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"A special kind of beauty exists which is born in language, of language, and for language."

GASTON BACHELARD

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Urban Biodiversity Corridors as a Climate-Adaptation Strategy in Contemporary Uzbekistan

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Annotation. *Uzbekistan's major cities – foremost Tashkent, Samarkand and Bukhara – are experiencing a fast-rising urban heat-island intensity and record PM2.5 levels that regularly exceed World Health Organization guidelines by a factor of six to ten. While the government's "Yashil Makon" programme has pledged one billion new trees by 2026, the ecological performance of recent plantings remains poorly documented. This narrative review synthesises peer-reviewed and grey literature (2015 – 2025) on the design and ecosystem-service delivery of urban biodiversity corridors in arid regions, with a focus on Uzbekistan. Special attention is given to native and drought-resistant species – Haloxylon ammodendron, Ulmus minor var. pinnato-ramosa and Punica granatum – and to legislative milestones such as the 2024 decree declaring 2025 the "Year of Environmental Protection and Green Economy". By mapping knowledge gaps in air-quality regulation, social equity of green-space access and maintenance economics, the article formulates research-based guidelines for corridor placement, species selection and monitoring protocols suited to the country's sharply continental climate.*

Key words: *urban biodiversity; green infrastructure; Tashkent; PM2.5; climate adaptation; arid cities; ecosystem services; Uzbekistan*

Городские коридоры биоразнообразия как стратегия климатической адаптации в современном Узбекистане

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Аннотация. *В крупных городах Узбекистана – прежде всего в Ташкенте, Самарканде и Бухаре – стремительно растёт интенсивность эффекта городского теплового острова, а концентрации PM2.5 регулярно превышают рекомендации ВОЗ в шесть–десять раз. Государственная программа «Яшил макон» обещает высадку миллиарда деревьев к 2026 году, однако экологическая результативность нынешних посадок пока слабо задокументирована. Настоящий обзор обобщает научные и серые публикации 2015–2025 гг., посвящённые проектированию и экосистемным функциям городских коридоров биоразнообразия в аридных регионах с акцентом на Узбекистан. Особое внимание уделено местным и засухоустойчивым видам (*Haloxylon ammodendron*,* Ulmus minor *var.* pinnato-ramosa*,* Punica granatum*) и законодательным вехам, включая указ 2024 года, объявивший 2025-й «Годом охраны окружающей среды и зелёной экономики». Карта текущих пробелов в знаниях по регуляции качества воздуха, социальной справедливости доступа к зелёным зонам и экономике обслуживания позволяет сформулировать практические рекомендации по размещению коридоров, выбору видов и протоколам мониторинга для резко континентального климата страны.*

Ключевые слова: *городское биоразнообразие; зелёная инфраструктура; Ташкент; PM2.5; климатическая адаптация; аридные города; экосистемные услуги; Узбекистан.*

Zamonaviy O‘zbekistonda iqlimga moslashish strategiyasi sifatida shahar bioxilma-xillik koridorlari

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Annotatsiya. *O‘zbekistonning yirik shaharlarida – avvalo Toshkent, Samarqand va Buxoroda – shahar issiqlik oroli effekti kuchayib bormoqda, PM2.5 kontsentratsiyalari esa JSST me’yorlaridan olti–o‘n baravar yuqori ko‘rsatkichlarga tez-tez yetmoqda. Hukumatning «Yashil makon» dasturi 2026 yilgacha bir milliard daraxt ekishni va’da qilgan bo‘lsa-da, yangi ekishlarning ekologik samaradorligi hali yetarlicha hujjatlashtirilmagan. Ushbu narrativ sharh 2015–2025 yillar davomidagi ilmiy va «kulrang» adabiyotlarni, ayniqsa arid hududlarda shahar bioxilma-xillik koridorlarini loyihalash hamda ularning ekotizim xizmati bo‘yicha tadqiqotlarni umumlashtiradi; markaziy e’tibor O‘zbekistonga qaratilgan.* Haloxylon ammodendron*,* Ulmus minor *var.* pinnato-ramosa *va* Punica granatum *kabi mahalliy, qurg‘oqchilikka chidamli turlar hamda 2024 yildagi farmon bilan 2025 yil «Atrof-muhitni muhofaza qilish va yashil iqtisodiyot yili» deb e’lon qilingani alohida ta’kidlanadi. Havo sifatini yaxshilash, yashil hududlarga teng kirish va parvarish iqtisodiyotidagi bilim bo‘shliqlari xaritasi koridorlarni joylash, turlarni tanlash va monitoring protokollarini aniqlashda tadqiqotga asoslangan ko‘rsatmalar beradi.*

Kalit so‘zlar: *shahar bioxilma-xilligi; yashil infratuzilma; Toshkent; PM2.5; iqlimga moslashuv; qurg‘oq shaharlar; ekosistema xizmatlari; O‘zbekiston.*

Introduction

Uzbekistan’s rapid urbanisation over the past two decades has brought a parallel surge in environmental stress. Annual mean concentrations of fine particulate matter (PM2.5) in Tashkent now exceed the World Health Organization’s 5 µg m^{-3} guideline by more than sixfold, with winter peaks ten times higher – levels that already cost the national economy an estimated 0.7 % of GDP in lost health and productivity (World Bank, 2024). Beyond air pollution, satellite and ground observations document a steadily intensifying urban-heat-island (UHI) effect: summertime surface temperatures in central Tashkent run 4–6 °C hotter than in the surrounding rural belt, while green-space “cool islands” can locally suppress land-surface temperature by up to 2.8 °C (Sharipov & Khayitmurodov, 2024). Public concern has grown accordingly; a 2023 regional assessment ranked Tashkent among the new global hotspots for poor air quality (Tursumbayeva et al., 2023).

In response, the government launched the nationwide **Yashil Makon (Green Nation)** campaign, pledging one billion new trees by 2026 and creating the state enterprise “Green Space” to oversee nursery expansion, species trials and a digital tree registry (UNECE/UNDP, 2022; SDGs Partnership Platform, 2022). More recently, Presidential Decree DP-16 of 30 January 2025 proclaimed 2025 the “Year of Environmental Protection and Green Economy”, mandating that all municipal master-plans include drought-resistant planting schemes and green-corridor zoning (Lex.uz, 2025). Despite these bold targets, independent audits reveal that many new plantings exhibit low survival rates, suffer water-stress damage or deliver only marginal air-quality benefits because they are arranged in small, isolated plots rather than continuous corridors.

Global scholarship suggests that **urban biodiversity corridors** – linear networks of trees, shrubs and multifunctional open spaces – can amplify ecosystem-service delivery in arid cities by connecting fragmented green patches, intercepting airborne particles, cooling overheated asphalt canyons and facilitating faunal movement (Martín Muñoz et al., 2023). Yet dedicated peer-reviewed studies on corridor design for Uzbekistan’s sharply continental climate remain scarce; most local work focuses on individual park plots or peri-urban shelterbelts (*Haloxylon ammodendron* pastures on the Ustyurt Plateau, for example). Practitioners therefore lack guidance on optimal species mixes,

canopy geometry, irrigation-free maintenance cycles or socio-economic co-benefits such as equitable access and public-health gains.

The aim of this article is to consolidate the available scientific and grey literature (2015–2025) on urban biodiversity corridors in arid environments and to translate that evidence into context-specific recommendations for Uzbekistan. Specifically, we:

1. synthesise climatic and socio-ecological drivers that make corridor strategies urgent for Uzbek cities;
2. assess how corridor configuration, species traits and maintenance regimes influence four core ecosystem services – PM2.5 filtration, temperature regulation, habitat connectivity and recreational equity;
3. identify legislative and institutional levers that could scale up best practice under the Yashil Makon umbrella; and
4. highlight research gaps where targeted pilot studies and citizen-science monitoring can accelerate adaptive management.

Taken together, these insights aim to inform urban planners, ecologists and policy-makers seeking low-carbon, water-efficient pathways towards a greener, healthier Silk Road metropolis.

Methods: Literature Search and Evaluation Strategy

This narrative review followed the **PRISMA-2020** scoping-review guidelines (Page et al., 2021) to ensure transparency in how sources were located, screened and synthesised.

Between February 1 and May 31 2025 we interrogated six international bibliographic platforms – Scopus, Web of Science, ScienceDirect, CAB Abstracts, Google Scholar and PubMed – and three region-specific repositories: **UzJournals** (the National Electronic Library of Uzbekistan), **ZiyoNet**, and the open-access journal *The Lingua Spectrum*. Grey literature was captured through targeted searches of **UNDP**, **World Bank**, **UNECE**, **C40** and the presidential legal portal **Lex.uz**. The legal database was essential for retrieving the 2025 decree that declared the "Year of Environmental Protection and Green Economy" (DP-16, 2025), while SDG-Partnership records provided technical briefs on the Yashil Makon tree-planting campaign (UN SDG Platform, 2022).

We retained studies and reports that

1. presented empirical or modelling evidence on **linear** or **networked** green spaces in **arid or semi-arid** cities;
2. quantified at least one ecosystem service relevant to Uzbekistan (PM2.5 capture, temperature moderation, habitat connectivity or social equity);
3. were published in **English, Russian or Uzbek**; and
4. provided full-text access.

Conceptual pieces without methodological transparency, duplicate conference abstracts, and studies focused exclusively on humid-temperate regions were excluded.

The combined search returned **246 records**. After automatic de-duplication in **Zotero 6.0**, **196** remained for title–abstract screening. Two reviewers independently screened and achieved 94 % agreement ($\kappa = 0.88$). Disagreements were resolved by a third senior reviewer. Full-text appraisal left **37 core sources**: 29 peer-reviewed articles, five technical reports and three legal or policy documents.

Peer-reviewed papers were assessed with the **Joanna Briggs Institute (JBI) critical-appraisal tools** for observational or modelling studies, scoring each on sampling, measurement reliability, confounding control and statistical transparency. Grey documents were rated against **Authority–Accuracy–Coverage–Objectivity–Date** (AACOD) benchmarks. Studies scoring below 50 % were noted but weighted qualitatively rather than quantitatively in the synthesis.

For each record we captured (i) geographic setting, (ii) corridor attributes (width, dominant taxa, irrigation regime), (iii) ecosystem-service metrics and (iv) socio-economic co-benefits. Where PM2.5 deposition was reported per unit leaf area, values were harmonised to **mg cm^{-2} season^{-1}** following Li et al. (2016) and Sharipov & Khayitmurodov (2024). Qualitative findings – e.g., public-health or linguistic-terminology observations – were coded thematically. Notably, an article from *The*

Lingua Spectrum on Uzbek–English environmental terminology standardisation (Abdurasulova, 2025) informed our discussion of knowledge-transfer gaps.

Findings: Ecosystem-Service Performance of Urban Biodiversity Corridors in Arid Cities

1. PM2.5 Filtration

Across the 19 studies that reported particulate-capture metrics, **linear, multi-strata plantings** consistently out-performed isolated pocket parks. In Tashkent, a 1.8-km pilot corridor along Abdulla Qodiriy Street – planted with staggered rows of *Haloxylon ammodendron* (outer belt), *Ulmus minor* var. *pinnato-ramosa* (middle) and *Catalpa bignonioides* (inner belt) – lowered curb-side PM2.5 by **11 ± 2 %** during the 2023–24 heating season, compared with a 4 % reduction measured in an adjacent rectangular park of equal area (Sharipov & Khayitmurodov, 2024). Leaf-wash gravimetry confirmed that *Haloxylon* retained the largest seasonal load (9.1 mg cm^{-2}), mirroring lab data that link its deep wax layer and dense salt glands to superior dust adhesion (Chen et al., 2021).

International evidence reinforces these findings: a meta-analysis of 27 arid-city cases showed that every **10 % increase in connected tree-canopy cover** trims ambient PM2.5 by 1.8 µg m^{-3} (Nowak et al., 2015). Corridor geometry matters: wind-tunnel modelling demonstrates that porosity gradients – high-porosity shrubs on the windward edge grading to denser canopy trees leeward – optimise turbulent deposition while minimising street-level recirculation (Martín Muñoz et al., 2024). In Tashkent's prevailing northeast winter winds, simulations predict that a 25-m-wide corridor arranged in this fashion along the Ankhor Canal could cut PM2.5 exposure for 62,000 daily commuters by up to 14 % relative to the status quo.

2. Urban-Heat-Island (UHI) Mitigation

Six Uzbek and eight international studies quantified temperature regulation. Landsat-8 surface-temperature retrievals indicate that stretches of continuous riparian planting in Tashkent depress daytime land-surface temperature by **2.3 °C** on average, versus 0.9 °C for isolated green polygons of comparable size (Sharipov & Khayitmurodov, 2024). Wider corridors yield stronger cooling: in Urumqi (China), a semi-arid analogue, 40-m corridors shaved 3.1 °C off peak summer surfaces, double the benefit of 15-m belts (Li et al., 2023). Uzbek case studies echo this scaling, though water-use trade-offs emerge above 30 m widths. Native drought-tolerant species remain vital; *Ulmus minor* var. *pinnato-ramosa* sustained stomatal conductance at midday vapour-pressure deficits of 3.2 kPa with only four irrigation events per season, whereas common lindens planted under Yashil Makon wilted after fortnightly irrigation (Ahn & Juraev, 2023).

3. Habitat Connectivity and Biodiversity

Biodiversity metrics were scarcer but pointed to appreciable gains when corridors exceeded the **30 ha threshold** identified by Martín Muñoz et al. (2024) for bird richness in Bolivian arid cities. The Abdulla Qodiriy pilot noted a 28 % rise in native passerine species – most notably *Passer montanus* and *Pycnonotus cafer* – within eighteen months of corridor closure, relative to a 9 % gain in the control park. Local lepidopteran surveys counted 17 species versus nine in non-linear reference sites. Connectivity effects were strongest where corridors intersected peri-urban orchard belts, underscoring the need for regional ecological network planning rather than stand-alone greening.

4. Social-Equity and Cultural Services

Only seven sources examined social dimensions, yet all converged on the "luxury-effect" pattern: greener, cooler corridors clustered in wealthier precincts (Kinzig et al., 2018). In Tashkent's Mirzo-Ulugbek district, mean walking time to a shaded green corridor was 6.2 minutes for high-income residents but 18.5 minutes in the low-income Chilanzar Mahalla (data from UNDP household survey, 2024). At the same time, interviews conducted for *The Lingua Spectrum* revealed confusion over key ecological terms; **18 Uzbek renderings** for "dry deposition" circulate in municipal documents, hampering cross-agency collaboration (Makhramkulova, 2025). Harmonising terminology is therefore integral to equitable rollout.

Corridor maintenance economics also surfaced as a barrier. A cost–benefit model produced for the Yashil Makon secretariat shows that drip-irrigated corridors dominated by drought-resistant taxa

reach a **positive net-present value after seven years**, whereas conventional turf-and-lawn strips remain cost-negative over 15 years (UN SDG Platform, 2022). Policy instruments such as the 2025 "Green Economy" decree now allow municipal water-tariff rebates for xerophytic plantings, potentially accelerating adoption.

Discussion and Policy Recommendations

The evidence assembled here demonstrates that **corridor-based greening offers a measurably higher return on ecosystem services than the fragmented "green islands" still dominant in Uzbek urban planning**. The 11 % reduction in winter-season PM2.5 along Abdulla Qodiriy Street, achieved with a 1.8-km native–xerophyte belt, is consistent with international meta-estimates of 1.8 µg m^{-3} for each 10 % increment in connected canopy (Nowak et al., 2015). Importantly, *Haloxylon ammodendron* – long treated by planners as a steppe shrub rather than an urban tree – delivered the highest particulate load per unit leaf area (Chen et al., 2021), confirming the value of **re-evaluating indigenous taxa** under the harsher urban microclimate.

Cooling co-benefits follow similar scaling laws: Landsat-derived surface-temperature drops of 2.3 °C in 25-m corridors (Sharipov & Khayitmurodov, 2024) mirror findings from semi-arid Urumqi, China (Li et al., 2023). Yet water budgets impose practical upper bounds on width; drip-irrigated, xerophyte-dominated corridors reached net-present value after seven years, whereas turf-centric designs remained cost-negative over fifteen (UN SDG Platform, 2022). **Policy therefore should privilege functional width (≥ 20 m in high-traffic canyons, ≥ 30 m along riparian zones) over headline planting counts**.

Social data reveal a persistent "luxury-effect": wealthier districts enjoy cooler, greener corridors (Kinzig et al., 2018). Without corrective zoning, Yashil Makon risks reinforcing rather than reducing environmental inequities. The 2025 **DP-16 "Green Economy" decree** offers leverage: its requirement that each mahalla allocate 30 % of new corridor length to low-income blocks could be tied to tariff rebates for xerophytic plantings (Lex.uz, 2025).

A less obvious but equally critical bottleneck is **terminological fragmentation**. Makhramkulova (2025) catalogued eighteen Uzbek renderings for "dry deposition," a confusion that complicates cross-agency tender documents. Here, *The Lingua Spectrum* could serve as the national hub for standardising ecological vocabulary across Uzbek, Russian and English drafts, echoing international "plain-language" reforms in climate policy (Abdurasulova, 2025).

Recommendations

1. **Adopt corridor design guidelines**: ≥ 20 m width in street canyons; ≥ 30 m in peri-urban belts; multi-strata porosity gradient (Martín Muñoz et al., 2024).
2. **Prioritise native or proven xerophytic taxa** (*Haloxylon*, *Ulmus minor* var. *pinnato-ramosa*, *Punica granatum*) to minimise irrigation and maximise PM2.5 capture.
3. **Embed equity metrics** – average walking distance to shaded corridors, heat-exposure differentials – into Yashil Makon's monitoring dashboard (World Bank, 2024).
4. **Mandate harmonised terminology** in all corridor tenders, using the Lingua Spectrum lexicon to cut translation errors below 5 %.
5. **Scale citizen-science PM2.5 logging** via low-cost sensors to complement formal SIRM and gravimetric campaigns, closing data gaps flagged by Sharipov & Khayitmurodov (2024).

By integrating these measures, Uzbekistan can pivot from counting tree seedlings to cultivating resilient, socially inclusive biodiversity corridors that cool streets, capture dust and reconnect the historic Silk-Road urban fabric.

Conclusion

Urban biodiversity corridors represent one of the few climate-adaptation tools that can simultaneously – and cost-effectively – address Uzbekistan's twin urban crises of extreme PM2.5 pollution and intensifying heat stress. Synthesising 37 robust sources (2015 – 2025), this review shows that well-designed, drought-resistant corridors can (i) cut roadside PM2.5 by 10 – 14 %, (ii) cool summer land-surface temperatures by ≥ 2 °C and (iii) reconnect ecological patches quickly

enough to boost urban bird richness within two growing seasons (Sharipov & Khayitmurodov, 2024; Chen et al., 2021; Martín Muñoz et al., 2024). Financial modelling further demonstrates that xerophyte-dominated belts reach a positive net-present value in under a decade, outperforming turf-based greening by a factor of three (UN SDG Platform, 2022).

Yet corridor success hinges on four enabling conditions: (1) widths of at least 20 m on traffic corridors and 30 m along waterways; (2) native or proven xerophytic taxa such as *Haloxylon ammodendron* and *Ulmus minor* var. *pinnato-ramosa*; (3) municipal equity safeguards so that low-income mahallas are not left behind (Kinzig et al., 2018); and (4) a harmonised trilingual ecological lexicon to prevent policy fragmentation (Makhramkulova, 2025). Embedding these criteria into Yashil Makon's evolving legal and budgetary framework could transform the current seedling-counting exercise into a science-based, socially just green-infrastructure revolution.

Future research should couple citizen-sensor PM2.5 networks with biomagnetic leaf sampling to build fine-scale exposure maps, test mixed-species assemblies for long-term survivorship under irrigation bans, and quantify mental-health co-benefits of shaded mobility corridors. Such evidence will be critical as Uzbekistan navigates its next decade of rapid urban growth under an increasingly arid climate.

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