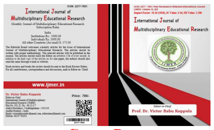
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PLANNING THE COMPLETE TRANSIT JOURNEY: A COMPARATIVE EVALUATION OF FIRST-AND-LAST-MILE ACCESSIBILITY IN DELHI, SEATTLE, AND BERLIN

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Abstract

Transit planning frequently evaluates rail and bus systems through route length, frequency, capacity, ridership, or in-vehicle travel time. These measures overlook the portions of a journey that occur before boarding, during transfers, and after alighting. This article develops a Complete Transit Journey framework and applies it to Delhi, India; Seattle, United States; and Berlin, Germany. The framework evaluates seven interdependent dimensions: spatial reach, network continuity, multimodal integration, universal accessibility, safety and security, affordability and legibility, and climate comfort and resilience. A structured qualitative comparison of policy documents, agency guidance, and scholarly research shows that the three metropolitan systems possess different strengths. Delhi Metro provides extensive regional reach and high-capacity service, but heterogeneous pedestrian environments, fragmented feeder provision, curb disorder, heat, and institutional division can impose substantial access penalties. Seattle's expanding Link light-rail system increasingly incorporates equitable transit-oriented development and station-access policy, yet topography, arterial barriers, incomplete pedestrian and bicycle networks, and dispersed land use constrain effective station catchments. Berlin benefits from dense mixed-use form, integrated fares, frequent multimodal service, and high levels of step-free access, although accessibility gaps, disrupted elevators, peripheral service differences, and housing displacement remain consequential. Across all three cases, geometric station buffers overstate practical accessibility because travelers experience distance through street connectivity, crossings, slopes, waiting time, transfers, information, perceived safety, weather exposure, and physical ability. The article argues that first-and-last-mile access should be funded, governed, and evaluated as an integral component of transit capital and operations. It concludes with a performance standard based on door-to-door accessibility rather than infrastructure mileage alone.

Keywords: First Mile; Last Mile; Transit Accessibility; Complete Journey; Delhi Metro; Sound Transit; Berlin; Universal Design; Multimodal Integration; Transport Equity

Table 1. Complete Transit Journey Evaluation Framework

Dimension	Planning question	Illustrative measures
Spatial reach	Who can reach the platform within reasonable generalized cost?	Network-based time, slope, delay, destinations, traveler profiles
Network continuity	Is the route connected, direct, and maintained?	Sidewalk and bicycle gaps, crossings, barriers, detours
Multimodal integration	Do access modes and transfers function as one system?	Feeder frequency, transfer wait and fare, curb operations
Universal accessibility	Is a step-free, intelligible route reliably available?	Elevators, ramps, tactile guidance, boarding, outage detours

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Safety and security	Can travelers complete the trip without traffic or personal danger?	Crash risk, speed, lighting, harassment, perceived safety
Affordability and legibility	Is the trip financially and cognitively manageable?	Fare burden, payment, wayfinding, language, real-time information
Climate comfort and resilience	Is access usable under present and future conditions?	Shade, shelter, drainage, heat, smoke, snow, redundancy

Note. Generalized cost includes time, money, effort, uncertainty, safety, comfort, and traveler capability.

1. Introduction

A transit trip does not begin when a passenger boards a train or bus. It begins at a front door, workplace, school, clinic, shop, or other origin and continues through a sequence of sidewalks, crossings, bicycle links, feeder services, station entrances, fare gates, platforms, transfers, and destination-side connections. Each segment imposes time, monetary cost, physical effort, uncertainty, and exposure to risk. If one segment is inaccessible or unreliable, the usefulness of the entire transit investment can be reduced.

Conventional planning often simplifies this journey. Station-area analysis commonly draws circular buffers around transit stops, assuming that distance adequately represents access. Travel-demand models may represent access and egress through average time penalties. Project appraisal typically emphasizes in-vehicle travel time, ridership forecasts, and construction cost. These abstractions are useful for regional modeling, but they can conceal barriers that travelers experience at street level. A station located 600 meters away may be practically inaccessible if the route requires crossing a high-speed arterial without a safe signal, climbing a steep grade, navigating a broken footway, or waiting for an unreliable elevator.

The first-and-last-mile problem has gained prominence as cities expand rapid transit while pursuing decarbonization, accessibility, and equity. Research shows that out-of-vehicle experience influences satisfaction and transit use, and that the pedestrian environment shapes whether riders walk to and from stations (Park et al., 2021; Venter, 2020). The problem is not limited to a literal mile. It concerns the complete access chain and the cumulative burden imposed by its weakest link.

This article compares Delhi, Seattle, and Berlin. Delhi represents a high-density and rapidly evolving megacity with a large metro network, diverse paratransit, intense mixed traffic, and highly variable pedestrian conditions. Seattle represents an expanding North American light-rail region where new stations intersect with topography, wide arterials, incomplete sidewalks, bicycle-network gaps, and dispersed metropolitan development. Berlin represents a mature European network with extensive rail, tram, bus, walking, and cycling integration, supported by unified fares and transit-oriented urban form.

The analysis asks three questions. First, which physical, operational, financial, informational, and environmental factors determine effective station access? Second, how do Delhi, Seattle, and Berlin address these factors through planning and implementation? Third, which performance measures would allow transit agencies and cities to evaluate complete journeys rather than isolated infrastructure? The article's central argument is that first-and-last-mile conditions are not secondary amenities. They are functional components of transit capacity, ridership, equity, and resilience.

2. Conceptualizing the Complete Transit Journey

Accessibility is the ease with which people can reach destinations and opportunities, combining transportation, land use, time, and individual capability (Geurs & van Wee, 2004). This differs from mobility, which concerns movement, and from proximity, which concerns spatial distance. A transit line may increase mobility while delivering limited accessibility if stations are poorly connected to destinations, service is infrequent, transfers are costly, or nearby housing is unaffordable.

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The first-and-last-mile literature frequently examines walking distance, feeder modes, bicycle access, shared mobility, or microtransit. These interventions can increase station reach, but mode availability alone is insufficient. A bicycle-share station has limited value without safe routes. A feeder bus does not create seamless access when schedules are uncoordinated or transfers require additional fares. Ride-hailing may extend geographic reach while increasing curb conflict, cost, and exclusion for people without smartphones or bank accounts.

The complete journey is best understood as a chain of linked stages. The traveler must reach a stop or station, enter and navigate the facility, wait, board, travel, transfer if necessary, alight, exit, and reach the destination. Reliability compounds across stages. A five-minute access delay can become a much larger penalty when it causes a missed low-frequency connection. Similarly, an elevator outage can transform a nominally accessible trip into an impossible one.

Equity is embedded in this chain. Travelers differ in walking speed, physical ability, income, caregiving responsibility, luggage, exposure to harassment, work schedule, and access to digital information. A standardized half-mile walkshed may be reasonable for a healthy adult under favorable conditions and unrealistic for an older adult, a wheelchair user, a parent with a stroller, or a traveler moving through extreme heat. Complete-journey evaluation must therefore be person-specific and time-specific.

Climate conditions are also increasingly important. Heat, intense rainfall, snow, smoke, flooding, and wind affect walking, waiting, cycling, elevators, power, and surface transit. Station resilience cannot be defined solely by the ability of trains to operate. The accessible route to the station and the waiting environment must remain usable during foreseeable conditions.

3. Complete Transit Journey Evaluation Framework and Method

The framework developed for this study combines accessibility, universal design, network connectivity, multimodal integration, and climate resilience. It contains seven dimensions. Spatial reach evaluates the destinations and population that can reach transit within reasonable generalized cost, rather than a geometric radius. Network continuity evaluates whether routes are connected, direct, maintained, and free of impassable barriers. Multimodal integration evaluates feeder services, transfers, bicycle access, curb management, fare coordination, and schedule alignment.

Universal accessibility evaluates step-free routes, elevators, ramps, tactile guidance, boarding interfaces, resting opportunities, accessible information, and the reliability of these features. Safety and security include traffic danger, crossing design, lighting, personal security, harassment, visibility, and emergency conditions. Affordability and legibility evaluate fares, transfer charges, wayfinding, real-time information, language access, payment options, and the cognitive effort required to complete a trip. Climate comfort and resilience evaluate shade, shelter, drainage, heat, snow and ice management, flood exposure, air quality, and operational redundancy.

The cases were selected through a most-different-systems design. The comparison does not assume that one model can be transferred intact to another. Delhi, Seattle, and Berlin differ in density, income, governance, modal culture, network maturity, and street form. These differences are analytically useful because they reveal which elements of complete-journey planning are universal and which require contextual adaptation.

The study uses structured qualitative analysis of transit agency policies, station-access guidance, mobility legislation, accessibility information, planning documents, and peer-reviewed research. It is not a station-by-station audit and does not assign a composite city score. Citywide averages would mask substantial variation among central, peripheral, elevated, underground, and interchange stations. The cases instead identify recurring mechanisms, institutional responsibilities, and evaluation gaps.

4. Delhi: Metropolitan Reach and Street-Level Friction

Delhi Metro has transformed metropolitan mobility by creating a high-capacity electric rail network across Delhi and the National Capital Region. Its network scale and interchange structure allow millions of passenger journeys and connect

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employment centers, educational institutions, commercial districts, and residential areas. Metro expansion has therefore increased regional reach in a way that surface modes alone could not achieve.

Regional reach does not guarantee seamless station access. Delhi's station environments vary sharply. Some stations are embedded in dense mixed-use districts with abundant walking, autorickshaw, cycle-rickshaw, bus, and shared-mobility connections. Others are located along wide arterials, elevated corridors, large intersections, or planned districts where direct pedestrian access is interrupted. Informal commerce and paratransit can provide valuable access while also competing for limited footway and curb space. The planning task is to organize these activities without eliminating the flexible services on which passengers depend.

Research on Delhi Metro demonstrates that pedestrian-environment quality affects willingness to walk the first and last mile (Sharma, 2022; Umair et al., 2025). Distance interacts with footway continuity, crossing delay, traffic exposure, land-use activity, lighting, and perceived security. Women may face distinct constraints related to harassment, lighting, crowding, and travel time. Heat and air pollution add physiological cost, particularly where routes lack shade or waiting areas.

Delhi also illustrates the value and difficulty of feeder integration. Buses, autorickshaws, e-rickshaws, cycle-rickshaws, taxis, walking, and private two-wheelers extend station catchments. Yet service quality, fare integration, operating space, information, and regulatory treatment vary. Feeder services are often evaluated by the number of vehicles or routes rather than coordinated frequency, passenger wait, transfer cost, or access to underserved neighborhoods. App-based modes increase choice for some users while excluding others and contributing to curb congestion.

Universal accessibility has improved through elevators, escalators, reserved spaces, tactile elements, and low-floor services, but the complete accessible path extends beyond station property. A station elevator cannot compensate for a missing curb ramp, obstructed footway, unsafe crossing, or inaccessible feeder vehicle. Responsibility for these elements is distributed among Delhi Metro Rail Corporation, road-owning agencies, municipal bodies, traffic police, bus operators, and private or informal providers.

Delhi's most important institutional challenge is therefore boundary management. Metro agencies control the station and rail service, while the decisive access conditions often lie on streets managed by other entities. Station-area plans should establish a defined accessibility zone, a lead coordinating body, funded improvements, curb operations, maintenance obligations, and outcome reporting. Measures should include reliable door-to-platform time, safe crossing access, feeder frequency, transfer price, step-free route availability, heat exposure, and accessibility for women, older adults, children, and disabled travelers.

5. Seattle: Expanding Rail in a Discontinuous Urban Fabric

The Seattle region is undertaking a major expansion of Link light rail, Sounder commuter rail, and bus rapid transit. New stations extend high-capacity transit to additional communities and reshape regional travel. Sound Transit's System Access Policy and subsequent access planning recognize that ridership, connectivity, social equity, safety, health, and passenger experience depend on how people reach stations (Nelson\Nygaard, n.d.). The agency's equitable transit-oriented development policy also links station investment to affordable housing and regional growth (Sound Transit, n.d.-a).

Seattle's access challenge is shaped by topography and street discontinuity. Hills, waterways, freeways, rail corridors, superblocks, and wide arterials can make short straight-line distances misleading. In parts of the city and region, sidewalks are missing or incomplete. Bicycle routes may terminate before reaching stations, and crossings of high-speed roads can impose delay or danger. These barriers shrink practical station catchments and disproportionately affect travelers who cannot drive or use a bicycle.

Station design has increasingly incorporated bicycle parking, bus transfers, pick-up and drop-off areas, pedestrian bridges, and public-realm improvements. Northgate provides a notable example of a bicycle and pedestrian bridge designed to

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connect neighborhoods and institutions across Interstate 5. Such investments demonstrate that a single strategic link can expand a station's useful catchment more effectively than generalized improvements that do not close network gaps.

The regional institutional environment remains complex. Sound Transit constructs and operates regional rail, King County Metro and other agencies operate buses, cities manage most local streets, the Washington State Department of Transportation controls major highways, and land-use decisions are divided among jurisdictions. A station-access improvement may therefore require coordination across capital programs, ownership boundaries, schedules, and maintenance responsibilities.

Seattle has also experimented with on-demand first-and-last-mile services linked to transit and ORCA fare payment (Sound Transit, 2019). Such services can improve access in lower-density areas or for passengers facing mobility constraints. Their evaluation should include public cost per trip, service availability, wait time, wheelchair access, labor conditions, geographic equity, and whether the service replaces or complements fixed-route transit.

Climate conditions reveal another dimension. Rain, darkness during winter commuting periods, wildfire smoke, heat events, and localized flooding influence walking, cycling, and waiting. Shelter, lighting, drainage, tree canopy, and accessible real-time information should be incorporated into station-access programs. Seattle's principal opportunity is to use rail expansion as a deadline for completing safe access networks before stations open, rather than treating access improvements as later municipal projects competing for separate funds.

6. Berlin: Integrated Networks and the Remaining Accessibility Gap

Berlin's transit system is structured as a multimodal network rather than a collection of isolated services. U-Bahn, S-Bahn, tram, bus, regional rail, walking, and cycling are coordinated through the Verkehrsverbund Berlin-Brandenburg fare and information system. Frequent service and dense mixed-use development reduce the generalized cost of access and transfers. Many passengers can reach multiple lines or stops, creating redundancy when one route is disrupted.

The Berlin Mobility Act establishes a policy basis for prioritizing public transport, walking, and cycling. This legal and planning environment supports station access through pedestrian networks, cycling infrastructure, bicycle parking, traffic calming, and integration with surface transit. Unified ticketing reduces the monetary and cognitive burden of transfers, while widely available service information improves legibility.

Universal accessibility is comparatively advanced but incomplete. BVG reports that 86 percent of U-Bahn stations are step-free and have guidance systems for blind passengers, while S-Bahn Berlin reports that approximately 90 percent of its stations are accessible (Berliner Verkehrsbetriebe, n.d.; S-Bahn Berlin, n.d.). These percentages demonstrate substantial progress, but they also identify a remaining system gap. In a network, inaccessible stations and elevator outages can invalidate otherwise accessible routes and force long detours.

Berlin's dense station spacing and connected street pattern favor walking, yet access quality is not uniform. Large roads, complex interchanges, construction, bicycle-pedestrian conflict, and peripheral land-use patterns can impose barriers. Winter conditions, heat, and heavy rainfall affect access and waiting. A mature system must therefore maintain elevators, surfaces, lighting, drainage, and information with the same seriousness applied to train operations.

Affordability and housing location are also part of the complete journey. Integrated fares simplify travel, but rising housing costs can displace lower-income households toward peripheral areas with longer journeys or less frequent service. Transit-oriented accessibility can deteriorate even when the network itself remains unchanged. Evaluating Berlin therefore requires combining station access with housing affordability, service span, and access to jobs across the metropolitan region.

Berlin's main lesson is that integration produces cumulative benefits. Frequent service reduces the penalty of an imperfect transfer, unified fares reduce transaction cost, mixed land use shortens access distance, and redundant networks increase

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resilience. However, the remaining accessibility gap demonstrates that high system averages do not guarantee an accessible trip for every passenger.

7. Comparative Findings

The three cases confirm that effective station catchments are shaped by generalized cost rather than distance alone. Delhi's density places many destinations near stations, but street-level friction can make short trips difficult. Seattle's lower-density geography and topographic barriers can place nearby areas outside a practical walkshed. Berlin's dense network and connected street structure reduce access cost, although accessibility outages and peripheral differences remain important.

Multimodal integration differs in form. Delhi relies on a rich ecology of formal, semi-formal, and informal feeder modes. This flexibility expands reach but creates challenges involving fares, curb space, information, regulation, and working conditions. Seattle relies on scheduled buses, walking, cycling, park-and-ride, and selected on-demand services within a multi-agency regional structure. Berlin's greatest strength is integrated fares and coordinated networks, which reduce the penalty of transfers.

Universal accessibility exposes the weakest-link character of complete journeys. All three systems have invested in accessible stations and vehicles, but travelers require a continuous path. The relevant unit of analysis is not the accessible asset. It is the accessible origin-to-destination itinerary at a specified time, including the possibility of elevator outages, construction, weather, and missed connections.

Safety combines traffic danger and personal security. Delhi's mixed traffic, arterial crossings, and harassment concerns can create major access barriers. Seattle's wide arterials, high vehicle speeds, incomplete sidewalks, and dark winter periods affect both real and perceived safety. Berlin generally benefits from lower-speed environments and active streets, but complex intersections, cycling conflicts, and nighttime conditions still matter. Gender-responsive and disability-responsive audits should supplement aggregate crash analysis.

Climate comfort is underdeveloped as a formal transit-access metric. Delhi requires heat, shade, air quality, and monsoon drainage to be treated as basic access conditions. Seattle requires rain protection, drainage, lighting, smoke response, and increasing heat preparedness. Berlin requires heat adaptation, winter maintenance, shelter, and reliable operation during storms. Climate-sensitive access improvements can extend the hours and seasons during which transit remains usable.

Finally, governance determines whether access gaps are closed. Transit agencies often control vehicles and station property, while local governments control sidewalks, crossings, land use, lighting, and curbs. Feeder operators, road agencies, police, utilities, and private property owners add further complexity. A complete-journey standard needs a lead institution, shared performance measures, committed finance, and enforceable maintenance responsibilities.

8. A Door-to-Door Performance Standard

The comparison supports a shift from facility-based reporting toward door-to-door performance. Station access should be evaluated through network-based walksheds and rollsheds that reflect actual routes, slopes, crossings, signal delay, surface quality, and barriers. These analyses should use multiple traveler profiles rather than a single walking speed.

Transit projects should report the share of residents and jobs able to reach platforms within specified time and cost thresholds, with results disaggregated by income, disability, age, gender, and neighborhood. Accessibility should also be measured at different times of day because service frequency, lighting, safety, and elevator availability vary.

Access programs need a hierarchy of indicators. Inputs include funding, staff, and agreements. Outputs include sidewalks, crossings, elevators, bicycle links, feeder routes, and shelters. Intermediate outcomes include access time, wait time, transfer reliability, step-free itinerary availability, perceived safety, and climate exposure. Final outcomes include transit ridership, access to essential destinations, household transportation burden, traffic injuries, emissions, and distributional change.

Capital approval should include a funded station-access catchment program extending beyond transit property. The program should identify the responsible agency for every critical connection and include lifecycle maintenance. Where access depends on a local street project, the schedule should be integrated with station opening. Where informal or private feeder services are essential, planning should provide safe operating space, passenger protections, and equitable regulation.

Real-time information should include the complete journey. Passengers need accessible information about elevator outages, blocked entrances, construction detours, bicycle availability, feeder disruption, and weather-related hazards before beginning a trip. Non-digital alternatives remain necessary for passengers without smartphones or data access.

The final standard is experiential: can a person reach an essential destination safely, affordably, reliably, legibly, and with dignity? This question should guide investment even when the highest-value intervention is a crossing, elevator, shaded footway, bus-priority segment, or missing bicycle connection rather than additional rail infrastructure.

9. Limitations and Future Research

This study is based on system-level documents and research rather than original station audits or passenger surveys. Conditions vary substantially within each metropolitan area, and official accessibility designations may not capture temporary outages, street obstructions, crowding, or individual experience. Cross-city comparison is also affected by differences in terminology, data availability, and institutional scope.

Future research should apply the framework to matched station types, including central interchanges, elevated arterial stations, suburban terminals, and neighborhood stations. GIS network analysis could quantify profile-specific catchments, while travel diaries and interviews could document time, stress, effort, and uncertainty. Particular attention should be given to disabled travelers, women, older adults, caregivers, shift workers, and passengers with limited incomes. Longitudinal research could then test whether targeted access improvements change ridership, accessibility, safety, and mode choice.

10. Conclusion

Delhi, Seattle, and Berlin demonstrate that the value of transit is produced across an entire journey. Delhi offers extraordinary metropolitan reach but faces variable street conditions and fragmented feeder governance. Seattle is expanding regional rail while confronting topography, arterial barriers, incomplete active-transportation networks, and multi-agency responsibility. Berlin shows the benefits of dense urban form, unified fares, frequent multimodal service, and high levels of station accessibility, while also revealing the consequences of remaining network gaps and peripheral housing pressures.

The comparison rejects the assumption that a circle drawn around a station represents actual access. Practical accessibility is created through connected routes, safe crossings, manageable slopes, reliable feeders, affordable transfers, step-free facilities, legible information, personal security, and protection from climate conditions. These factors interact, and failure at one stage can invalidate the rest of the trip.

First-and-last-mile access should therefore be treated as core transit infrastructure. It should be planned before station opening, funded with capital and operating resources, governed across institutional boundaries, maintained throughout the asset lifecycle, and evaluated through door-to-door outcomes. The appropriate measure of success is not simply how many people live near transit, but how many can use it to reach daily opportunities safely, reliably, affordably, and with dignity.

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