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Enabling gender responsive low-carbon transport in India using SDG5 framework

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Abstract: Gender and mobility are strongly related and address challenges of safety and accessibility for women. Studies worldwide highlight the need to create more gender-responsive transport systems that maximize women's mobility, civic participation, and safety. Gender inequality in urban transport is evident in Indian cities in terms of women's longer walking trip lengths, longer time spent in commute and hence time poverty, impoverished health, and compromised personal safety. Even the public transport systems, often perceived as more gender-equal, overlook women's needs and mobility concerns such as affordability and scheduling. This article presents transportation challenges faced by women (recorded through primary surveys and focus-group discussions) and further investigates how low-carbon urban transport, as perceived under the Paris Agreement and Sustainable Development Goals (SDGs), can be delivered with gender-equitable outcomes. For a more holistic perspective, the assessment is grounded in two Indian cities, Surat (4.5 million population), a fast-growing industrial metropolis, and Udaipur (0.5 million population), a small but important tourist destination in the nation.

Keywords: gendered mobility; low-carbon transport; gender-sensitive transport; Global South; public transport

1. Introduction

Amid the intersecting crises of COVID-19, the climate emergency, and rising economic and political insecurity, progress on gender equality has not only failed to move forward but has begun to reverse [1]. Around the world, a growing backlash against women's rights is threatening even well-established freedoms and protections [1]. At the current rate of progress, it will take another 286 years to reform legal frameworks to promote, enforce, and monitor gender equality in public life [1]. Violence against women and girls continues to rise in the wake of the intersecting crises; estimates indicate that 736 million women across the globe have experienced physical or sexual violence at least once in their lifetime [2]. In urban areas, stressors like lack of access to decent work, ill-planned infrastructure, and unreliable and inadequate urban systems (including transport systems) limit women's attainment of economic and social rights. In addition, safety in mobility is a particular concern for women; about 49 percent of women in urban areas feel less safe walking alone at night [3].

Transport is crucial to women's empowerment, enabling their access to economic opportunities and participation in civic and public life. Women's mobility, especially in low-income households, often increases their family's chances of escaping poverty (SDG5.2 and 5.5) [4]. Urban transport also has a direct, two-way relationship with

SDG5, as easy access to economic, social, and civic opportunities (via transport), in turn, increasing women's trip rates and hence additional travel demand (**Table 1**). In cities with affordable healthcare services, access to robust transport systems is also linked to improved health outcomes for women, young and old (SDG5.6). Yet transport systems in cities worldwide fail to cater to women and girls, curbing their mobility and restricting their economic and interpersonal growth [3,4].

Although transport is considered gender-neutral, studies over the last decade show that transport is deeply gendered. Gender-responsive planning is a differentiated planning culture that considers the gender-, age-, and group-specific interests [5]. The lack of gender-responsive transport systems is universal. Yet women in the global South often experience exacerbated impacts of inequity and discrimination owing to the highly unequal urbanization landscape and the prevalence of traditional gender roles. For example, studies indicate that women in developing countries are less likely to have access to personal vehicles or hold a driver's license than men [6], reducing their options to access work, healthcare, and other essential services. Lack of transport access along with the fear of sexual violence hinders women's workforce participation; in developing countries, these factors are believed to decrease Female Workforce Participation Rate by 16.5% [7]. Moreover, in about 20 countries of the global South, laws restrict women from working the same way as men. Studies indicate that road-based transport solutions in these cities deepen gender inequity, especially for poor women [6,8–11]. Hence, there is a dire need to redesign transport plans and policies to suit women's travel behaviour and solidify their "right to the city" claims by maximizing their mobility and safety.

This paper argues for locating urban transport solutions within the SDG frame. In other words, the transport solutions for the cities need to be contributing to achieving the SDG targets. The critical thrust of the SDGs is the social goals of poverty and inequality reduction, improvement in human development, human-centric economic growth, environmental sustainability, and partnerships. While the SDGs have a separate goal related to gender, all other goals too have a cross-cutting gender concern. This paper picks up the gender goal and assesses urban transport from a gender lens to achieve gender equity. The paper's objectives are to conceptualize the links of SDG5 targets in particular and embellish the conceptual understanding with the data obtained from the ground. This exercise also helps in understanding whether the transport options available in the cities of the global South would enable achieving the SDG5 targets and what options need to be included to be able to do so. We are therefore arguing two things in this paper: firstly, sustainable transport or low-carbon transport has to be gender inclusive, and second, the achievement of SDG5 requires addressing transport.

The following section briefly presents the methods used for the analysis. This is followed by a section that introduces the two cities in India within which the research is grounded to develop our arguments. The sections after that present conceptual linkage of transport and gender development based on literature as well as primary data for the achievement of three broad aspects included in the SDG5 targets: (i) women's safety and comfort while using transport, (ii) women's access to economic and civic opportunities, and (iii) women's access to healthcare in urban areas. The last section discusses the policy implications.

Table 1. Conceptual relationship between urban transport and gender equity through the SDG5 framework.

SDG5 Targets	Relationship with Urban Transport	Relationship with Non-motorized Transport (NMT)	Relationship with Intermediate Public Transport (IPT)	Relationship with Public Transport (PT)
5.1. End all forms of discrimination against all women and girls everywhere	Transport systems, albeit public transport, possess the potential to eliminate discrimination against women and girls by providing access to economic and civic opportunities. Mediating Condition: Transport systems (especially public transport) must be affordable, reliable, and well-connected.	Women walk more often than men, longer distances than men, and women tend to walk with dependents. Adequate and safe pedestrian and cycling infrastructure ensures women's access to economic and civic opportunities.	IPT is the only motorized transport mode that efficiently responds to women's travel needs. Yet the higher IPT costs increase women's transport expenditure. For example, although the average trip lengths of women are 38% shorter than men's, their average travel costs are 35% higher than men's [11]. High transport costs deter women's willingness to travel as they often must justify it.	Women's travel demand in Latin America and South Asia shows that women take shorter and more frequent trips for multiple purposes at off-peak hours and with dependents [8]. Due to the lack of gender mainstreaming in public transport system routing and design, women are often forced to use IPT for convenient access at higher prices or walk to save money. Hence, public transport systems that cater to women's travel needs are crucial for mobility and participation.
Women's Safety & Comfort	Transport systems possess the potential to eliminate violence against women and girls in the public sphere by ensuring safe access to basic services, education, employment, and public spaces. Mediating Condition: Routing and scheduling of public transport systems can create safe mobility options; footpaths can be designed to maximize women's personal and sexual safety.	Since women's dependence on non-motorized transport modes—especially walking—is far greater than men's, adequate and safe non-motorized infrastructure is vital in enabling their mobility. Yet, the poor state of NMT infrastructure in cities of the global South makes women more susceptible to violence against women.	Most South Asian cities lack integration of IPT in the City Development Plans and Mobility Plans. Hence, the IPT sector often needs more infrastructure provision, fair regulation, or other operating norms. Therefore, women who largely depend on IPT tend to face precarious boarding conditions, overcrowding, and inconsistency in fares. All this increases their susceptibility to exploitation and violence; hence, formalizing and regulating IPT is crucial for ensuring women's safety.	Women tend to chain trips and travel during off-peak hours; hence, the low frequency translating to longer waiting times and lower ridership make women more susceptible to harassment and violence while accessing PT. Routing of PT can ensure bus stops in service-level proximity to increase women's use of PT.

Table 1. (Continued).

	SDG5 Targets	Relationship with Urban Transport	Relationship with Non-motorized Transport (NMT)	Relationship with Intermediate Public Transport (IPT)	Relationship with Public Transport (PT)
Women's Access to Economic & Civic Opportunities	5.3 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure, and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate	Public transport systems form vital components of any city's public services. Their ability to provide access to basic services and employment makes them crucial elements of any city's social protection policies. Hence, transport systems are essential in reducing women's unpaid work. Mediating Condition: Public transport systems must be affordable, safe, and well-connected.		IPT enables women to travel from "home to home," reducing time spent in unpaid work. However, since this convenience comes with a steep travel cost, most low-income women resort to walking, increasing their time poverty. Or these are unsafe for women, which requires better governance of IPT. Mediating Condition: Better governed IPT.	Time spent walking to work due to lack of affordability for public transport forms a considerable share of women's unpaid work. Hence, women's time allocated to unpaid work increases due to the lack of affordable, convenient, and safe transport; this time can be substituted by paid work or personal care if affordable public transit is available.
	5.4 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life	Along with enabling access to education and employment, transport systems possess the potential to ensure women and girls have equal opportunities by allowing them to participate in public life, politics, and social interaction. Mediating Condition: Transport systems (especially public transport) must be affordable, safe, and reliable.	Safe, adequate, and well-maintained footpaths are crucial for women's interactions with the public and civic realm, as most "non-work" trips in South Asian cities are generally within walking distance. And since most women walk to work, walking infrastructure becomes crucial for women's effective participation. Yet the poor state of walking and cycling infrastructure in these cities often curtails women's mobility and representation.	Similar to 5.1	While access to public transport is linked with improved socio-economic and health outcomes for women, the poor state of public transport systems (inadequate coverage, lack of last-mile access, poor frequency of buses, unsafe and ill-maintained bus-stops, overcrowding, etc.) in most cities of the global South deter women from actively choosing public transport and curtails their mobility. This affects their full and effective engagement in the city.
	5.5. Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women	Transport-sector platform economy avenues like Mobility-as-a-Service (MaaS), i.e., Ola, Uber, Lyft, etc., empower women (i) by enabling 'safer,' door-to-door mobility, and (ii) employing women within the transport sector (ex. Pink Auto in Jaipur, Sakha Cabs in Delhi). Mediating Condition: for increased employment in the transport sector via platform economy avenues, women would need access to vehicles (cars or auto-rickshaws)	GIS-enabled apps like SafetyPin ^a —using big data to improve infrastructure and services in cities for women- enhance women's perception of safety while walking.	Women-run autos via platform economy provide women employment in the transport sector and enhance safety for women passengers.	Display of route information and automated vehicle monitoring (AVM) system and smartphone applications for the city's PT system (like London's TfL GO or Mumbai's M-Indicator) allow women to predict waiting times and best routes, facilitating better decision-making while traveling.

Table 1. (Continued).

SDG5 Targets	Relationship with Urban Transport	Relationship with Non-motorized Transport (NMT)	Relationship with Intermediate Public Transport (IPT)	Relationship with Public Transport (PT)
<p>Women’s Access to Healthcare</p> <p>5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences</p>	<p>Although universal access to sexual and reproductive health for women and girls goes beyond physical accessibility to healthcare facilities, transport systems are crucial in ensuring access to healthcare. Similarly, access to healthcare for women goes beyond access to sexual and reproductive health, as women are primary caregivers (irrespective of their employment status) and are often responsible for healthcare trips of dependents (children, elderly, or differently-abled household members). Mediating Condition: Adequate and affordable healthcare and maternal care facilities are available</p>	<p>NMT infrastructure is vital to access primary healthcare (as it is ideally provided within a walking radius). NMT infrastructure also forms a core part of the last-mile access to PT—more appropriate for longer distances.</p>		<p>Affordable, reliable, and safe PT systems are crucial for women to access healthcare facilities. Yet, many cities lack transport, and land-use integration (especially healthcare) hinders women’s healthcare access.</p>

^a SafetyPin is a personal safety app designed to enable women (and other vulnerable groups) take safer mobility decisions based on the safety scores of a neighborhood. These scores are based on safety audits that evaluate a neighborhoods physical and social infrastructure.

2. Methods

To identify relevant SDG5 goals for assessment, we undertook a rigorous scoping literature review of over 250 publications that focused on the global South context. To validate the findings from the literature and ground the interactions in cities, we chose two case study cities- Surat, an industrial metropolis, and Udaipur, a tourist town with rich cultural and built heritage. The cities were selected based on- (i) the diversity of their socio-demographic profile, (ii) the contrasting city size, urban fabric and built form, (iii) the diversity of their economic base, (iv) availability of well-developed transportation plans, (v) the presence of political and administrative will for a transition towards Low-Carbon Mobility, and (vi) easy access from the city of the authors. We then critically assessed the mobility and development plans in both cities to evaluate the service levels. Quality of service of transport is measured by the Level of Service (LOS) benchmarks (often referred to as service levels). These are based on numerous parameters like level of comfort, fleet, average waiting time, average speeds, street light, intersection delay, and encroachment, etc. As per MoHUA's Service Level Benchmark (SLB) Handbook, the Service Level is measured on a scale of 1 to 4, indicating the lowest to highest LOS, for each element of the transport system, i.e., the Non-Motorised Transport (NMT), the Public Transport (PT), and others. Service levels of each component of the transport system in case study cities were compared against the national transport SLBs [12]. They were marked compliant for those services that aligned with national benchmarks and non-compliant if otherwise. To further ground the assessment, the authors, in consultation with the urban local bodies in both case studies, conducted three focus group discussions with about 35 participants on the following three themes: (i) mobility challenges and scope in rapidly urbanizing cities, (ii) mobility challenges and scope in heritage towns, and (iii) mobility of socio-economically vulnerable groups. This was followed by analyses of 1,665 samples of detailed transport user surveys (containing about 75 questions), 350 household surveys, and 185 semi-structured stakeholder interviews in both cities- all via stratified random sampling. These surveys captured demand-side trends, including travel patterns, mobility challenges, safety, affordability, resilience by mode, socio-economic and health impacts of transport projects, their willingness to shift, and recommendations for enhanced access and mobility. The literature review forms the framework to assess urban transport and SDG5 interactions, and the critical analyses and fieldwork form the final assessment.

Transport landscape of Surat and Udaipur¹

Udaipur, the City of Lakes, is a small, compact, 12-minute city with rich cultural and built heritage and a natural ecosystem. Its population in 2011 was 0.63 million. It is among the world's fifteen most-visited tourist destinations and receives India's second-largest fleet of international tourists. Several state and national highways surround Udaipur; the city is rapidly urbanizing along the highways. Udaipur lacks a robust formal Public Transport (PT) system; a weak fleet of thirteen buses operates on five routes in the city (**Table 2**, Section 2). Hence, the city's Intermediate Public Transport (IPT) system, operating on 27 designated routes (shared rickshaws and auto-rickshaws), functions as its informal PT (Refer **Figure 1**). Rapid urbanization

unaccompanied with robust public transport networks results in rapid motorization (annual growth rate of 11.3%). Udaipur's lively historic core is rendered with narrow lanes, a concentration of economic activities, and multiple heterogeneous road users (refer to **Figure 1**). Udaipur represents several global North and South tourist towns, grappling with adequate and inclusive transport provision within its dense urban fabric and limited resources.

Table 2. Transport system characteristics in Surat Urban Development Area (SUDA) and Udaipur Urban Control Area (UUCA) for 2016 [13–15].

		Surat	Udaipur
Demography	Population (as per census 2011)	5,929,821	637,717
	Area (in sq km)	958	348
	Density (people per sq km)	6190	1833
Transport Characteristics	Registered Vehicles	4,195,348	580,271
	Annual Vehicular Growth	9%	11.3%
	Trip Rate	1.6	1.1
	Female Trip Rate	-	0.67
	Average Trip Length (in km)	6.04	5.09
	Annual Vehicle Kilometres Travelled	9,400,415,130	880,489,000
	Mode Share (as of 2016)		
	Pedestrian	40%	48%
	Cycle	2%	2%
	PT	1.4%	2%
	IPT	10.3%	11%
	2-W	35.6%	34%
	4-W	2%	3%
	Other	8%	NA
Transport Systems & Infrastructure	Road Network Length (in km)	5773	1585
	Bridges, Fly-overs & Underpasses	123	7
	Non-motorized Transport		
	Footpath Coverage	20%	4%
	Cycle-Track Coverage	8%	0%
	Pedestrian Crossing	38	0
	Public Transport		
	City Bus Fleet	811	13
	City Bus Network (in km)	274	89
	City Bus Routes	29	5
	BRT Bus Fleet	116	NA
	BRT Network (in km)	102	NA
	BRT Routes	35	NA
Intermediate Public Transport			
IPT Fleet	38,000	8950	
IPT Routes	52	29	

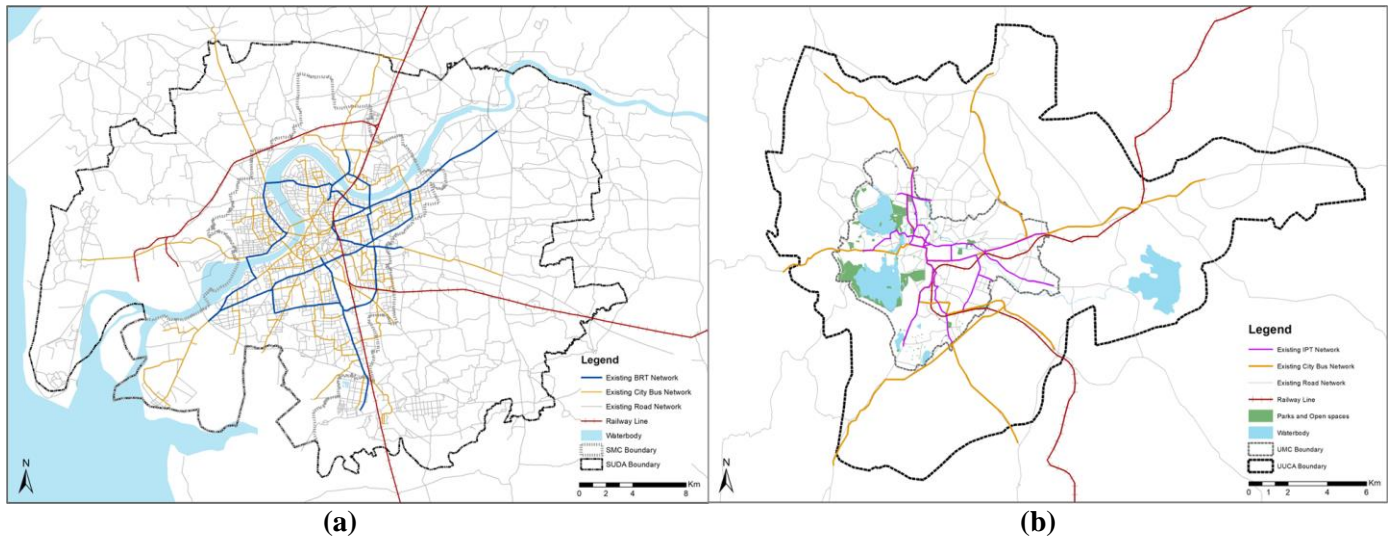


Figure 1. Public transport network maps of (a) Surat; and (b) Udaipur.

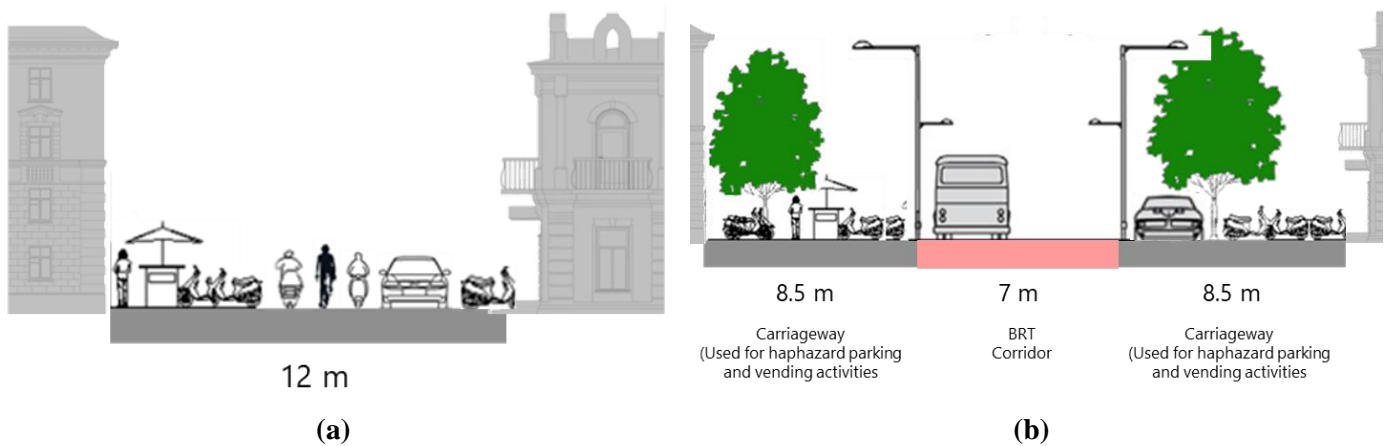


Figure 2. A typical street section in case study cities. (a) Udaipur with mixed traffic, informal vending activities, and haphazard parking, making it unsafe; (b) Surat with inadequate NMT infrastructure and a spill-over of parking and vending activities on the carriageway creating conflicts.

Surat, with a population of 5.9 million in 2011, is among the world's fastest-growing cities and has a high concentration of migrant population (26% of the total population) owing to its labour-intensive textile and diamond industry. Surat is compact and polycentric, rapidly urbanizing along its radials. Surat's formal PT system consists of a Bus Rapid Transit (BRT) system (length of 102 km), a City Bus, and an upcoming Metrorail (proposed length of 274 km). Surat's IPT Fleet, mainly the autorickshaws (three-wheelers), primarily operates on 52 designated routes (**Table 2**). Even individual IPT trips that provide point-to-point connections are possible. Intensification of road-based transport solutions and disinvestment in public transportation over the past two decades has resulted in a 22% decline in non-motorized transport (NMT) (walking and cycling) trips' share and a 4.3% decline in PT mode-share. Additionally, the rise in average household incomes increased dependency on personal motorized vehicles, leading to a tripling of traffic volume over the last decade. Incompatible land uses placed in proximity and contested road space result in frequent traffic congestion and high conflicts amongst motorized and

non-motorized users (refer to **Figure 2**). Surat represents several rapidly urbanizing cities in the global South, grappling to transition from road-based transport solutions to a more active and public transport-oriented approach.

Both cities serve a residential and a large floating population. Traffic composition, prioritization of vehicular movement, absence of lane segregation, and the current state of infrastructure lead to local sustainability issues. Private vehicles—two-wheelers (2Ws) and four-wheelers (4Ws)—make up a majority of the traffic composition and total trips in both cities. The lack of a robust and affordable PT network results in low ridership, leading to vulnerable groups' reliance on the IPT and NMT, especially in Udaipur. On the one hand, there is a high dependency on private motorized vehicles, especially 2Ws, in both cities, whereas, on the other hand, service levels for half the trips are made on foot. Everyday observations from both cities indicate that women have a considerably lower trip rate (a proxy for mobility) than men, have much longer trip lengths, and have more significant barriers to accessibility.

3. Gender & urban transport through the SDG5 framework

SDG5, Gender Equity, has nine targets that aim to eliminate all forms of discrimination and violence against women and girls, recognize the value of unpaid care and domestic work, ensure women's participation in decision-making, enable access to health and economic opportunities, and strengthen policies that promote gender equality and women empowerment. Six of the nine targets detailed in the SDG5 framework have links with urban transport and are selected for analysis in this paper (**Table 1**, Section 2). Gender equity means that men and women are able to enjoy the same conditions and opportunities to exercise their rights and achieve their social, economic, political, and cultural potentials. It differs from gender equality, which only means that the same opportunities are there, but does not include if they can be accessed [16]. To understand the role of urban transportation in forwarding women's empowerment and gender equity, the travel patterns and needs of women and girls in the context of Indian cities must be understood. Although the continually expanding literature on women's travel behaviour indicates nuances across socio-economic status, below we summarize differential travel patterns among men and women, the range of constraints that govern women's travel behaviour, and its linkages with SDG5 and then link this understanding with the findings from the two cities.

3.1. Women's safety & comfort while using urban transport

This thematic area responds to two SDG5 targets: 5.1 on ending discrimination and 5.2 on eliminating violence against women and girls. Although women's safety and comfort while using transport go beyond the SDG5 framework to include transport route planning, service levels of transport infrastructure, urban design parameters, maintenance, and governance parameters, we argue that incorporating these two targets within the traditional and rather technical transport planning practice has a more significant potential in mainstreaming gender-responsive transport.

3.1.1. Women's safety and comfort while using non-motorized transport

Literature and census data from Indian districts show that women walk more

often than men (refer to **Figure 3**), have longer distances than men, and are in more precarious conditions than men. Walking is the most preferred mode of transport for women in the countries of the global South [4,9,10], especially for poor women, as they face more significant cultural barriers (dressing and other) to cycling and often cannot afford public transport [17]. Irrespective of trip lengths, the share of women walking to work in India is much higher than men [18]. Since women's dependence on pedestrian infrastructure is greater than that of men, the poor state of pedestrian infrastructure in Indian cities causes women discomfort, increases their fear of harassment on the road or even sexual violence (SDG5.1 & 5.2), and curbs their mobility [19–21]. Additionally, studies show that harassment while walking down the street is a common occurrence for all women and is exacerbated by the inadequate and ill-maintained physical infrastructure like inadequate lighting on streets and underpasses, deserted alleys connecting their residences to the transit, etc. [22,23].

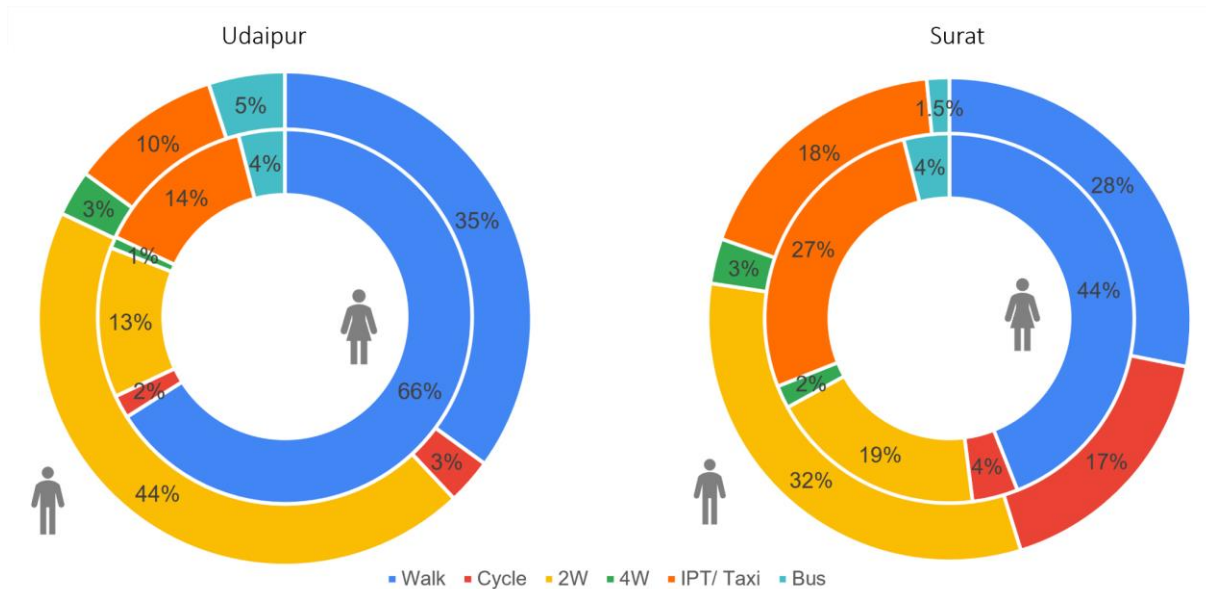


Figure 3. Gendered mode share in Surat and Udaipur.

Source: Data projected for 2016 using LCMP/ CMP statistics and B-28 sheets from Census of India, 2011 (Due to lack of disaggregated data availability in Surat, we have used the census data from the last population census in India. Such a data is not available at city level and hence we have used district data. We presume that Surat district would largely comprise of Surat city and its agglomeration. For Udaipur, we use the disaggregated trip data from the LCMP).

In our case study cities, we find that women walk to undertake various purpose trips. In Surat, 48% of trips are via walking and cycling (refer to **Figure 3**). 85% of non-work purpose trips are undertaken on foot, yet the city has inadequate infrastructure coverage for walking and cycling; only 20% and 7.6% of the total road network have footpaths and cycle tracks, respectively. The footpaths' networks exclude low-income neighbourhoods in Surat, creating a dire need for accessible transport infrastructure [13]. Similarly, 68% of women's trips in Udaipur are via walking and cycling, yet only 1%–4% of Udaipur's road network has any form of pedestrian or cycling infrastructure. Both cities lack supporting infrastructure for walking and cycling, like street lights, signalized junctions, pedestrian crossings, shade, benches, etc. (refer to **Figures 1 and 2**). Our assessment of Surat's walking and cycling infrastructure falls in service level category 3, using the Government of India's

service level benchmarks [12]. The city has to reach the service level of 1, the highest one if the entire city has to have a well-designed walking and cycling network, which essentially will benefit women. In Udaipur, the service level of walking and cycling infrastructure is 4 (the poorest on the scale), requiring significant improvement. Despite the poor state of NMT infrastructure in both cities, women opted to walk in both cities due to the unavailability of personal vehicles (21%) and PT's lack of affordability and reliability (32%).

We are emphasizing improvement in walking and cycling infrastructure because our fieldwork reports that 40% of women responded with issues related to road safety, 23% of women expressed inconvenience and discomfort (due to lack of walking and cycling infrastructure), and 93% of women walking in both cities reported feeling unsafe (personal & sexual safety) while making a trip. The focus group discussions, highlight the captive nature of female pedestrians and concerns about safety while commuting on foot (refer to Excerpts 1 & 2).

Excerpt 1: A 32-year-old woman from Udaipur describes her concerns about commuting via walking, "There are no streetlights and footpaths in my neighbourhood ... along with that, fast-moving vehicles on the carriageway make me very nervous while walking."

Excerpt 2: A girl in her early twenties from Surat narrated her perception of personal safety while walking, "I am forced to walk on the carriageway ... which feels unsafe! There are frequent accidents on the crossroads, too."

3.1.2. Women's safety and comfort while using public transport

Women tend to depend on public transport more than men [24]; women lack access to personal motorized vehicles, making public transit the most affordable motorized mode. The role of women as primary caregivers (despite their employment status) results in a more 'complex' travel demand than men who essentially have a single work trip demand. Hence, studies of women's travel demand in South Asia show that women take shorter and more frequent trips for multiple purposes (also known as trip-chaining) at off-peak hours [6,17,25]. More than a quarter of women's trips are caregiving-related and include traveling with a dependent (children, elderly, etc.,) [6,8,26]. While access to public transport is linked with improved socio-economic and health outcomes for women, the poor state of public transport systems (inadequate coverage, lack of last-mile access, poor frequency of buses, unsafe and ill-maintained bus-stops, overcrowding, etc.) in the majority Indian cities deter women from actively choosing public transport and curtail their mobility [16,27,28] (SDG5.1 & 5.2).

Surat has one of the largest BRT networks in India; its integration with the existing city bus services doubled PT mode share in just one year. Yet PT mode share in Surat is much lower (3%) than the national average (21%) for similar-sized cities, owing to the poor last-mile connectivity in Surat; only 53% of households in Surat live within a 10-minute walk to a bus stop/ bus station. Even for those households that fall within a walkable distance of the PT stop/ station, the poor state of NMT infrastructure deters them from accessing PT- especially during extreme weather events (heavy monsoons and hot summers) (refer to Excerpt 3, 4). Meanwhile, in Udaipur, poor PT coverage and low frequency prevent women from using PT (refer to Excerpt 4).

Among PT women users, less than 15% in Surat and 4% in Udaipur actively choose PT. PT system’s level of service in both cities is 4 (lowest on a scale of 1–4), compromising women’s comfort and safety (refer to **Figure 4**). However, of all the transport modes, women report PT as the ‘safest’ mode of transport.

	Surat			Udaipur		
	Safety & Comfort (SDG 5.1 & 5.2)	Access to Opportunities (SDG 5.4, 5.5 & 5.8)	Access to Healthcare (SDG 5.6)	Safety & Comfort (SDG 5.1 & 5.2)	Access to Opportunities (SDG 5.4, 5.5 & 5.8)	Access to Healthcare (SDG 5.6)
NMT						
NMT Network Coverage						
NMT Infrastructure Quality						
NMT Mode Share						
PT						
PT Network Coverage						
PT Infrastructure Quality						
PT Service Quality						
PT Affordability						
IPT						
IPT Network Coverage						
IPT Infrastructure Quality						
IPT Service Quality						
IPT Affordability						
		Synergy	Trade-off	Mixed Impact		

Figure 4. Analysing transport modes using SDG5 Framework in Surat & Udaipur.

Excerpt 3: A woman in her late forties discusses her mode preference during summer, “the BRT stop is much furtherer than the city bus, and the trip is more expensive; I only choose BRT during summers, as the AC (air-conditioned) buses are far more comfortable than the city buses. I wish getting to the bus station was also this comfortable as I walk there in the heat.” The focus group participants indicated that they prefer BRTS over the city buses during heat, as the air-conditioned buses are more comfortable than the city buses. But as the BRTS bus stop is often further than the city bus stops, and the trip is more expensive, low-income women can only afford to choose BRTS during extreme heat.

Excerpt 4: “Another woman in her late forties from Surat discusses the hassle of accessing PT during monsoon, “The nearest bus stop is 2 km away... on a regular day, I walk to the bus stop, but during heavy monsoon, it is difficult to find any transportation from my area as it is completely submerged in water... even to take an auto-rickshaw, one has to walk to the main road- which again is a challenge during floods....” Several low-income women in Surat, often residing in low-laying areas discussed how frequent and rampant water-logging in their neighbourhoods further curtailed their mobility during heavy monsoon.”

Excerpt 5: A 36-year woman discusses the challenges of using Udaipur’s City Bus, “To take the bus, I often have to wait for long durations, and go through unnecessary, tedious transfers (mode-switches within a single trip) due to low

frequency, the seats (in the bus) are usually full, and I have to stand for most of the ride... this tires me, and so I prefer autos over buses, although its more expensive to take autos..." The focus group participants highlighted that poor accessibility, weak network and low frequency of city buses, along with uncomfortable travel conditions force women to spend more on transport.

3.1.3. Women's safety and comfort while using intermediate public transport

As evident from the above anecdotes, women prefer IPT over PT in both cities, owing to IPT's route flexibility and wider coverage, enhancing convenience. In Udaipur, with 27 fixed routes and regulated fares, IPT provides a much wider coverage (55%) than PT; Surat's IPT sector is largely chaotic and often costs double than a PT trip, 52 routes offer a considerably wider coverage, especially in the low-income areas, where PT is inaccessible. IPT makes 27% of women's mode share in Surat and 14% of women's mode share in Udaipur, compared to 18% and 7% of men's mode shares in respective cities (refer **Figure 3**), indicating women's higher dependence on IPT than men. While several women in both cities preferred IPT over PT for convenience, IPT fared poorly in terms of personal and sexual safety (refer to Excerpt 6); the lack of infrastructure in both cities leads to unsafe on-boarding conditions for women amidst heavy vehicular traffic; 67% of women IPT users report concerns about sexual and personal safety using IPT, especially during the night.

Excerpt 6: A woman in her late twenties reported the lack of institutional mechanisms in cases of sexual harassment while using shared autos, "I have faced sexual harassment in shared autos... it's frustrating that there is no redressal mechanism... no provision for my safety, and no one to help me.... Who should I go to? Whom should I speak to? How can IPT drivers operate without knowledge of such regulations!"

Poor and inadequate NMT and PT systems, as well as crowded, unregulated IPT vehicles, make women feel unsafe and uncomfortable, compromising women's safety and mobility in both cities (refer to **Figure 4**).

3.2. Women's access to economic and civic opportunities

This thematic area responds to three of the nine SDG5 targets: 5.4 on recognizing the value of unpaid work, 5.5 on access to equal opportunities and effective participation, and 5.B on women empowerment via technology.

Target 5.B indirectly interacts with urban transport and responds to women's employment in the transport sector and women's access to Mobility as a Service (MaaS) via platform economy. Only 20% of women in India are employed in the logistics sector, and only 1% of all commercial driving licenses are women-owned [29]. Apart from various societal and cultural barriers, the lack of skills (to drive a vehicle or to use a smartphone) greatly impacts women's inability to access services or be a part of the workforce [30].

Women face more significant barriers to accessing economic opportunities than men. At the same time, transport projects provide access to financial and civic opportunities; transport systems dominated by private, fossil-fuelled light-duty vehicles further limit accessibility for women [31]. In Indian districts, where private motorized vehicles are the predominant mode of commuting to work, the share of

women commuting to work is much lower than that of men [18]. Reasons for this include (i) the majority of households in Indian districts tend to own only one vehicle (predominantly a two-wheeler), which is used by the head of the household (predominantly men) for commuting to work, and (ii) cultural barriers and resource constraints keep women from driving or knowing how to drive. Women do not prefer long-distance commutes as they have to earn enough to justify high travel expenses and need to intermittently check on their families, especially children/ elderly at home [16]. Women are known to forgo an opportunity to work outside their neighbourhoods if they perceive transport fares and services as expensive and unreliable [5]. Discrimination against women and girls that manifests through denial of their physical mobility (like street harassment) usually pushes women out of the workforce.

3.2.1. Women's access to opportunities through non-motorized transport

Walking is the predominant mode of walking for low-income groups in both cities; about 55% of all pedestrian trips and 89% of cycling trips are undertaken to access economic opportunities. In Udaipur, low-income women have the lowest trip rate and the highest walking mode share. Women pedestrians in both cities walk unusually long distances (2–5 km); of the 38% women who walk to work in Udaipur, almost 2/3rd of them walk for 5–10 km. 30% and 65% of pedestrian women in Udaipur reported a monthly household income of less than Rs. 5000 (very low-income households) and Rs. 25,000, respectively (low-income households). Time spent walking to work due to poor public transport systems forms a considerable share of women's unpaid work (SDG5.4). Hence, women's time allocated to unpaid work increases due to the lack of affordable and convenient public transport; this time can be substituted by paid work or personal care/ leisure if affordable public transit is available. Hence, lack of supporting pedestrian infrastructure, Udaipur's weak PT system and Surat's unaffordable fare (refer to Excerpt 7) cause heavy trade-offs for women's (and other vulnerable groups) access to economic and civic opportunity (refer to **Figure 4**).

Excerpt 7: A migrant worker in her early thirties who often walks to work in Surat narrated that, "If I have to take the bus to work, it often involves multiple long transfers, and the bus-stop too is quite far... so either I have to walk to work, as it is more reliable than the bus or take the auto, despite it being expensive...so, to minimize costs, I often walk to work."

3.2.2. Women's access to opportunities through public transport and intermediate public transport

Udaipur's poor City Bus coverage leads to low ridership; 25% of IPT trips and 33% of 2W trips have a trip length of 5 km or more, making them most suitable via PT. Yet the lack of a robust PT network caps the PT mode share in Udaipur at 3%, forcing vulnerable populations (especially urban poor and women) to walk. Over 90% of all PT users belong to the low-income group (52% earning less than Rs. 5000 monthly, and 39% earning less than Rs. 25,000 monthly), dependent on PT to access economic opportunities, indicating captive users or 'no-choice' users form a large portion of PT ridership. Women's travel behaviour that involves trip-chaining and travel during off-peak hours results in longer waiting hours and longer trip times than men's [9,32,33]. Women PT users in both cities report longer waiting times for the

buses, discomfort while waiting on the carriageway due to the lack of bus stops/stations, and inconvenience of using PT due to its limited routes and lack of route information (refer Excerpt 8, 9 & 10). These factors result in greater time poverty for women than other citizens, especially low-income women. 99% of PT women users wished to own a private vehicle to improve their access to economic opportunities. This indicates a trade-off with access to economic and civic opportunities in the two case study cities (refer to **Figure 4**).

Excerpt 8: A migrant worker in Surat discussed her preference for IPT, “If we need to go to destinations that fall outside the fixed routes (PT), we spend more time and energy as there are lots of mode transfers... so many of us prefer auto-rickshaws, even though they are more expensive.”

Excerpt 9: A woman in her mid-forties indicated the lack of last-mile connectivity in Surat forces her to spend more time commuting than required, “I have stopped using the city bus/ BRT services as the nearest bus-stop is about 3km away and I have no means of reaching (personal vehicle) there, and had to walk to the bus-stop... that made me waste so much time. I now take the shared auto... it’s more expensive, but I get to my work on time.”

Excerpt 10: A young woman in Udaipur narrated a similar account of the city’s PT system, “Although the buses are cheap, I find commuting via buses very inconvenient and time-consuming due to its limited coverage. Doing multiple chores via buses is tough... so I wait for my brother or father to drive me sometimes or take the auto.”

3.3. Women’s access to healthcare via transport

Although universal access to sexual and reproductive health for women and girls goes beyond physical accessibility to healthcare facilities, we included this target to highlight the significance of urban transport in healthcare accessibility; access to healthcare for women goes beyond access to sexual and reproductive health, as women are primary caregivers (irrespective of their employment status) and are often responsible for healthcare trips of dependents (children, elderly or differently-abled household members). In the presence of inclusive healthcare services, urban transport directly influences health outcomes by providing access to them. The availability of adequate, affordable, and well-connected transport systems is linked to a reduced risk of premature deaths. Access to hospitals/ clinics is critical for society, especially women, and efficient transportation systems are need of the hour to connect women to such healthcare facilities (SDG5.4 & 5.6). Evidence also shows that access to reliable transport systems, especially better connectivity between rural and urban areas in the Global South, reduces perinatal, neonatal & maternal mortality [34]. As per the National Family Health Survey, at least 23.2% of women stated that the distance to a health facility is an issue in accessing health care. In addition, 21.5% of women reported that having to opt for transport systems to reach these centres was a concern [35]. Although this is more relevant in a rural context, especially in the case of maternal and neonatal mortalities, reliable and affordable public transport networks are crucial to enhance access to healthcare even in urban areas, especially for low-income women.

About 22% of women's trips in Surat and about 14% of women's trips in Udaipur are attributed to healthcare- far greater than men's trips in both cities supporting the findings from the literature. 82% of women said they walk to the nearest clinics/hospitals, even with dependents. However, more than 52% of women travel for more than 5 km to reach healthcare facilities. If given other mode choices to commute to healthcare facilities, 37% of females would opt for the alternate options instead of their current one. 24% of women reported that owning a personal vehicle and a driver's license would enable easy and quick access to healthcare. Most women in both cities stated that walking to healthcare facilities during deserted hours (afternoons and late evenings) scared them, and they often relied on their family members or female neighbors. Due to heavy waterlogging, low-income women in Surat mentioned difficulty walking to clinics (and other primary healthcare facilities), especially during monsoons. In cases of emergency, women in Surat used the 108-helpline number to call for an ambulance or contact (via phone) women auto-rickshaw drivers in their vicinity.

A young woman from Surat's Kailash Chokdi area (a low-lying area along the river) narrated her challenge of accessing transport and healthcare during monsoon, "Buses are the most affordable mode of transport, but become very unreliable during monsoon... there's often a long waiting time and more transfers (mode-changes within a single trip) ... so I have to walk everywhere in the water... I'm also responsible for regularly taking my grandparents to the nearby clinic, so it's a hassle to take them there walking in the water."

4. How can low-carbon transport proposals be more gender-responsive?

SDG5 discusses nine targets to achieve gender equality, as discussed above. However, there are various other targets corresponding to reduced poverty of women (as stated in SDG 1.2 and 1.4), reducing mortalities and improving access to healthcare services (as defined in SDG 3.1, 3.4 and 3.7), promoting secure working environments, entrepreneurship (as described in SDG 8.3 and 8.8) and providing access to safe and sustainable transport systems and public spaces (as highlighted in SDG 11.2 and 11.7). A deeper study of the inclusion of women and girls and empowering them in the transport sector is essential to understand and address all issues they face, especially in Indian cities.

Revising the existing notion of low-carbon transport planning (focused on environmental sustainability) to include social aspects of sustainable mobility (like gender equity) is crucial to achieving sustainable development. Hence, learnings from assessing the current transport situation in Surat and Udaipur pave the way for designing a more gender-responsive low-carbon transport system in developing countries.

City-specific recommendations pertain to each transport system intervention. NMT forms a crucial component of low-carbon transport, as it enables a switch from private motorized modes to NMT for shorter trips and functions as a vital last-mile mode (to PT) for longer trips. Hence, both cities must focus on large-scale improvement of NMT to foster low-carbon transport. In addition, PT forms the

backbone of low-carbon transport; hence, both cities must focus on improving PT mode shares. For this, Surat must concentrate on ensuring PT is accessible to and affordable for women, especially low-income women, and Udaipur must focus on expanding its coverage. Lastly, although not traditionally viewed as a low-carbon mode, IPT is vital to low-carbon transport in developing countries. It is a sustainable alternative to personal motorized vehicles due to high demand (among women), higher vehicle occupancy, and sustainable fuel. Surat must focus on mainstreaming IPT to work as a feeder service to PT, while Udaipur must concentrate on enhancing IPT infrastructure and quality of services.

Transport authorities must conduct comprehensive gender audits to institutionalize gender equity. Cities must prioritize transport supply to increase women's safety and mobility. For this, large-scale infrastructure improvements in NMT and PT are required to achieve a service level of 1 (highest). To ensure women's safety and improved access to transport, regular safety audits of transport infrastructure (footpaths, bike lanes, metro stations, bus stations, etc.) must be conducted. Gender-action plans should be altered based on the learnings from the safety audits. Network-specific interventions for each component include

- Improved safety of women and girls in cities: Introducing speed limits throughout the city to minimize road crash fatalities, largely pedestrianizing walled city areas in both cities to enhance the presence of women of all ages on streets, introducing a well-constructed and wide footpath network with no encroachments for unobstructed and convenient movement, improving street lighting and other street infrastructure to enhance the personal safety of women, improving the bicycle network throughout the city with supporting infrastructure to increase women ridership, implementing efficient infrastructure for safety (bus stops, onboarding) and enabling Transit Oriented Development (TOD) with mixed-use development to the enhanced safety of women while using PT and formulate stricter regulations and implementation to avoid overcrowding (& subsequent harassment) in vehicles.
- Eliminate time poverty of women in cities: Redesigning streets with Complete Street guidelines for enhanced last mile, gender-responsive routing of buses (to vulnerable areas) to serve more low-income women, subsidizing PT for women commuters to make it more affordable, and re-purposing mini-buses as feeder buses along high-demand routes in Udaipur to enable a higher access and transit ridership among women. Also, subsidies for women commuters should be introduced to make IPT more affordable.
- Expanding access to transport for women: Formalizing IPT by proposing IPT stations, fair fare structures and routes, strengthening the operations of Pink Autos in Surat (& proposing the same in Udaipur) to enable greater employment opportunities for women in the transport sector, develop EV infrastructure in residential spaces to enable a broader reach of EVs among women, encourage women drivers to own E-rickshaws through heavy subsidies and run awareness programs on the benefits of electric mobility.

For Udaipur, pedestrianizing the old city results in a lively public space for all ages and genders with formalized vending activities (refer to **Figure 5**). For Surat, the proposals translate into streets with equitable road space distribution and activity

zones, making it safe for all (refer to **Figure 6**).



Figure 5. A pedestrianized street section in Udaipur service leveled for motorized traffic, prioritizing safety for all ages and genders, acting as a public space.

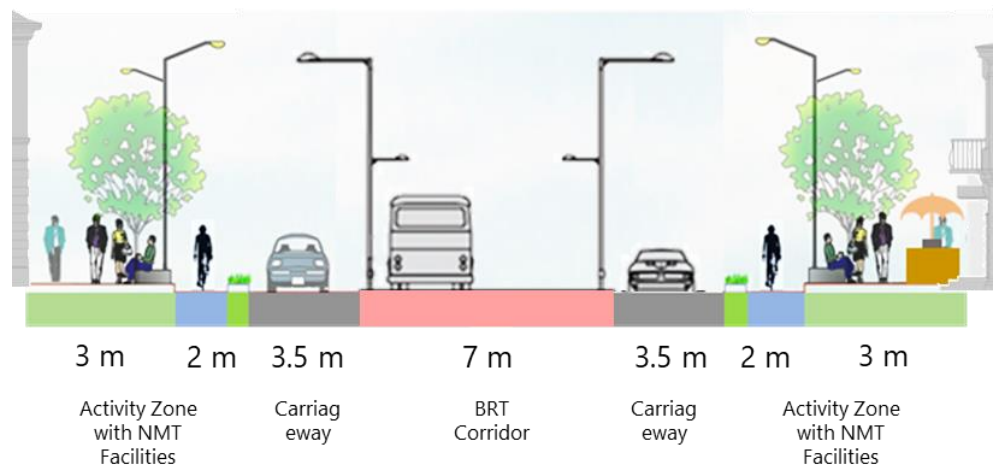


Figure 6. A typical street section in Surat with spaces allocated to BRT, footpaths, cycle tracks, bus lanes, and vending activities, maximizing safety and mobility for all.

In general, although cities anchor the implementation of gender-responsive transport planning and design, the state has a vital role. We present below state actions that can enhance gender-inclusion in transport with examples:

- (i) Incorporate gender-responsive transport planning in national and sub-national transport-sector visions.
- (ii) Mandate gender budgeting in cities. Gender-Responsive Budgeting began in India in 2005–2006 as a fiscal innovation, and was rapidly adopted by 57 out of the 58 central government ministries in India [36]. Despite being in effect for 18 years, it has low adoption among urban local bodies, due to a lack of mandate [36]. Hence, mandating it would ensure that rights and needs of women are embedded into municipal functions.
- (iii) Create a monitoring and evaluation framework to measure the impact of transport on gender equity.
- (iv) Create a financing mechanism that enables local bodies to upgrade public transport networks; Gujarat’s Chief Minister Urban Bus Service Scheme aims at

providing Viability Gap Funding of 50% or Rs. 12.50 per km to Transit Authorities and Urban Local Bodies [37].

- (v) Promote and incentivize investments in non-motorized infrastructure provision and maintenance; local governments in Europe and South America are forming Active Mobility Strategies to receive dedicated funding for non-motorized infrastructure provision; In 2014, Fortaleza, Brazil, leveraged its online, app-based parking system to fund its Strategic Cycling Infrastructure Plan with network length of 524-km [38]; in 2019, Ireland created a Comprehensive Active Travel Investment Program to receive 20% of the annual transport budget, drastically increasing its annual active transport budget from 12.64 million to 360 million [39].
- (vi) Mandate gendered transport data collection in cities to record disaggregated trip data to enable gender-responsiveness in transport policies and plan; The Capital Region Urban Transport (CRUT), Bhubaneshwar, India, collects gender disaggregated tickets to take evidence-based decisions [40].
- (vii) Decrease barriers for women's employment in transport sector by subsidizing intermediate public transport (like auto-rickshaws and E-rickshaws) vehicle ownership and other incentives; Since 2021, Ministry of Transport and Infrastructure in Turkey started a female internship for its rail connectivity project [41]; ride-sharing services like Grab in Philippines and PickMe in Sri Lanka have special initiatives to increase women workforce participation rate in their organizations; Delhi-Meerut Regional Rapid Transit System Investment Project: Gender Equality and Social Inclusion Action Plan aims to ensure over 50% jobs in operations are held by women [42].
- (viii) Increase women's participation in urban and transport planning outreach efforts [43]; Vadodara has appointed an 'inclusivity manager' to understand the challenges faced by women cyclists [44].

Gender-inclusive transport goes beyond the transport sector and requires a change in the paradigm of urban development. Gender-inclusive planning requires interventions in the policies and programmes, everyday governance for safety and security, financing, infrastructure planning and design, management of these infrastructures, and pricing of public transport. One-off provisions or tinkering with transport system will not give sustainable and long-term solutions.

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Notes

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