2, the indicators for QoL encompass aspects like safety, comfort, recreation (Ease of Living Index, 2021, p. 29), happiness and satisfaction, social justice (equity), affordability, leisure, cleanliness, economic security, choices, and social relationships.

4.4. Scope of the study

AoU (2020) highlights that settlement planning influences lifestyle patterns, which can lead to health issues. When streets fail to welcome cyclists and pedestrians through safe infrastructure, they leave them vulnerable to injuries and deaths, making them lose their interest in a sustainable transportation mode, as highlighted in Section 1. Promoting a healthy lifestyle among the youth involves providing access to inclusive streets, reducing vehicular emissions, and incorporating high-quality transport design. This discussion pivots back to the crucial role of NMT infrastructure in public spaces in governing individuals' quality of life.

5. Case study

The Public Works Department of the Government of Delhi has advocated for NMT lanes along 16 short road stretches on the busiest roads in Delhi (Mani, 2022). Among these is the Inner Ring Road, a pivotal 55 km arterial route which is almost signal-free and designed for high-speed traffic. It is also the most crash-prone road in Delhi with the most fatalities in 2022 (Bhat, 2023) because of the long-standing lack of pedestrian-friendly infrastructure.

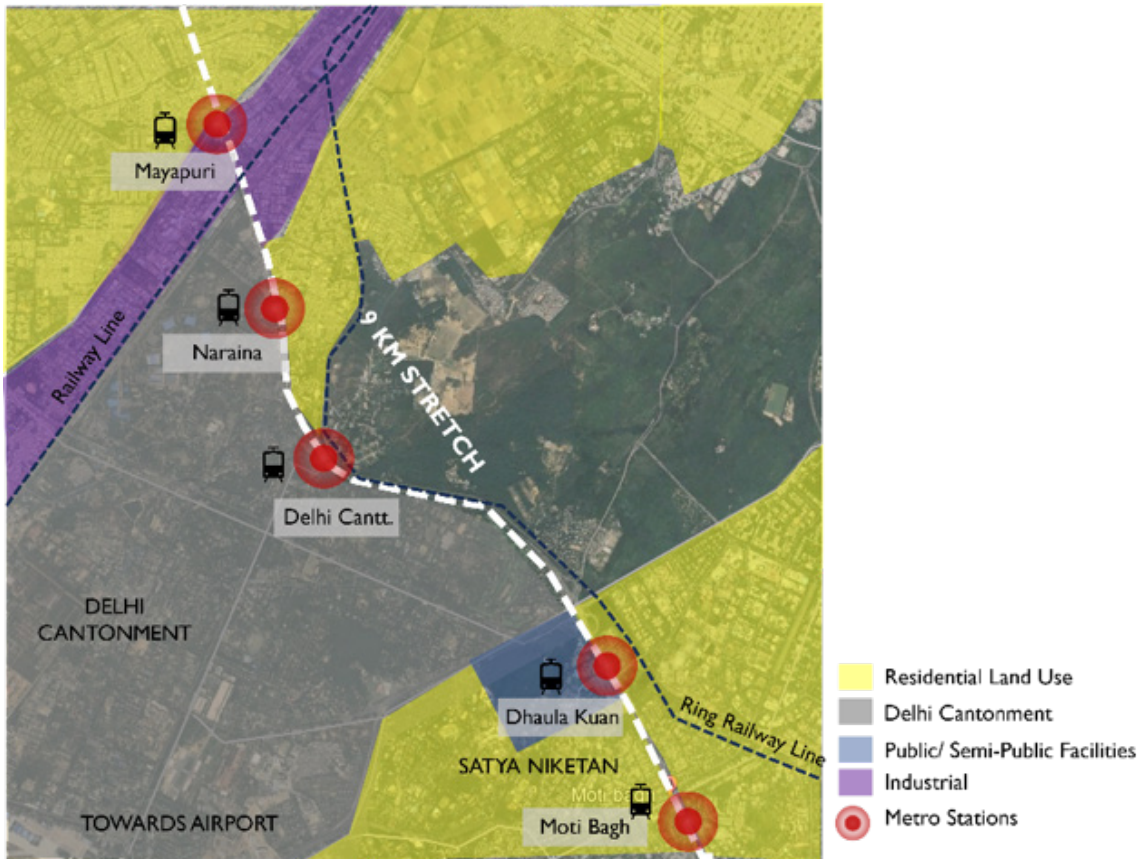
The pilot redesign of a 9 km stretch of the Inner Ring Road extends from the Core of the City to its northwest, connecting the residential, institutional, and leisure zone of Moti Bagh to the institutional and inter-city transit area of Dhaula Kuan. It extends to Delhi Cantonment's administrative zone and traverses densely populated settlements in Naraina and Mayapuri. Aligned with a metro line, it encompasses five metro stations and numerous bus stops (Figure 3).

Before the transformation, roadside spaces were either underutilised or left abandoned, hampering the safety of pedestrians and daily commuters (Figure 4). The previous Right of Way varied between 60 to 80 meters but has now been re-organised to accommodate 10 to 16-meter-wide public walkways without compromising the number of car lanes (Figure 5).

6. Gathering Youth perceptions

Youth, comprising 96 individuals aged between 15 and 29, were interviewed on their perception of the NMT street. Respondents were divided into five user groups - UG1: Females aged 15-21, UG2: Males aged 15-21, UG3: Females aged 22-29, UG4: Males aged 22-29, and UG5: Others (persons with disability), based on observations during site visits. Figure 6 summarises the stakeholder perception and compares the responses with the assessment factors from existing literature.

Users' narrations help understand how the street transformation have affected their quality of daily travel. The number of positive responses, tabulated in Table 1, aids in calculating the extent of influence of the NMT integration on their well-being. Column 'B'



Key plan

Figure 3. 9 km stretch (Moti Bagh-Mayapuri) selected for study (Google Earth, Master Plan for Delhi 2041)

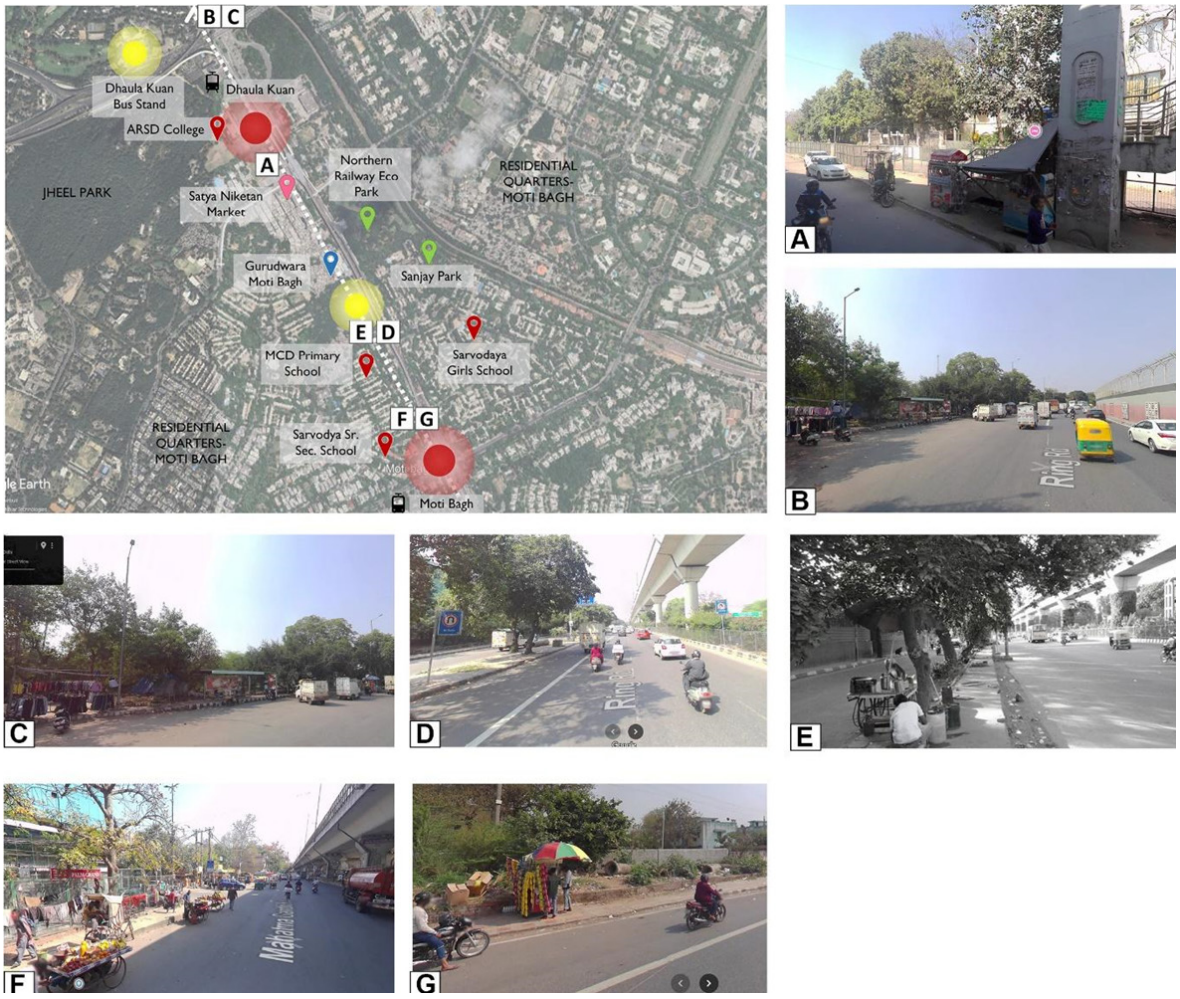


Figure 4. Google street views extracted to depict the condition of the street before NMT infrastructure. (Google Maps, 2024)

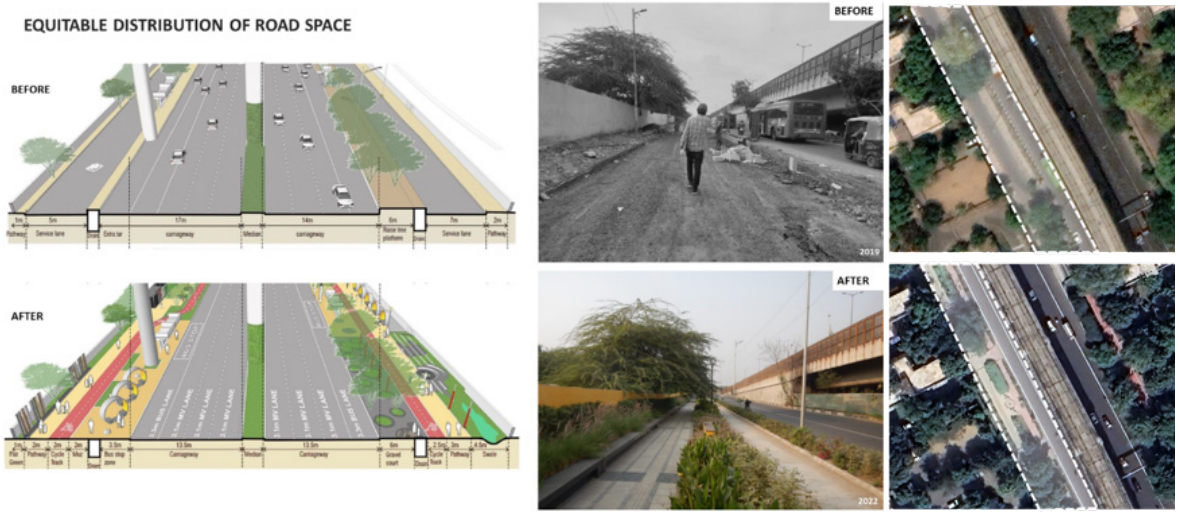
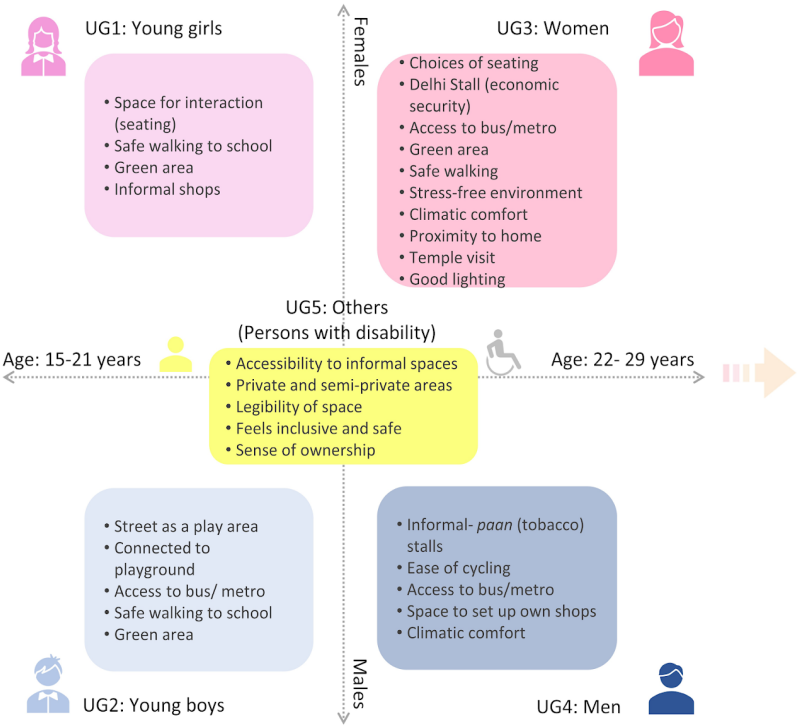


Figure 5. A comparison of the road between 2017 and 2024, showing vehicular traffic bays integrated with NMT infrastructure. (Oasis Designs Inc., 2024 and Google Earth)



Assessment Factors from Perceptions	Assessment Factors from Literature Review
Seating	Choice and Location of Seating
Aesthetics, Lighting	Maintenance
Informal Spaces	Informal Spaces, Temporal Diversity of Use
Accessibility- Walking, Public Transport	Accessibility- walking, Affordability, Economic Opportunities
Climatic Comfort	Climatic Comfort, Tree Cover, Integration with nature
Recreational (Playing/Sports)	Layout Quality
Connectivity	City-level connectivity
Legibility	Legibility
Cycle to work/ leisure	Layout Quality
Land use (Temples, Proximity to home)	Permeability, Land Use, Neighbourhood Connectivity,

Quality of Life (Well-being) Indicators from Perceptions	Quality of Life (Well-being) Indicators from Literature Review
Safety	Safety (Physical)
Stress-free	Comfort (Physical)
Ease (of walking, cycling, sitting, observing, eating)	Climatic Comfort (Physical)
Privacy	Adaptability (Mental)
Identity	Satisfaction (Mental)
	Privacy (Mental)
	Identity (Mental)
	Meaningfulness (Mental)
	Equity (Social)
	Inclusivity (Social, Economic)
	Social Cohesion (Social)

Figure 6. On-ground views gathered during interactions with the youth on how they associate with space. (Author, 2024)

lists assessment factors that impact the physical, mental, social and economic well-being, as narrated by users in order of their prevalence. Columns 'C' and 'D' show the percentage of positive responses from each user group out of 96 participants before and after the transformation respectively. Column 'E' indicates the variation in responses, with negative values indicating a decrease in positive feedback. Here, it must be noted that a low value does not necessarily mean a low impact but may be due to a lack of opinions from the participants or no change in services. Hence, qualitative reasoning behind the numbers is important. Column 'F' defines the magnitude impact based on-0-25%: Extremely low; 26-50%: Low; 51-75%: Moderate; 76-100%: High.

Table 1: Change of responses reported by 5 user groups helps justify the impact of NMT on the QoL of the youth (Author, 2024)

S. No.	QoL Indicators	Assessment Factors for NMT that impact (A) in the order of its relevance	Positive responses reported by User Groups (before NMT integration) (in numbers)						Positive responses reported by User Groups (after NMT integration) (in numbers)						Change in a positive response (in %)	Extent of Impact on QoL (Result)
	(A)	(B)	(C)						(D)						(E)=(D)-(C)	(F)
			UG1 (12)	UG2 (28)	UG3 (17)	UG4 (34)	UG5 (05)	% (96)	UG1 (12)	UG2 (28)	UG3 (17)	UG4 (34)	UG5 (05)	% (96)		
I	**Indicators for Physical Well-Being**															
1	Safety	Accessibility (Safe walking)	4	5	0	8	0	18%	11	22	14	33	5	89%	70.83%	Moderate
		Layout Quality	0	2	0	4	0	6%	9	24	14	28	3	81%	75.00%	Moderate
		Lighting	0	3	1	8	0	13%	11	26	15	34	4	94%	81.25%	High
		City-level Connectivity	2	4	5	19	2	33%	8	15	8	25	3	61%	28.13%	Low
		Permeability	0	22	3	29	0	56%	6	27	11	33	3	83%	27.08%	Low
		Informal Spaces	10	18	14	25	2	72%	12	28	15	33	4	96%	23.96%	Extremely Low
		Temporal Diversity of Use	3	0	2	1	0	6%	10	25	16	28	4	86%	80.21%	High
		Land Use	6	15	12	28	4	68%	8	18	15	31	5	80%	12.50%	Extremely Low
2	Comfort (ease of walking/cycling, stress-free)	Neighbourhood Connectivity	2	14	2	12	0	31%	5	20	5	14	0	46%	14.58%	Extremely Low
		City-Level onnectivity	0	4	5	15	0	35%	3	11	5	15	0	35%	10.42%	Extremely Low
		Lighting	0	3	1	8	0	13%	11	26	15	34	4	94%	81.25%	High
		Choice/Location of Seatings	0	2	0	3	0	5%	12	24	17	34	4	95%	89.58%	High
		Layout Quality	0	2	0	4	0	6%	9	24	14	28	3	81%	75.00%	Moderate
		Maintenance	0	1	0	0	0	1%	11	26	17	33	5	96%	94.79%	High
		Legibility	0	4	1	8	1	15%	11	27	17	34	5	98%	83.33%	High
3	Climatic Comfort (shade during extreme sun/rain)	Tree Cover	9	17	12	21	2	64%	12	20	17	29	3	84%	20.83%	Extremely Low
		City-level Connectivity	0	4	4	15	0	24%	1	5	4	15	0	26%	2.08%	Extremely Low
		Layout Quality (Integration with Nature)	0	2	0	4	0	6%	11	28	17	34	4	98%	91.67%	High
II	**Indicators for Mental Well-Being**															
4		Choice/Location of Seatings	0	2	0	3	0	5%	12	24	17	34	4	95%	89.58%	High

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Table 1: Change of responses reported by 5 user groups helps justify the impact of NMT on the QoL of the youth (Author, 2024)

S. No.	QoL Indicators	Assessment Factors for NMT that impact (A) in the order of its relevance	Positive responses reported by User Groups (before NMT integration) (in numbers)						Positive responses reported by User Groups (after NMT integration) (in numbers)						Change in a positive response (in %)	Extent of Impact on QoL (Result)
	Adaptability (NMT lanes turning into spaces for relaxation/ recreation)	Layout Quality	NA	2	NA	4	0	6%	NA	28	NA	34	4	69%	62.50%	Moderate
		Tree Cover	4	17	6	27	2	58%	8	20	17	29	3	80%	21.88%	Extremely Low
5	Satisfaction	Lighting	0	3	1	8	0	13%	11	26	15	34	4	94%	81.25%	High
		Permeability	0	22	3	29	9	56%	6	27	11	33	3	83%	27.08%	Low
		Tree Cover	9	17	12	21	2	64%	12	20	17	29	3	84%	20.83%	Extremely Low
		Land Use	6	15	12	28	4	68%	8	18	15	31	5	80%	12.50%	Extremely Low
6	Privacy	Choice/Location of Seatings	NA	2	0	3	0	5%	NA	19	5	28	3	57%	52.08%	Moderate
		Permeability	0	22	3	29	0	56%	6	27	11	33	3	83%	27.08%	Low
7	Indentity	Informal Spaces	10	18	14	25	2	72%	12	28	15	33	4	96%	23.96%	Extremely Low
		Temporal Diversity of Use	3	0	2	1	0	6%	10	25	16	28	4	86%	80.21%	High
		Maintenance	0	1	0	0	0	1%	11	26	17	33	5	96%	94.79%	High
8	Meaningfulness	Legibility	0	4	1	8	1	15%	11	27	17	34	5	98%	83.33%	High
		Informal Spaces	10	18	14	25	2	72%	12	28	15	33	4	96%	23.96%	Extremely Low
III	**Indicators for Social Well-Being**															
9	Equity	Layout Quality	0	2	0	4	0	6%	9	28	17	34	4	96%	89.58%	High
		Temporal Diversity of Use	3	0	2	1	0	6%	10	25	16	28	4	86%	80.21%	High
10	Inclusivity	Accessibility	0	8	3	16	1	29%	12	28	17	34	5	100%	70.83%	Moderate
11	Social Cohesion	Temporal Diversity of Use	3	0	2	1	0	6%	10	25	16	28	4	86%	80.21%	High
		Choice/Location of Seatings	0	2	0	3	0	5%	12	24	17	34	4	95%	89.58%	High
		Informal Spaces	10	18	14	25	2	72%	12	28	15	33	4	96%	23.96%	Extremely Low
		Lighting	0	3	1	8	0	13%	11	26	15	34	4	94%	81.25%	High
IV	**Indicators for Economic Well-Being**															
12	Inclusivity	Affordability	12	28	17	34	5	100%	12	28	17	34	5	100%	0.00%	No change
		Economic Opportunities	NA	16	NA	34	5	57%	NA	19	NA	28	5	54%	-3.13%	Decrease

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7. Assessing Non-Motorised Transport (NMT) infrastructure

As stated earlier, the impact of factors collated jointly from youth perceptions and literature review was assessed using well-being as a component of QoL. The indicators of QoL (extracted in Section 1) were divided into the sub-components of well-being, i.e. physical, mental, social and economic. These indicators were linked with the assessment factors based on the perceptions of the youth perceptions (Table 1).

7.1. Planning assessment factors

a. Land use

The vibrant land use spans 16 schools, a college, a medical facility, a district-level park, two city-level parks, a Sikh temple, some small shrines, and a cluster of restaurants and residences along the road (Figure 7). It attracts youth, who constitutes 64% of the overall users. As land use remains unchanged post-transformation, the extent of its influence on well-being, though positive, is low (Table 1).

Figure 7. Adjacent land use encompassing schools, parks, colleges and restaurants that attract youth. (Google Earth and Author, 2024)

b. City-level (Connectivity and Continuity)

The street prioritises pedestrians and cyclists within an 800-metre radius of the metro stations, creating a successful Multi-Modal Integration hub (Figure 8), per the Unified Traffic and Transportation Infrastructure (Planning and Engineering) Centre (UTTIPEC) (*Street Design Guidelines*, 2010, p.75). Metro stations, equipped with bus stops, auto rickshaw stands, e-rickshaws, foot-over bridges and car halts, are integrated with NMT and rental bike stands enabling easy access to diversified mobility options and last-mile connectivity. Youth feel comfortable adopting public transport. Thus, its impact on the physical well-being of the youth is positive (Table 1). Despite providing safe walking and travel comfort with tree cover, the NMT lanes are frequently interrupted by large road intersections, like the one at Dhaula Kuan (Figure 8E) and become less than a metre wide at some points (Figure 9P), lowering the extent of the impact on physical well-being.

c. Neighbourhood continuity

The continuity of NMT lanes from the main road to lower-order streets is crucial for the user's continued comfort. However, the collector streets leading to adjacent areas (Figure 9) lack bicycle lanes, disrupting the comfort of safe walking/cycling. A high order of 'Comfort' in Table 1 reflects a desire for lane continuity among users but due to discontinuous NMT lanes, the extent of the impact on their physical well-being is low.

Figure 8. Last-mile connectivity with diversified mobility options within 800m of Moti Bagh metro station (Google Earth and Author, 2024) and Dhaula Kuan interchange (E) disrupting the connectivity (Tourism News Live, 2019).

7.2. Design assessment factors

Figure 9. Design features on site. (Author, 2024; Picture N: Oasis Designs Inc., 2024)

a. Layout quality

Table 1 shows an 85-92% variation in safety, comfort, equity and climatic comfort indicators. The old, hindered footpaths (Figure 4A, C, D, E) have now been replaced with segregated and wide NMT lanes that allow equitable availability of street space for pedestrians and cyclists, enhancing social well-being (Figure 9D, P). Skid-free thermoplastic surfaces provide men with adaptability for skateboarding (Figure 9N) but are unpopular among females. However, cyclists and persons with disability feel unsafe due to speeding four-wheelers at the crossings between cycle lanes and car lanes (marked in blue in Figure 9 key plan), thus limiting the change in safety and comfort to 75%. Despite the provision of bollards (Figure 9A), the intrusion of motorcyclists in NMT lanes during peak traffic hours

concerns young girls and boys. Also, the lack of amenities like toilets and drinking water affects users' comfort.

b. Accessibility

Women and persons with disability show higher favourability to segregated lanes and the use of tactile features (Figure 9C, G). A 100% variation in Table 1 reflects improved safety and inclusivity, which enhances their physical and social well-being.

c. Choice and location of seating

Figures 9F, H, I, J and M depict horseshoe-shaped seats, concrete slabs for people of different heights, and stone benches. These seats are located close to public transport stops and vending spaces, promoting comfort, spaces to interact, and adaptability, with 90% variation as compared to no seats in the old layout (Figure 4E, F). A few isolated seats also provide privacy to some, but its impact on social well-being is low.

d. Informal spaces

Informal stalls selling food and clothing significantly enhance identity, indicated by a 96% positive response, thereby promoting mental well-being (Table 1). These vendors attract people by providing affordable items, promoting meaningfulness, safety, and social cohesion (Figure 9K, L, M). While the response of integrating informal spaces with formal design is positive due to safer access to these services, its value is low because of unchanged availability before and after the transformation (Figure 4A, C, G).

e. *Temporal diversity of use*

The street now equips areas for diverse uses. Users have observed fun musical evenings or stalls set up under makeshift shaded areas (Figure 9B), which add an "element of surprise" and make space safer, equitable and welcoming people for interactions. It gives the public space a new identity with an 80% hike in physical, social and mental well-being (Table 1).

f. Lighting

Young girls and women rank lighting among the top contributors to safety, comfort, satisfaction and social cohesion. The provision of energy-efficient LED light poles, high-mast lights and floodlights (Figure 10B, G, J) ensures the elimination of dark spots encouraging females to use the street at night. This is demonstrated by an 81% hike in positive responses contributing to physical, mental and social well-being.

g. Permeability

Females feel safe in an open and free environment where NMT lanes co-exist with car lanes providing them with visual accessibility (Figure 10E, F). This increases the responses for safety, satisfaction and privacy. However, the variation is only 27% as men found no difference in permeability, as depicted in Table 1.

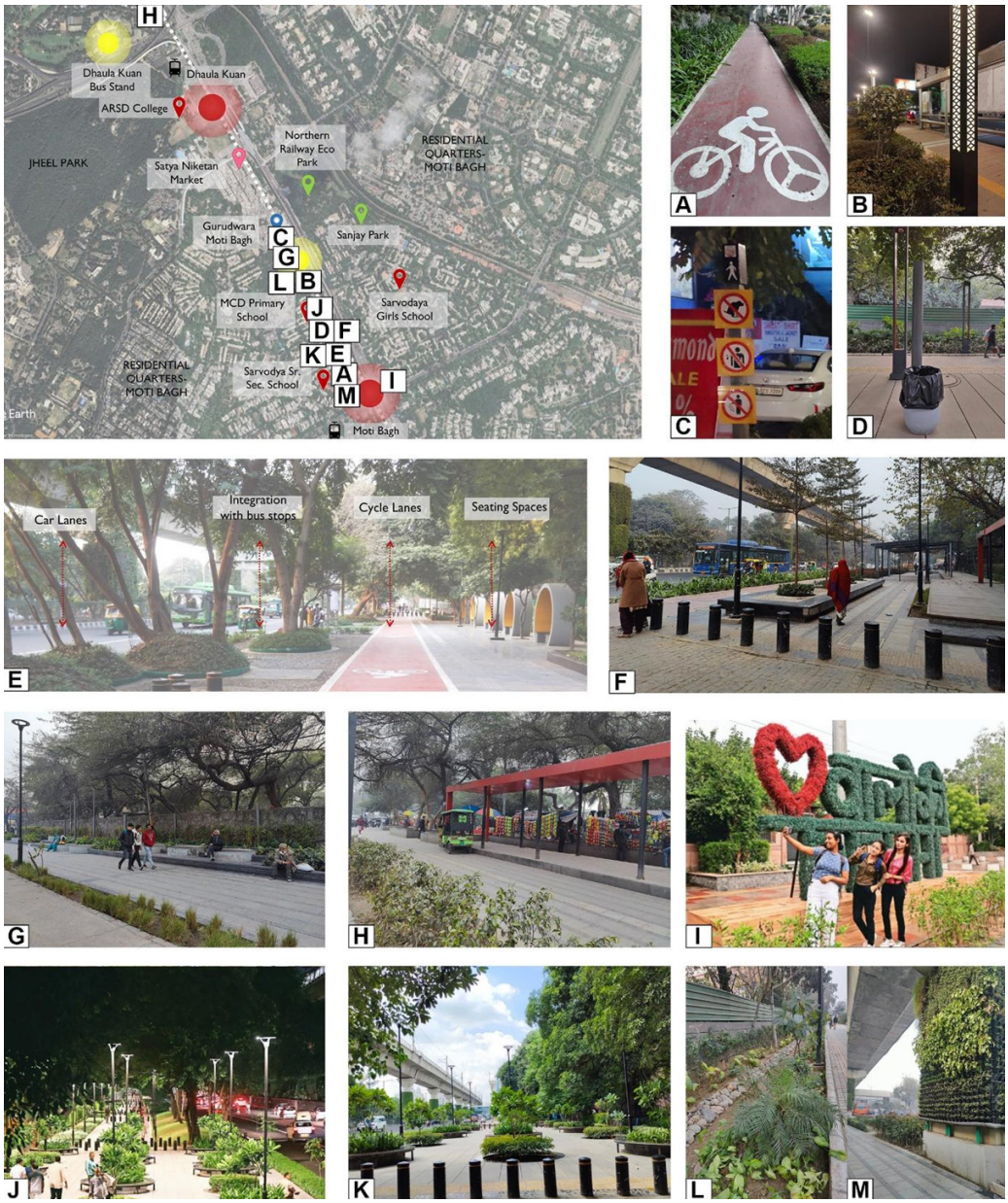

Figure 10. Design features observed on-site. (Author, 2024; Picture K: Oasis Designs Inc., 2024; Picture I, J: The Indian Express, 2022)

h. Maintenance

In contrast to the unkept sidewalks (Figure 4G), the new design prioritises cleanliness through dustbins and 'selfie points' as social landmarks (Figure 10D, I), leading to a 95% increase in comfort and identity.

i. Legibility

Floor signs indicating lanes for cycling and signs on poles showing prohibited uses (Figure 10A, C) have increased the legibility by 83%. It enhances comfort and meaningfulness, according to all user groups.

j. Tree cover

Vertical gardens on metro pillars, hedges and lush trees create a cool micro-climate, providing climatic comfort and satisfaction to 84% of the users interviewed (Figure 10K, L, M). Artificial bioswales enhance stormwater infiltration and drainage during rainfall, bearing environmental benefits. 80% of users, mainly men, use the shade to relax, noting its contribution to adaptability (Table 1). A low value in variation implies that the availability of tree cover remains the same. However, insufficient tree cover on wide NMT lanes forces cyclists to shift to walking lanes during scorching heat, causing discomfort to pedestrians.

k. Affordability and economic opportunities

A continued presence of informal vending, auto-rickshaws and other transport services has kept the street's affordability at 100%, showing "no change" in the value (Figure 9K, L). However, there is a slight decline in positive feedback for economic opportunities from vendors due to reduced customer foot traffic caused by NMT lanes separating them from their primary customers (four-wheelers), as compared to when they could be closer to cars (Figure 4A, F, G). This has restricted their response to inclusivity.

8. Outputs

8.1. Scoring methodology

Table 2 scores the overall QoL in four steps. First, individual scores for each assessment factor are calculated in Column E. This is based on the positive responses collected from various user groups and the multiplication factor assigned from the priority order collected from the users. An assessment factor may be prioritised differently from one indicator to the other. Next, the individual scores are added in Column F to get a collective score for each indicator. Thirdly, an average of these indicators is calculated in Column G to derive separate scores for physical, mental, social and economic well-being. Finally, a collective score for Quality of Life is derived in Column J based on the scores from the last step and an equal multiplication factor of 0.25 is assigned to each one of the four sub-components of well-being. Hence, a cumulative score of well-being depicts the contribution of well-designed NMT streets towards the QoL, as perceived by youth.

8.2. Scoring the indicators

Figure 11 highlights the factors that need to be positively addressed in a public street to improve the indicators linked with it. It depicts that a design feature may influence more than one indicator, suggesting that more than one indicator can be addressed by focusing on one design feature.

Physical well-being:

As per Figure 11, most factors relate to safety and comfort with accessibility, layout quality, lighting, maintenance, legibility, informal spaces, and tree cover being the most influential factors among others. While city-level and neighbourhood are crucial, they received less than 50% positive responses due to interruptions in safe mobility, as discussed in Section 7.

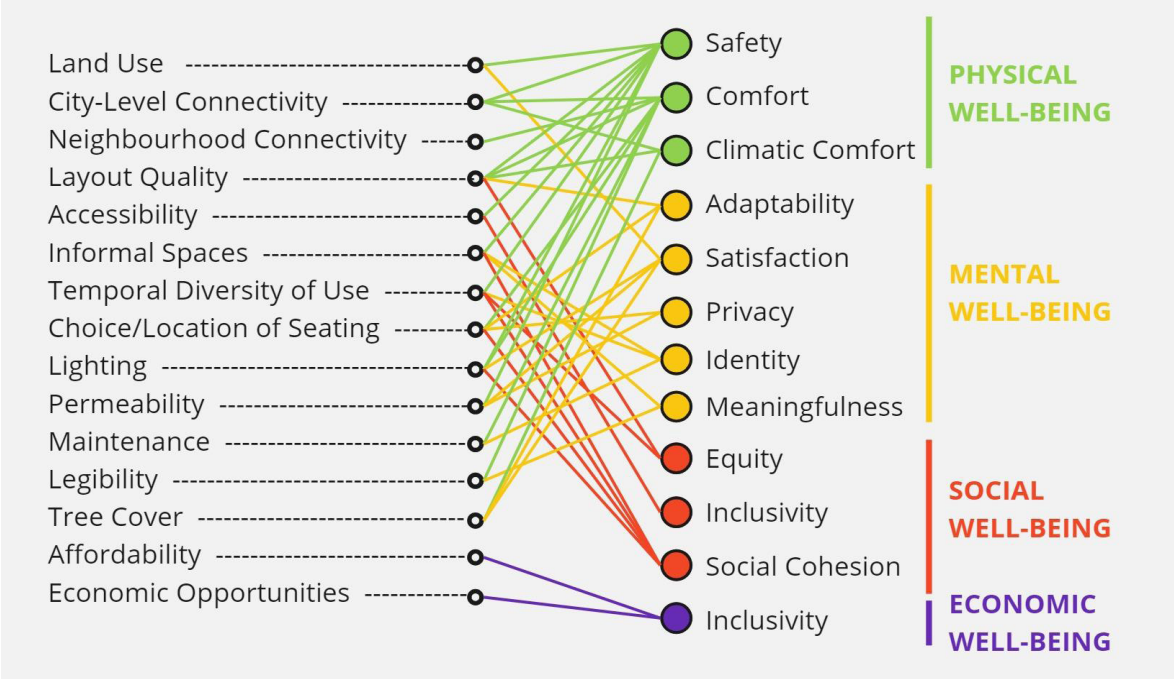

Figure 11. Linkages between assessment factors and indicators established by user groups. (Author, 2024)

Moreover, unsafe crossings, insufficient tree cover, and unavailability of public toilets limit the average score of physical well-being to 72.9 making it the least ranked among the sub-components of an individual's well-being. This suggests that there is still significant room in achieving the goal of enhancing physical well-being while re-designing streets.

Mental well-being:
Mental well-being, which includes indicators like adaptability, satisfaction, privacy, identity and meaningfulness is affected by the choice and location of seating, tree cover, permeability, informal spaces, maintenance and legibility. The score is lowered to 85.66 due to issues with layout quality and privacy of seating areas, particularly for males who prefer sleeping in the shade. Females did not respond to these factors, affecting the numerical value.

Social well-being:
In comparison to equity and inclusivity, more factors influence social cohesion in public spaces (Figure 11). These factors also receive over 85% positive feedback from users, resulting in a social well-being score of 94.5- the highest among all. This indicates that the new design enhances the social integrity of the public street by catering to informal spaces and bringing people together.

Economic well-being:
Economic well-being is impacted by affordability and economic opportunities, with the former being stagnant but the latter receiving negative feedback. The experiences of vendors, discussed in Section 7, suggest a reduction in opportunities for them due to the current layout. This suggests room for improvement in an individual's economic well-being.

Quality of Life:
The cumulative score of 83 is from a mix of positive responses in the factors linked to social and mental well-being and some negative feedback that still poses a challenge to the physical and economic integrity of the space. While it is more than the QoL score of 39.14 before transformation, a scope of improvement lies in integrating NMT with current streets in Delhi.

9. Conclusion

The issue of fatality risk and injuries reported among pedestrians and cyclists stems from a lack of footpaths and encroachments. It is addressed in the new design through segregated cycling and walking tracks, which ensure safe pathways for school children, working individuals and recreational users by enhancing their physical safety by 75-80%. Nevertheless, physical well-being can still be developed by extending NMT lanes on collector streets, enabling continuity while travelling. Moreover, safe crossings or speed control measures, integration of NMT on large road interchanges, and restricting encroachments by motorcyclists may enhance user safety and comfort.
The street integrates physical necessities with social needs by incorporating informal spaces, seating areas, and nature and providing seamless links to public transport services, ensuring last-mile connectivity for daily commuters. This holistic approach now welcomes skateboarders, joggers, entertainers and vendors during evenings and weekends. It has significantly improved their social well-being by 95% in compareison to before, promoting 'social sustainability' and underscoring the importance of NMT as a social infrastructure.
While the design principally guarantees economic well-being for customers by maintaining the provision of affordable services in an organised fashion, street vendors have criticised this reorganisation as "fatal for business". Therefore, consulting vendors to better comprehend their requirements could influence innovative approaches to economic well-being.
Hence, the NMT infrastructure design improves the quality of life for users by 53%, but some indicators still show room for improvement. Once the pertaining issues are tackled, a fair allocation of road space and quality public space is expected to encourage more users to adopt cycling as a mode of transportation. Consequently, this paper lays the groundwork for further research on an anticipated shift in the modal share in car-centric Indian cities. This shift will alleviate traffic congestion and reduce carbon emissions, thus creating healthier cities, especially for the younger population.
The study fills a gap in the existing literature by examining the contribution of NMT to improved health and well-being of the youth in Indian cities, thus improving their QoL. As India navigates urbanisation, the findings can guide the policy frameworks, street design guidelines and planning strategies for NMT in other cities like Pune, Ahmedabad, Mumbai, and Bengaluru. It may also nudge a shift in the planning approaches towards inclusive, sustainable, and youth-centric strategies that shape public spaces in other cities.

Table 2: Schoring Well-being of Youth Post-NMT Integration and Computing Quality of Life (Author, 2024)

S. No.	QoL Indicators	Assessment Factors for NMT that impact (A)	Positive responses	Factor of multiplication	Individual Score Contribution	Total score for each QoL indicator	Average score for well-being	Factor of Multiplication	Individual score contribution	Total score for Quality of Life	Quality of Life before NMT
	(A)	(B)	(C)	(D)	(E)=C*D*100	(F)=∑E	(G)=Avg. (F)	(H)	(I)=G*H	(J)=∑I	
Indicators for Physical Well-Being											
1	Safety	Accessibility (Safe walking)	89%	0.25	22.1	84.1	72.9	0.25	18.22	82.6	39.14
		Layout Quality	81%	0.25	20.3						
		Lighting	94%	0.15	14.1						
		City-level Connectivity	61%	0.1	6.1						
		Permeability	83%	0.1	8.3						
		Informal Spaces	96%	0.05	4.8						
		Temporal Diversity of Use	86%	0.05	4.3						
		Land Use	80%	0.05	4.0						
2	Comfort	Neighbourhood Connectivity	46%	0.25	11.5	66.4					
		City-Level onnectivity	35%	0.25	8.9						
		Lighting	94%	0.2	18.8						
		Choice/Location of Seatings	95%	0.1	9.5						
		Layout Quality	81%	0.1	8.1						
		Maintenance	96%	0.05	4.8						
		Legibility	98%	0.05	4.9						
3	Climatic Comfort	Tree Cover	84%	0.6	50.6	68.2					
		City-level Connectivity	26%	0.3	7.8						
		Layout Quality (Integration with Nature)	98%	0.1	9.8						
Indicators for Mental Well-Being											
4	Adaptability	Choice/Location of Seatings	95%	0.5	47.4	82.9	85.7	0.25	21.42		
		Layout Quality	69%	0.4	27.5						
		Tree Cover	80%	0.1	8.0						

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S. No.	QoL Indicators	Assessment Factors for NMT that impact (A)	Positive responses	Factor of multiplication	Individual Score Contribution	Total score for each QoL indicator	Average score for well-being	Factor of Multiplication	Individual score contribution	Total score for Quality of Life	Quality of Life before NMT
5	Satisfaction	Lighting	94%	0.4	37.5	87.4					
		Permeability	83%	0.3	25.0						
		Tree Cover	84%	0.2	16.9						
		Land Use	80%	0.1	8.0						
6	Privacy	Choice/Location of Seatings	57%	0.6	34.4	67.7					
		Permeability	83%	0.4	33.3						
7	Identity	Informal Spaces	96%	0.5	47.9	97.3					
		Temporal Diversity of Use	86%	0.3	25.9						
		Maintenance	96%	0.2	19.2						
8	Meaningfulness	Legibility	94%	0.2	18.8	97.3					
		Informal Spaces	95%	0.1	9.5						
Indicators for Social Well-Being											
9	Equity	Layout Quality	96%	0.6	57.5	92.1					
		Temporal Diversity of Use	86%	0.4	34.6						
10	Inclusivity	Accessibility (for all)	100%	1	100.0	100.0					
		Temporal Diversity of Use	86%	0.4	34.6						
		Choice/Location of Seatings	95%	0.25	23.7		94.6	0.25	23.64		
11	Social Cohesion	Informal Spaces	96%	0.25	24.0	91.6					
		Lighting	94%	0.1	9.4						
Indicators for Economic Well-Being											
12	Inclusivity	Affordability	100%	0.5	50.0	77.1	77.1	0.25	19.27		
		Economic Opportunities	54%	0.5	27.1						

Table 2: Schoring Well-being of Youth Post-NMT Integration and Computing Quality of Life (Author, 2024)

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