IMPROVING THE CLIMATIC, FUNCTIONAL AND ERGONOMIC DESIGN PRINCIPLES OF URBAN BUS STOPS IN UZBEKISTAN: A CASE STUDY OF URGENCH CITY

Matkarimov Feruzbek Timur ugli
2nd-year Doctoral Student, Urgench State University named after Abu Rayhan Beruni, Uzbekistan
E-mail: feruzbek.matkarimov@bk.ru

ABSTRACT

Urban bus stops are small but strategically important elements of the public transport system: they shape the first and last stages of a passenger's journey and influence perceived safety, accessibility and comfort. In cities of Uzbekistan, bus-stop design must respond not only to functional and architectural requirements but also to pronounced seasonal climatic conditions. This article develops an integrated design framework for improving urban bus stops, using Urgench as a contextual case study. The study combines a focused review of international design guidance, qualitative reconnaissance of typical bus-stop conditions reported for Urgench, climate-sensitive design analysis and a multi-criteria synthesis. The analysis identifies six interdependent design dimensions: climatic protection, user comfort, universal accessibility, urban integration, passenger information and durability/maintenance. A conceptual design model is proposed, incorporating solar protection, controlled ventilation, wind and dust mitigation, shaded seating, step-free access, tactile orientation, legible route information and modular components. The article does not claim statistically representative survey results or measured performance outcomes; instead, it establishes a transparent, replicable framework for subsequent field measurement and prototype evaluation. The proposed approach can support context-sensitive modernization of bus stops in Urgench and other secondary cities in Uzbekistan.

Keywords: *bus stop; public transport; urban design; climate-responsive architecture; universal accessibility; passenger comfort; Urgench; Uzbekistan.*

1. INTRODUCTION

Public transport infrastructure is experienced by passengers not only inside vehicles but also in the spaces where they walk, wait, transfer and board. A bus stop is therefore more than a shelter: it is an interface between the transport network and the public realm. Its location, accessibility, microclimate, information provision and maintenance affect the quality of the entire journey. Urban design guidance increasingly treats stops as part of the pedestrian

environment and emphasizes safe access, shelter, seating, shade, legible information and universal design [1–3].

The design challenge is particularly relevant in Uzbekistan, where the continental climate creates substantial seasonal contrasts. World Bank climate material describes Uzbekistan as having an extreme continental climate and reports a July mean temperature of approximately 27–29°C across much of the country, with higher values in the south [4]. These regional averages do not substitute for site-specific measurements in Urgench, but they demonstrate why shade, roof performance, ventilation, material selection and protection from wind and precipitation should be treated as core design parameters rather than optional amenities.

The international accessibility framework also requires equal access to the physical environment, transport and information systems. Article 9 of the United Nations Convention on the Rights of Persons with Disabilities calls for the identification and removal of barriers to accessibility in transport and public facilities [5]. Accordingly, a contemporary bus stop should be usable by older adults, children, people with disabilities, passengers carrying luggage and people with temporary mobility limitations.

In Urgench, preliminary reconnaissance and the author’s reported observations indicate recurring design concerns that warrant systematic assessment: insufficient shade and weather protection at some stops, limited seating comfort, weak wind protection, inconsistent passenger information and inadequate consideration of accessible movement. These observations are treated here as qualitative problem indicators, not as a statistically representative inventory. The central research problem is how to combine climatic, functional, ergonomic and urban-design requirements into a coherent, locally adaptable bus-stop design approach.

The aim of this study is to formulate an integrated set of design principles and a conceptual model for improving urban bus stops in Uzbekistan, with particular attention to the climatic and urban context of Urgench. The objectives are: (1) to identify the main performance dimensions of a high-quality bus stop; (2) to interpret international guidance in relation to local climatic and social conditions; (3) to organize the identified issues into a multi-criteria framework; and (4) to propose design recommendations for further architectural development and field validation.

2. MATERIALS AND METHODS

2.1. Research design

The study uses an exploratory, qualitative and design-oriented research strategy. It combines documentary analysis, comparative review of selected international guidance, contextual climate analysis and a structured synthesis of preliminary observations. This

approach is appropriate at the framework-development stage because the purpose is to define design criteria and relationships before conducting a larger measured field survey.

2.2. Study context

Urgench is considered as a representative secondary-city context in the Khorezm region. The analysis focuses on ordinary on-street bus stops rather than major intercity terminals. The local context is considered through four interacting factors: hot-season solar exposure, seasonal wind and dust, pedestrian movement along urban streets, and the needs of a diverse passenger population. National-scale climate data are used only to establish the broad climatic rationale; detailed design must be informed by local measurements of air temperature, surface temperature, wind direction and speed, solar exposure and shade duration.

2.3. Sources and analytical procedure

The documentary review examined: (a) public-transport stop design guidance, including the New Zealand Transport Agency’s guidance on stop location, capacity, design and maintenance [1]; (b) the Pittsburgh Regional Transit stop and street design guidance, which sets out accessibility, boarding-area, seating and shelter considerations [2]; (c) the National Association of City Transportation Officials’ principles on stops as gateways, passenger movement and universal design [3]; (d) the United Nations Convention on the Rights of Persons with Disabilities [5]; and (e) the World Bank’s climate and public-transport materials relevant to Uzbekistan [4,6].

A qualitative issue-to-response matrix was then developed. Each issue was linked to a design objective, a spatial or technical response, and a proposed indicator for future evaluation. The six dimensions were selected because they jointly address passenger experience, climatic suitability, safe access and long-term operation.

2.4. Scope and limitations of field evidence

The Urgench case discussion is based on preliminary qualitative reconnaissance information and problem descriptions available to the author. No sample size, passenger-count dataset, measured thermal-comfort series or completed statistically representative questionnaire was supplied for this manuscript. Therefore, the article does not report invented percentages, measured temperature reductions, ridership effects or statistical significance. The framework should be validated through a documented audit of a defined sample of stops, time-stamped photographs, pedestrian and passenger counts, microclimate measurements and user interviews.

2.5. Multi-criteria synthesis

The design framework uses six criteria: climate adaptation (C1), user comfort (C2), universal accessibility (C3), urban integration (C4), information and digital services (C5), and durability/maintenance (C6). At this stage, the criteria are treated as a structured checklist

rather than a weighted numerical index. Weighting should be undertaken in a subsequent phase using expert assessment or a transparent multi-criteria decision method, supported by empirical data.

3. RESULTS

3.1. Key design problems and their implications

The synthesis indicates that weaknesses at bus stops are rarely isolated. For example, a shelter that provides a roof but has poorly oriented side panels may protect against direct sunlight at one time of day while allowing strong crosswinds or dust to enter. A bench placed within the clear pedestrian route may improve the possibility of sitting but obstruct wheelchair movement or passenger circulation. A digital display without a readable static route map may fail during power or network interruptions. These examples demonstrate the need to assess the stop as an integrated spatial and operational system.

Observed / potential issue	Design objective	Recommended response	Proposed evaluation indicator
Insufficient shade and heat protection	Reduce direct solar exposure	Deep roof overhang; high-reflectance roof; shaded seating; tree integration where feasible	Shaded waiting-area percentage; surface and air temperature
Wind, dust and rain exposure	Provide adjustable environmental protection	Permeable side screens; orientation to prevailing winds; drainage and roof detailing	Wind speed at seating level; rain ingress; dust exposure
Uncomfortable or inadequate seating	Support different passenger needs	Back-supported seating; armrests at selected locations; standing/leaning options	Seat availability; user comfort rating
Barriers for wheelchair users and older adults	Ensure continuous accessible journey	Step-free approach; firm, slip-resistant boarding area; clear circulation and tactile cues	Accessible-route audit; unobstructed boarding area

Weak route and arrival information	Improve legibility and confidence	Consistent stop ID; route map; large-print static information; optional real-time display	Information completeness and legibility audit
Maintenance and vandalism challenges	Extend service life and reliability	Modular replaceable parts; corrosion-resistant materials; accessible service components	Maintenance frequency; component replacement time

Table 1. Qualitative issue-to-response matrix for the modernization of urban bus stops.

The matrix is intended as a design and audit instrument. The indicators are proposed for future measurement and should not be interpreted as results already collected.

3.2. Climate-responsive architectural principles

Climate adaptation should begin with orientation and passive design. The roof should provide sufficient shade during the hours of peak passenger use, while its material and surface finish should limit unnecessary solar heat gain. A ventilated roof build-up or a ventilated canopy gap can reduce heat accumulation beneath the shelter. Side screens should be designed selectively: fully enclosed walls may reduce wind exposure but can restrict air movement and visibility. Perforated or partially screened panels can provide a balance between protection, ventilation and passive surveillance.

The shelter should be oriented after a site-specific assessment of solar paths, prevailing winds, street geometry and pedestrian approach routes. Vegetation can supplement architectural shade where irrigation, root space, visibility and maintenance conditions permit. Rainwater should be directed away from the boarding zone and pedestrian path. Material selection should account for ultraviolet exposure, corrosion, thermal touch comfort, vandal resistance, repairability and local availability.

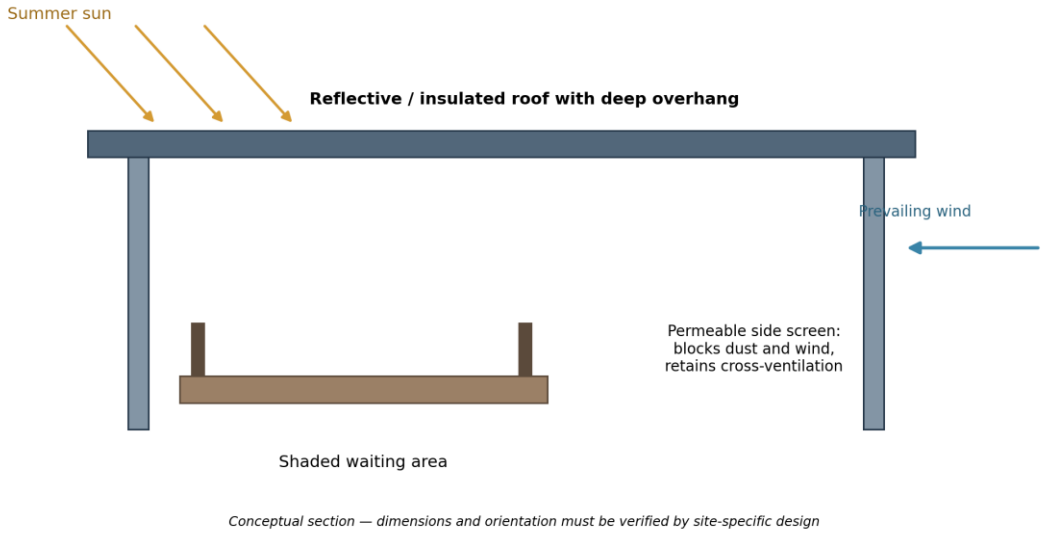


Figure 1. Conceptual climatic section illustrating shade, ventilation and selective wind protection (author’s diagram).

3.3. Universal accessibility and ergonomic comfort

Accessibility must be continuous from the surrounding sidewalk to the boarding area. The stop should not be treated as accessible merely because a ramp or tactile tile is present: the approach path, waiting space, seating arrangement, boarding surface and information system must work together. The UN Convention establishes the broader obligation to provide access to transport and information on an equal basis [5]. Practical stop-design guidance similarly emphasizes firm and stable boarding areas, clear circulation, readable signage and seating that does not obstruct accessible movement [2].

Ergonomic design should accommodate different body sizes, ages and abilities. Seating with back support can benefit older passengers and people who cannot stand for long periods. Armrests may assist sitting and standing, while a portion of the waiting area should remain unobstructed for wheelchair users and passengers with strollers. Tactile guidance and high-contrast information can support passengers with visual impairments. Information should be available in a static form even when digital systems are installed.

3.4. Urban integration and passenger information

A bus stop should connect directly to the pedestrian network and be positioned with regard to safe crossings, visibility, nearby destinations and the operating needs of buses. NACTO frames stops as gateways to the transit system and emphasizes their relationship with sidewalks, adjoining buildings, shade, seating and clear information [3]. This perspective is important for secondary cities, where stop improvements can also strengthen the quality of the street environment.

Passenger information should follow a consistent hierarchy: stop name and unique identifier; route numbers and destinations; network map; service information; and, where technically feasible, real-time arrival data. Digital displays should be weather-protected, readable in daylight and maintainable. A static fallback is essential so that basic information remains available during outages.

3.5. Proposed integrated design framework

The proposed framework organizes the bus stop as a coordinated system rather than a collection of separate objects. Climate adaptation establishes the environmental envelope; comfort and ergonomics define the waiting experience; universal accessibility secures equitable use; urban integration connects the stop to the street; passenger information supports wayfinding; and durability ensures that the design remains functional over time.

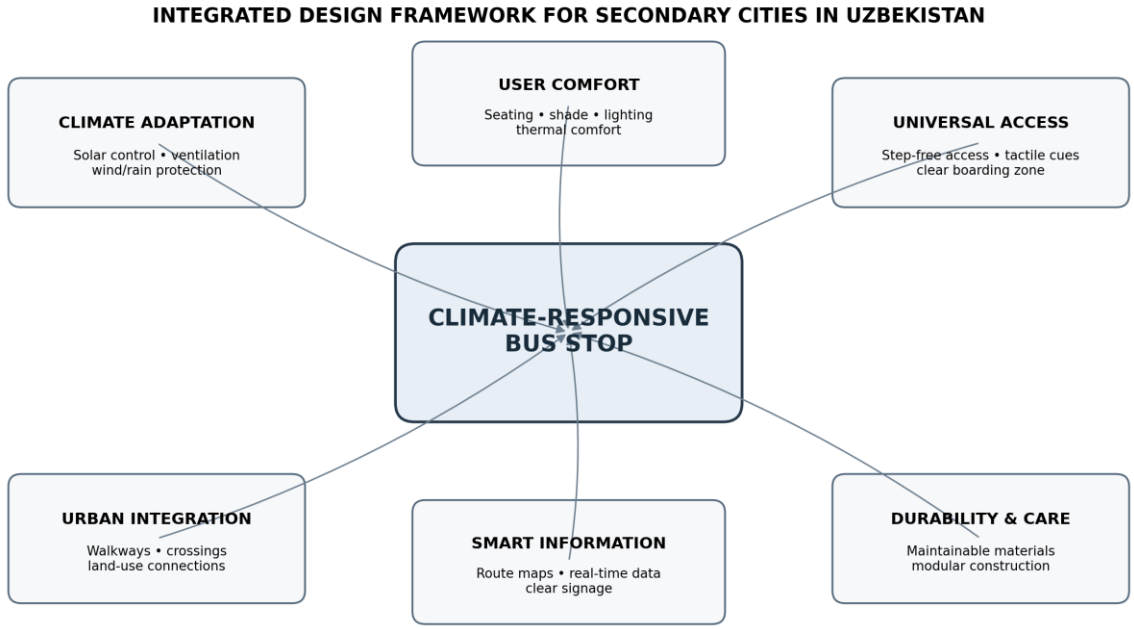


Figure 2. Integrated design framework for climate-responsive bus stops in Uzbekistan (author’s diagram).

For practical application, the framework can be translated into three intervention levels. Level 1 (basic stop) provides a safe approach, identifiable stop sign, clear boarding zone and essential route information. Level 2 (shelter stop) adds shade, weather protection, seating, lighting and waste management. Level 3 (high-demand or interchange stop) provides greater passenger capacity, multiple seating zones, enhanced real-time information, improved pedestrian connections and additional accessibility features. The appropriate level should be determined by passenger demand, street width, land use, transfer function and available maintenance resources.

4. DISCUSSION

The findings support a shift from object-based shelter design to performance-based stop design. International guidance consistently treats accessibility, safety, comfort, location and maintenance as linked requirements [1–3]. The proposed framework adapts these themes to the climatic and urban context of Uzbekistan. Its main contribution is the explicit integration of climate response with universal accessibility and operational durability in one design logic.

The climate dimension is especially important because a shelter that is visually modern may still perform poorly if it traps heat, lacks adequate shade or is incorrectly oriented. Conversely, excessive enclosure can compromise ventilation and visibility. The design task is therefore to balance solar protection, airflow, wind mitigation and passive surveillance through orientation, roof geometry and selective screening. The national climate profile provides a rationale for this focus, but local microclimate monitoring is required before fixing dimensions or material specifications [4].

The accessibility dimension should also be understood as a network issue. A well-designed shelter cannot compensate for a broken sidewalk, unsafe road crossing or inaccessible boarding interface. This is consistent with the rights-based approach of the UN Convention and with contemporary stop-design guidance [2,5]. For Urgench, the proposed approach implies that modernization projects should assess the complete pedestrian route to the stop, not only the shelter structure.

The framework also has implementation implications. Municipal authorities and transport operators should establish a stop inventory, classify stops by demand and context, define minimum service standards, and assign responsibility for cleaning, repairs and information updates. Modular construction can help standardize components while allowing variation in shelter size, screen orientation and equipment. However, modularity should not lead to a single universal prototype applied without regard to street width, passenger demand or local climate exposure.

The limitations of this study are deliberate and transparent. The manuscript is a framework-development article based on documentary analysis and preliminary qualitative case information. It does not claim that the proposed model has been built, tested or statistically validated. Future work should include a georeferenced inventory of bus stops in Urgench; standardized photo documentation; passenger counts at peak and off-peak periods; interviews with older adults and people with disabilities; and measurements of air temperature, surface temperature, solar exposure and wind at waiting height. A pilot prototype could then be evaluated against the indicators in Table 1.

5. CONCLUSION

This study proposes an integrated framework for improving the climatic, functional and ergonomic design of urban bus stops in Uzbekistan, using Urgench as a contextual case. The analysis shows that bus-stop quality should be assessed through six connected dimensions: climate adaptation, user comfort, universal accessibility, urban integration, passenger information, and durability/maintenance.

The main design recommendations are to provide effective solar shading; use ventilated roof and selectively permeable side-screen solutions; orient shelters in response to local sun and wind conditions; ensure comfortable and inclusive seating; maintain a continuous step-free route to the boarding area; provide legible static information alongside optional digital displays; and select durable, repairable materials. These measures should be coordinated with sidewalks, crossings and bus operations.

The proposed framework offers a basis for developing context-sensitive design standards and pilot projects in Urgench and other secondary cities. Its next research stage should quantify existing conditions, involve passengers in the evaluation process and test the performance of a prototype under local climatic conditions. In this way, bus stops can be transformed from minimal roadside structures into accessible, climate-responsive and integrated elements of the urban public-transport environment.



Figure 3. Illustrative visualization of a climate-responsive and accessible urban bus stop (AI-generated conceptual image; not a photograph of an existing facility).

ACKNOWLEDGEMENTS

The author acknowledges the academic and institutional environment of Urgench State University. No external funding is declared for this conceptual study.

CONFLICT OF INTEREST

The author declares no conflict of interest.

DATA AVAILABILITY

No new quantitative dataset was generated for this framework-development article. The qualitative case context is based on preliminary reconnaissance information. Supporting field records should be collected and documented in the subsequent empirical phase.

REFERENCES

[1] Waka Kotahi NZ Transport Agency. (2026). Bus stops guideline. Public Transport Design Guidance. https://nzta.govt.nz/partners/design-guidance/public-transport-design-guidance/bus-stops (accessed 2 November 2026).

[2] Pittsburgh Regional Transit. (n.d.). Bus Stop & Street Design Guidelines. https://engage.rideprt.org/busstops/designguidelines (accessed 2 November 2026).

[3] National Association of City Transportation Officials (NACTO). (n.d.). Station & Stop Principles. Transit Street Design Guide. https://nacto.org/publication/transit-street-design-guide/stations-stops/station-stop-principles/ (accessed 2 November 2026).

[4] World Bank. (2022). Climate Risk Country Profile: Uzbekistan. World Bank Group. Climate Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/uzbekistan (accessed 2 November 2026).

[5] United Nations. (2006). Convention on the Rights of Persons with Disabilities, Article 9: Accessibility. https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/article-9-%20accessibility.html (accessed 2 November 2026).

[6] World Bank. (2026). Public Transport Improvement Roadmap for the Tashkent Region. World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099010526101012841 (accessed 2 November 2026).

[7] Institute for Transportation and Development Policy (ITDP). (n.d.). Principles of Station Design. BRT Planning Guide. https://brtguide.itdp.org/branch/master/guide/brt-stations/principles-of-station-design (accessed 2 November 2026).

[8] American Public Transportation Association (APTA). (2025). Design of On-street Transit Stops and Access from Surrounding Areas. APTA SUDS-UD-RP-005-12, Rev. 1. https://www.apta.com/standard/apta-suds-ud-rp-005-12/ (accessed 2 November 2026).