REIMAGINING CENTRAL ASIAN CITIES FOR A RESILIENT AND LOW-CARBON FUTURE

Kazakhstan
Kyrgyz Republic
Tajikistan
Turkmenistan
Uzbekistan

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Foreword

Building Resilient and Low-Carbon Cities in Central Asia: A Pathway to a Sustainable Future and a Livable Planet

In a time when the clarion call for sustainability resonates across the globe, the focus on building resilient low-carbon cities has never been more pressing. Central Asia, with its unique challenges and opportunities, has embarked on a transformative journey toward a sustainable future. The Reimagining Central Asia Cities for A Resilient and Low-Carbon Future (CARL-Cities) study presents an integrated approach that sheds light on the path to achieving this vision.

Cities are pivotal in the global climate response, with the potential to contribute up to 40 percent of the emission reductions required to limit global warming to 1.5 degrees Celsius. Recognizing this immense potential, the CARL-Cities study delves deep into the urbanization landscape of the Central Asia region, analyzing the patterns, trends, and challenges faced by its medium to large cities. The aspiration to cultivate cities that are both resilient and low-carbon is not merely an ambition; it is a necessary evolution. In the face of climate change and its myriad challenges, the strategies outlined here offer a beacon of hope and a guide for action. They reflect a deep understanding of the unique challenges faced by Central Asian cities, as well as the universal principles that underpin sustainable urban development.

The findings of the CARL-Cities study highlight the urgent need for decisive policy actions and concrete implementation mechanisms at the subnational level. This study emphasizes the importance of engaging local stakeholders and fostering people-centered urban planning and design. By promoting compact growth, appropriate densification, and people-oriented urban forms, cities can free up resources that would otherwise be associated with unnecessary expansion, and create livable environments that enhance the quality of life for their residents. It also underscores the significance of investing in green infrastructure and nature-based solutions to mitigate the impacts of natural hazards as well as the need to improve urban mobility and public transport, and decarbonize energy systems to significantly reduce emissions.

This document is a call to action for policy makers, urban planners, industry leaders, and citizens alike. It is an invitation to embark on a collective journey toward a future where cities are not only the heartbeats of economic vitality but also bastions of ecological harmony and resilience.

As we embark on this transformative journey, let us embrace the opportunities that lie ahead. By adopting ambitious yet achievable goals, we can build cities that not only mitigate climate change but also enhance the well-being and quality of life for all residents. Together, we can create a future in which Central Asia's cities lead the way in sustainable development, setting an example for the world to follow.

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Abbreviations

AHURP
Affordable Housing and Resilient Urban Renewal Project

AQI
Air Quality Index

BAU
Business as Usual

BRT
Bus Rapid Transit

CA
Central Asia

CARL-Cities
Central Asia Regional Study on Resilient and Low-carbon Cities

CCS
Carbon Capture and Storage

CH_4
Methane

CHP
Combined heat and power

CHPP
Combined heat and power plant

CNG
Compressed natural gas

CO_2
Carbon dioxide

CO_2e
carbon dioxide equivalent

CRP
City Resilience Program

CSF
Climate Support Facility

DeHSt
German Emissions Trading Authority

ECA
Europe and Central Asia region

EDGAR
Emissions Database for Global Atmospheric Research

ESA
European Space Agency

ETS
Emission Trading System

EV
Electric vehicles

FUA
Functional urban area

Gcal
giga calorie

GCAP
Green City Action Plan

GDP
Gross domestic product

GEDS
Green Economy Development Strategy

GFDRR
Global Facility for Disaster Reduction and Recovery

GFW
Global Forest Watch

GHG
Greenhouse gas emissions

GHS-FUA
Global Human Settlements Functional Urban Areas

GHSL
Global Human Settlement Layer

GIS
Geographic information system

GWh
Gigawatt hours

ha
Hectare

NDC
Nationally Determined Contributions

INDC
Intended Nationally Determined Contributions

inh
Inhabitant

IPCC
Intergovernmental Panel on Climate Change

ISPU
Air Pollution Standard Index (Indeks Standar Pencemar Udara)

JRC
Joint Research Centre

KAZ
Kazakhstan

KGZ
Kyrgyz Republic

$kgCO_2eq$
Kilogram of carbon dioxide equivalent

km
Kilometer

km^2
Square kilometer

KML
Keyhole Markup Language

KMZ
Keyhole Markup Language Zipped

kWp
Kilowatt-peak

kWh
Kilowatt hour

LCR
Land consumption rate

LEZ
Low emission zone

LNG
Liquefied natural gas

LPG
Liquefied petroleum gas

LST
Land surface temperature

LULUCF
Land use, land-use change, and forestry

m
Meter

MDTF
Multi-donor trust fund

$MtCO_2e$
Megatonnes of carbon dioxide equivalent

MW
Megawatt

MWp
Megawatt-peak

N_2O
Nitrous oxide

NBS
Nature-based solution

NDVI
Normalized Difference Vegetation Index

NDS-2040
National Development Strategy 2018-2040

NGO
Non-governmental organization

NOAA
National Oceanic and Atmospheric Administration

NTL
Nighttime lights

OECD
Organization for Economic Co-operation and Development

OSM
Open Street Maps

PGA
Peak ground acceleration

PGR
Population growth rate

PM_{10}
particulate matter 10 microns

$PM_{2.5}$
particulate matter 2.5 microns

POI
Point of interest

PV
Photo voltaic

SEP
Stakeholder engagement plan

SFRARR
Strengthening financial resilience and accelerating risk reduction in

SME
Small and medium sized enterprises

SSP
Shared Socioeconomic Pathways

SURGE
Sustainable Urban and Regional Development

SWOT
Strengths, weaknesses, opportunities, and threats

TJK
Tajikistan

TKM
Turkmenistan

TOD
Transport-oriented development

tpa
tons per annum

TWh
Terawatt hours

UGA
Urban green area

UHI
Urban heat island

US-EPA
Environmental Protection Agency of the United States of America

USSR
Union of Soviet Socialist Republic

UZB
Uzbekistan

VIIRS
Visible Infrared Imaging Radiometer Suite

WSUD
Water Sensitive Urban Design

WTE
waste-to-energy

μm
microns

Source: CAPSUS, 2023, Shakhrisabz [Photograph]

Context

Executive summary

Climate mitigation is a crucial issue in Central Asia (CA), where Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan rely heavily on carbon-based energy.

For example, Kazakhstan's energy sector accounts for 78 percent of its emissions (OECD 2019). Central Asian cities are among the world's most polluted, especially in winter, due to coal and low-quality fuel use for heating. These countries have some of the highest greenhouse gas (GHG) emissions per unit of GDP globally, driven by energy-subsidized heavy industry, inefficient public buildings, and challenging geography with sparse populations and cold climates.

Climate adaptation holds critical importance for CA, a region highly vulnerable to natural disasters. Over the past two decades, 90 floods and 56 earthquakes have affected 2.5 million people and caused over $1.5 billion in damages (Scaini 2022). Annually, these natural disasters cost CA countries between $3.5 billion and $4.2 billion (World Bank 2023). Global warming is expected to worsen these issues, leading to more extreme heat, water scarcity, longer droughts, increased storm variability and intensity, glacial melt, deforestation, and soil erosion, underscoring the need for integrated adaptation and resilience solutions.

CA countries have taken steps toward resilient and inclusive growth, but local actions are needed. The Kyrgyz Republic, Tajikistan, and Uzbekistan have included resilience and climate vulnerabilities in their nationally determined contributions (NDCs). Kazakhstan aims for carbon neutrality in electricity and heat production by 2060, and is the first country in CA to establish an emissions trading scheme. Since 2019, Uzbekistan has focused on climate adaptation and renewable energy investment through key policy reforms. However, many strategies are ambitious but lack concrete implementation mechanisms, especially at the subnational level, where action is most needed.

Cities are pivotal in climate response, capable of achieving up to 40 percent of the emission reductions needed to limit global warming to 1.5 degrees Celsius (C40 and ARUP 2016). Urban areas must lead climate change mitigation by reducing emissions and carbon footprints. Simultaneously, cities can bolster adaptation and resilience by hazard-resistant infrastructure, improving institutional risk preparedness, developing long-term risk reduction strategies, and diversifying access to climate adaptation funding. Additionally, urban climate initiatives offer significant local cobenefits, further incentivizing action.

1 See Global Flood Database.
2 Earthquakes with a Richter magnitude size above 6.3 based on the SFRARR Earthquake Catalogue.

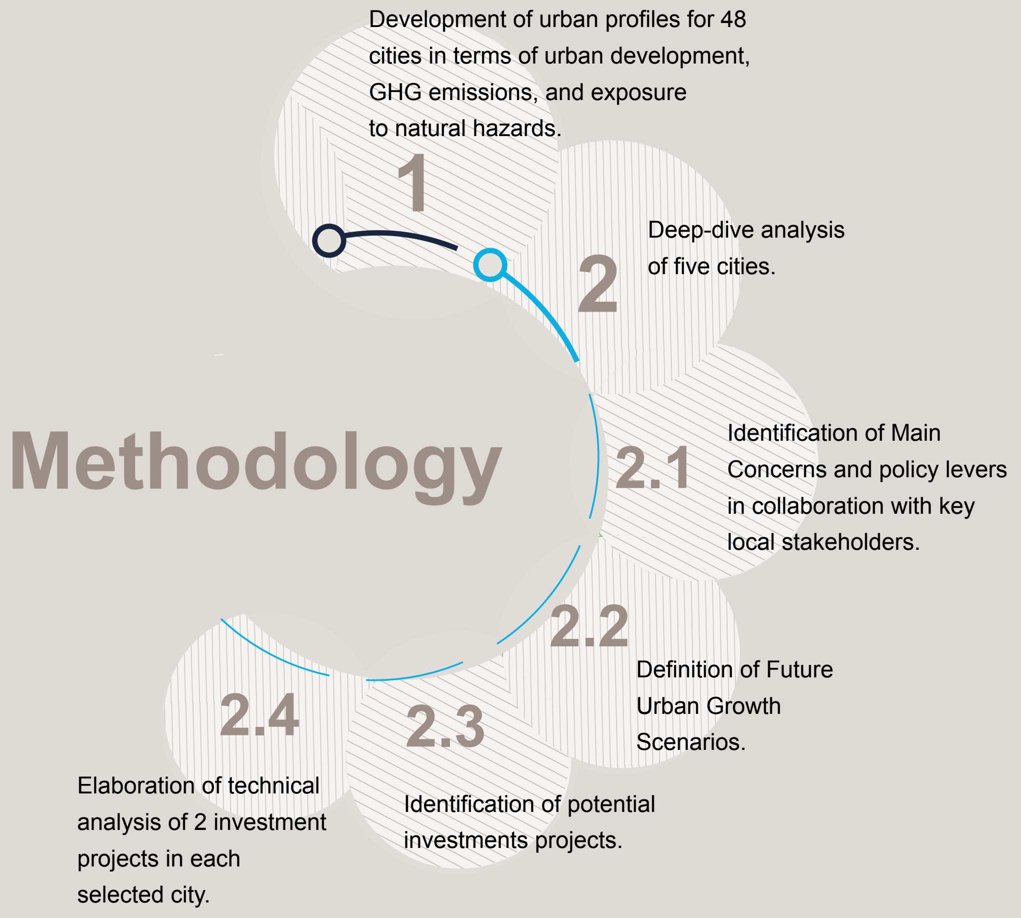
Impetus of the Study, and Diagnostic Framework

This study is a novel attempt to analyze the patterns and trends of urbanization in medium to large cities in Central Asia. It encompasses a broad range of parameters, and employs an evidence-based approach to outlining strategic directions and actions for fostering green and resilient urban development.

The Central Asia Regional Study on Resilient and Low-carbon Cities (CARL-Cities/Study) is an innovative attempt to systematically understand urbanization and its potential in CA. It analyzes urban growth trends in medium to large cities using comprehensive parameters and an evidence-based approach to promote green and resilient urban environments. The study enhances knowledge of local challenges and identifies actionable steps for cities across the five countries to develop low-carbon, climate-resilient cities and regions.

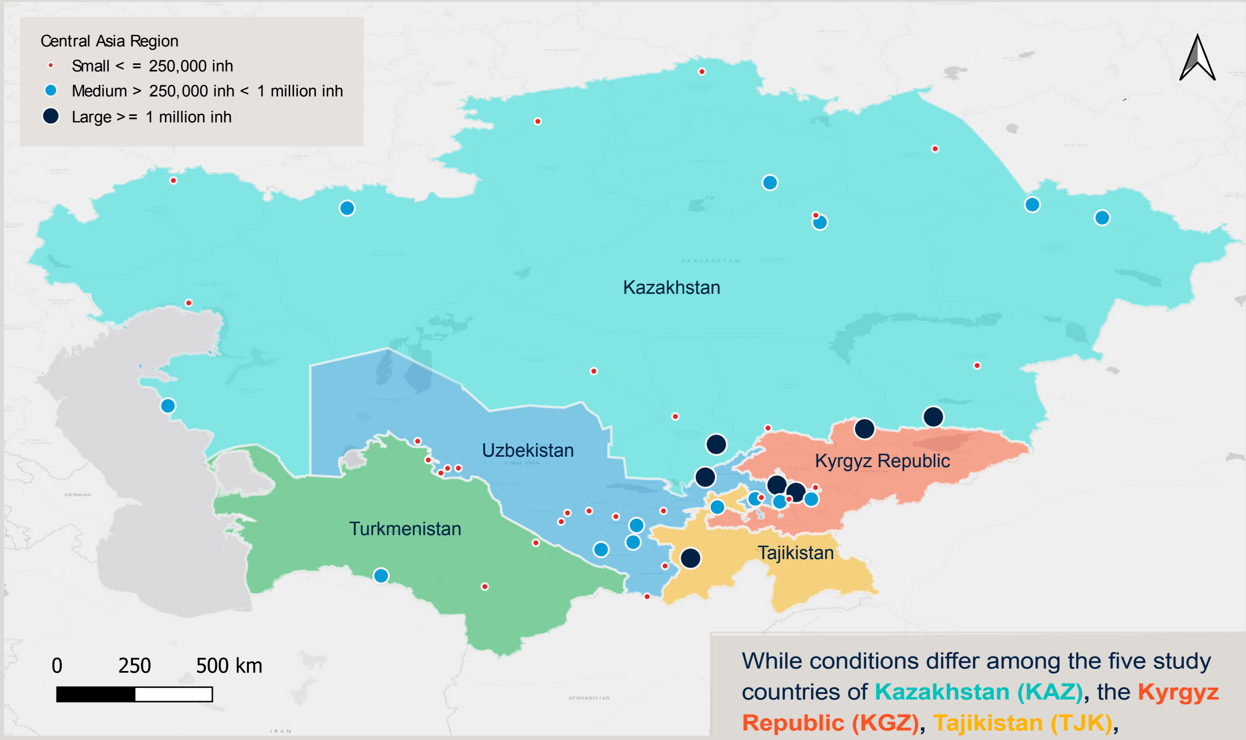
The study began by creating urban and spatial profiles for 48 cities, followed by a detailed analysis of five cities to project future scenarios and inform policy decisions (figure ES.1 and map ES.1). It developed practical technical proposals for potential investment projects aligned with identified policy levers, providing cities with a strategic advantage in achieving environmental goals. The process included extensive stakeholder consultations, workshops, and exchanges at national and subnational levels in all five countries.

Figure ES.1 Diagram Summarizing the Methodology Used



Source: CARL-Cities 2024.

Map ES.1 CARL-Cities Study Areas



The CARL-Cities Study Areas

The selection of the study areas for the Macro Assessment **includes all the 48 urban areas with population above 150,000 inhabitants** and is based on the Global Human Settlements Functional Urban Areas (GHS-FUA) dataset, which delineates the commuting area of the local workforce in a given urban area. Leveraging the FUA dataset allows the assessment to have a common criterion across the region for every city in every country. **A Micro Analysis was also conducted for the cities of Almaty, Bishkek, Dushanbe, Namangan and Shakhrisabz.**

While conditions differ among the five study countries of **Kazakhstan (KAZ)**, the **Kyrgyz Republic (KGZ)**, **Tajikistan (TJK)**, **Turkmenistan (TKM)**, and **Uzbekistan (UZB)**, several common patterns prevail across the region, these include:

- **Rapid urbanization**
- **Urban expansion**
- **Uneven densification**
- **Limited access to urban services**
- **Uneven economic development**
- **High greenhouse gas emissions**
- **Climate hazards**

Source: CARL-Cities 2024.

The study conducted a comprehensive urban and spatial analysis for 48 urban areas in Central Asia, identifying key urbanization and climate-related characteristics. It assessed urban development across five main dimensions: *urban form, urban services and amenities, urban environment, economic activity, and urban mobility.* These urban areas, each with over 150,000 residents, comprise about 32.1 percent of the region's population[3]. The study leveraged international databases to create a standardized measurement framework, allowing easy comparisons across cities in the five Central Asian countries.

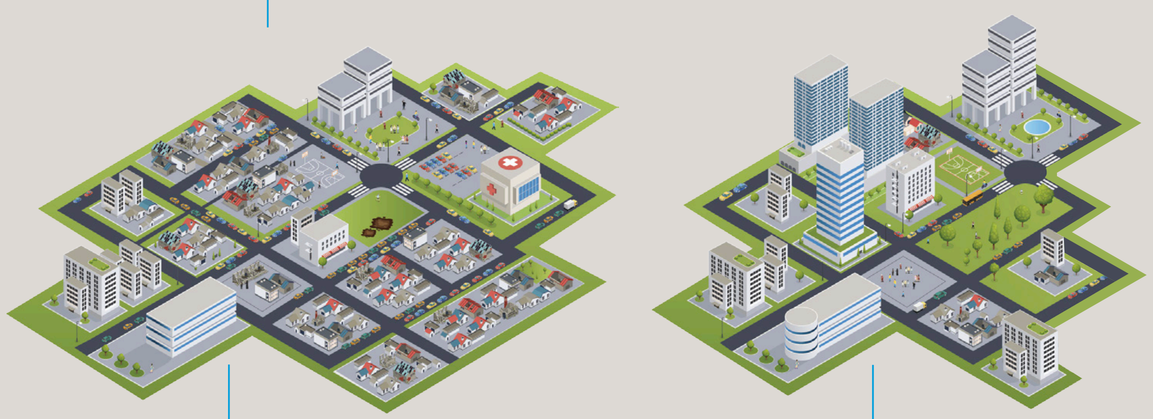
To explore pathways to a resilient and low-carbon future, the study modeled scenarios for 2050 in five cities: Almaty, Bishkek, Dushanbe, Namangan, and Shakhrisabz (figure ES.2). This in-depth analysis used quantitative, qualitative, and spatial data to inform policy and decision-making. It compared two urban growth scenarios for 2050: No-Intervention and Vision, which depict potential future outcomes for the cities based on the proposed policy levers, including policy measures and investments.

The analysis contrasted the two scenarios on potential outcomes like GHG emissions, vulnerability to natural hazards, service accessibility, and sustainable urban development, emphasizing the impact of local decisions aligned with green growth. This modeling aims to guide future policy and investment decisions. Consultations with key country and city stakeholders led to the selection of two climate mitigation and adaptation projects for each of the five cities, with preliminary technical analysis conducted for these ten potential investments.

Figure ES.2 Modeling of Urban Growth Scenarios

SCENARIO modeling

Within each city, the deep dive assessment encompasses the development and analysis of two urban growth scenarios: 'No-intervention' and 'Vision' scenarios.



No intervention

The **'No-intervention'** assumes that no significant change will be made on urban policy and considers investments in basic infrastructure for expanding the urban footprint.

Vision scenario

The '**Vision scenario**' assumes that all expected population growth will be accommodated within the current urban footprint due to densification strategies. This scenario also incorporates key urban policy measures and capital investments.

Source: CARL-Cities 2024.

3 Based on Population, total | Data for 2020.

This report summarizes the study's key findings and recommendations. The following background analysis and technical resources produced through the study complement the report:

1. **Diagnostic report on urban and spatial profile of 48 cities** (complemented by derived spatial data for each city, and associated appendixes on the methodology and data sources).
2. **Country summaries** for each of the five CA countries, based on their urban and spatial profiles.
3. **Individual city reports capturing deep-dive analysis and scenario modeling** for the five selected cities--Almaty, Bishkek, Dushanbe, Namangan, and Shakhrisabz--and associated appendixes on the methodology and data sources.
4. **Technical analysis reports of proposed investments and urban solutions** for each of the ten potential investment projects.

Key Findings: Current Urbanization Situation in Central Asia

Findings from the CARL-Cities study reveal a region that is experiencing a steady rise in urbanization while facing immense climate-related challenges. While conditions differ among the five countries studied, several common patterns prevail across the region. These include rapid urbanization, urban expansion, uneven densification, limited access to urban services, uneven economic development, a high level of greenhouse gas (GHG) emissions, and climate hazards.

Central Asia (CA) is urbanizing, and its cities are expanding rapidly. The 48 urban areas studied grew by an average of 36.3 percent between 1990 and 2020, with large urban areas growing at a faster rate than the rest, both in terms of population and physical extent. These large settlements account for almost half of urban land consumption in the region. In addition, the urban areas in CA have relatively low population density, with 25 percent of the studied areas experiencing a reduction in population density.

CA's urban areas largely display unsustainable spatial expansion patterns. Fifty-eight percent of the areas studied show a "leapfrog" development pattern, while 39 percent are characterized by fragmented development. These types of urban expansion leave underused land and promote a dispersed, disconnected, and distant city structure.

CA's cities are economic drivers, but the economic growth rates vary considerably. Annual growth of economic activity for the 48 cities was 2.42 percent, with 64 percent of them experiencing some growth. The largest cities observed an average growth ranging from 3.9 percent to 4.5 percent per annum.

Most of the urban areas in CA have critically low access to urban services, and amenities such as health and education facilities, public spaces, sports, and cultural venues. The average share of the population in CA with walking accessibility to urban amenities is limited. Only 6.8

4 The urban areas were classified based on its population into small cities (under 250,000 inhabitants), medium cities (between 250,000 and 1,000,000 inhabitants), and large cities (more than 1,000,000 inhabitants).

percent of the citizens are close to health clinics, 16.5 percent close to schools, 8 percent to public spaces, 8 percent to sports facilities, and 3 percent to cultural centers.

Cities in CA face serious climate and environmental challenges. They are exposed to natural disasters, urban heat, and air pollution. The study reveals that 75.6 percent of the population is located within an earthquake-prone area; 17 percent is exposed to the urban heat island (UHI)[5] effect; 2.5 percent is at risk of being impacted by pluvial flooding; 3.5 percent is at risk of being impacted by fluvial flooding; and 1.1 percent of the urban population could be affected by landslides. Most of these natural hazards are exacerbated by climate change.

CA cities contribute significantly to GHG and air pollutants, and they lack sufficient urban green areas. The cities analyzed in this report annually contribute a per capita average of 11.7 tons of CO_2 eq per capita (in GHG emissions) and 3.1 kg of PM10 (air pollution). In addition, the cities studied have insufficient green areas. Most of the 48 CA cities have a very low provision of green areas, with a regional average of 7.6 m^2 per capita, less than half the European average of 18.2 m^2 per capita.

Cities offer major opportunities for achieving national emissions reduction commitments. For instance, the city of Almaty (KAZ) plays a relevant role in achieving the country's carbon reduction commitments. Kazakhstan has pledged to reduce its GHG emissions by 15 percent by the end of 2030 without significant international assistance. Achieving net-zero emissions in Almaty alone could fulfill nearly 60 percent of the country's reduction commitment.

Way Forward to Achieve Resilient and Low-Carbon Cities

The green policies and investments proposed for these urban areas could reduce their GHG emissions by half on average, and with similar or less costs than in a business as usual scenario.

A resilient, low-carbon future in CA cities can be achieved without significant additional financial resources but through decisive policy interventions and strategic investments in sustainable infrastructure. Savings from compact urban growth can significantly offset costs to achieve low-carbon, resilient development. Scenario modeling (figure ES.3) shows similar capital investment costs for both scenarios but vastly different benefits. For the five cities, the vision scenario could reduce GHG emissions by an average of 58 percent by avoiding costs related to urban sprawl and inefficient resource use. Almaty's Vision scenario aims for net-zero emissions, demonstrating the commitment and potential costs of achieving carbon neutrality.

Urban areas should pursue compact growth and strategic densification to reduce costs, enhance quality of life, and achieve low-carbon development. Compact vertical development and strategically placed infrastructure can avoid the high costs of urban expansion while improving access to public services. This requires robust urban planning, people-centered design, effective development control and enforcement, as well as cross-sectoral interventions such as integrating land use with urban transport planning. Energy efficiency in buildings, industries, and transport systems offers significant savings, while cleaner energy solutions can reduce air pollutants and GHG emissions.

Effective urban planning and strategic investment in green infrastructure and nature-based solutions are essential for adapting to climate impacts. Cities can reduce flooding and landslide risks by limiting development in high-risk areas and using appropriate construction methods and technologies. Increasing green spaces and implementing passive building designs can mitigate urban heat island effects, especially in vulnerable areas. Nature-based solutions and green infrastructure are crucial for flood management and ecosystem conservation.
Engaging local stakeholders is vital for successful green urban development. This study's workshops, held with subnational and city officials helped validate and refine our understanding of the primary challenges and the viability of proposed solutions. These interactions highlighted local concerns affecting residents' quality of life, such as private vehicle use, energy production, waste management, public transport, and modernizing essential services and infrastructure.

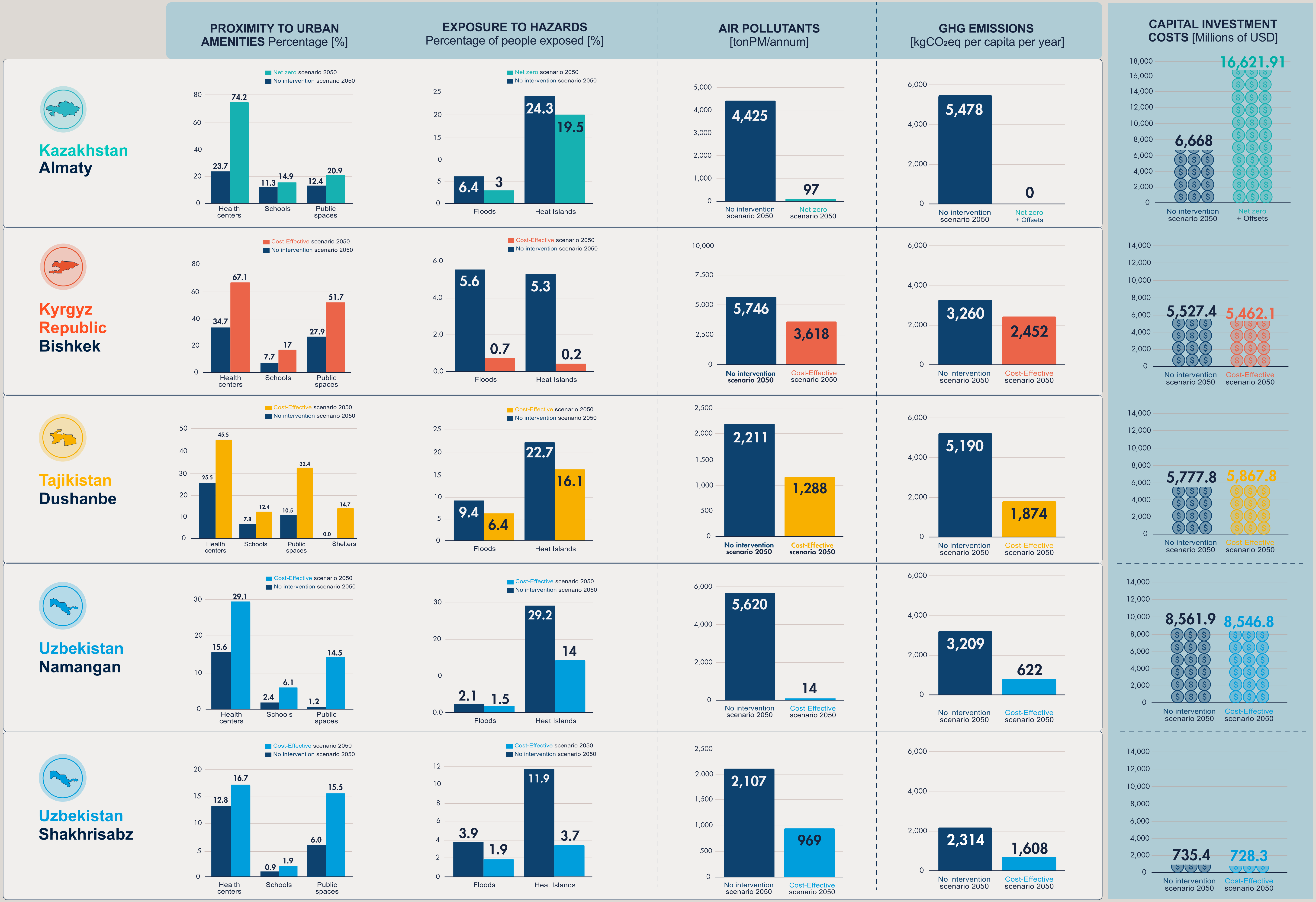
The study's findings led to tailored recommendations for addressing urban and climate challenges in the five selected cities. These recommendations include policies and projects to create livable, green cities; enhance access to infrastructure and amenities; adapt to and mitigate natural and climate impacts; and improve job accessibility. While broadly applicable across Central Asian cities, these recommendations are grounded in local context and international best practices, providing a roadmap for transitioning to a low-carbon, resilient future.

The CARL-Cities study shows that cities can achieve a resilient, low-carbon future through smart urban policies and investments without straining finances. By adopting compact growth, strategic densification, energy efficiency, cleaner technology, and expanding green public transportation, cities can reduce GHG emissions, improve quality of life, and redirect savings to sustainable projects. Nature-based solutions and resilient infrastructure are crucial for mitigating climate impacts like floods and UHI effects. These findings offer valuable insights for policymakers and urban planners to guide cities toward sustainability and resilience.

5 UHI was defined as those area with a temperature higher than 2 degrees above the annual average surface temperature.

Figure ES.3 Summary of Selected Indicators and Results from Scenario-Modeling

Source: CARL-Cities 2024.



Source: CAPSUS, 2023, Namangan [Photograph]

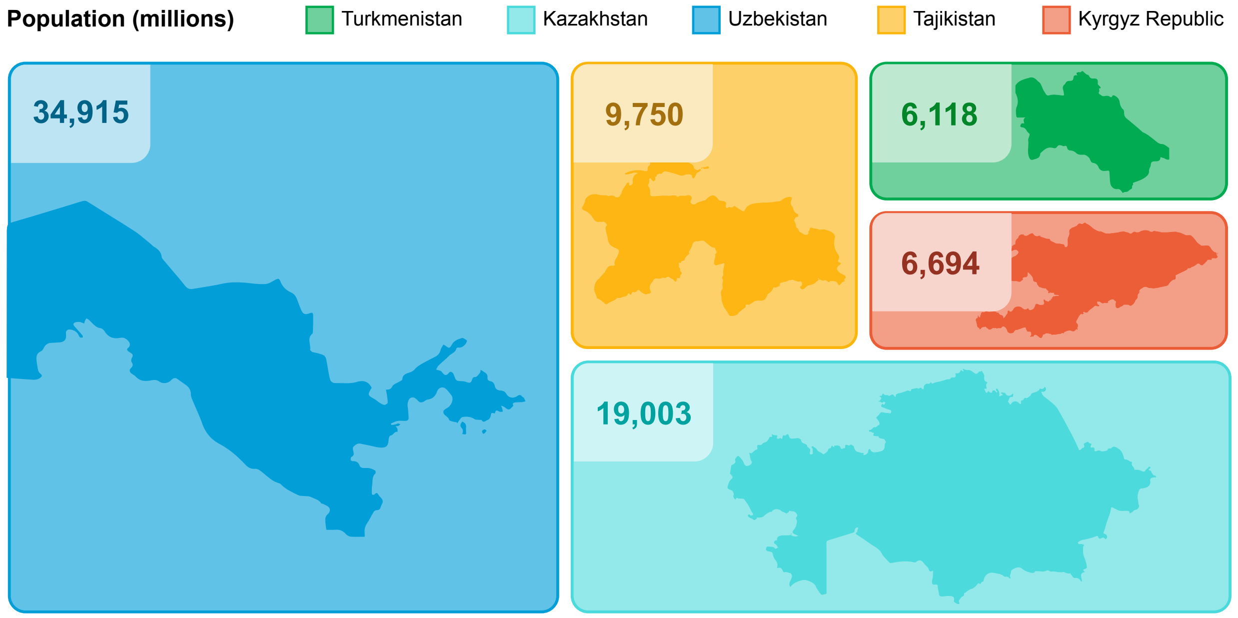
1 Introduction

Regional Context

Central Asia (CA) is characterized by its landlocked geography, its post-soviet economy, and the geopolitical significance of its neighbors. Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan all lack access to oceanic routes and they border Russia, China, Afghanistan, and Iran (Dabrowski and Batsaikhan 2017). The region's cities were planned during the Soviet era to meet national economic needs, leading to single-focus cities (residential, manufacturing, etc.) that now face diversification challenges. Recent urban growth has exacerbated issues like insufficient public transportation, congestion, inefficient energy use, environmental degradation, and urban sprawl.

Population growth in CA is strong but uneven (figure 1.1). Uzbekistan is the most populous with 34.9 million people, followed by Kazakhstan (19 million), Tajikistan (9.7 million), Kyrgyz Republic (6.6 million), and Turkmenistan (6.1 million) (UN DESA 2022). The region's population of 78 million in 2022 is expected to grow to 102 million by 2050 (UN DESA 2018).

Figure 1.1 Urban Population in Central Asia

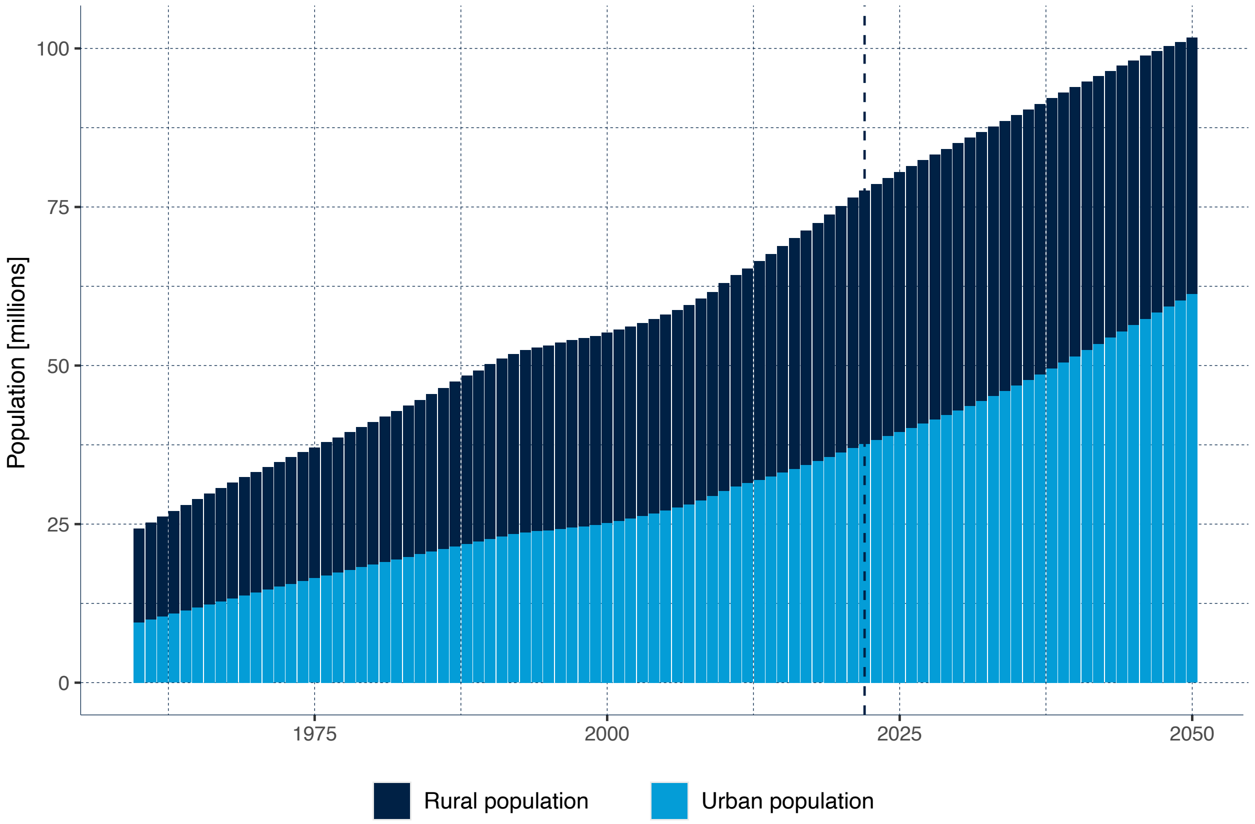


Source: United Nations, Department of Economic and Social Affairs, Population Division 2022.

Population growth in the region has been driven by steady urbanization, with 49 percent of the population now living in urban areas, primarily in large cities[6]. The urban population has grown from 9 million in 1970 to 38 million in 2022 and is expected to reach 60 percent by 2050 (figure 1.2). Although this shows a positive trend, it is still below the urbanization rates of Latin America and the Caribbean (82 percent), China (64 percent), and Europe (75 percent). The region also has many small and medium-sized cities, a legacy of its rural, agrarian, and industrial economy planned around monofunctional cities.

6 The urban areas were classified based on population into small cities (under 250,000 inhabitants); medium cities (between 250,000 and 1,000,000 inhabitants); and large cities (more than 1,000,000 inhabitants).

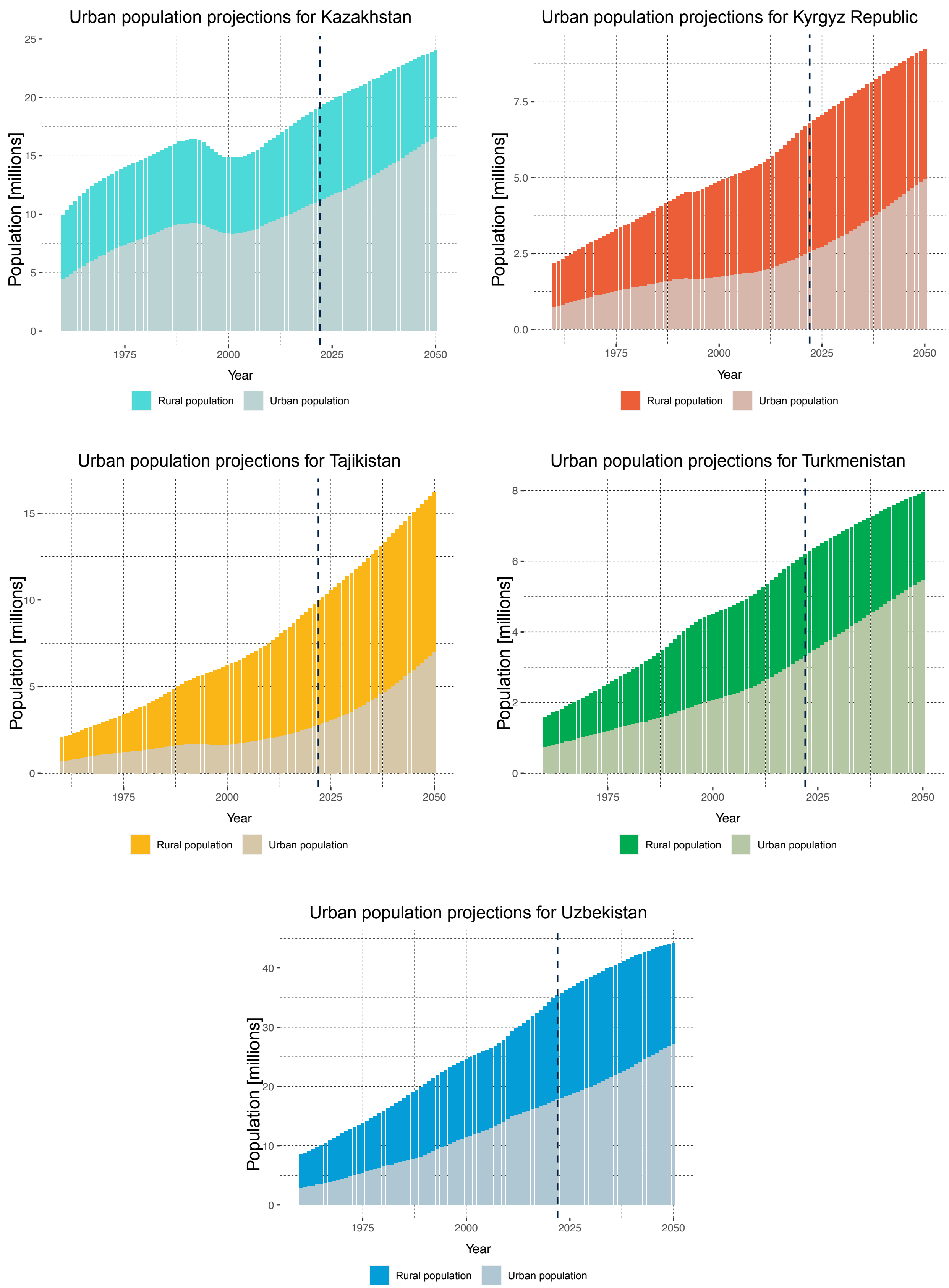
Figure 1.2 Urban Population Projections for Central Asia



Source: United Nations, Department of Economic and Social Affairs, Population Division 2022.

The Central Asian countries are urbanizing at different rates (figure 1.3). In 2020, Kazakhstan and Turkmenistan had the highest urban populations at 57 and 53 percent, respectively, projected to reach 70 and 68 percent by 2050. Tajikistan, while strongly urbanizing, will remain predominantly rural, increasing from 25 to 43 percent urban by 2050. Similarly, Uzbekistan's urban population is estimated to be 49 percent, while the Kyrgyz Republic is estimated to be 37.8 percent urban, with most residents in rural areas by 2050.

Figure 1.3 Urban Population Projections in Central Asia, by Country



Source: United Nations, Department of Economic and Social Affairs, Population Division 2022.

Policy and Institutional Context

Central Asian countries are implementing long-term sustainability measures by setting climate-resilient targets within national development frameworks. As part of their Intended Nationally Determined Contributions (INDCs), they have set emission reduction goals (table 1.1)[7]. Kazakhstan aims to reduce GHG emissions between 15 (unconditional target) and 25 percent (conditional target) by 2030 and achieve carbon neutrality in electricity and heat production by 2060. The Kyrgyz Republic targets a 16 percent (unconditional target) and 43 percent (conditional target) reduction by 2030. Tajikistan aims for a 30-40 percent (unconditional) reduction by 2030 from 1990 levels, with a conditional goal of halving emissions. Uzbekistan plans to reduce GHG emissions per unit of GDP by 35 percent from 2010 levels by 2030. Turkmenistan commits to a 20 percent reduction from 2010 levels by 2035.

Urban planning in CA is integrated into national development documents. There are no standalone national urban plans, except in Kazakhstan, which has frameworks like the "National Project of Strong Regions," the "Law on Agglomerations Development," and the spatial development forecast until 2030. The Kyrgyz Republic's urban targets are part of its National Development Strategy 2040. Tajikistan, Turkmenistan, and Uzbekistan give less prominence to urban planning in their national plans. Uzbekistan created an Urbanization Agency and began developing an urbanization strategy, but the work was suspended in 2020, and the agency was disbanded.

The climate change policy planning process in Central Asia is supported by national strategies, plans, and policies. Key documents include national development strategies, national adaptation policies, sectoral development strategies, and green economy programs. However, these documents often include limited climate change considerations. For example, Kazakhstan's "Kazakhstan-2050" strategy aims to transition to a low-carbon economy but lacks specific details. The Kyrgyz Republic's National Strategy until 2040 includes climate change adaptation measures with a focus on environmental quality. Uzbekistan's "New Uzbekistan 2022-2026" strategy calls for climate change adaptation measures but provides no specifics. Tajikistan's 2030 Strategy views climate change through an environmental quality lens and calls for adaptation measures.

Central Asian countries prioritize mitigation in key sectors like energy, construction, transportation, and waste management. The energy sector, particularly in Uzbekistan and Kazakhstan, is a major focus due to its high carbon emissions. Efforts include transitioning to low-carbon energy sources and expanding renewables like wind, solar, and biogas. Since 2019, Uzbekistan has enacted policy reforms for climate adaptation and renewable energy investment. Kazakhstan introduced an emission trading system (ETS) in 2013 to curb GHG emissions in energy, industry, and oil and gas sectors (German Emissions Trading Authority 2017). However, sectoral documents often prioritize socioeconomic development and environmental quality over climate change, and specific sectoral mitigation targets with quantifiable metrics are often lacking, limiting progress tracking and resource optimization. Market-based mitigation mechanisms remain largely unexplored.

Adaptation efforts focus on enhancing resilience in water, agriculture, energy, and transportation sectors due to the region's vulnerability to climate change. The agricultural and water sectors are prioritized due to threats from droughts and diminishing water flows, impacting food and water security. Consequently, all of the countries incorporate this priority into their national documents. The Kyrgyz Republic and Tajikistan, reliant on hydropower, emphasize water and energy sector adaptation. Tajikistan also focuses on adapting transportation infrastructure due to its mountainous geography.

National development plans and strategies often lack specific climate-related targets. Uzbekistan's subnational programs align with the New Uzbekistan Development Strategy, which lacks climate targets. Kazakhstan's plans link to the National Development Plan until 2025, focusing mainly on environmental quality. Tajikistan's Midterm Development Program until 2025 and the Kyrgyz Republic's National Development Program until 2026 also lack concrete climate resilience targets. Without national-level green development agendas, city governments cannot commit to low-carbon and climate-resilient objectives.

7 There can be two types of targets within an INDC: conditional and unconditional. **Unconditional targets** are emission reduction targets that a country commits to achieving regardless of any external assistance. They represent the country's own domestic efforts to reduce emissions. **Conditional targets** are emission reduction targets that a country commits to achieving if they receive international support. This support can come in various forms, such as financial aid, technology transfer, or capacity building.

Table 1.1 Climate Change Commitments by Country

	Kazakhstan	Kyrgyz Republic	Tajikistan	Turkmenistan	Uzbekistan
Objective	Target reduction of 15%–25% of greenhouse gas (GHG) emissions by 2030	Target reduction of 16%–43% of GHG emissions by 2030	Target reduction of 50%–70% of GHG emissions by 2030	Target reduction of 20% of GHG emissions in 2030	Target reduction GHG emissions per unit of GDP by 35% by 2030
Unconditional target	A 15% reduction in GHG emissions by December 31, 2030, compared to the base year	A 16.63% and 15.97% reduction in GHG emissions by 2025 and 2030, respectively	Not to exceed 60–70% of emissions from 1990 levels by 2030	Target reduction of 20% of GHG emissions in 2030 compared to the business as usual (BAU) scenario relative to 2010 emission levels	Not defined
Conditional target	A 25% reduction in GHG emissions by 2030. Subject to international investment	Target reduction of 43.62% of greenhouse gas emissions under the BAU scenario by 2030	Not to exceed 50–60% of emissions from 1990 levels by 2030	Not clearly defined	Not defined
Base year	1990	1990	1990	2010	2010
Period	2021 - 2030	2025 - 2030	2018 - 2030	2020-2030	2020-2030
Strategic sectors (mitigation)	-Energy -Agriculture -Waste -Land-Use Change -Forestry	-Energy -Agriculture, -Forestry and other types of land use **Industrial processes and use of products **Waste	-Industry -Industry and construction -Agriculture -Transport -Forestry and biodiversity	-Energy -Industrial processes -Agriculture -Waste	-Energy -Industrial processes and product use (PPPU) -Agriculture -Forestry and other land uses -Waste

Source: National INDCDs. (Kyrgyz Republic 2021; Republic of Kazakhstan 2016; Republic of Tajikistan 2021; Republic of Turkmenistan 2016; Republic of Uzbekistan 2021).

In Central Asia, national climate strategies often overlook the roles of subnational authorities like regions and cities. National documents rarely specify urban or regional responsibilities for adaptation, mitigation, and funding. Cities and regions typically lack the administrative and financial capacity for independent low-carbon development. Exceptions include larger cities with special administrative status, such as Almaty and Astana in Kazakhstan, which have the autonomy to set ambitious climate targets due to greater financial resources. The Kyrgyz Republic grants subnational authorities administrative autonomy but maintains financial dependence on the central government.

Empowering subnational governments would enhance their ability to address climate change effectively. Limited engagement of urban areas in promoting a green, sustainable agenda poses a challenge in aligning subnational and national objectives. Local governments, not involved in decision-making, lack guidance on translating national plans into local programs and have limited control over city planning and management.

Institutional strengthening and local capacity-building are critical for developing low-carbon, resilient cities in Central Asia. While some local policies align with national objectives, many lack specific targets and measurable goals for climate resilience and green development. Enhancing the integration of climate-related goals into existing frameworks and developing new instruments for local sustainability actions are essential. Collaboration among national and subnational entities, innovative sustainable urban planning, and strategic investments are crucial for achieving a low-carbon, resilient urban future in Central Asia.

Rationale and Scope of the Study

The Central Asia Regional Study on Resilient and Low-Carbon Cities (CARL-cities) is a novel attempt to systemically understand urbanization and its potential in Central Asia. It sheds light on the urban growth trajectories and trends in medium-to-large cities in CA, examined through a set of comprehensive parameters, and provides an evidence-based approach to charting a path and taking actions toward developing green, resilient cities.

This study explores the challenges and solutions for low-carbon, climate-resilient urban development at the subnational level in Central Asia (CA). Understanding these challenges is essential for creating effective strategies to support sustainable urban development in the region. The study identifies potential actions based on common urban development concerns: natural hazards, carbon intensity, social infrastructure, and environmental issues. Addressing these challenges can help CA cities transition to low-carbon, climate-resilient development and enhance urban planning and sectoral capacity with a long-term climate change vision.

The report presents key findings from urban and spatial profiles of 48 cities in the region and insights from in-depth assessments of five selected cities. The macro-level analysis provides an overview of these 48 urban areas, identifying strengths and major concerns, and mapping them spatially. The assessment focused on five dimensions: urban form, urban services and amenities, urban environment, economic activity, and urban mobility. The analyzed cities, each with a population over 150,000, represent about 32.1 percent of the CA region's total population[8].

A deep-dive analysis was conducted on Almaty (KAZ), Bishkek (KGZ), Dushanbe (TJK), Namangan (UZB), and Shakhrisabz (UZB) to examine policy options and interventions. This analysis used quantitative, qualitative, and spatial data, along with local stakeholder engagement. Scenario modeling estimated the potential benefits of key project investments through 2050, comparing a No Intervention scenario and a Vision scenario.[9] The No Intervention scenario identifies the strengths and weaknesses of the status quo, while the Vision scenario estimates the effects of climate change mitigation and adaptation measures. This modeling serves as a basis for further discussion and policy development.

8 Based on Population, total | Data for 2020.

9 The Vision scenario presents two distinct approaches: Cost-Efficient and Net Zero. The Cost-Efficient scenario, implemented in Bishkek, Dushanbe, Namangan, and Shakhrisabz, focuses on maximizing environmental and social impact within constrained budgets. This approach prioritizes strategic urban policies and investments that reduce GHG emissions while improving local living conditions. In contrast, the Net Zero scenario, adopted by Almaty, sets ambitious goals for achieving net-zero emissions. This requires more transformative policies and a high level of investment.

Source: CAPSUS, 2023, Bishkek [Photograph]

2 Urban and Spatial Profiles of 48 Cities

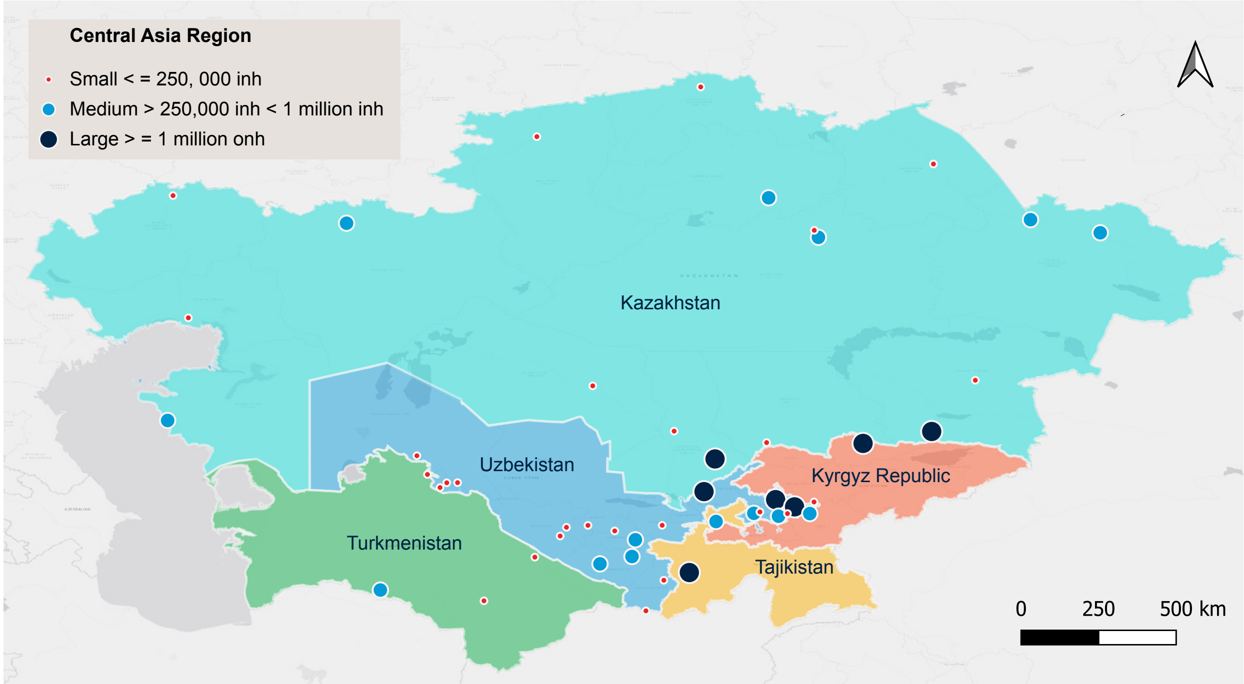
This section summarizes findings from the urban and spatial profiles of 48 urban areas across five Central Asian countries, identifying key urbanization and climate-related characteristics. The macro assessment focused on urbanization, development trends, growth patterns, disaster risks, and greenhouse gas (GHG) emissions. It built a spatial profile for each study area to understand urban growth trajectories, current characteristics, and trends in urban form, environment, mobility, access to amenities, and economic activity.

Macro Assessment Methodology

The CARL-Cities Study Areas

The study areas for the macro assessment were selected using the Global Human Settlements Functional Urban Areas (GHS-FUA) dataset (Schiavina et al. 2019)[10], which defines urban areas based on local workforce commuting patterns[11]. Leveraging the Functional Urban Areas (FUA) dataset ensures a consistent criterion across the region, focusing on labor markets rather than political or administrative boundaries. The region has 104 functional urban areas, mostly in Uzbekistan and Kazakhstan. All areas with populations over 150,000 were included, resulting in 48 study areas. Map 2.1 shows their locations.

Map 2.1 CARL-Cities Study Areas

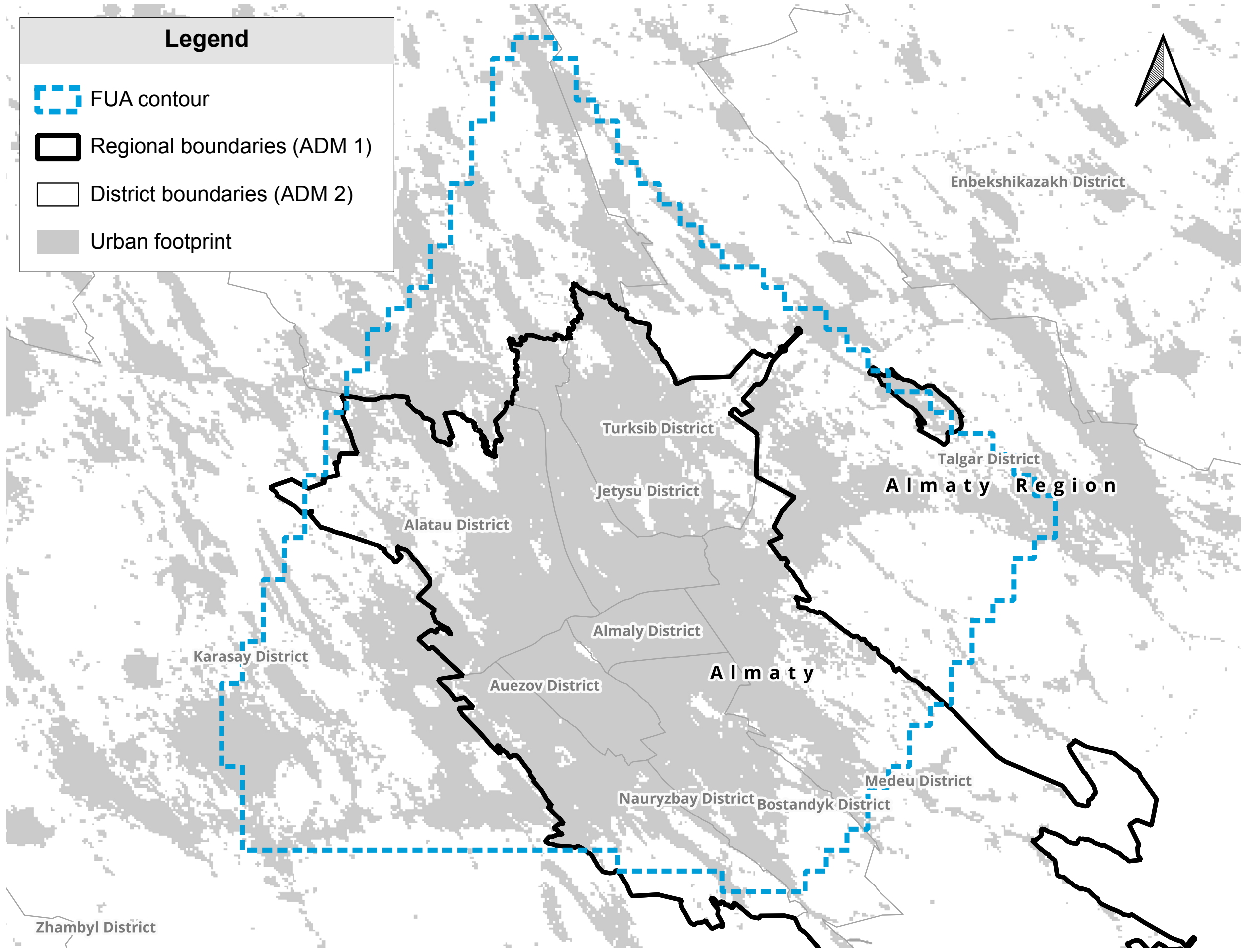


Source: CARL-cities 2024 based on Schiavina et al. 2019.

10 According to the OECD, a functional urban area (FUA) consists of a city and its commuting zone, where the latter represents the area of influence of the city in terms of labor market flows.
11 As commuting and local unit boundaries are not available in most countries, the GHS-FUA estimates the FUA based on a probabilistic model trained with actual OECD FUA boundaries. The GHS-FUA uses spatial building blocks instead of local administrative units.

Map 2.2 shows a sample study area in Kazakhstan, illustrating how the FUA aligns with the urban footprint and administrative boundaries. The FUA extends beyond these boundaries to include all urban areas functionally connected to the city core. Using the FUA ensures an accurate understanding of urban dynamics and identifies relevant externalities in the city's surroundings.

Map 2.2 Example Study Area: Almaty, Kazakhstan



Source: CARL-cities 2024 based on Schiavina et al. 2019.

Macro Assessment Indicators

The study evaluates the current performance of 48 cities using indicators and data from international databases, providing a standard framework for comparison. Due to data limitations, the base year for each indicator ranges from 2012 to 2023, often requiring multiple data sources. The macro assessment covers five focus areas: urban form, urban services and amenities, urban environment, economic activity, and urban mobility (table 2.1). Urban form indicators include urban footprint and land consumption, population density, and settlement fragmentation. Accessibility to social infrastructure and public services, such as health clinics, schools, public spaces, sports facilities, and cultural centers, was also measured. The urban environment was assessed using indicators for greenery, the UHI effect, hazard exposure, GHG emissions and particulate matter emissions. Economic activity was evaluated through changes in nighttime lights and jobs/housing balance. Urban mobility was assessed based on accessibility to structured public transportation and intersection density. Appendix A provides detailed information on each focus area, including indicators, data sources, base year, units, and calculation methods.

Table 2.1 Set of Indicators for the Macro Assessment

Topic	Indicator	Description
1 Urban Form	1.1 Urban Footprint	This indicator refers to the total built-up area of a city or urban area, including streets, buildings, open space, infrastructure, and urban amenities.
	1.2 Population Density	Population density considers the number of people or inhabitants per square kilometer. The population density is calculated by dividing the total number of inhabitants by the total FUA area.
	1.3 Settlement Fragmentation	This indicator measures the fragmentation level of the urban footprint of settlements and includes the classification of urban development patterns. Urban settlement fragmentation is the lack of continuity and contiguity of the urban footprint, resulting in built-up area patches or islands.
2 Urban services and amenities	2.1 Proximity to urban amenities and facilities	Accessibility is measured as the percentage of the population living within the coverage area[12] of urban facilities and amenities. One subindicator is calculated for each of the following categories of urban facilities: Health, Education, Public Spaces, Sports, Financial, and Culture.
3 Urban environment	3.1 Urban Greenery	This indicator will examine the area of greenery in the urban areas from satellite imagery and compare it with Open Street Maps (OSM) public green area data features to estimate the total surface of the study area's greenery. The resulting area will be divided by the total population to estimate the square meters of urban green area per person.
	3.2 UHI	This indicator estimates the percentage of the population living within UHI zones. UHI are defined as those areas that are warmer than their surrounding areas[13].
	3.3 Exposure to Natural Hazards	The percentage of people residing within areas prone[14] to pluvial flooding, earthquakes, and landslides. The indicator is calculated by dividing the number of inhabitants that live within the hazard risk zone by the total population.
	3.4 Greenhouse Gas Emissions	This indicator estimates CO_2, CH_4, N_2O, and F-gas emissions expressed in CO_2 equivalent (CO_2e) as a proxy for the annual average greenhouse gas emissions.
	3.5 Particulate Matter Emissions	The emissions per capita of $PM_{2.5}$ and PM_{10} will serve as a proxy measure of air pollution. The indicator is calculated by dividing the total amount of $PM_{2.5}$ and $PM1_{0}$ emissions by the total settlement population.
4 Economic Activity	4.1 Economic Activity Change	The economic activity indicator is calculated as the average annual change in nighttime Lights (NTL) between 2012 and 2021. This metric provides an estimate of economic activity within the settlements based on the intensity of artificial lights captured by satellite imagery during nighttime hours.
	4.2 Job/Housing Balance	The job/housing balance indicator is the share of the study area population living in economic hotspots, defined as the zones within the study area with high economic activity. This indicator uses nighttime light emissions (NTL) as a proxy measure of economic activity[15].
5 Urban Mobility	5.1 Proximity to bus stops and bicycle parking	Accessibility is captured as a proxy through the percentage of the population living within the coverage area[16] of urban structured public transportation.
	5.2 Intersection Density	The intersection density is calculated by dividing the number of street intersections within the FUA by the built-up area of the settlement.

Source: CARL-cities 2024.

12 Area accessible on foot within a specified distance from urban amenities, such as a school, park, or public transit station. The distance thresholds vary for each type of urban amenity, as defined in appendix A.
13 UHIs were defined as zones within the study area exhibiting a land surface temperature (LST) exceeding the local average by at least 2°C.
14 Appendix A provides more detail on the definition of risk-prone areas.
15 The results of the 48 study areas show a weak correlation of 0.32 between the job/housing balance and population density.
16 The area that is accessible on foot within a specified distance from bus stops and bicycle parking stations. The distance thresholds vary for bus stops and bicycle parking, as defined in appendix A.

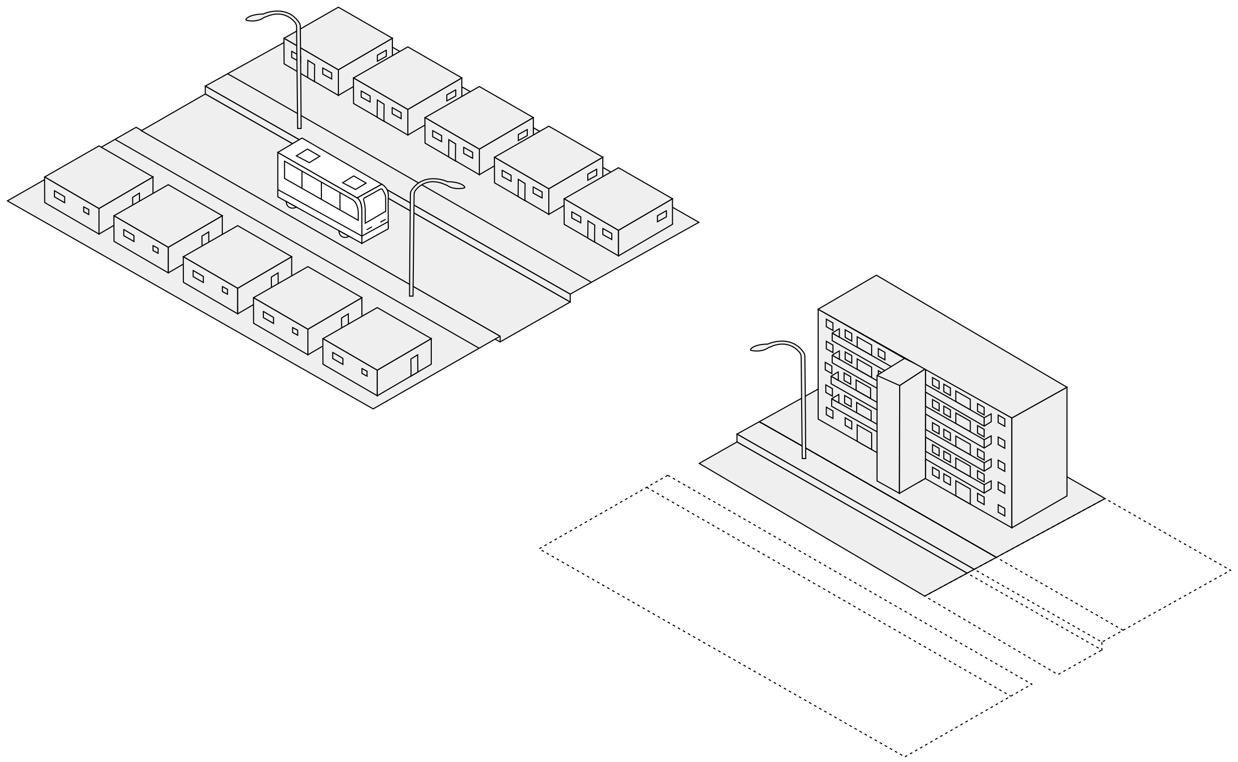
Key Findings on the Current Urbanization Situation in Central Asia

Urban Form

Urban form is crucial: distant, dispersed, and disconnected cities face significant sustainable development challenges and require more resources for daily operations. Mobility issues are pronounced due to greater distances and dispersed populations, making public transport more expensive and less efficient. Residents spend more time and energy reaching destinations, increasing pollution and congestion. Low-density cities also have higher per capita demands for energy, land, and resources. For example, ten families in single-family homes consume more resources than in an apartment complex. Therefore, a city's urban form and development type are key to identifying its sustainability challenges and opportunities (figure 2.1).

Sustainable and efficient urban development is more cost-effective. A compact, connected city uses resources efficiently due to shorter travel distances and economies of agglomeration. From a public budget perspective, city expenses correlate with the built-up area size, while income correlates with population. If a city's size grows faster than its population, expenses will outpace income, potentially causing fiscal imbalance. Unfortunately, many urban areas in CA exhibit such unsustainable sprawl patterns.

Figure 2.1 Same Density in Two Different Urban Forms



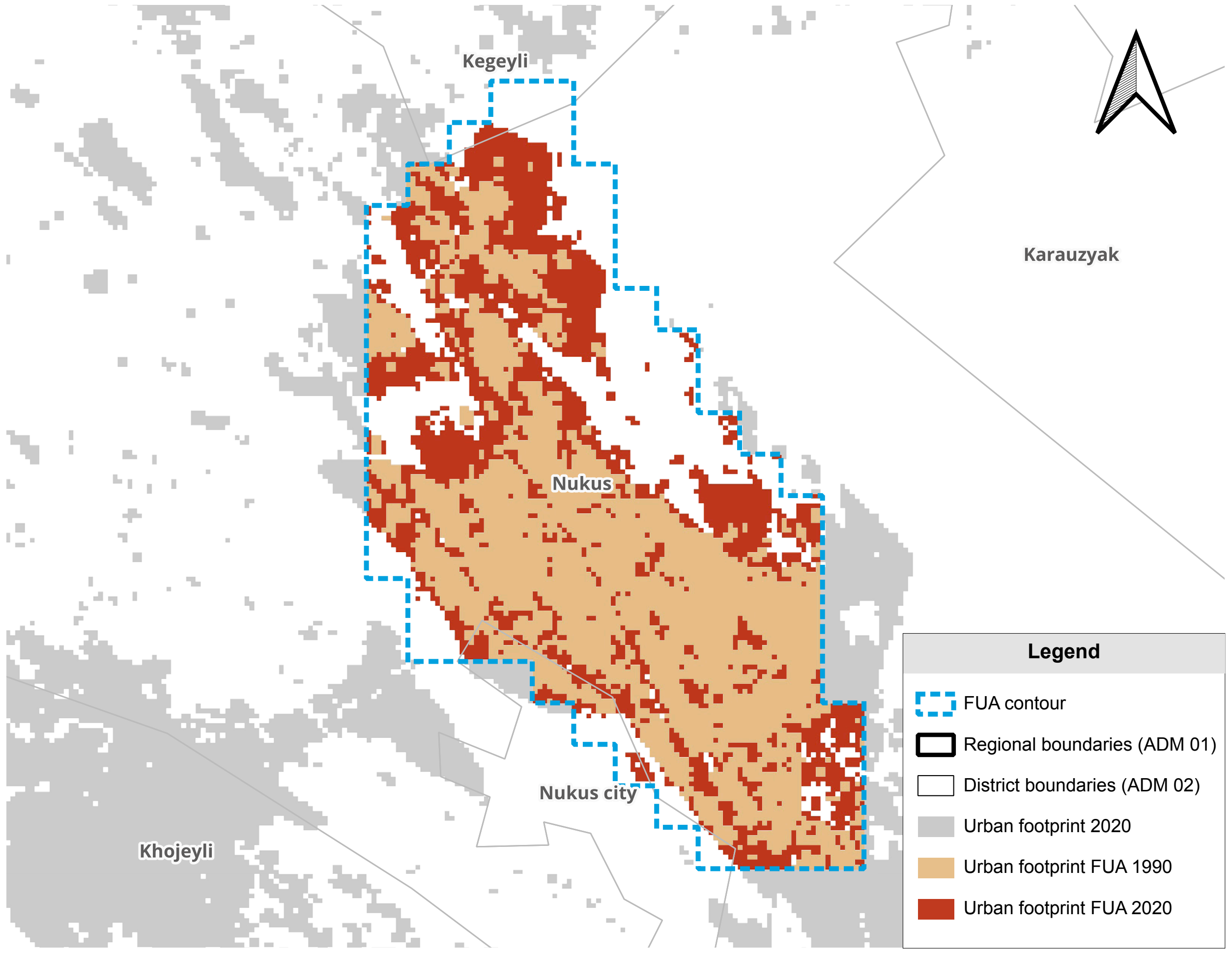
Source: CARL-cities 2024.

Urban Footprint

Cities in CA have expanded rapidly. Between 1990 and 2020, the built-up area of analyzed urban settlements grew by an average of 36.3 percent, consuming 545 square kilometers (km^2). Major changes occurred in the Kyrgyz Republic (52.2 percent), Turkmenistan (47.6 percent), and Kazakhstan (38.2 percent), surpassing the regional average. In Uzbekistan and Tajikistan, urban expansion increased by 31.2 percent and 25.7 percent respectively.

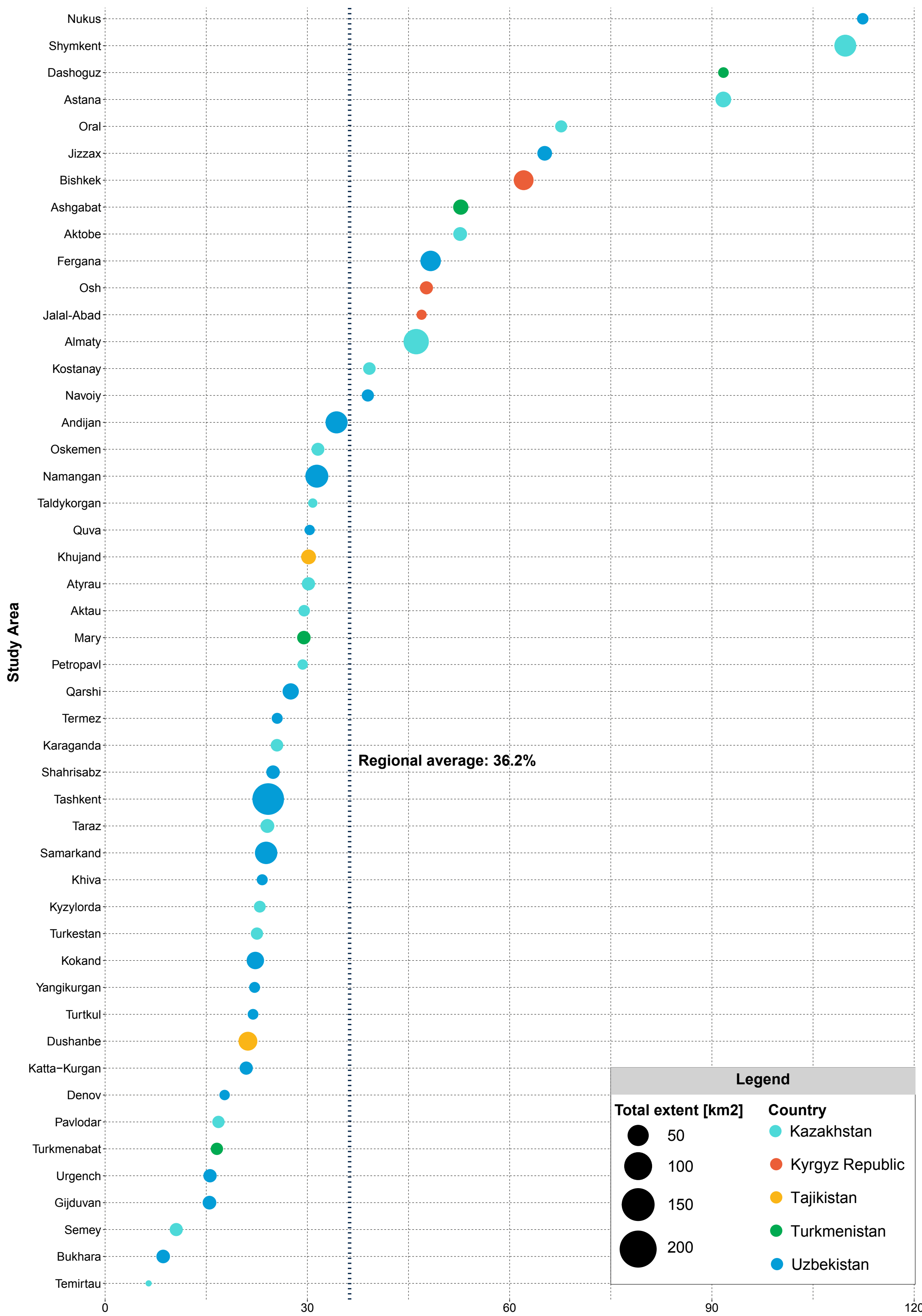
Urban expansion in CA cities varies significantly, correlating with city size. From 1990 to 2020, large cities (over one million inhabitants) expanded by 244 km^2 (44.7 percent), medium-sized cities (250,000 to one million people) by 159 km^2 (29.1 percent), and small cities (150,000 to 250,000 people) by 143 km^2 (26.2 percent). The most significant expansions were in Nukus, UZB (112.4 percent), Shymkent, KAZ (109.8 percent), Dashoguz, TKM, and Astana, KAZ (both 91.7 percent), and Oral, KAZ (67.6 percent). The least expansion occurred in Temirtau, KAZ (6.5 percent), Bukhara, UZB (8.6 percent), Semey, KAZ (10.6 percent), and Gijduvan and Urgench, UZB (both 15.5 percent) (see map 2.3 and figure 2.2).

Map 2.3 Urban Footprint Growth Between 1990-2020 in Nukus (UZB)



Source: GHS-POP R2022A Schiavina et al. 2022.

Figure 2.2 Urban Footprint Growth 1990-2020



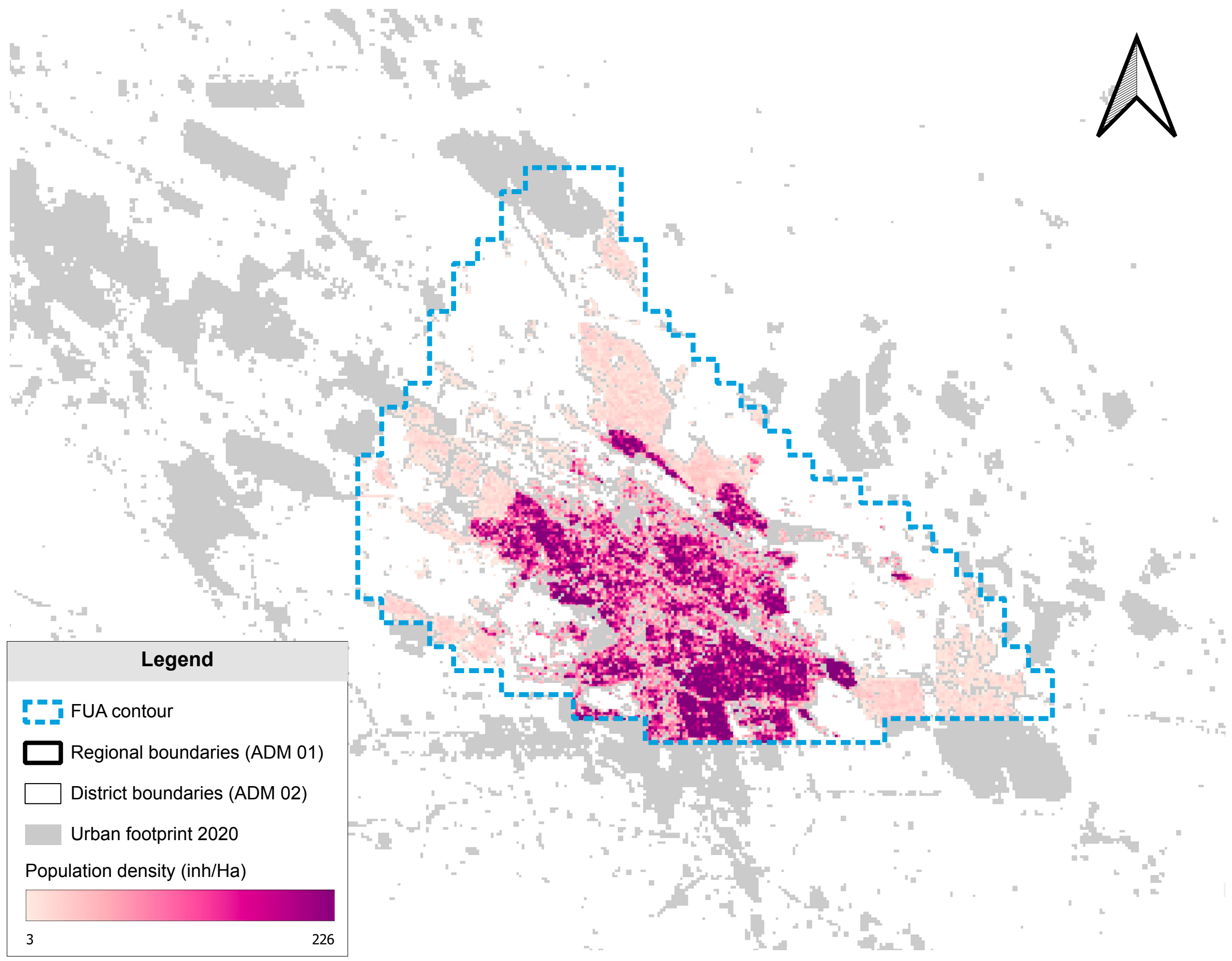
Source: GHS-POP R2022A Schiavina et al. 2022.

Population Density

Appropriate population density benefits sustainable development by enabling efficient resource use, reducing energy consumption, and increasing access to amenities and public transportation. The average population density of the 48 analyzed urban areas is 1,594 inhabitants per square kilometer. Larger cities tend to attract more residents, with significant density increases between 1990 and 2020: large settlements gained an average of 2,486 people per square kilometer, medium-sized settlements gained 372, while small settlements saw a decrease of 723. Oral and Petropavl (KAZ) had the lowest densities, while Dushanbe (TJK), Bishkek (KGZ), and Tashkent (KAZ) had the highest.

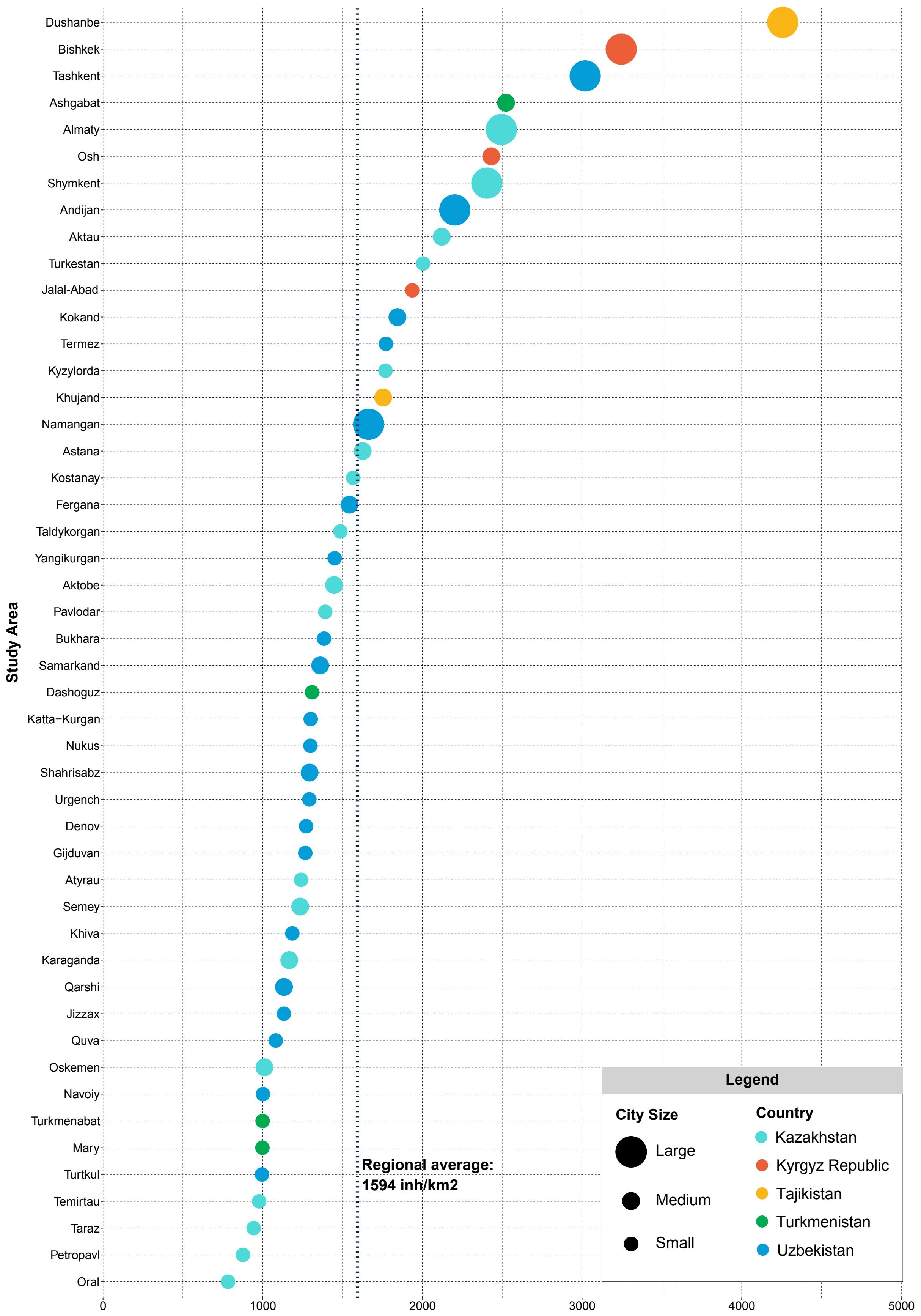
Without policy interventions, some CA cities may lose their density advantage. Population trends vary by country: Tajikistan had mixed results (half of the cities increasing in population density and half losing it), Kazakhstan saw a density decline in 61 percent of urban areas, and the Kyrgyz Republic experienced decreases in all analyzed settlements. Conversely, Turkmenistan and Uzbekistan showed positive trends, with all Turkmenistan cities and 76 percent of Uzbek cities increasing in density in recent decades (see map 2.4 and figure 2.3).

Map 2.4 Population Density, Ashgabat (TKM)



Source: Pesaresi, et al. 2015; GHS-POP R2022A Schiavina et al. 2022.

Figure 2.3 Population Density in the Region



Source: Pesaresi, et al. 2015; GHS-POP R2022A Schiavina et al. 2022. Higgs, C. et al. 2021.

Settlement Fragmentation

Urban areas in CA exhibit unsustainable spatial expansion. The average fractal degree[17] of 1.7 indicates dispersed urban growth with leapfrog and scattered development (table 2.2 and maps 2.5 to 2.7).[18] About 58.3 percent of urban areas show leapfrog development, 39.6 percent have scattered[19] development, and only 2.1 percent display continuous peri-urban expansion.

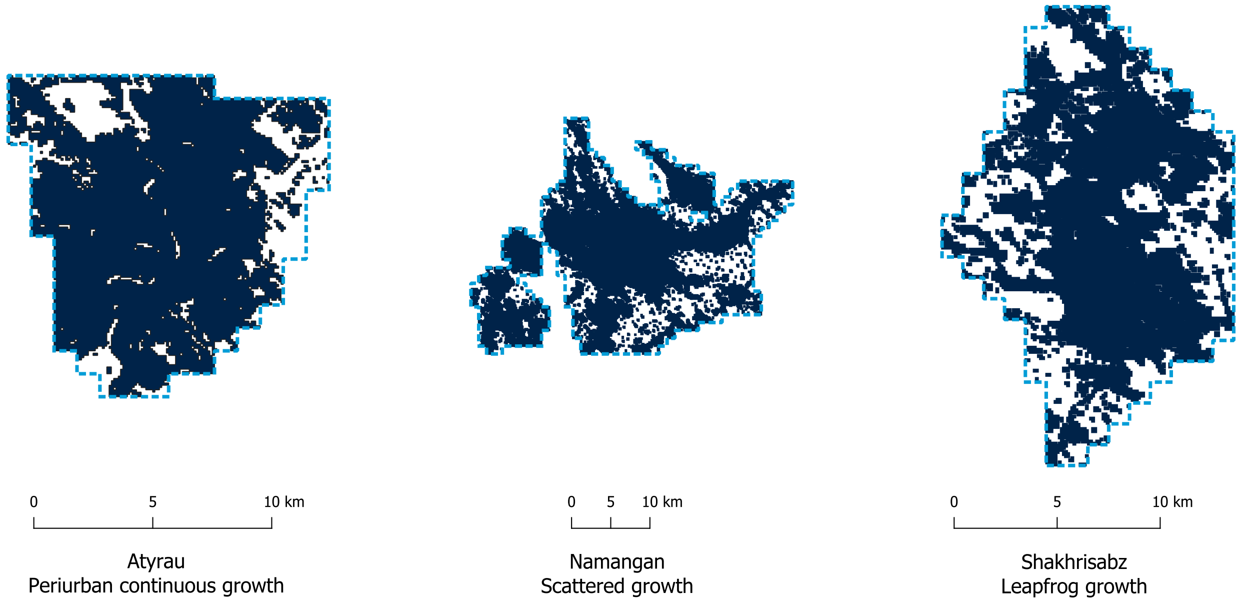
Table 2.2 Spatial Patterns Classification

Spatial Pattern	Fractal Degree	Description
Compact[21]	**1.9 - 2**	In this type of development, the urban footprint exhibits minimal voids or empty spaces. Compact urban development is a direct outcome of expanding or consolidating built-up areas primarily within the pre-existing and established urban footprint. The compact urban footprint often emerges as a consequence of infill expansion, where new development takes place within the available spaces in the urban core without increasing the overall urban extent (Sun et al. 2013).
Peri-Urban Continuous Growth	**1.81 - 1.9**	This form of urban development occurs when the urban footprint expands outward from the consolidated urban area, specifically within its periphery. It represents a contiguous expansion of the settlement.
Scattered Growth	**1.715 - 1.81**	Scattered development is typified by a fragmented, diffuse, and dispersed pattern of urban expansion. This urban growth expands beyond the boundaries of the consolidated urban footprint. Scattered development refers to an urban growth pattern where new or existing urban areas and constructions are spread out and are not contiguous with the existing consolidated urban footprint. In scattered development, the dispersion of built-up areas takes on the appearance of isolated, individual small patches scattered across the study area.
Leapfrog	**0 - 1.715**	Leapfrog development is characterized by a discontinuous urban fabric, marked by isolated built-up patches or “islands” that stand apart from the urban core. This type of development is commonly associated with settlements located at a considerable distance from existing urban areas.

Source: CARL-cities 2024. Categories adjusted based on Suárez-Meaney et al. 2022.

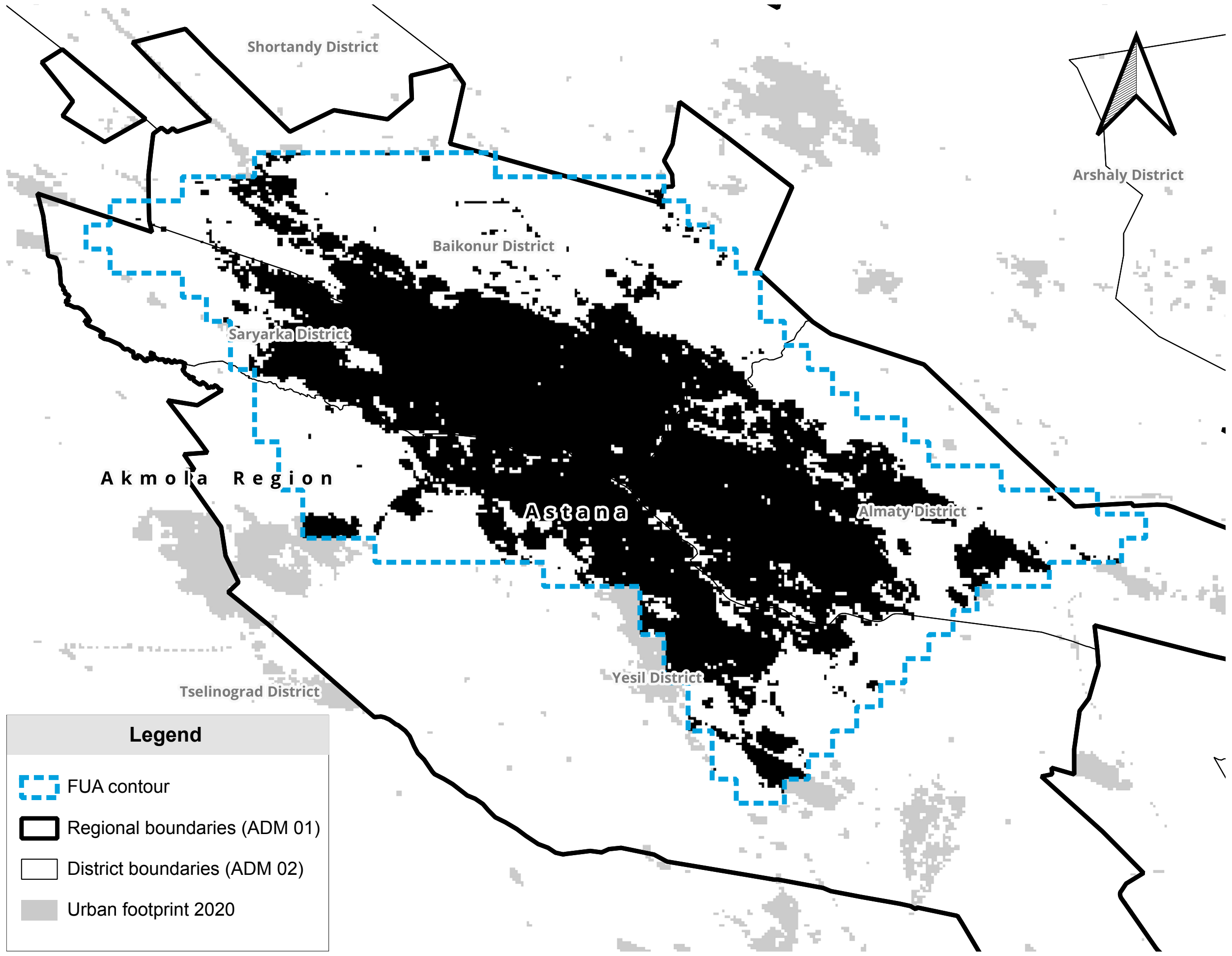
17 The fractal degree measures the filled and empty space within the study area, compared to a simple geometric shape, such as a square. The urban footprint is categorized as a filled area, while land with no built-up surface is considered “empty” space. This value quantifies the dispersion of the urban settlement’s footprint.
18 Leapfrog development shows a discontinuous urban fabric characterized by isolated built-up patches or “islands” that are separated from the urban core. This type of development is typically identified as settlements far away from existing ones.
19 Scattered development is characterized by a discontinuous, diffuse, and dispersed fragmentation of the urban footprint.
20 This pattern is characterized by an expansion next to the existing settlements or urban centers. This spatial development is consolidated in the surrounding functional area.
21 In this context, the term compact should not be confused with the compact city approach. During the calculation of this indicator, it was observed that settlements with high fractal degrees, which are typically considered compact cities, often display a significant level of confetti-like urban dispersion, as observed in Tashkent. In such cases, the level of dispersion is so pronounced that it becomes difficult to differentiate between vacant urban land and farmland. Therefore, the compactness described by this indicator primarily refers to the observed homogeneity in the shape of the urban area and should not be directly associated with the compact city approach.

Map 2.5 Examples of Spatial Development in Central Asia



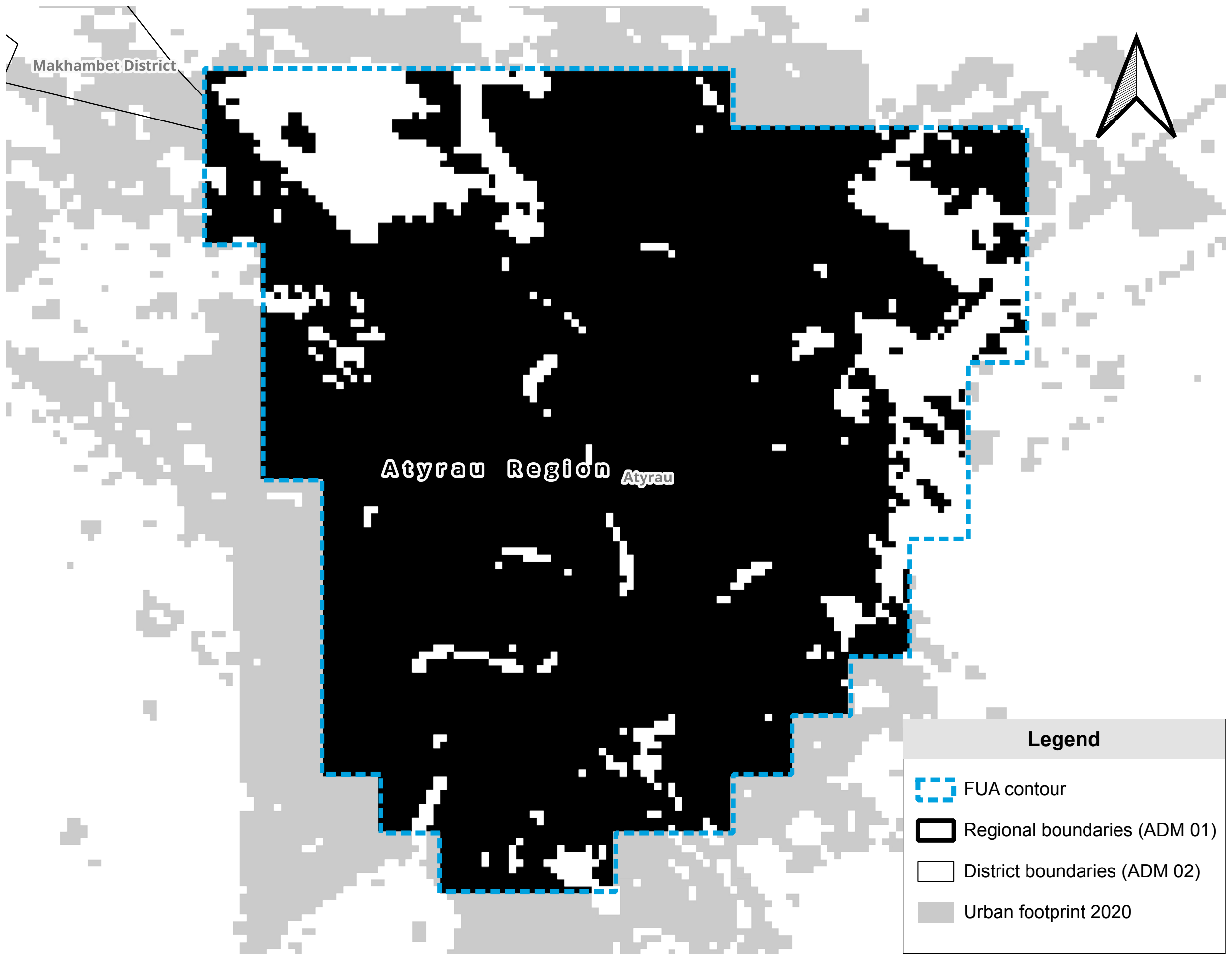
Source: World Pop, 2023.

Map 2.6 Leapfrog Urban Dispersion in Astana (KAZ) (Fractal Degree 1.53)



Source: GHS-POP R2022A Schiavina et al. 2022.

Map 2.7 Periurban Continuous Growth in Atyrau (KAZ) (Fractal Degree 1.82)

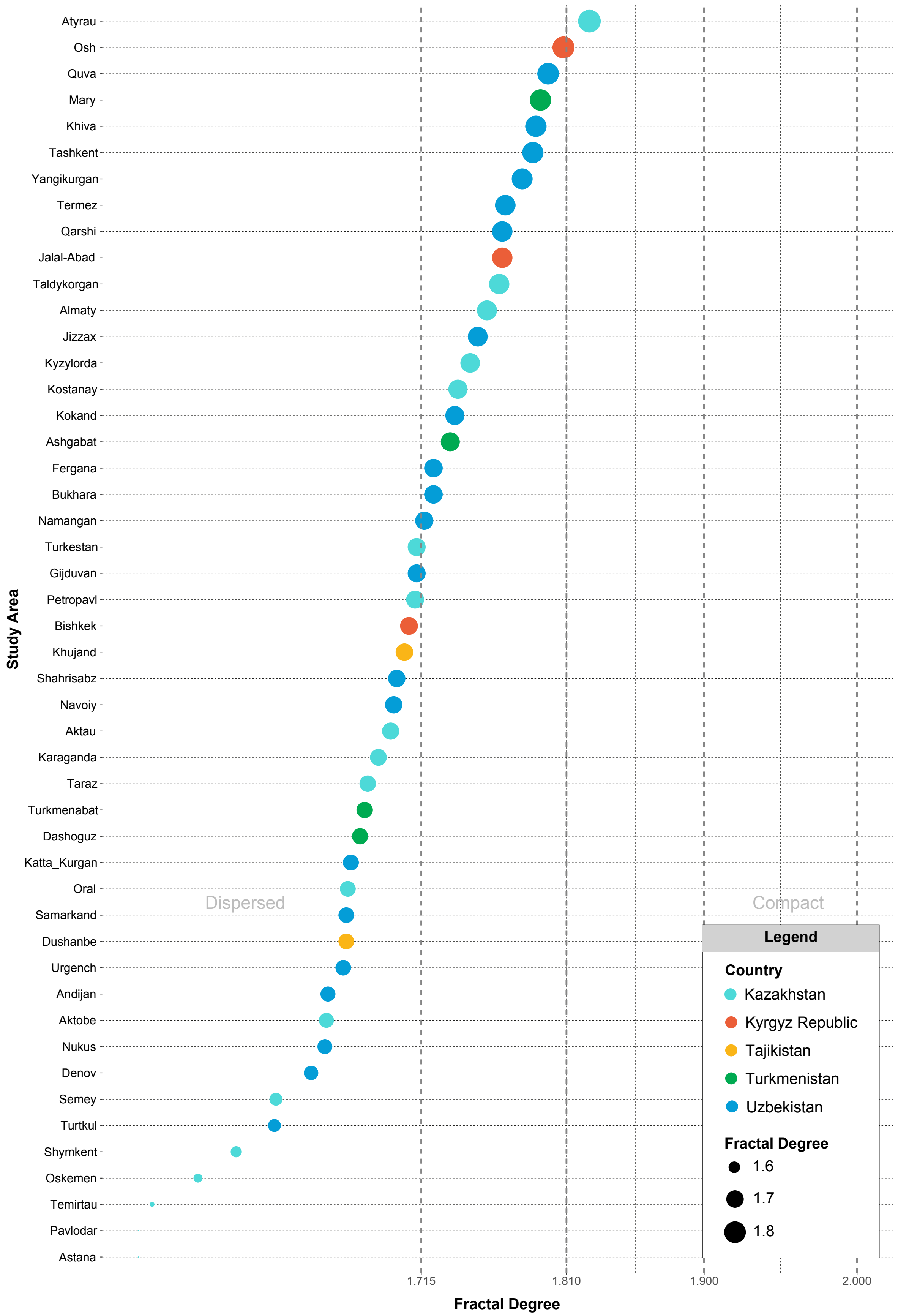


Source: GHS-POP R2022A Schiavina et al. 2022.

The urban development model in CA leads to a resource-intensive region with negative medium- and long-term impacts. Urban expansion scenarios based on Shared Socioeconomic Pathways (SSPs) indicate a growing land demand in the coming years (figures 2.4 and 2.5). SSPs, used in the IPCC's sixth assessment report, help understand how societal choices affect land use and GHG emissions, and how to achieve the Paris Agreement goals.

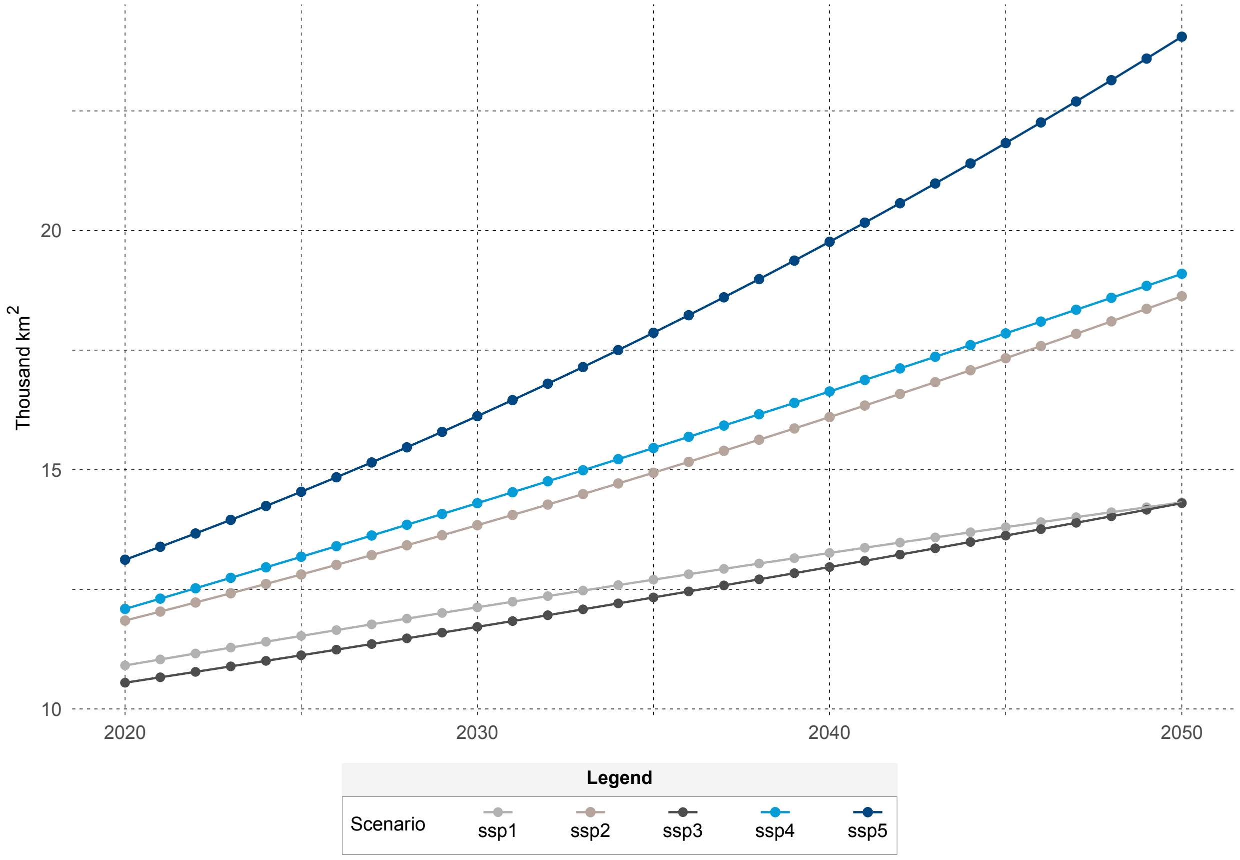
Overall, urban expansion and population growth in CA are increasing at similar rates, which is uncommon in most developing cities. This trend maintains density and supports sustainable urban development. However, large variations are observed for each city.

Figure 2.4 Urban Dispersion in Central Asia



Source: GHS-BUILT-S R2022A Pesaresi et al. 2022.

Figure 2.5 Urban Expansion Projections in CA (Based on SSPs)



Source: Calculations based on Gao and O'Neil 2020.

Urban Services and Amenities

Proximity to social infrastructure and public services affects trip length and quality of life. Key destinations typically include job centers, schools, markets, parks, health clinics, sports facilities, and cultural venues. Close amenities increase access and reduce the need for motorized transport, lowering congestion, pollution, and GHG emissions.

Urban expansion necessitates new infrastructure and services. Without investment, access to these amenities may decline, especially in areas with decreasing density and sprawl. Building new amenities is costlier and slower than upgrading existing ones. Effective urban planning can address growth challenges and mitigate negative environmental and social impacts through proper design and management.

Accessibility to Urban Amenities and Services

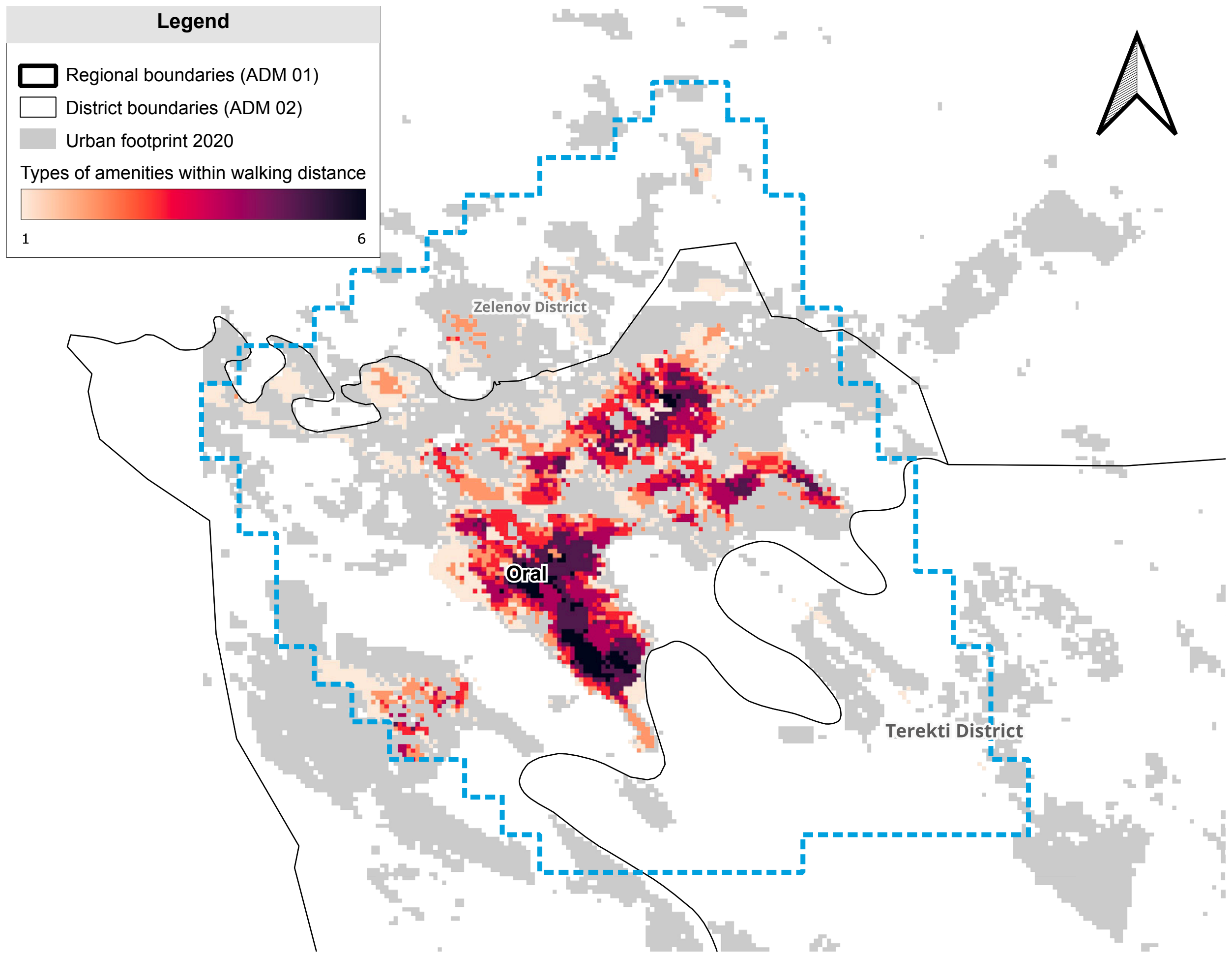
Most urban areas in CA have severely limited access to essential services and amenities. Health clinics, schools, parks, sports venues, and cultural centers are distant for most residents. Average accessibility is only 16.5 percent for schools, 6.8 percent for health clinics, 8 percent for parks and sports facilities, and 3 percent for cultural centers[22]. Bishkek (KGZ) has the highest proximity to amenities, followed by Oral (KAZ) (map 2.8), Semey (KAZ), Ashgabat (TKM), and Taldykorgan (KAZ). These areas scored well in education and financial facilities.

22 According to the 20-minute city framework implemented by the Victoria State Government (2022), accessible urban amenities are defined as local health facilities within 800 meters, schools within 800 meters, public spaces within 300 meters, sports facilities within 800 meters, and cultural facilities within 800 meters.

Overall, all study areas had low proximity to cultural, sports, and health facilities (figure 2.6). Key findings include:

- **Educational facilities are the most accessible urban amenities,** with 16 percent of the population living within walking distance. Bishkek (KGZ) leads with 40 percent of residents near schools, followed by Ashgabat (TKM) and Nukus (UZB) at 33 percent each, and Petropavl (KAZ) at 32.4 percent. Lower results were seen in Shakhrisabz (UZB) at 2.6 percent, Mary (TKM) at 3.1 percent, and Gijduvan (UZB) at 3.4 percent.
- **Walkable access to parks and public spaces averages 8 percent,** with Bishkek (KGZ) at 51 percent, Ashgabat (TKM) at 26 percent, and Pavlodar (KAZ) at 20 percent.
- **Proximity to cultural spaces is low, averaging 3 percent.** Bishkek (KGZ) has the highest at 11 percent, followed by Oral (KAZ) at 9.3 percent and Taldykorgan (KAZ) at 8.3 percent. Namangan, Denov, and Yangikurgan (UZB) have no residents within walking distance of cultural amenities.
- **Accessibility to sports facilities averages 6 percent.** Bishkek (KGZ) leads with 22.36 percent, followed by Atyrau (KAZ) at 17.3 percent and Taldykorgan (KAZ) at 16.4 percent. Gijduvan (UZB) and Shakhrisabz (UZB) have no residents near sports facilities.

Map 2.8 Quantity of Urban Amenities Within Walking Distance in Oral (KAZ)



Source: GHS-POP R2022A Schiavina et al. 2022; Open Street Maps.

Figure 2.6 Share of Population with Access to Urban Amenities

Source: GHS-POP R2022A Schiavina et al. 2022; Open Street Maps.

Urban Environment

The urban environment was assessed using indicators for greenery, the UHI effect, hazard exposure, GHG emissions and particulate matter emissions:

- **Urban greenery** reduces climate hazards, provides environmental benefits, and increases park accessibility. Green spaces offer recreation, enhance well-being, and ensure ample per capita green space. They contribute to environmental sustainability through climate regulation, shading, carbon sequestration, pollution mitigation, and water filtration. Strategically placed green areas act as natural buffers during floods, absorbing excess rainfall.
- **Urban Heat Island (UHI)** analysis helps understand how urbanization increases temperatures and heat exposure. According to the US-EPA, urbanization causes buildings and infrastructure to absorb and re-emit solar heat, creating "heat islands" that are hazardous during heat waves.
- **Flooding, seismic activities, landslides, and heat waves expose populations to natural disasters.** Climate change and the natural context of CA cities present risks that city administrations must manage. Understanding these risks helps urban planners identify suitable areas for expansion, optimal locations for amenities, and plan strategic densification. It also aids civil protection agencies in implementing preventive measures to reduce disaster risks.
- **Air pollutant emissions** pose immediate and future problems for CA cities. Urban activities demand natural resources and generate pollutants, impacting the environment. Particulate matter affects public health, while GHG emissions exacerbate climate change. These pollutants are linked to urban structure and environmental policies.

Urban Greenery

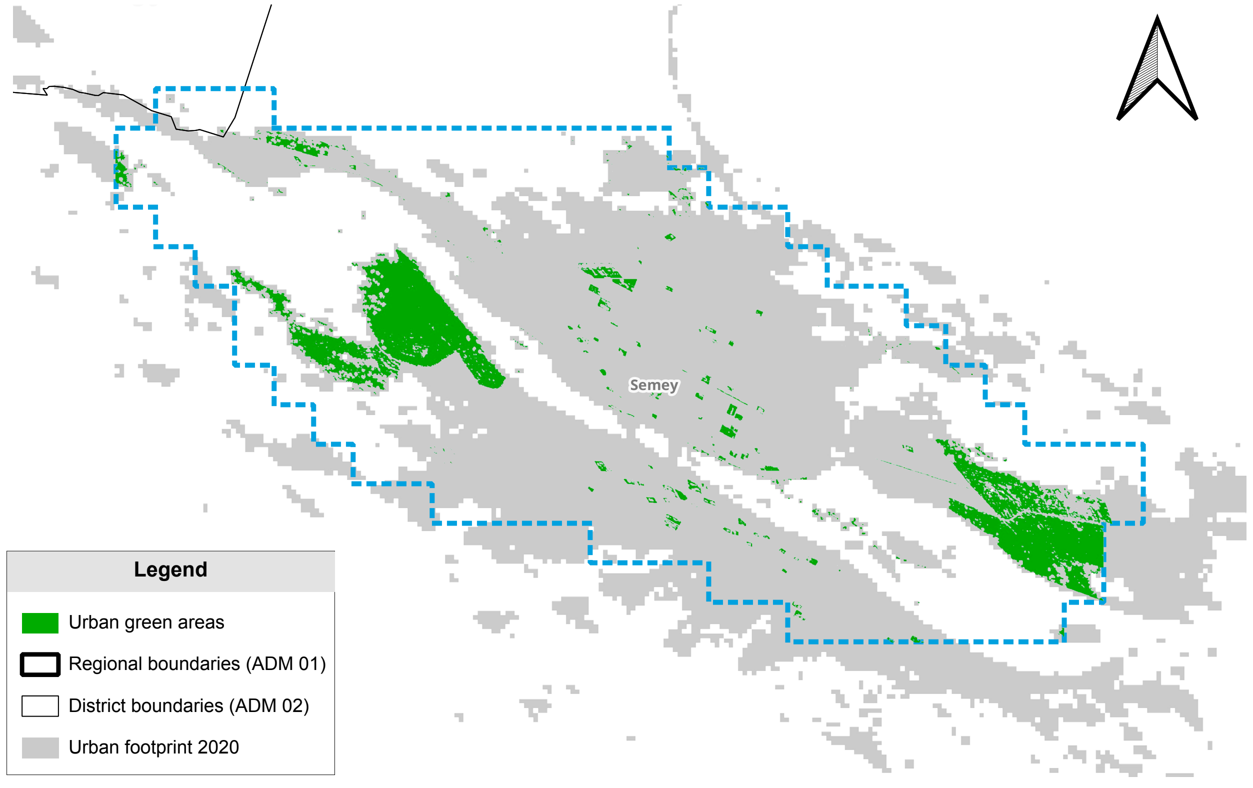
Most cities in CA lack adequate urban green areas (UGA), averaging only 7.6 square meters (m^2) per capita, 11 m^2 below the EU average of 18.2 m^2 (Varbova 2022) (figure 2.7). Kazakhstan cities fare better, averaging 16.4 m^2 per capita, with Semey (KAZ) at 51.6 m^2 (map 2.9). Tajikistan averages 6.8 m2, with Dushanbe (TJK) at 12 m^2. The Kyrgyz Republic averages 3.7 m^2, with Bishkek (KGZ) at 4.6 m^2. Uzbekistan averages 1.7 m^2, with Denov (UZB) at 4.8 m^2. Turkmenistan averages 1.9 m^2, with Turkmenabat (TKM) at 2.8 m^2. Adequate UGA is crucial for regulating urban microclimates and reducing the UHI effect.

Urban Heat Island

Approximately 13 percent of the total area and 17 percent of the population in the analyzed cities are subject to the UHI effect (figure 2.8)[23]. Significant variations exist between cities. Urgench (UZB), Turkmenabat (TKM), and Petropavl (KAZ) have over 45 percent of their populations exposed to UHI, while Yangikurgan has no exposure. (Map 2.10 highlights the situation in Temirtau (KAZ).) In contrast, nearly a third of the analyzed cities have less than 10 percent of their populations living in UHI-prone areas. For example, Karaganda (KAZ) is at 1 percent, Kyzylorda (KAZ) at 2 percent, and Ashgabat (TKM) at 3 percent. Given the steady increase of 0.28°C in average annual air temperature per decade from 1950 to 2016 (Haag, Jones, and Samimi 2019), and projections indicating greater rises in climate extremes compared to the global average (Liu et al. 2020), addressing the UHI effect is crucial for mitigating climate vulnerability.

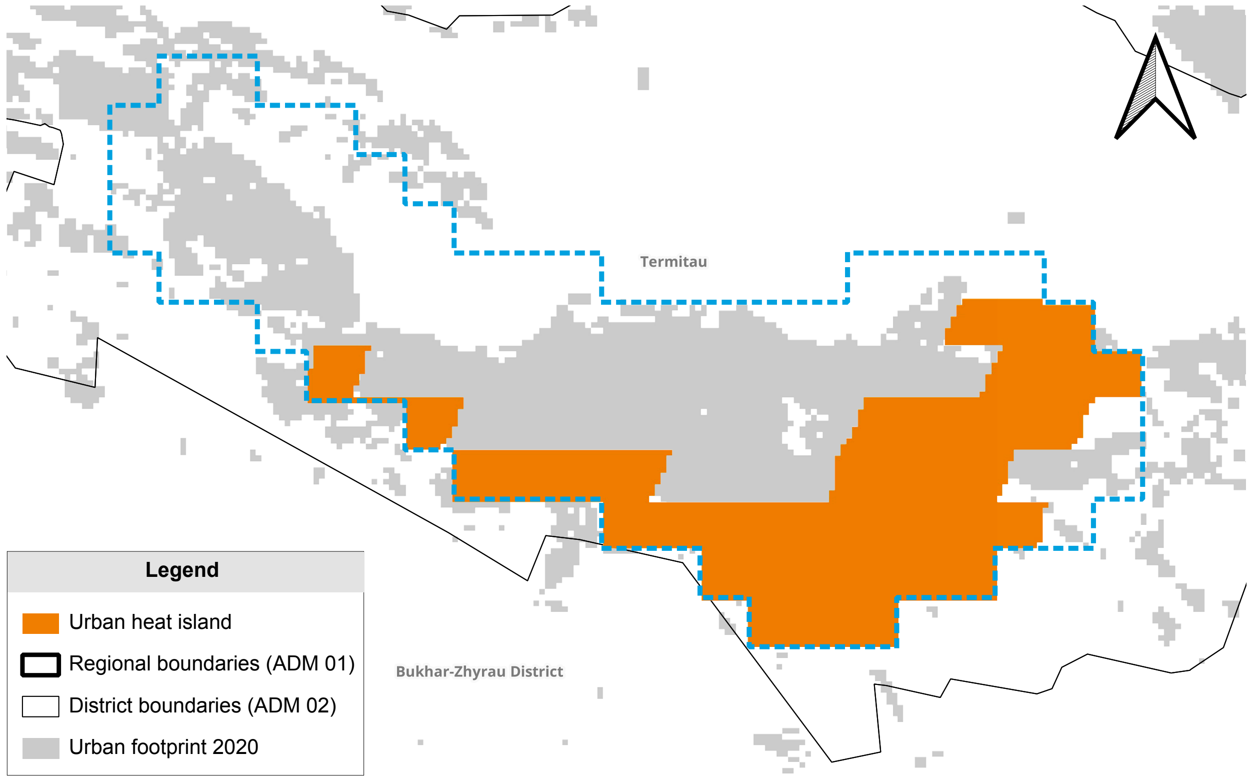
23 The exposed surface area of a UHI is determined by dividing the total area with a land surface temperature (LST) exceeding 2 degrees above the annual average temperature by the total settlement area. The identification of UHI-prone areas uses the yearly average of LST. For further details on the calculation, please refer to appendix A.

Map 2.9 Urban Green Areas in Semey (KAZ)



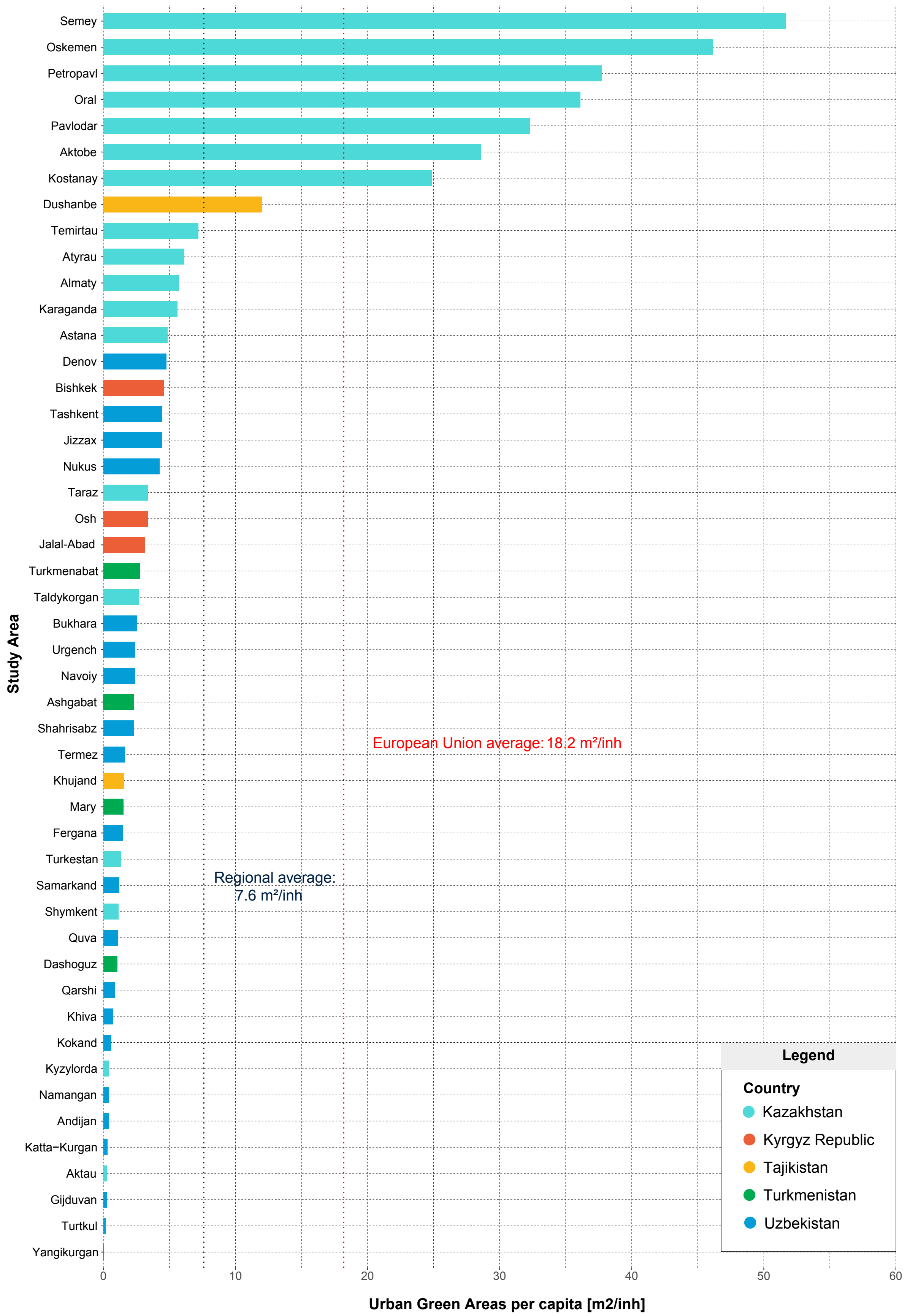
Source: GHS-POP R2022A Schiavina et al. 2022; GHS-BUILT-S R2022A Pesaresi et al. 2022. Source: CARL-cities 2024.

Map 2.10 Area Exposed to the UHI Effect in Temirtau (KAZ)



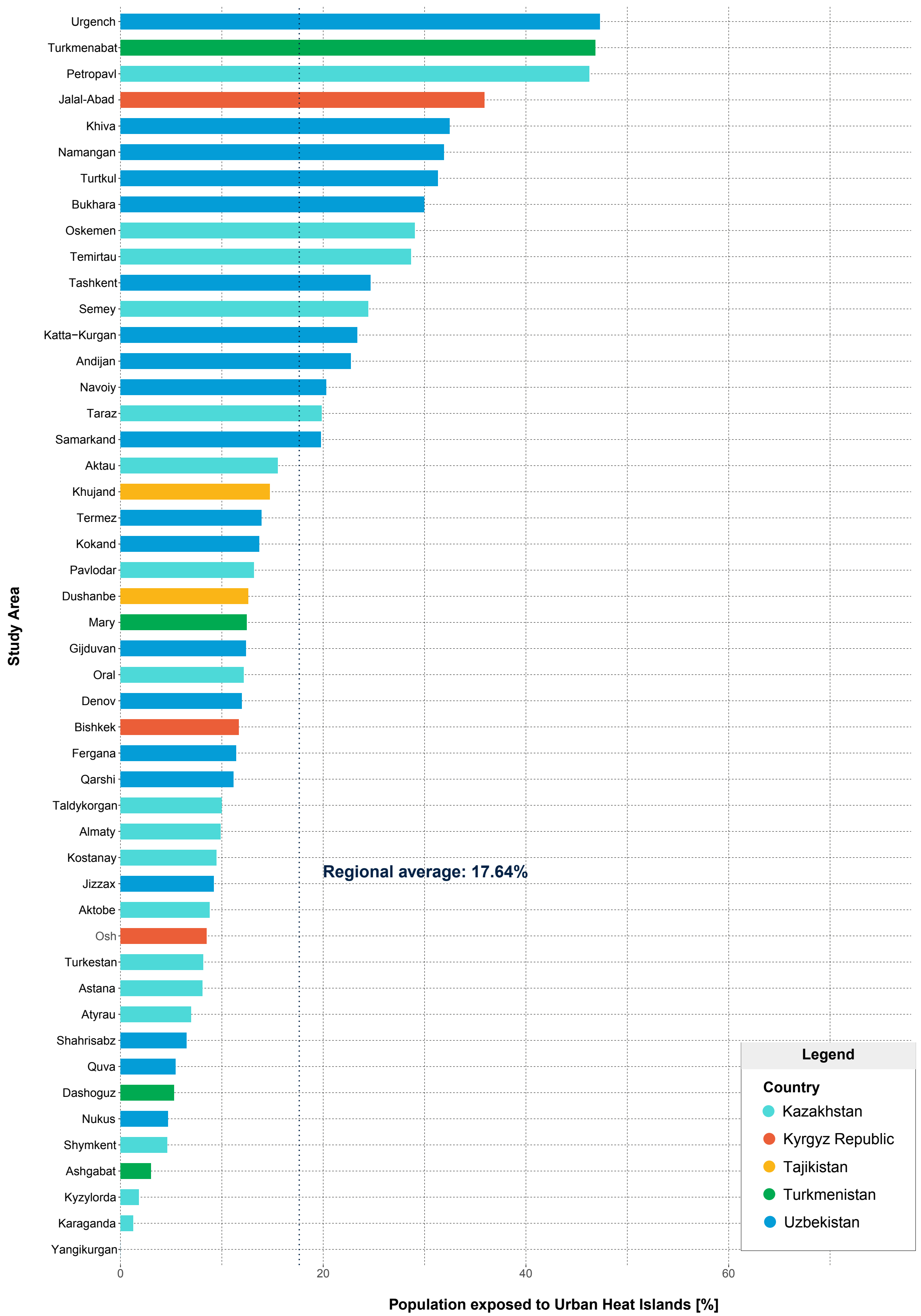
Source: GHS-POP R2022A Schiavina et al. 2022; Fick and Hijmans 2017; Open Street Maps.

Figure 2.7 Urban Green Areas Per Capita



Source: GHS-POP R2022A Schiavina et al. 2022; GHS-BUILT-S R2022A Pesaresi et al. 2022.

Figure 2.8 Population Exposed to the UHI Effect



Source: GHS-POP R2022A Schiavina et al. 2022; Fick and Hijmans 2017; Open Street Maps.

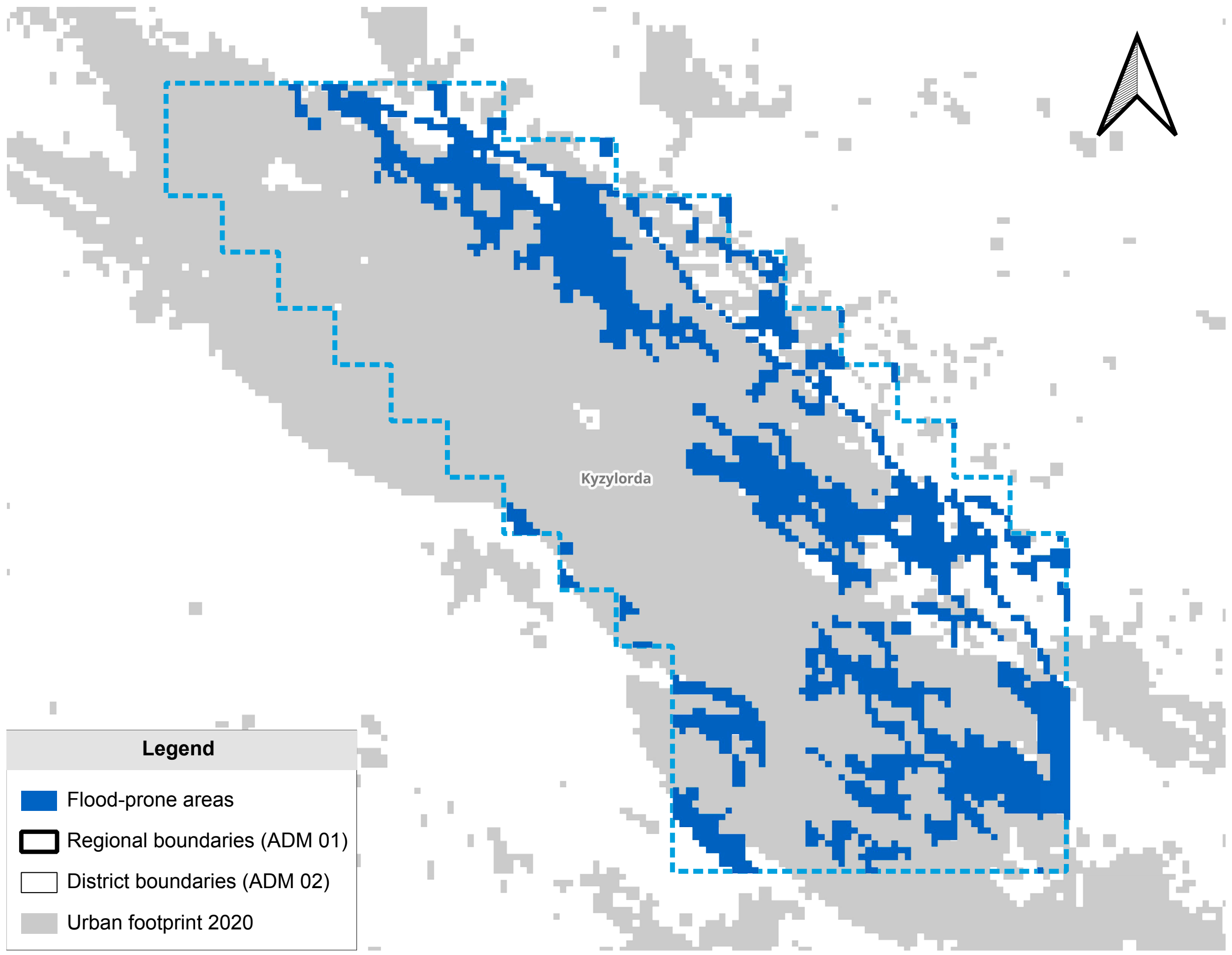
Exposure to Natural Hazards

CA cities are highly exposed[24] to natural hazards, including earthquakes, landslides, and floods (figure 2.9). Earthquakes are the dominant hazard due to the collision of the Eurasian and Indian plates. Floods are the second most prevalent, especially in mountainous areas and alluvial plains. Urban areas near the mountains of Tajikistan and the Kyrgyz Republic are at high risk for landslides.

Northern and central cities have less exposure to natural hazards. Only about 10 percent of the analyzed urban areas have very low exposure. In Turkestan (KAZ) (0.58 percent), Nukus (UZB) (0.73 percent), Aktau (KAZ) (0.86 percent), Karaganda (KAZ) (2 percent), and Pavlodar (KAZ) (2.22 percent), less than 3 percent of the population is exposed to natural hazards, with flooding being the most significant.

Earthquakes are a major threat, with 75.6 percent of the population in the studied urban areas living in earthquake-prone zones. In Tajikistan, the Kyrgyz Republic, and Uzbekistan, 95 percent, 91 percent, and 78 percent of the population, respectively, live in earthquake-prone areas. In Turkmenistan and Kazakhstan, the figures are 52 percent and 28 percent.

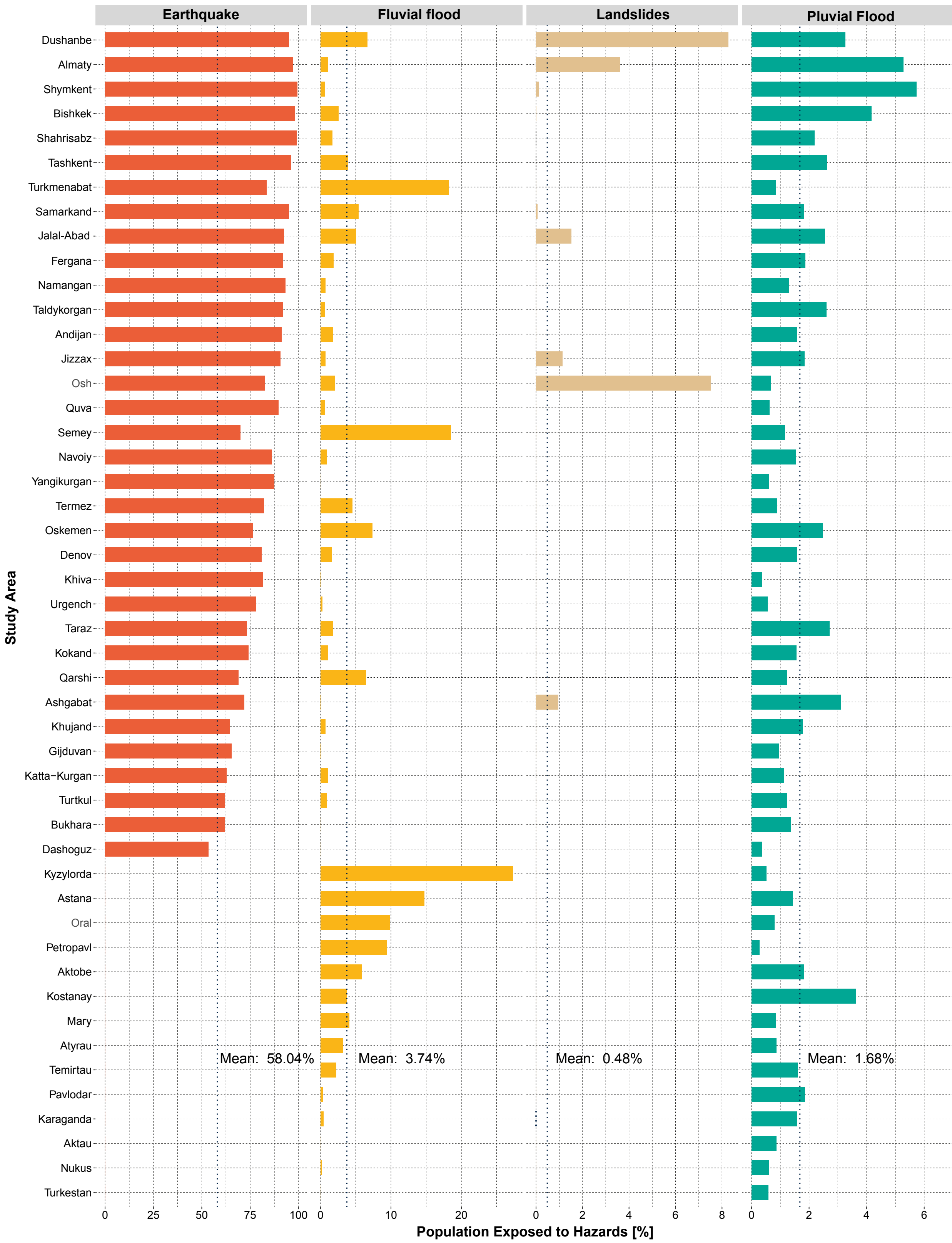
Map 2.11 Area Exposed to Floods in Kyzylorda (KAZ)



Source: GHS-POP R2022A Schiavina et al. 2022; World Bank 2022.

24 Exposure is defined as the percentage of people residing within areas prone to natural hazards such as pluvial flooding, earthquakes, and landslides. This is calculated by dividing the number of inhabitants living within the hazard-prone areas by the total settlement population. Earthquake-prone areas are those that would be affected by strong shaking, and have a peak ground acceleration (PGA) of 9.2 percent. Fluvial and pluvial flood-prone areas are those where the water depth could reach up to 0.5 meters. Landslide-prone areas are those that showed a 30 percent landslide susceptibility, representing a medium-level risk.

Figure 2.9 Population Exposure by Type of Hazard



Source: GHS-POP R2022A Schiavina et al. 2022; World Bank 2022.

In Dushanbe (TJK), Osh (KGZ), and Almaty (KAZ), landslides are the second major threat after earthquakes, affecting 8.27 percent, 7.53 percent, and 3.61 percent of the population, respectively. Other urban areas have less than 2 percent of the population exposed to landslides, which are more likely during spring and summer due to increased rainfall and extreme weather events from climate change.

Kyzylorda (KAZ) (map 2.11), Semey (KAZ), Turkmenabat (TKM), and Astana (KAZ) have the highest flood exposure, with 27.3 percent, 18.47 percent, 18.22 percent, and 14.73 percent of the population affected, respectively. Other cities with significant exposure include Oral (KAZ) (9.82 percent), Petropavl (KAZ) (9.36 percent), and Oskemen (KAZ) (7.33 percent). These results pertain to fluvial floods, as pluvial flood exposure in CA was generally not significant.

Dushanbe (TJK) is the most vulnerable settlement in the region (World Bank 2022). In Dushanbe (TJK), almost the entire urban population (98 percent) is susceptible to earthquakes, while approximately 8 percent is exposed to landslides, 6 percent to fluvial floods, and 3 percent to pluvial floods. After Dushanbe (TJK), the three settlements with the highest cumulative share of the population exposed to natural hazards are Almaty (KAZ), Shymkent (KAZ), and Bishkek (KGZ).

Particulate Matter Emissions[25]

Forty percent of the analyzed cities have a high proportion of per capita emissions of particulate matter (figure 2.10 and 2.11). According to the EDGAR database (Monforti et al. 2021), Temirtau (KAZ) had the highest level of air pollution intensity in the region[26]. This urban area generated 10.4 and 8.5 kg per capita of PM_{10} and $PM_{2.5}$, respectively, followed by Aktau (KAZ) (9 kg PM_{10} and 7.7 kg $PM_{2.5}$), and Aktobe (KAZ) (8.2 kg PM_{10} and 7 kg $PM_{2.5}$).

Among the analyzed settlements, Katta-Kurgan had the lowest relative emissions of PM_{10} and $PM_{2.5}$ pollutants, at 0.3 and 0.2 kg per capita, respectively. Other cities with low levels of pollutant emissions included Navoiy (UZB), (0.36 kg PM_{10} and 0.2 kg $PM_{2.5}$ per capita), and Namangan (UZB), Andijan (UZB), and Kokand (UZB), with almost 0.4 kg PM_{10} and 0.3 kg $PM_{2.5}$ per capita, each. The urban areas of Aktau (KAZ) and Temirtau (KAZ) have almost 30 times more PM_{10} emissions per capita than the area with the lowest emissions (Katta-Kurgan (UZB)).

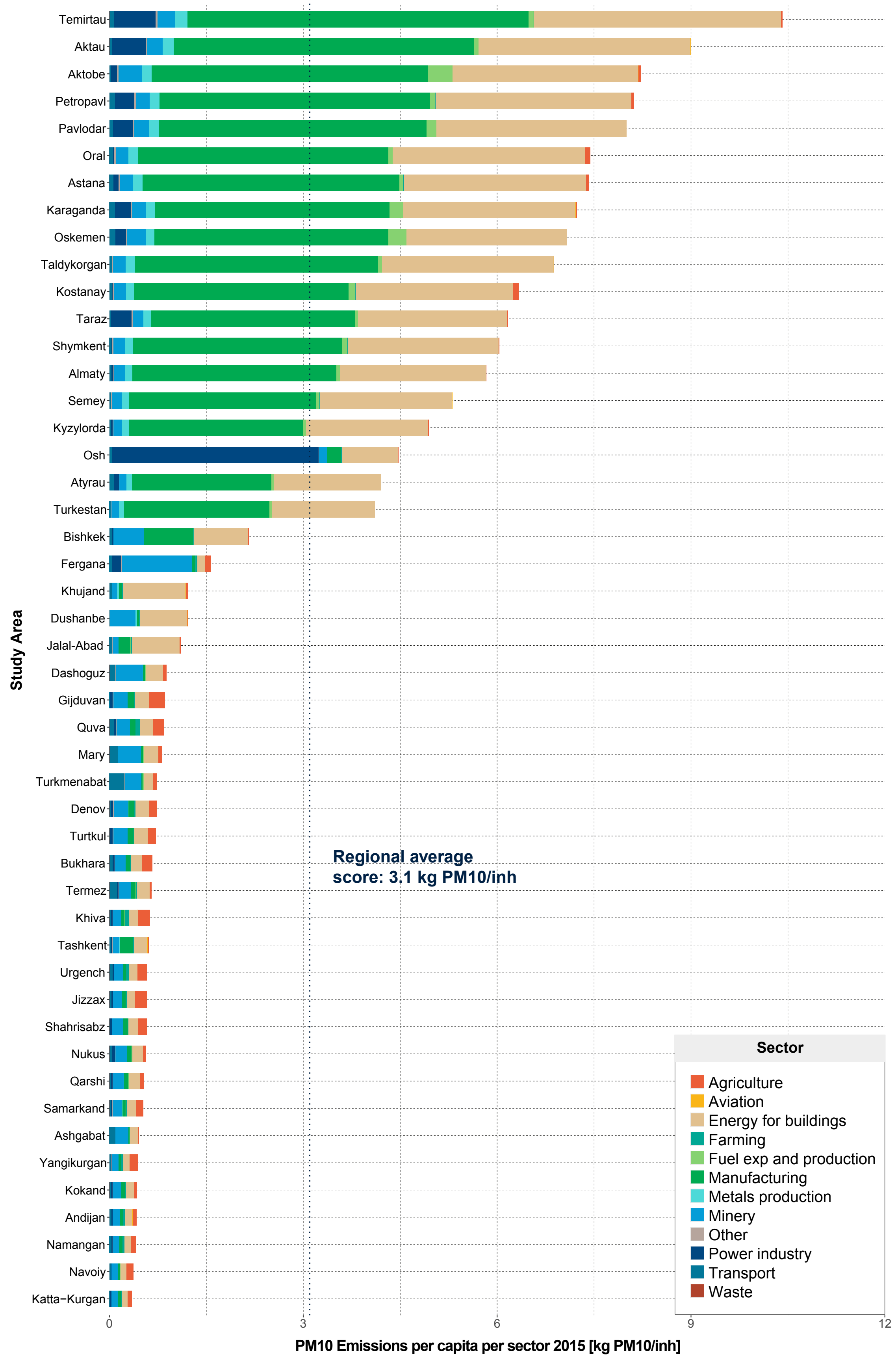
Manufacturing and energy for the construction sector are the major contributors to the emission of particulate matter in the analyzed cities. Figure 2.12 and Figure 2.13 indicate that in 2015, the manufacturing sector was responsible for nearly 45 percent of PM_{10} and 49 percent of $PM_{2.5}$ emissions. Emissions from the construction sector accounted for the second-most significant source, with 37 percent of PM_{10} and 38 percent of $PM_{2.5}$ emissions.

Between 1990 and 2015, the region experienced a decrease in the total emission of primary particulate matter. In the last decade, total $PM_{2.5}$ and PM_{10} emissions decreased by approximately 15.5 and 22 percent, respectively[27]. This downward trend is not common in all cities since some urban areas actually increased their particulate matter emissions. For instance, Aktau (KAZ) recorded the highest growth in emissions, with PM_{10} and $PM_{2.5}$ increasing by 120 percent and 109 percent, respectively. Astana (KAZ) also recorded a notable increase in emissions, with PM_{10} and $PM_{2.5}$ rising by 65.8 and 59 percent.

From 1990 to 2015, the agriculture, fuel production, and construction sectors recorded a significant increase in air pollutants. Agriculture witnessed a staggering surge, amplifying its particulate matter emissions nearly twentyfold. Likewise, emissions resulting from fuel-related activities experienced a substantial uptick of 300 percent, while the energy consumption associated with construction also rose by 125 percent over the period.

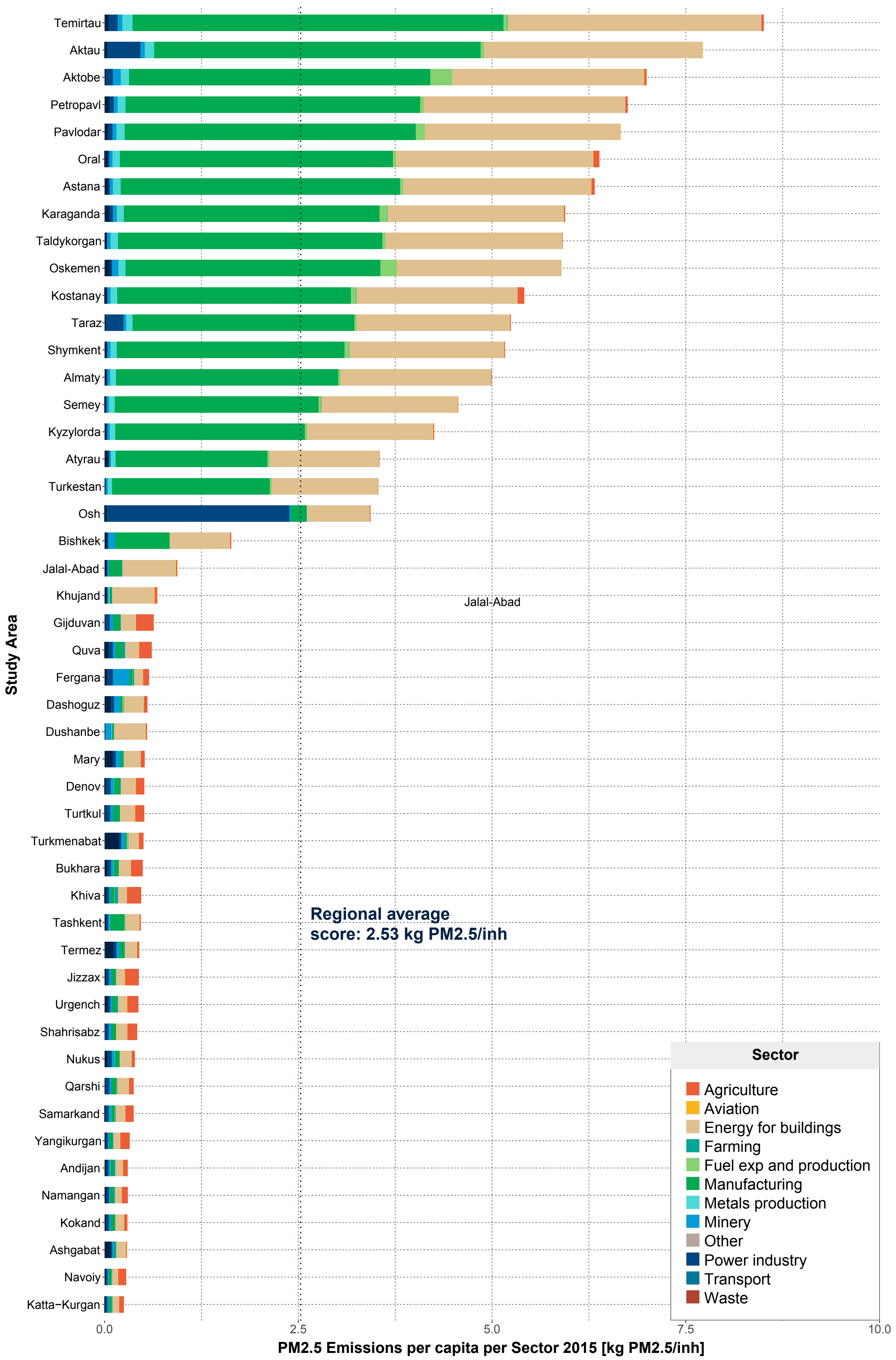
25 While this indicator is useful for assessing the emission of air pollutants, it is important to note that it is not an air quality index. An Air Quality Index (AQI) considers both the concentration of pollutants in the air and the potential health risks those pollutants pose to the population.
26 The analysis only considers emissions produced within the functional urban area. In addition, large-scale biomass burning with savannah burning, forest fires, and sources and sinks from land use, land-use change, and forestry (LULUCF) are excluded. Windblown dust is also not considered.
27 The analysis only considers emissions produced within the functional urban area. In addition, large-scale biomass burning with savannah burning, forest fires, and sources and sinks from land use, land-use change, and forestry (LULUCF) are excluded. Windblown dust is also not considered.

Figure 2.10 Emission of Particulate Matter PM_{10} in the Urban Areas



Source: Monforti 2021.

Figure 2.11 Emission of Particulate Matter $PM_{2.5}$ in the Urban Areas



Source: Monforti 2021.

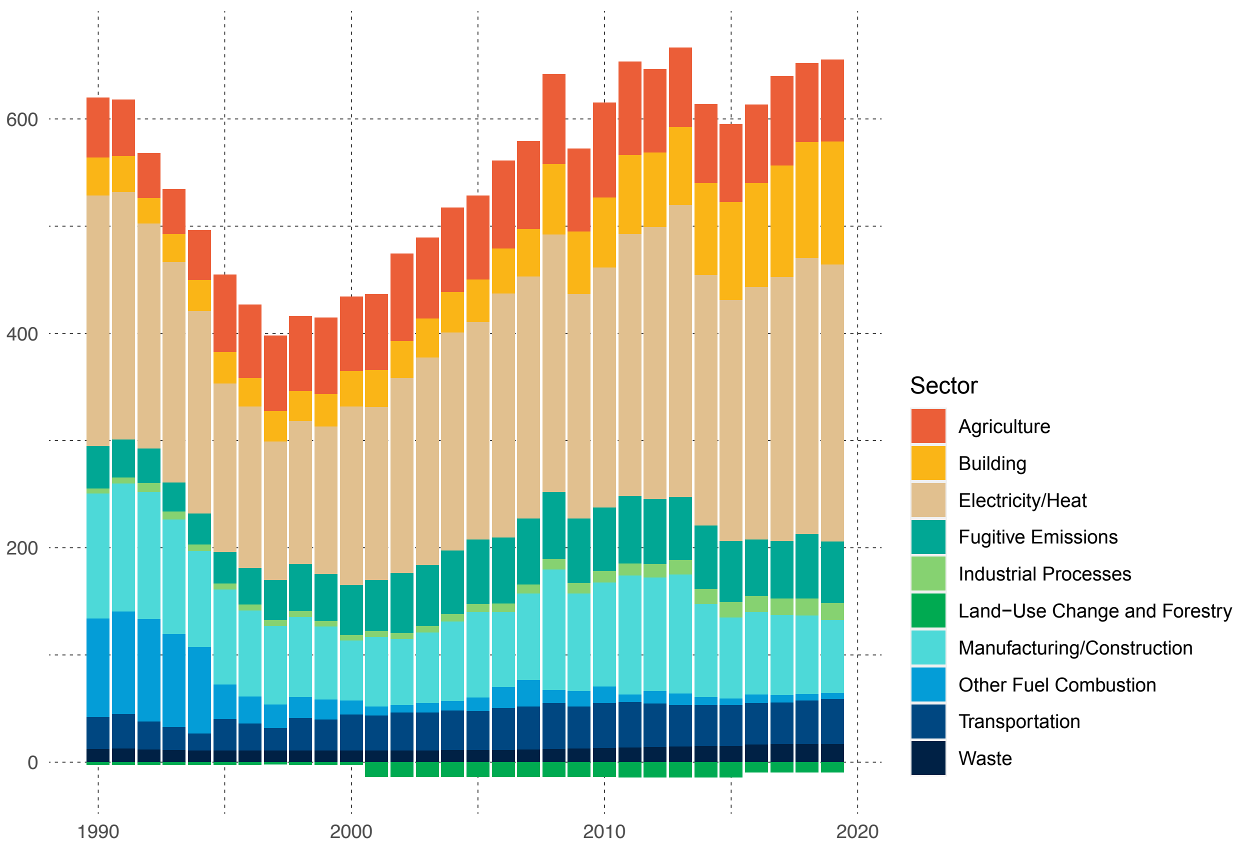
Greenhouse Gas Emissions

CA's greenhouse gas (GHG) emissions increased by 5 percent from 1990 to 2019. Figure 2.12 shows regional CO_2 emissions rising from 617 $MtCO_2e$ in 1990 to 645 $MtCO_2e$ in 2019, despite a dip in the mid-late 90s. However, figure 2.13 indicates varying trends among CA countries. Kazakhstan saw a drop in emissions followed by an increase from 1999 to 2013, then fluctuating levels. The Kyrgyz Republic and Tajikistan experienced a significant decline before 1995, stability until around 2010, and then a gradual increase. Uzbekistan's GHG emissions fluctuated from 1990 to 2019, ending slightly higher. Turkmenistan consistently increased its emissions, reaching about 160 $MtCO_2e$ by 2019.

The increase in national GHG emissions is mainly due to the energy sector, which accounted for 31% of emissions in 2018, with the electricity and heat sector generating 202 $MtCO_2e$ (Climate Watch Historical database). Emission sources vary by country. In Kazakhstan, the electricity and heat sector contributed 43 percent of emissions, and construction 13 percent. In Uzbekistan, the electricity and heat sector and agriculture each contributed about 30 percent and 20 percent, respectively. In Tajikistan, agriculture was the primary source at 39 percent, with electricity and heat, construction, and industrial processes collectively at 30 percent. In the Kyrgyz Republic, buildings contributed 42 percent and agriculture 36 percent. In Turkmenistan, fugitive emissions comprised 46%, followed by the electricity and heat sector at 16 percent.

Overall, Turkmenistan and Kazakhstan exhibit the highest carbon intensity within the region. Data for 2015[28] reveals that Turkmenistan and Kazakhstan emitted around 35.2 $MtCO_2e$ and 14.6 $MtCO_2e$ per capita, respectively. Uzbekistan, the Kyrgyz Republic, and Tajikistan showed a lower carbon intensity, below the regional average of 11.8 $MtCO_2e$. In those countries it was estimated at 5, 2.6, and 1.4 $MtCO_2e$, respectively.

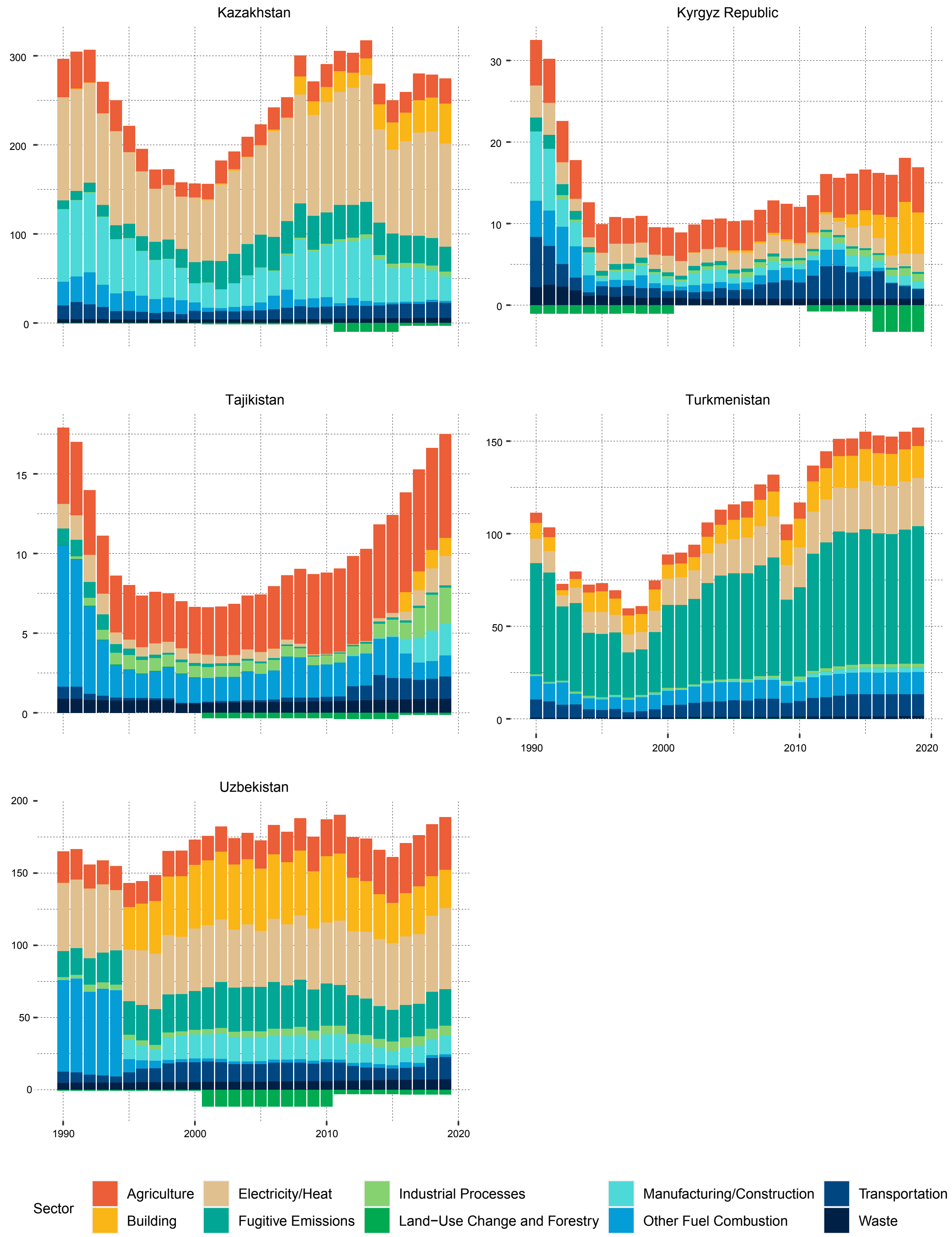
Figure 2.12 GHG Emissions by Sector for Central Asia



Source: Climate Watch 2022.

28 Calculations based on Climate Watch and World Population Prospects.

Figure 2.13 GHG Emissions by Sector Per Country



Source: Climate Watch 2022.

More than half of the analyzed settlements have GHG emissions exceeding the ECA regional benchmark. Figure 2.14 shows that about 65 percent of the analyzed urban areas recorded carbon emissions surpassing the Europe and Central Asia (ECA) average of 6.7 tCO_2e per capita. In 2015, Aktau (KAZ) had the highest per capita emissions at 53.3 tCO_2e, followed by Temirtau (KAZ) with 48 tCO_2e, and Karaganda (KAZ) with 40 tCO_2e. Conversely, urban areas in Tajikistan and the Kyrgyz Republic had the lowest GHG per capita emissions. Dushanbe (TJK) recorded the lowest at 1.29 tCO_2e, followed by Khujand (TJK) with 1.29, Jalal-Abad with 1.8, and Bishkek (KGZ) with 2.8 tCO_2e.

The waste and fuel production sectors show the highest increases in CO_2 emissions. According to Monfortu et al. (2021), the fuel production sector recorded the highest increase in GHG emissions, rising from 49.5 tCO_2e per capita in 1990 to 98.7 in 2015. The waste sector followed with a 22 percent increase in per capita emissions compared to 1990 levels. The farming, aviation, and agriculture sectors also experienced significant growth (8.8, 8.7, and 7.3 percent respectively) between 1990 and 2015.

Energy Mix in Central Asia

Electricity generation in the region increased by 66 percent over the last two decades, from 91.5 TWh in 2000 to 228.7 TWh in 2019. Despite this growth, the region remains heavily dependent on fossil fuels. From 1990 to 2019, about 75 percent of electricity was generated from natural gas (38 percent) and coal (34 percent). By 2019, natural gas's share rose to 42.9 percent, an increase of 26.7 TWh.

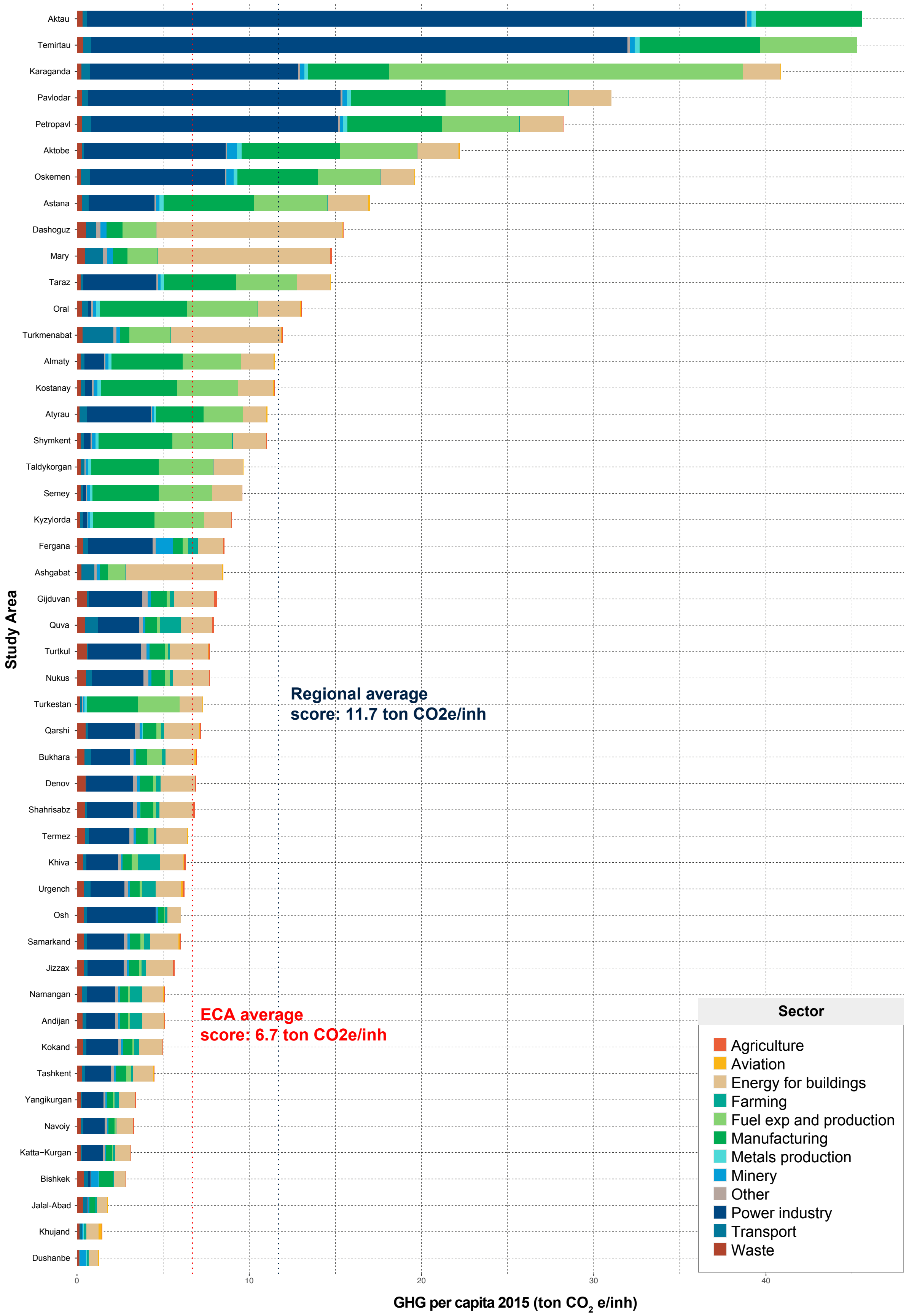
Renewable energy production increased by 25 percent between 1990 and 2019, accounting for 22.3 percent of electricity generation (51 TWh). In 2019, hydropower dominated, producing 49 TWh (96 percent), while solar and wind contributed minimally, generating 0.83 TWh (1.63 percent) and 0.70 TWh (1.39 percent), respectively. The Kyrgyz Republic transitioned from carbon-based to renewable electricity, with hydroelectric power rising from 63.48 percent in 1990 to 91.6 percent in 2019, while coal and natural gas shares decreased.

Despite advancements in renewables, CA's electricity and heat generation heavily relies on fossil fuels. Combined heat and power plants (CHPs) and household heating practices primarily use coal, with major plants shifting towards natural gas. In Turkmenistan, 99 percent of electricity generation relies on natural gas, and in Uzbekistan, it accounts for 85 percent[29].

In 2019, the region generated about 98.8 TWh of electricity from natural gas. Uzbekistan led with 54 percent of the region's natural gas-based electricity, followed by Turkmenistan (25 percent) and Kazakhstan (20 percent). Most hydropower infrastructure is in Kazakhstan, the Kyrgyz Republic, and Tajikistan (UNECE 2007). The Kyrgyz Republic and Tajikistan generate 91-93 percent of their electricity from hydropower but face critical shortages in winter due to reduced river flow, a situation likely worsened by climate change. This results in insufficient electricity, and leads to widespread energy shortages, a situation that might be exacerbated in the future due to climate change (Times of Central Asia 2024)[30].

29 See IEA Energy Statistics Data Browser.
30 Climate scientists predict that the flow of Kyrgyzstan's main river will decrease by 15–50 percent after 2030. That means the already low water levels in Kyrgyzstan's largest reservoirs could become even lower.

Figure 2.14 Greenhouse Gas Emissions Within the Functional Urban Areas



Source: Monforti 2021; Global Forest Watch 2018; GHS-POP R2022A Schiavina et al. 2022.

Economic Activity

The region's economy is transitioning from a centrally planned model to an open market, accelerating urbanization. Economic growth has increased over the last two decades due to commodity-based strategies, such as exporting hydrocarbons and minerals like oil, natural gas, aluminum, gold, cotton, and other metals. The share of agriculture in the regional economy has declined, with the unweighted average share of agriculture, forestry, and fishing in GDP dropping from 33 percent in 1990 to 14 percent in 2019[31].

The relationship between economic growth and urbanization in CA is not linear. In predominantly rural countries like the Kyrgyz Republic and Tajikistan, urbanization is slow, while in Kazakhstan and Uzbekistan, it is slightly declining (Baeumler et al. 2021). However, the region's large and medium-sized cities are experiencing faster population growth than those in other regions, such as Eastern Europe, likely due to improved job opportunities and amenities resulting from the economic shift from agriculture to industry, commerce, and services (Restrepo et al. 2017).

Economic Activity Change

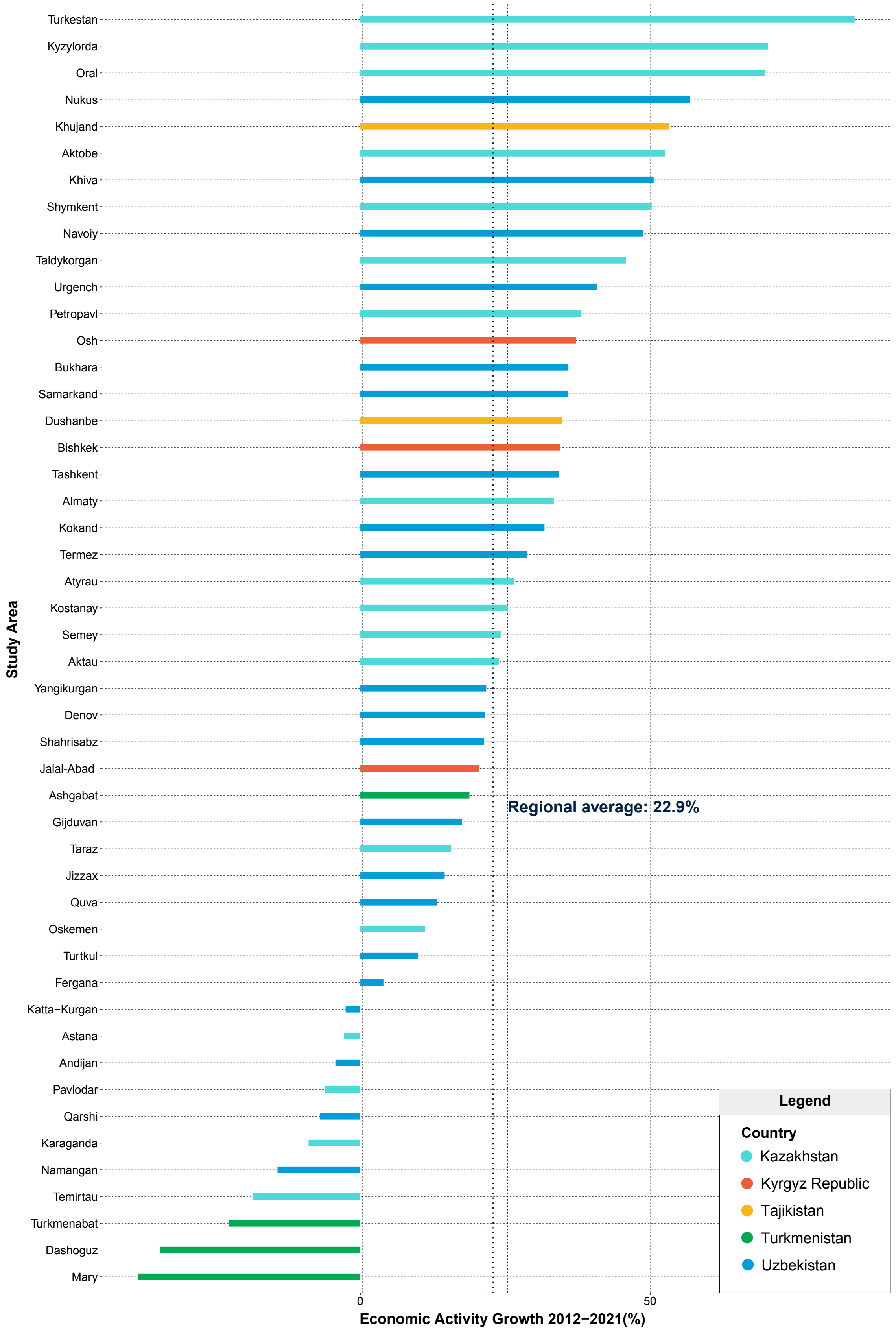
Nighttime lights-based economic activity in CA shows positive change, with the largest cities being the main economic drivers. However, economic activity growth is uneven. From 2012–21, the average annual growth of economic activity, measured using nighttime lights (NTL)[32] as a proxy for the 48 cities, was 2.42 percent.

There are significant disparities: 64 percent of the cities saw growth, while 36 percent experienced a decline. Major cities like Almaty (KAZ), Dushanbe (TJK), Bishkek (KGZ), and Tashkent (UZB) had average annual growth rates of 3.9 to 4.5 percent, while in Ashgabat (TKM), it increased by 2 percent. An exception is Astana (KAZ), which saw a decrease of -1.1 percent annually. Turkestan (KAZ) had the highest average increase in economic activity with an annual growth rate of 17 percent, followed by Oral (KAZ) at 10 percent and Kyzylorda (KAZ) at 9.5 percent. About 10 percent of the settlements had limited growth, with annual rates below 2 percent. Taraz (KAZ), Jizzax (UZB), and Shakhrisabz (UZB) had the lowest growth rates at 0.7 percent, 0.8 percent, and 1 percent, respectively. Mary (TKM), Dashoguz (TKM), and Temirtau (KAZ) recorded negative annual rates of 3.7, 3.6, and 3.5 percent.

31 See Agriculture, forestry, and fishing, value added (percent of GDP) | Data.

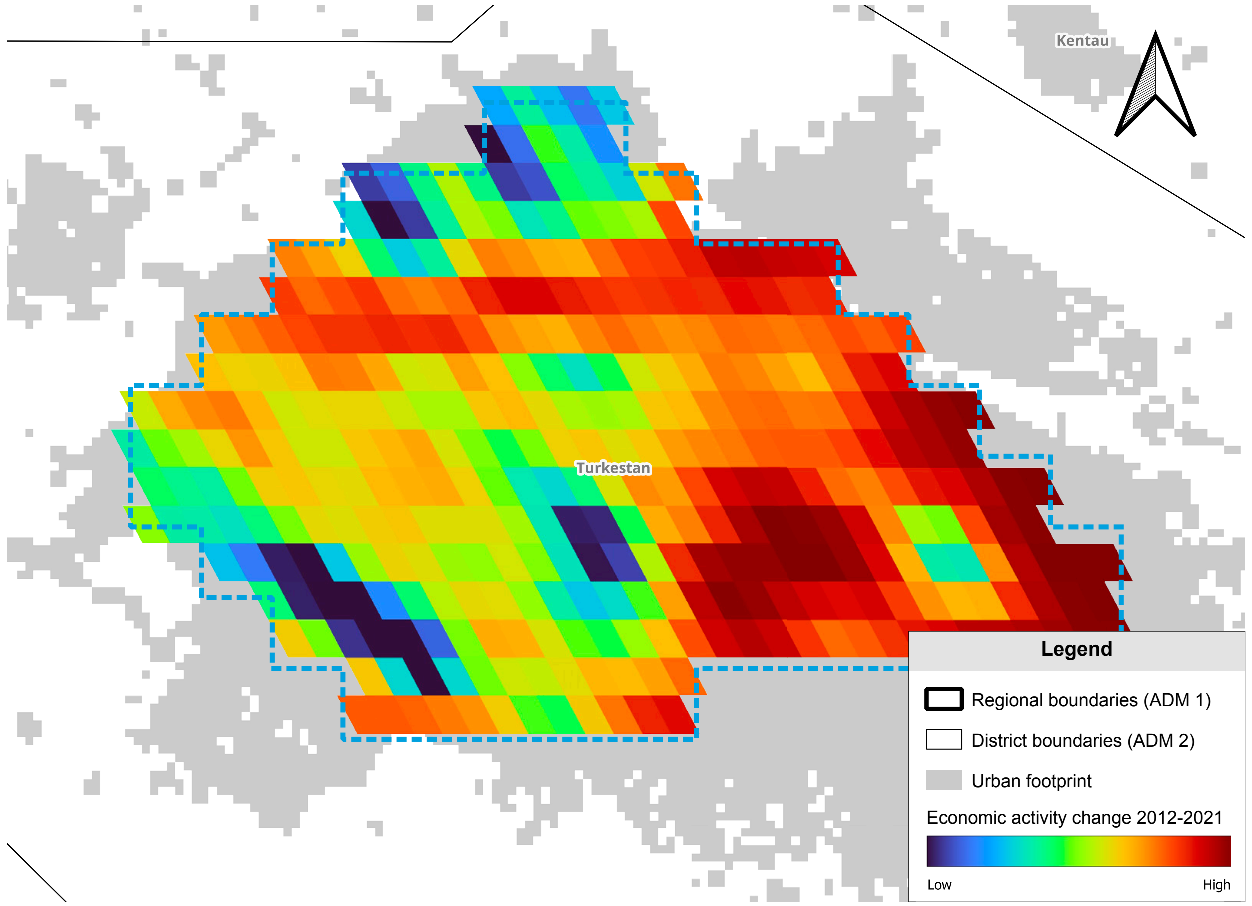
32 Nighttime light (NTL) serves as a proxy indicator for economic performance in regions where data availability is limited as noted by (Barzin et al. 2022). Research in this field has consistently demonstrated correlations between NTL emissions and several economic variables, including establishment and employment density. NTL is a useful tool for estimating subnational GDP levels and economic density (McCord and Rodriguez-Heredia 2022), although its accuracy diminishes when measuring year-on-year growth rates. NTL can still be used to predict GDP at the subnational level, but it is important to acknowledge its limitations, as other studies reveal that NTL is not the best proxy to estimate productivity in terms of wage incomes (Mellander et al. 2015).

Figure 2.15 Average Annual Growth of Economic Activity Between 2012 and 2021



Source: Annual Time Series of Global VIIRS Nighttime Lights Derived from Monthly Averages NOAA, Earth Observation Group (Elvidge et al. 2021).

Map 2.12 Change in Economic Activity from 2012 to 2021 in Turkestan (KAZ)



Source: NOAA, Earth Observation Group (Elvidge et al. 2021).

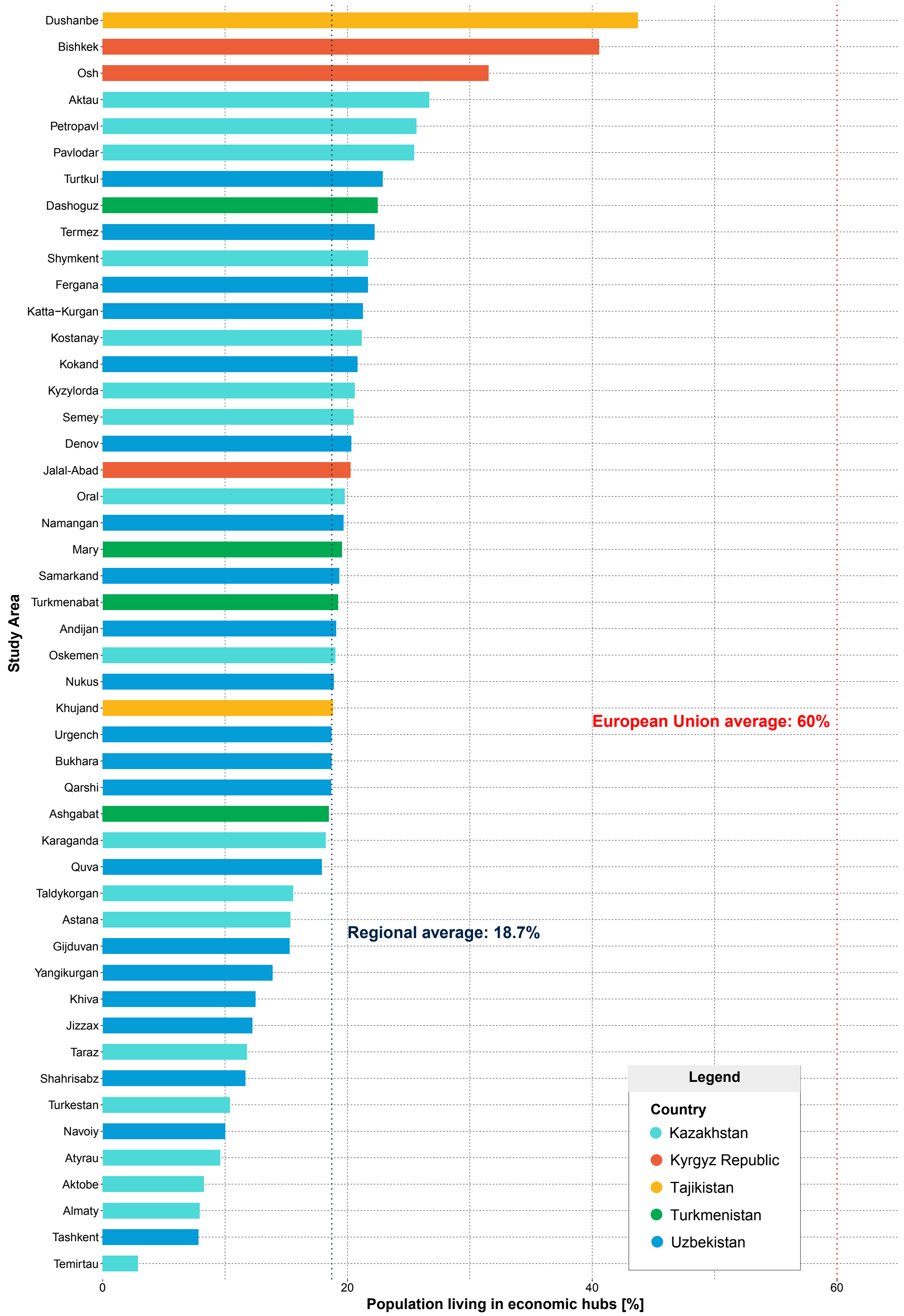
Job/Housing Balance

The job/housing balance in CA cities is low, with only about 19 percent of the population living near job opportunities[33], far below the recommended 60 percent (UN-Habitat 2023) (figure 2.16). Nationally, aggregated results show Tajikistan having the highest job/housing balance at 31 percent, followed by the Kyrgyz Republic at 30 percent. In Turkmenistan, 20 percent of the population lives within economic clusters, while Kazakhstan and Uzbekistan have lower shares at 16.6 percent and 17.3 percent, respectively. At the city level, Dushanbe (TJK), Bishkek (KGZ), and Osh (KGZ) have the highest shares of people living within economic clusters, with 43.7 percent, 40 percent, and 31 percent, respectively, although this still fall short of international standard. The lowest proportions are in Temirtau (KAZ) at 2.9 percent, Tashkent (UZB) at 7.8 percent, and Almaty (KAZ) at 7.9 percent (figure 2.16).

City size does not impact the job/housing balance in CA. In large settlements, 23 percent of the population lives in high economic activity areas, while medium and small settlements have 19 percent and 17 percent, respectively. These findings indicate that CA cities have monofunctional areas and large peripheral populations, with high economic activity concentrated in central areas and minimal activity in the outskirts. Improvement could come from supporting affordable inner-city housing, promoting mixed-use developments, and encouraging economic activities in residential areas.

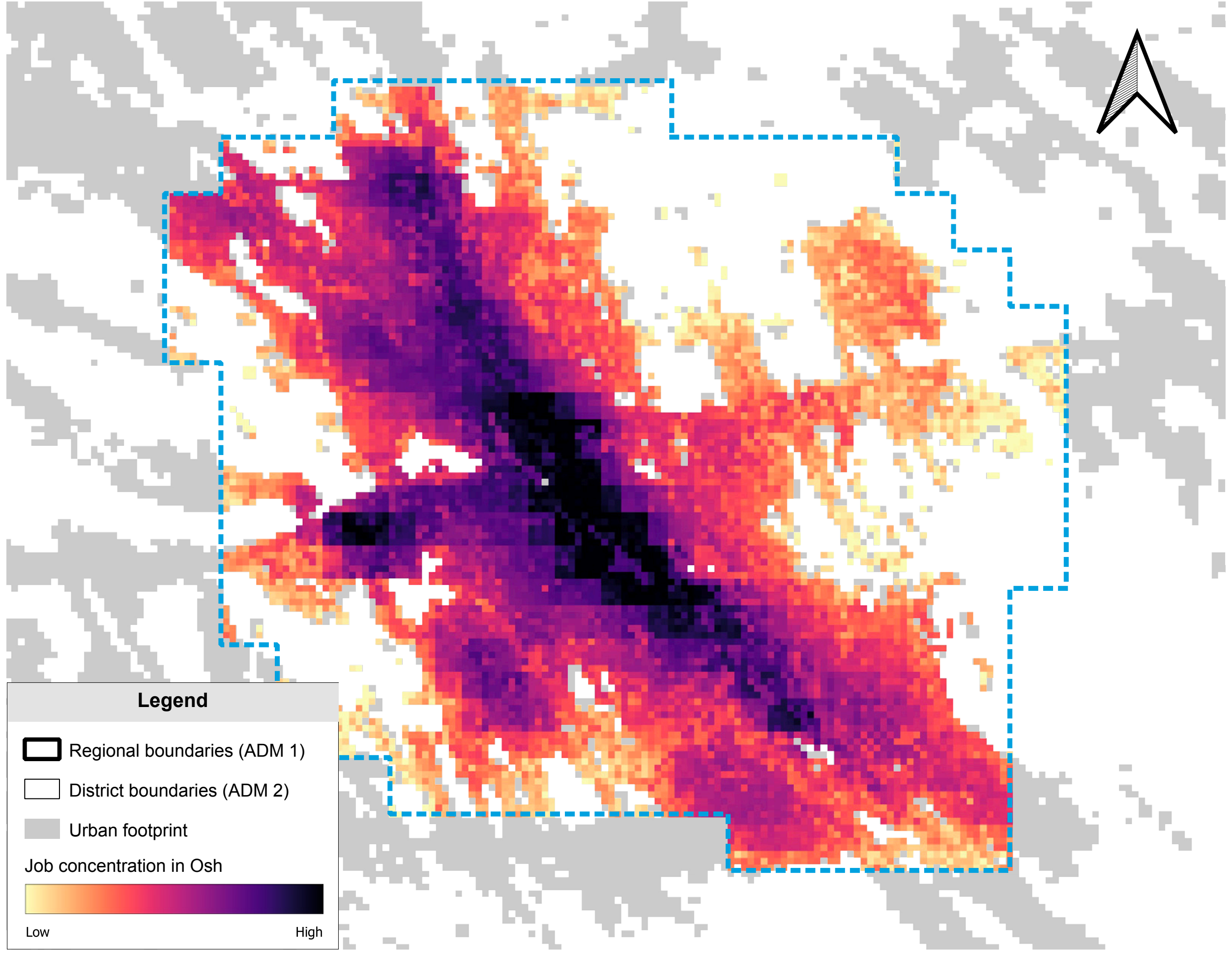
33 The definition of the economic clusters is based on the distribution of the employment concentration within the study areas. The employment concentration combines data on build-up area, population density, nighttime lights, vegetation intensity (NDVI), existing water bodies, and points of interest (OSM). Thus, economic clusters are identified as areas with employment concentration exceeding 3 standard deviations. All regions below this cut-off value were not considered economic clusters. For further details, please refer to appendix A.

Figure 2.16 Share of Population Living Within Economic Activity Clusters



Source: GHS-POP R2022A Schiavina et al. 2022; GHS-BUILT-S R2022A Pesaresi et al. 2022; Open Street Maps.

Map 2.13 Job Concentration in Osh (KGZ)



Source: GHS-POP R2022A Schiavina et al. 2022; GHS-BUILT-S R2022A Pesaresi et al. 2022; Open Street Maps.

Urban Mobility

Efficient, sustainable cities reduce travel distances and times by ensuring adequate density, balanced private and public services, and nearby urban amenities. They implement efficient public transportation and nonmotorized alternatives on a well-connected street network. Compact cities with a mix of population density, amenities, jobs, services, and sustainable mobility systems lower transportation time and cost, reducing negative environmental and social impacts.

Proximity to transportation systems, urban accessibility, and interconnection density can assess a city's mobility profile. When data on travel time, cost, and environmental impact are unavailable, these indicators can predict mobility challenges. This section presents results for the first two indicators, while the third is discussed under Public Services and Amenities, as mobility also reflects the level of public services available.

Accessibility to Bus stops and Bicycle Parking

Motorized transport, whether private vehicles or public transportation, dominates urban mobility in this region. Despite structured high-capacity public transportation options like trolleys and natural gas buses, most people use low-capacity, highly polluting options such as old private vehicles or public minivans called *Marshrutkas* (photo 2.1). This is due to factors like narrow, poor-quality roads in low-density areas, the spatial distribution of jobs and social infrastructure, insufficient high-capacity transport coverage, and low fuel costs (Yang 2019).

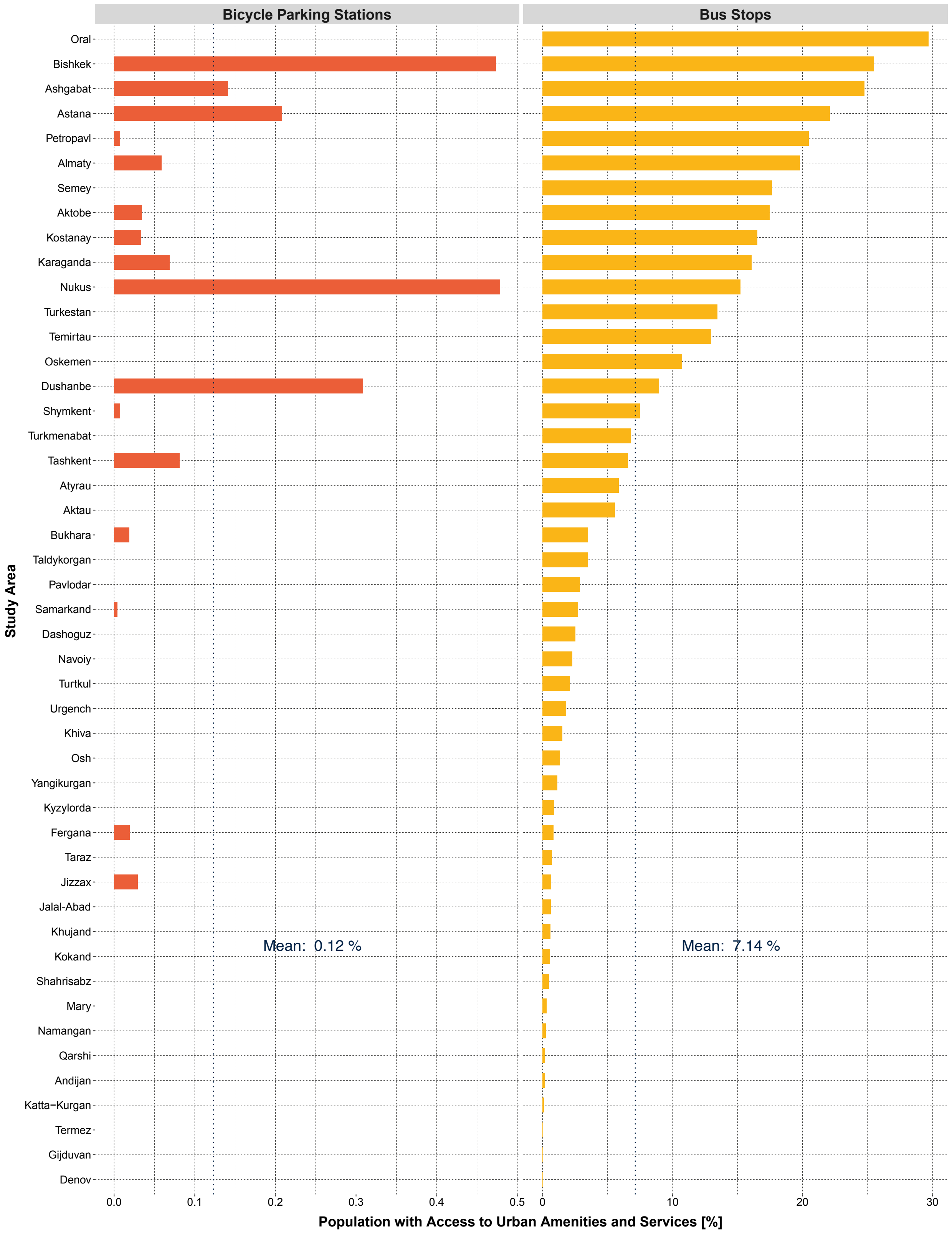
Photo 2.1 Trolleybus in Bishkek (KGZ)

Source: © CARLCities / World Bank. Further permission required for reuse.

Most urban areas in CA have insufficient access to public transportation, with only 7 percent of the population living within walking distance of bus stops. However, there are significant differences among cities. Oral (KAZ), Bishkek (KGZ), and Ashgabat (TKM) have the best access, with an estimated 29.7, 25.4, and 24.7 percent of their populations living close to bus stops. In contrast, Gijduvan, Termez, and Denov in Uzbekistan have less than one percent proximity (0.05, 0.05, and 0.04 percent, respectively), and Quva (UZB) was the only settlement with no bus stops within walking distance.

The bicycle parking indicator shows very low accessibility[34] across all urban areas, with fewer than 1 percent of the population having walking access to bicycle parking. Nukus (UZB) and Bishkek (KGZ) have the highest rates at 0.47 percent, followed by Dushanbe (TJK) at 0.3 percent. Tashkent (UZB) and Astana (KAZ) have only 0.08 and 0.2 percent, respectively. Nearly 66 percent of the settlements lack bicycle parking facilities within walking distance.

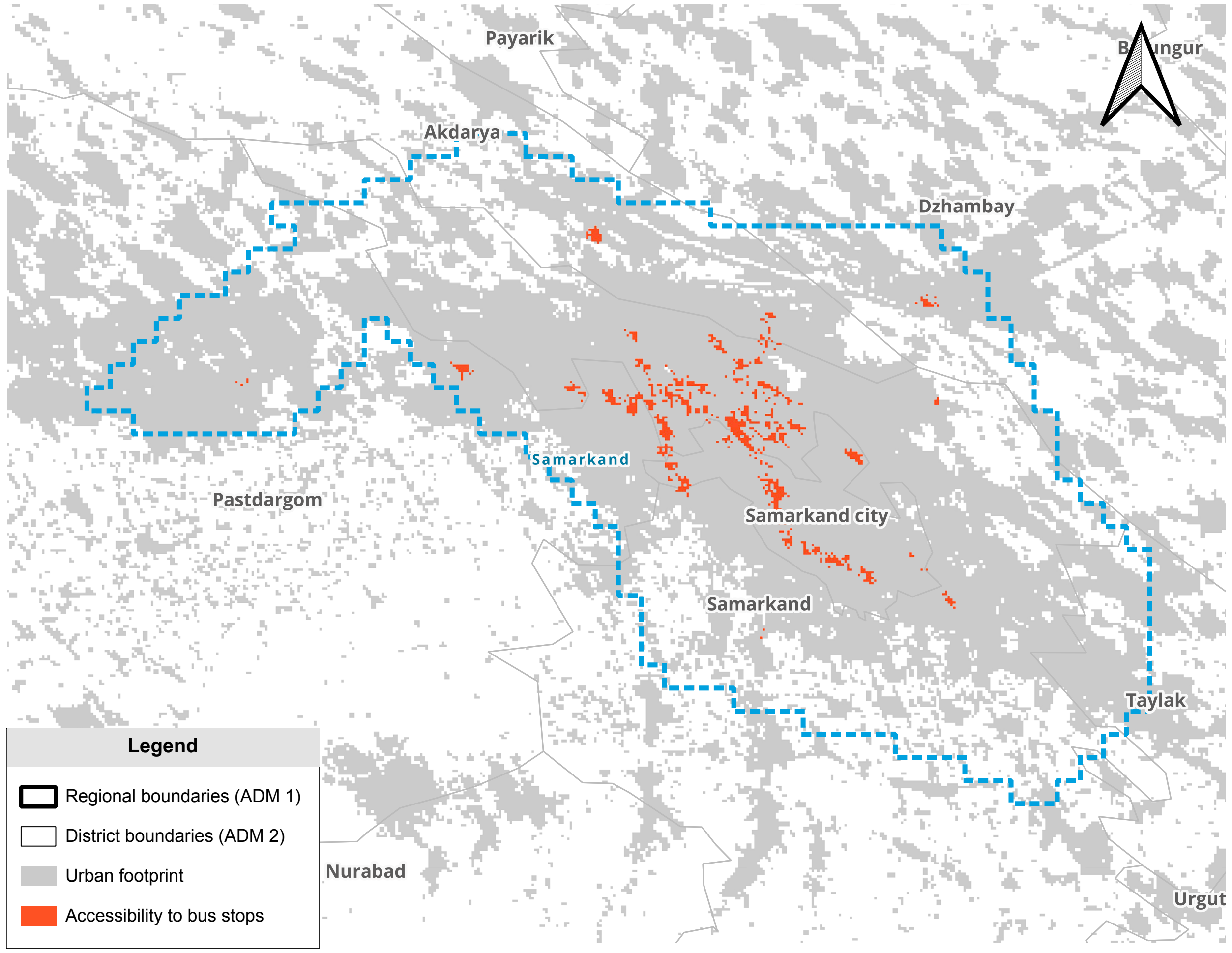
Figure 2.17 Urban Mobility Infrastructure in CA Cities



Source: GHS-POP R2022A Schiavina et al. 2022; Open Street Maps.

34 According to the Institute of Transportation and Development Policy's transit-oriented development (TOD) standard, bicycle parking is considered accessible if it is within a distance of 100 meters.

Map 2.14 Accessibility to Bus Stops and Bicycle Parking in Samarkand (UZB)



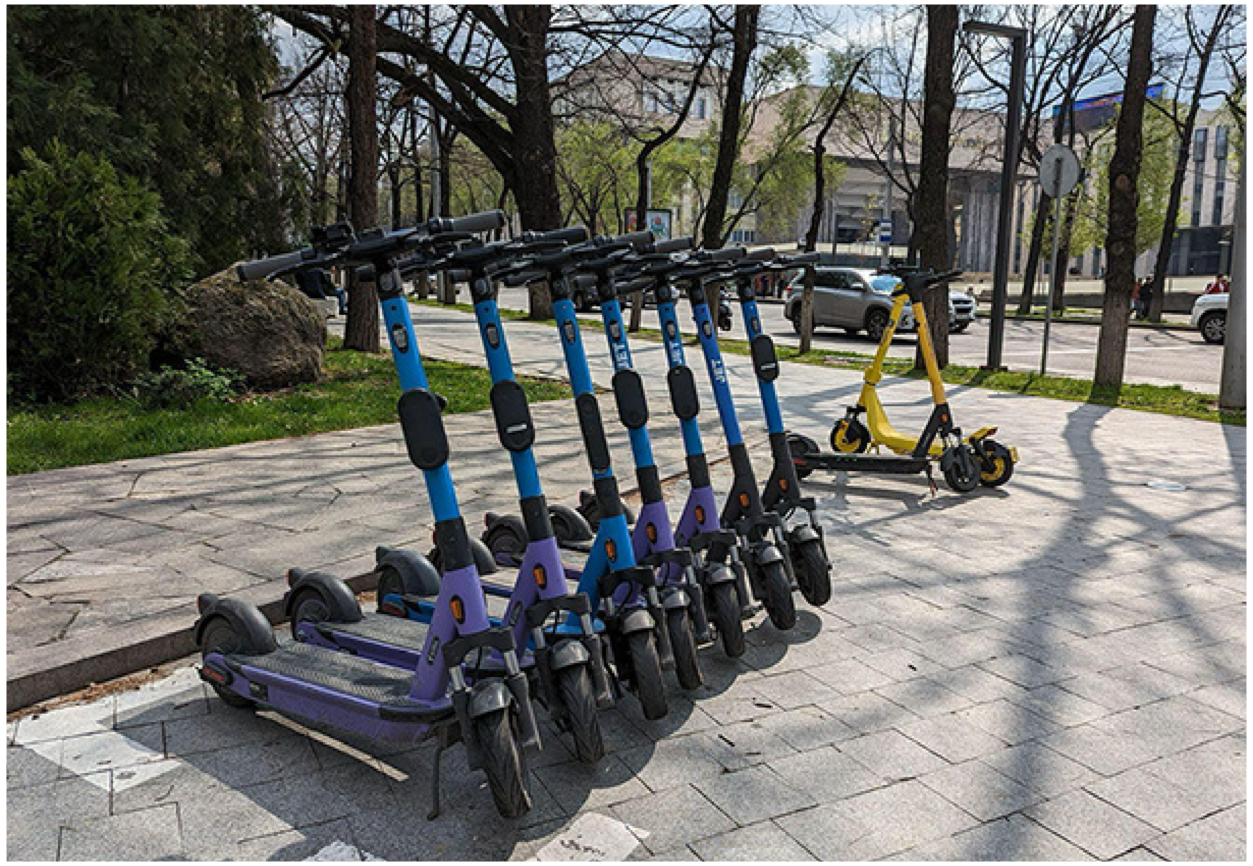
Source: GHS-POP R2022A Schiavina et al. 2022; Open Street Maps.

Intersection Density

Most cities in the region have dense street grids that promote walkability and enable fluent movement in multiple directions. About 70 percent of the analyzed urban areas have an intersection density[35] above the international benchmark of 100 intersections/km² (figure 2.18). Kazakhstan and Uzbekistan cities have high intersection densities, averaging 259 and 130 intersections/km², respectively. The Kyrgyz Republic, Turkmenistan, and Tajikistan cities have lower densities, with 191, 158, and 184 intersections/km², respectively. The highest densities are in Astana (KAZ) with 353 intersections/km², Ashgabat (TKM) with 290, Atyrau (KAZ) with 264, Aktobe (KAZ) with 263, and Oskemen (KAZ) with 251 intersections/km². The lowest densities are in Yangikurgan (UZB) with 23 intersections/km², Denov (UZB) with 29, Gijduvan (UZB) with 38, Termez (UZB) with 41, and Kokand (UZB) with 43 intersections/km². These findings suggest that the urban structure in most cities is adequate for walking, biking, and small-scale electric scooters (photo 2.2).

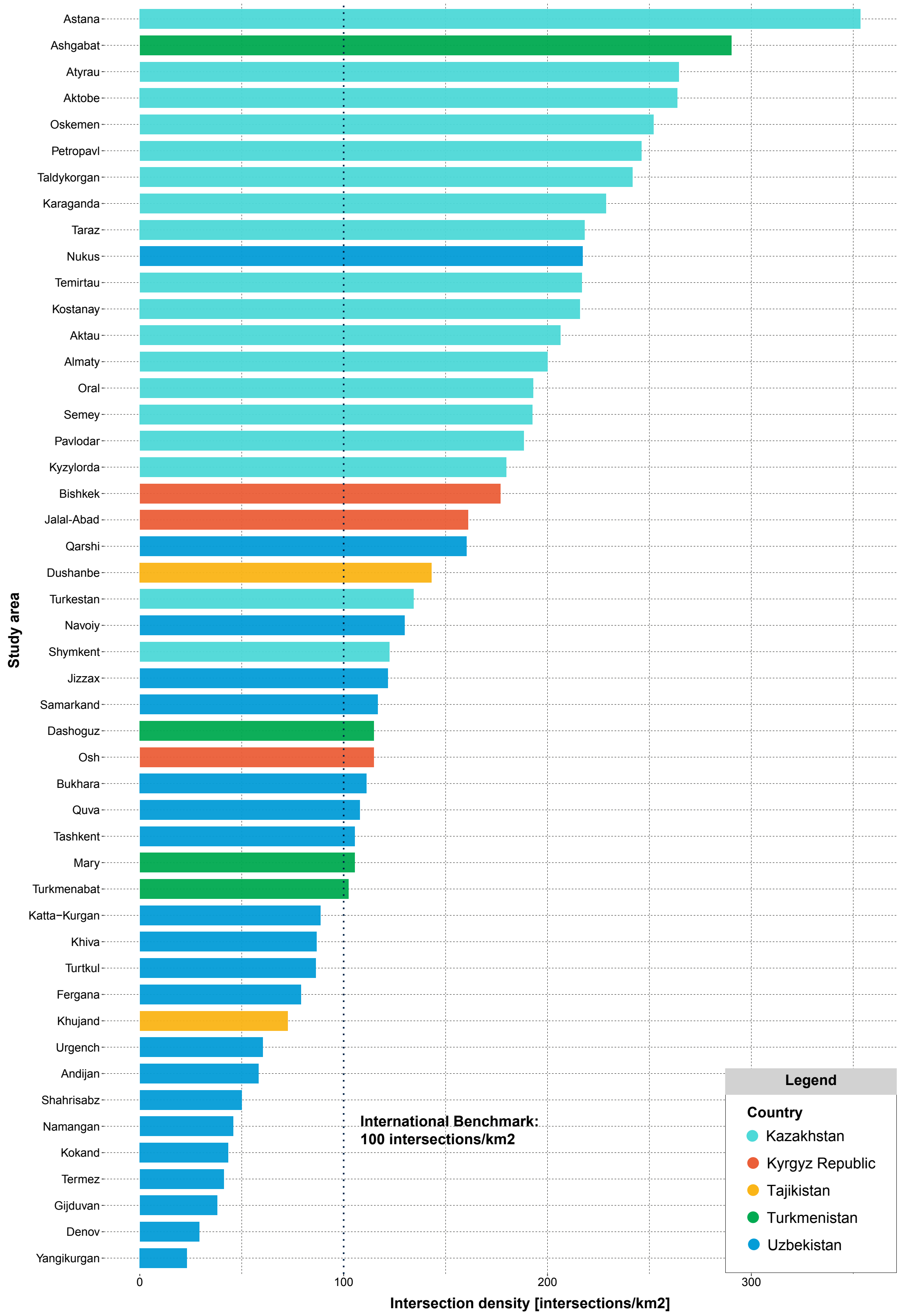
35 The intersection density was calculated by dividing the number of intersections and the built-up area.

Photo 2.2 E-Scooters as A Micromobility Alternative in Central Asia



Source: CARL-Cities / World Bank. Further permission required for reuse.

Figure 2.18 Intersection Density in CA Cities



Source: Open Street Maps.

Regional Takeaways

The CARL-Cities study shows that cities in this region have not yet realized their full economic, social, and environmental potential. Common patterns across the five countries include rapid urbanization, urban expansion, uneven densification, limited access to services, uneven economic development, high greenhouse gas emissions, and climate hazards.

Central Asia is urbanizing rapidly. Between 1990 and 2020, the population in the 48 urban areas studied grew by an average of 36.3 percent. A third of these areas saw population growth above 60 percent, while only 16 percent experienced a decline. This growing urban population increases the demand for infrastructure and services.

CA's urban areas have relatively low population density, averaging 1,593 inhabitants per square kilometer. Densities range from 782 in Oral (KAZ) to 4,256 in Dushanbe (TJK), compared to 9,068 in Barcelona. Between 1990 and 2020, 58% of urban areas saw density increases, while 42% saw decreases. The most significant decreases were in the Kyrgyz Republic, where all its cities witnessed declining density, and Kazakhstan where it is 60 percent.

Urban areas in CA are expanding rapidly, though less so than in Europe, Asia, and Africa (He et al. 2019.[36]). From 1990 to 2020, the studied urban areas expanded by an average of 36.3 percent, consuming 546 square kilometers of land. Large urban areas drove this expansion, accounting for nearly half of the region's land consumption and growing faster in both population (1.9 percent annual growth) and urban footprint (1.2 percent annual land consumption).

The urban areas of CA exhibit unsustainable spatial expansion patterns. About 58.3 percent show leapfrog development,[37] 39.6 percent have fragmented development, and only 2.1 percent display continuous peri-urban expansion. This significant expansion heightens challenges in providing access to infrastructure, services, employment, and efficient land use. These challenges lead to negative environmental impacts, such as higher greenhouse gas emissions from construction and transport. Urban growth also negatively affects access to essential amenities and public green spaces, increasing exposure to the UHI effect.

CA cities are economic drivers, but growth trends vary, and they have not reached their full potential. From 2012-21, the average annual growth of economic activities in the 48 cities was 2.42 percent, measured by nighttime lights as a proxy. However, 64 percent of the cities are growing, while 36 percent are in decline. The largest capitals (Almaty, Dushanbe, Bishkek, and Tashkent) show favorable growth, ranging from 3.9 percent to 4.5 percent per annum, except for Astana (KAZ), which saw a decrease of -1.1 percent annually.

The job/housing balance[38] in CA cities is extremely low, with only about 19 percent of the population living near job opportunities, far below the recommended 60 percent. Even in the best-performing cities like Dushanbe (TJK), Bishkek (KGZ), and Osh (KGZ), only 30-43 percent of the population is within economic clusters. This reflects the monofunctional land use in CA cities. Improving the job/housing balance could be achieved by promoting affordable inner-city housing, mixed-use developments, and encouraging complementary activities within economic hubs.

Most cities in the region have dense street grids that promote walkability and multi-directional movement. About 70 percent of the analyzed urban areas have an intersection density above the international benchmark of 100 intersections per square kilometer (UN-Habitat 2023). Kazakhstan and Uzbekistan have high intersection densities, while the Kyrgyz Republic, Turkmenistan, and Tajikistan have lower densities. Most urban areas have moderate accessibility to bus stops, with Oral (KAZ) performing best at 29.7 percent of its population living close to bus

36 Based on the United Nations Definition of Regions.
37 Leapfrog development shows a discontinuous urban fabric characterized by isolated built-up patches or "islands" that are separated from the urban core. This was measured by estimating the fractal degree of the settlement's urban footprint.
38 This refers to the share of population residing in the study areas who are living within economic clusters.

stops. However, access to bicycle parking is much lower across CA's urban areas.

Almost all studied urban areas have critically low access to urban services and amenities such as health and education facilities, public spaces, and cultural venues. The regional average accessibility to educational facilities is 16.5 percent, to health facilities is 6.7 percent, and to public spaces is only 8 percent.

Most of the 48 CA cities have very low provision of urban green areas, averaging 7.6 square meters per capita compared to the European average of 18.2 m². This shortage negatively impacts the environment, increases vulnerability to heat islands, and lowers the quality of life.

CA cities face significant climate and environmental challenges, including natural disasters, UHI effects, and air pollution. They are prone to earthquakes (58 percent), landslides (0.4 percent), fluvial floods (3.7 percent), and pluvial (1.7 percent) floods. About 17 percent of the population is exposed to the UHI effect.

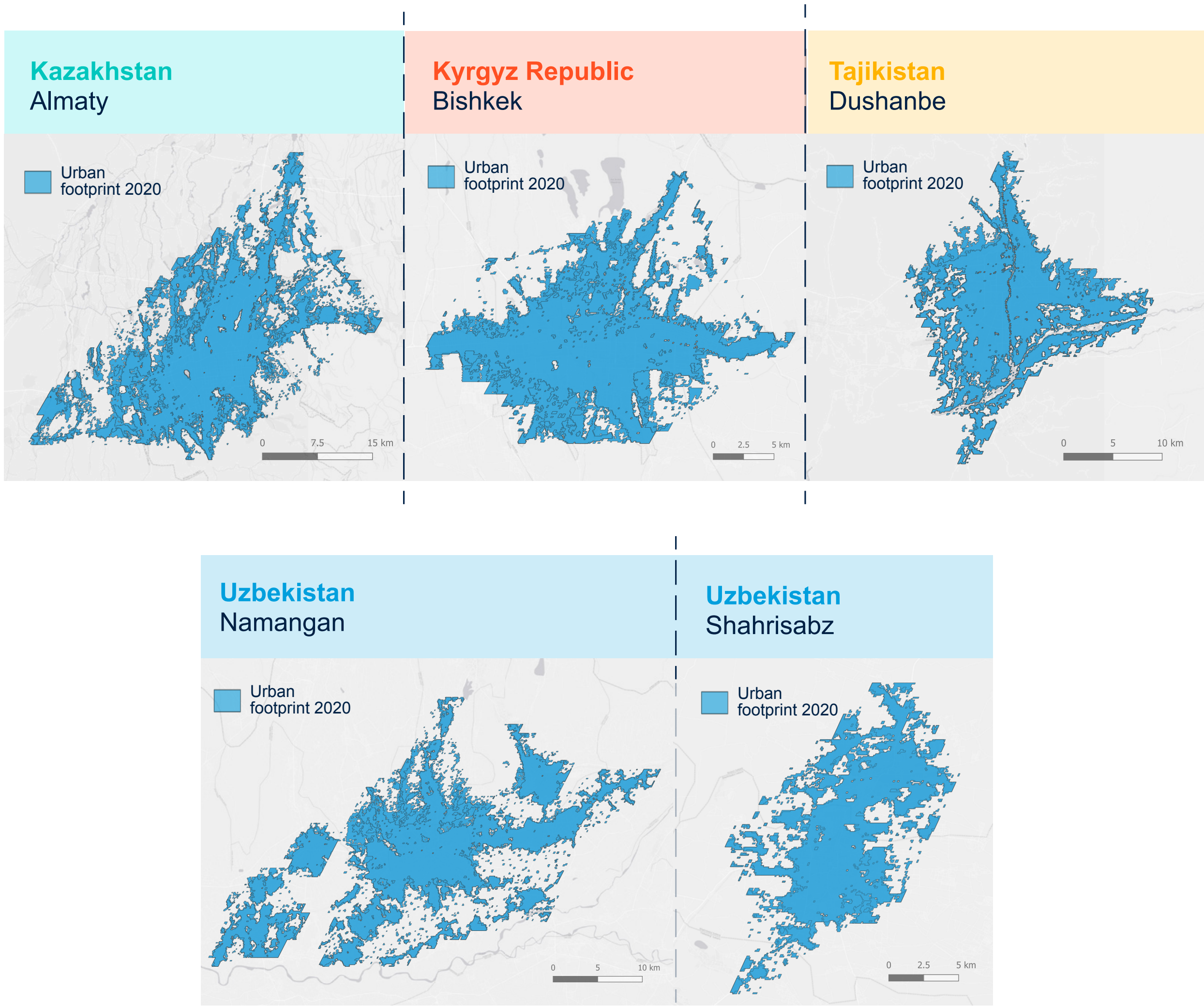
The average GHG emissions per capita in CA cities is high, at 11.7 tons CO_2e, 42 percent higher than the European and Central Asian average of 6.7 tons CO_2e. The main contributors are the power industry, manufacturing, energy for buildings, and fuel production. Turkmenistan and Kazakhstan have the highest carbon intensity in the region.

Source: CAPSUS, 2023, Almaty [Photograph]

3 Urban Growth Scenarios for 2050 in Five Cities

This section provides a thorough analysis of policy options and interventions for five Central Asian cities—Almaty, Bishkek, Dushanbe, Namangan, and Shakhrisabz—to promote low-carbon and climate-resilient development. The cities were assessed using quantitative, spatial, and qualitative methods to support evidence-based policymaking (figure 3.1). The findings for each modeled indicator are presented, along with results for all five cities, supported by maps and graphs. A subsection on actionable recommendations highlights the expected outcomes from proposed investments.

Figure 3.1 Cities Selected for the Deep-Dive Analysis



Source: CARL-cities 2024.

Two urban growth scenarios are compared: a No Intervention scenario and a Vision scenario (figure 3.2). The analysis highlights the benefits of using policy levers to mitigate emissions, reduce natural hazard exposure, and promote sustainable urban development. These policy levers were developed through a participatory process with local authorities and stakeholders to address critical issues in the five cities[39]. The growth scenarios, created using a combination of policy levers, simulate possible futures by modeling the effects of proposed policies. Each scenario considers historical evolution, current conditions, expected changes, and the cities' commitment to reducing emissions by 2050.

The proposed Vision scenario for Bishkek, Dushanbe, Namangan, and Shakhrisabz aims to deliver significant benefits through strategic interventions without burdening local budgets. The "No Intervention" scenario serves as a benchmark to compare potential gains from strategic investments against a business-as-usual approach. Local budgets, varying by city, were defined based on the total investment needed for basic infrastructure in new urban areas, including roads, water networks, sewage systems, public lighting, and electricity grids.

Almaty's Vision scenario examines the cost of achieving net-zero emissions through ambitious policies and investments. The Net-Zero scenario serves as a roadmap, exploring the policies and substantial investments required to transform Almaty into a carbon-neutral city. By analyzing investments in renewable energy and efficient infrastructure, this scenario illustrates Almaty's potential to achieve its net-zero emissions goal.

Figure 3.2 Deep-Dive Analysis: Modeling Urban Growth Scenarios

SCENARIO modeling

Within each city, the deep dive assessment encompasses the development and analysis of two urban growth scenarios: 'No-intervention' and 'Vision' scenarios.

No intervention

The **'No-intervention'** assumes that no significant change will be made on urban policy and considers investments in basic infrastructure for expanding the urban footprint.

Vision scenario

The **'Vision scenario'** assumes that all expected population growth will be accommodate within the current urban footprint due to densification strategies. This scenario also incorporates key urban policy measures and capital investments.

Source: CARL-Cities 2024.

39 Each city developed a tailored set of solutions, encompassing various policy levers and investments. For a comprehensive breakdown of these city-specific strategies, please refer to appendix C – Individual City Reports.

The performance of each scenario was measured using several indicators (table 3.1), which are numeric values describing the present or future conditions of an urban area in a given year. Indicators simplify the evaluation and monitoring of urban areas and are crucial for integrated urban planning. They were used to assess city performance on various topics in both the No Intervention and Vision scenarios. Additionally to indicators of the macro assessment, new categories were incorporated to assess energy consumption, solid waste collection service coverage, drinking water consumption, and estimated capital investment costs. These additional indicators provide a better understanding of the current state of the cities and the impact of proposed policies and investments. The analysis contrasted the scenarios across these benchmarks.

Table 3.1 Set of Indicators for the Deep-Dive Analysis

Key Dimension	Key Objective	Policy Levers	Specific Actions
1 Urban Form	Livable and green cities	People-centered urban design	– Develop and implement urban planning and design guidelines for compact and people-oriented urban forms.
		Sustainable urban growth	– Promote infill growth and contiguous peri-urban growth. – Encourage appropriate densification through updating urban plans and guidelines. – Establish urban limits where appropriate.
		Land use planning for resilience and equity	– Prevent construction and urban development in hazard-prone areas. – Update relevant building and construction codes to be seismic and climate-resilient. – Promote affordable housing in central areas. – Be sensitive and respond to market forces while safeguarding the public interest. – Adopt Transit-Oriented Approach (TOD)
2 Urban services and amenities	Easy access to infrastructure and services	Urban regeneration and multifunctional community facilities	– Redevelop and repurpose brownfield sites and underutilized plots. – Facilitate the construction and upgrade of housing units in well-served areas and neighborhoods. – Transform single-use public buildings into multifunctional community buildings. – Create a network of cultural and sports facilities. – Improve coverage and access to quality health care services. – Establish public spaces and buildings as shelters and disaster response centers.
3 Urban mobility		Low-carbon personal mobility	– Create and maintain safe paths for children and adults to walk and bike to schools and other urban amenities. – Build complete streets for a better walking and cycling experience.
		Efficient public transport	– Update and expand the public transportation network. – Decarbonize public transportation.
		E-mobility	– Invest in charging stations for electric vehicles. – Gradually disincentivize the use and ownership of private vehicles.

Key Dimension	Key Objective	Policy Levers	Specific Actions
4 **Urban environment**	Adapt to natural hazards and climate risks	Green infrastructure and nature-based solutions	- Restore and enhance urban green areas and nature in public spaces. - Increase access to consolidated urban green areas of at least 0.5 hectare within a 5-minute walk from residential areas.
		Wastewater management	- Build pollutant-specific wastewater treatment plants in industrial parks. - Modernize and rehabilitate water and sewage infrastructure. - Explore replacing or complementing gray water and waste infrastructure with green ones.
	Mitigate GHG emissions and environmental concerns	Energy and water efficiency	- Implement and update building regulations and norms to meet energy-efficient standards. - Incentivize the purchase and use of green appliances.
		Efficient heating provision	- Decarbonize cooking and heating systems in residential buildings.
		Renewable energy	- Promote the installation of renewable microgrid technology in residential units and commercial buildings.
		Decarbonize the power industry	- Modernize the CHP plants within cities to efficiently transition from coal to natural gas as the main fuel source. - Invest in carbon capture and storage in the manufacturing and industry sectors.
		Effective solid waste management	- Consolidate municipal waste management. - Implement integral "Waste-to-Energy" facilities.
		Enhanced air pollution control	- Develop local emission inventories of criteria air pollutants and GHGs. - Invest in an automatic pollution monitoring network. - Establish a vehicle verification program.
5 **Economic activity**	Enhanced access to jobs	Mixed-use and densification	- Incentivize mixed-use densification projects in existing urban areas and consolidated neighborhoods. - Promote new residential developments to allocate 25-30 percent of the constructed area to nonresidential uses (and job-generating uses).

Source: CARL-cities 2024. A detailed description of each indicator, calculation method, and source can be found in appendix A Individual City Reports and Urban Performance Methods.

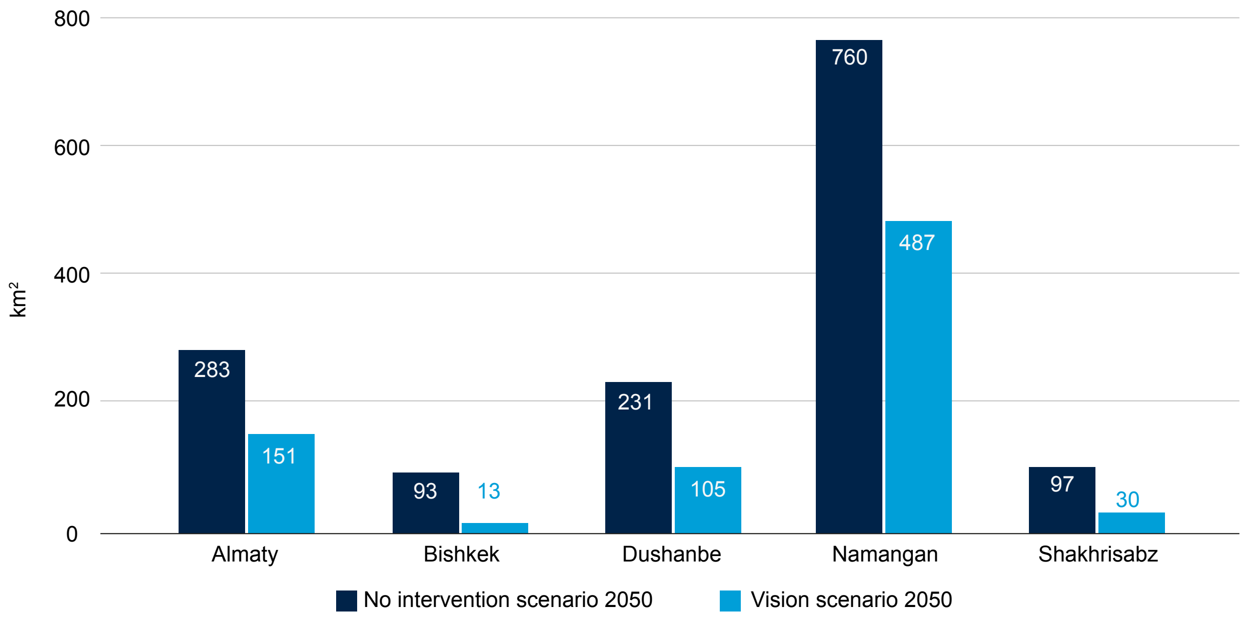
Urban Form

Urban Footprint

Efforts to contain urban expansion and implement strategic densification will promote efficient resource use and sustainable development while reducing nonurban land consumption. Figure 3.3 compares projected urban expansion in kilometer square for the five cities under two scenarios. Under the Vision scenarios, urban footprint growth is projected to be lower in all cities compared to the No Intervention scenario. This is due to stringent guidelines and regulations in the Net Zero and Cost-Efficient scenarios that control urban sprawl and promote densification. Consequently, most new population growth will occur within the current urban footprint, minimizing outward expansion. In contrast, the No Intervention scenario assumes no measures to control sprawl, leading to significant ecosystem degradation from converting nonurban land.

In Bishkek, proposed policies could control urban sprawl effectively, potentially minimizing 86 percent of urban expansion compared to the No Intervention scenario, resulting in substantial infrastructure cost savings. Shakhrisabz could see a 68 percent reduction in urban expansion. Dushanbe and Almaty are projected to reduce urban expansion by 54.5 and 46.5 percent, respectively. Namangan could reduce urban sprawl by 36 percent, but its overall projected expansion remains the largest among the five cities, potentially leading to higher infrastructure costs.

Figure 3.3 Comparison of Projected Urban Expansion

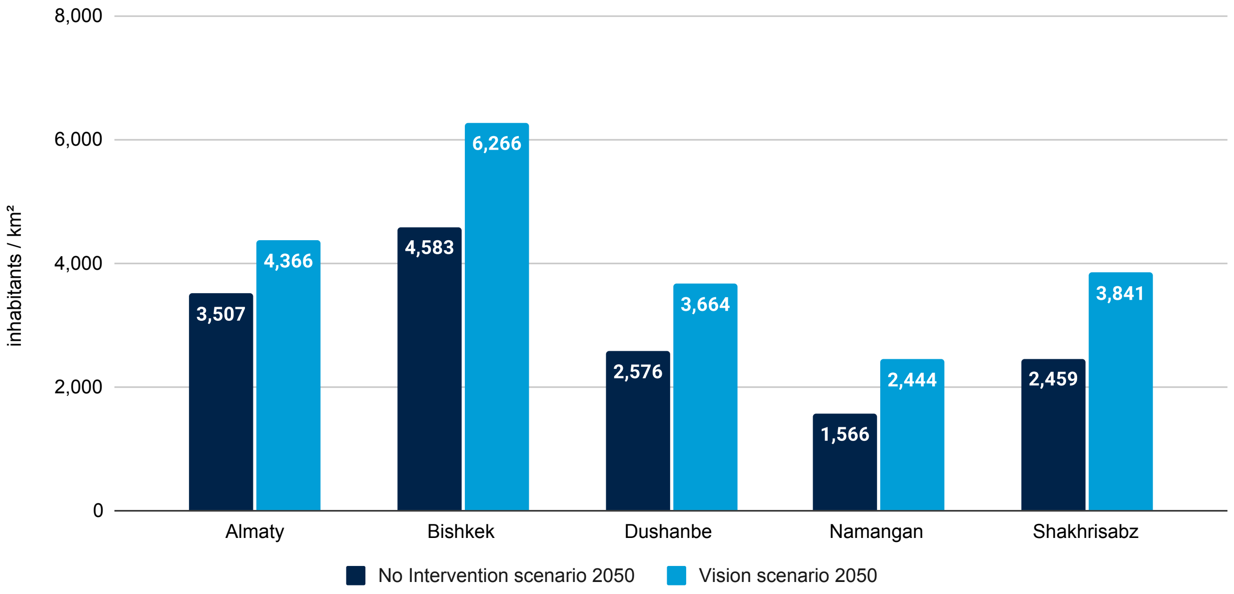


Source: CARL-cities 2024. Based on Urban Performance modeling.

Population Density

Implementing strategic densification and urban containment policies will lead to more efficient use of urban space (figure 3.4). The Vision scenario projects increased population density in all five cities compared to the No Intervention scenario, especially in those with currently low densities. Namangan and Shakhrisabz see the highest increases at 36 percent each, followed by Dushanbe with nearly 30 percent. Bishkek has the highest density under the Vision scenario, with a 27 percent increase, while Almaty experiences a 20 percent increase.

Figure 3.4 Comparison of Projected Population Density



Source: CARL-cities 2024. Based on Urban Performance modeling.

Urban Services and Amenities

Health Care Facilities

Expanding reachable health care facilities improves access to medical services, fostering a healthier community. Figure 3.5 shows the projected increase in the population living near hospitals or clinics in the five cities under the Vision scenario. Compared to the No Intervention scenario, the Vision scenario offers a significant improvement, with an average 46 percent increase in proximity to health care facilities due to new investments.

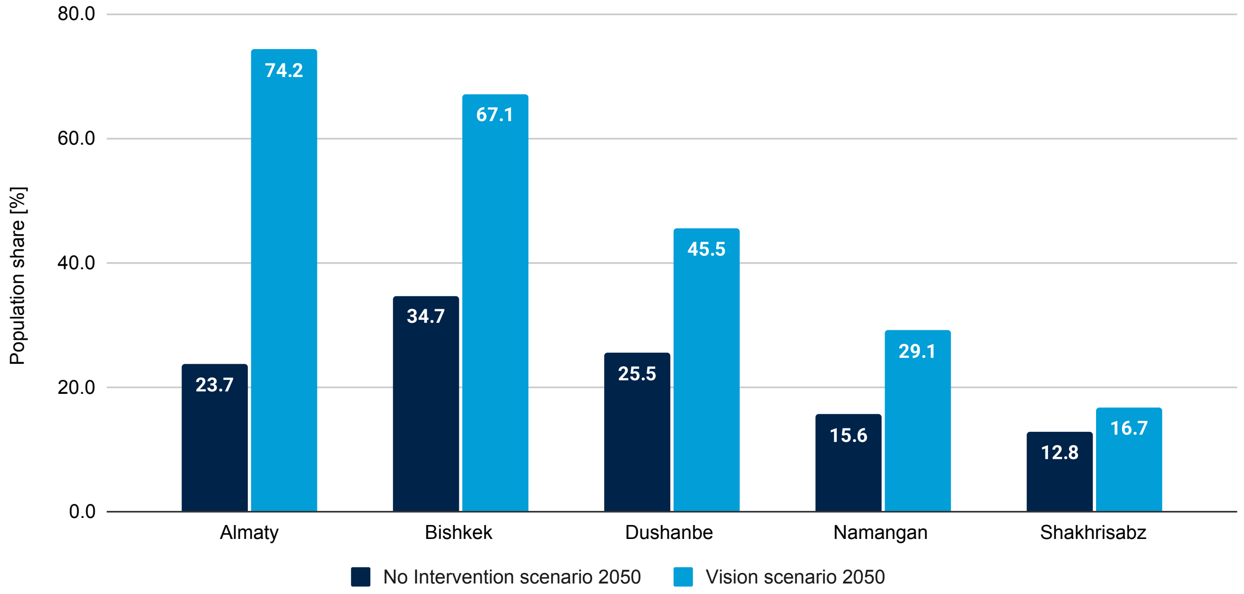
Investing in well-located social infrastructure, especially in densely populated areas, greatly enhances accessibility. Almaty leads in improved access, with nearly three-quarters of the population having convenient access to hospitals and clinics, almost double the coverage of the No Intervention scenario. Bishkek, Namangan, and Dushanbe also show significant progress, with improvements of 93 percent, 87 percent, and 78 percent respectively. Shakhrisabz is expected to see more modest progress due to its low density and scattered urban pattern.

Educational Facilities

Investing in new schools and educational centers improves residents' access to basic education and vocational training. Figure 3.6 shows the projected increase in the population living near these facilities across the five cities under the Vision scenario, nearly doubling compared to the No Intervention scenario.

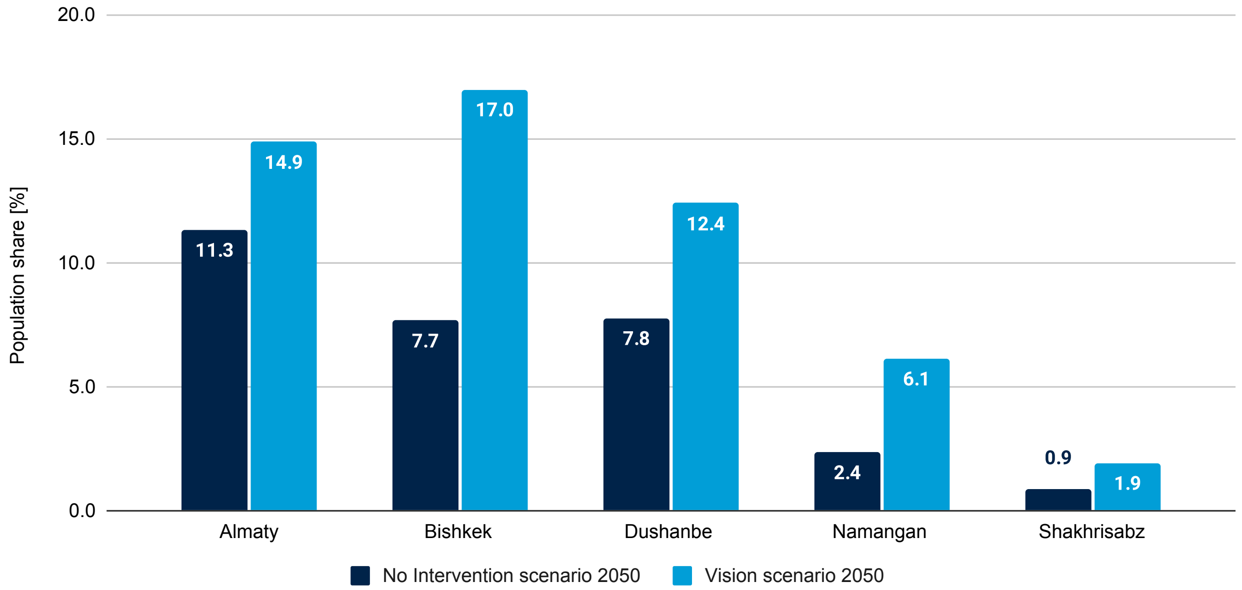
Strategically locating schools in densely populated neighborhoods bridges the gap in educational access. Namangan shows the most significant improvement, with access increasing 1.6 times from a low 2.4 percent. Bishkek and Shakhrisabz also see significant progress, with both cities projected to double the population living near schools compared to the No Intervention scenario, greatly enhancing educational opportunities for residents.

Figure 3.5 Expected Proximity Levels to Health Care Facilities



Source: CARL-cities 2024. Based on Urban Performance modeling.

Figure 3.6 Expected Proximity to Educational Facilities



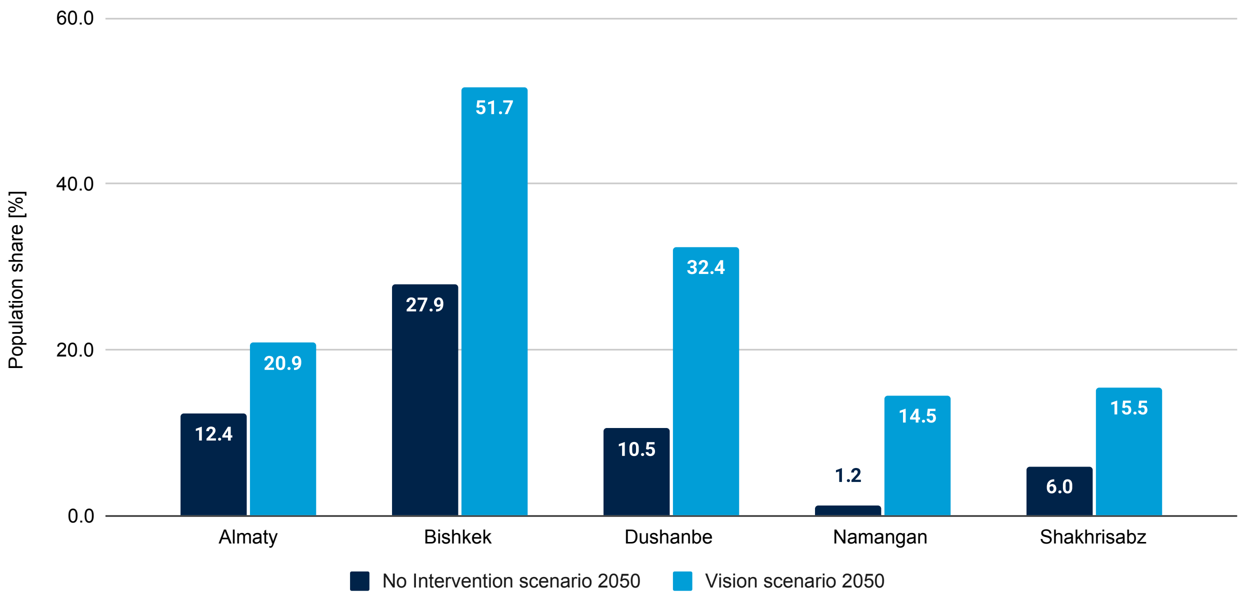
Source: CARL-cities 2024. Based on Urban Performance modeling.

Public Spaces

Strategic investment in new public areas can create vibrant spaces that empower communities and foster economic and cultural development. Figure 3.7 shows that the Vision scenarios project a significant increase in the population living near parks and open spaces across the five cities, with nearly 60 percent more residents having easy access compared to the No Intervention scenario.

Prioritizing well-located public spaces in densely populated neighborhoods closes the recreational access gap. Namangan shows the most substantial improvement, with accessibility increasing more than 11 times. Dushanbe and Shakhrisabz are projected to more than double the number of residents living near parks, with Dushanbe seeing a twofold increase and Shakhrisabz a 1.5-fold increase. This significantly enhances recreational opportunities, fostering a healthier and more vibrant urban environment.

Figure 3.7 Expected Proximity Levels to Public Spaces



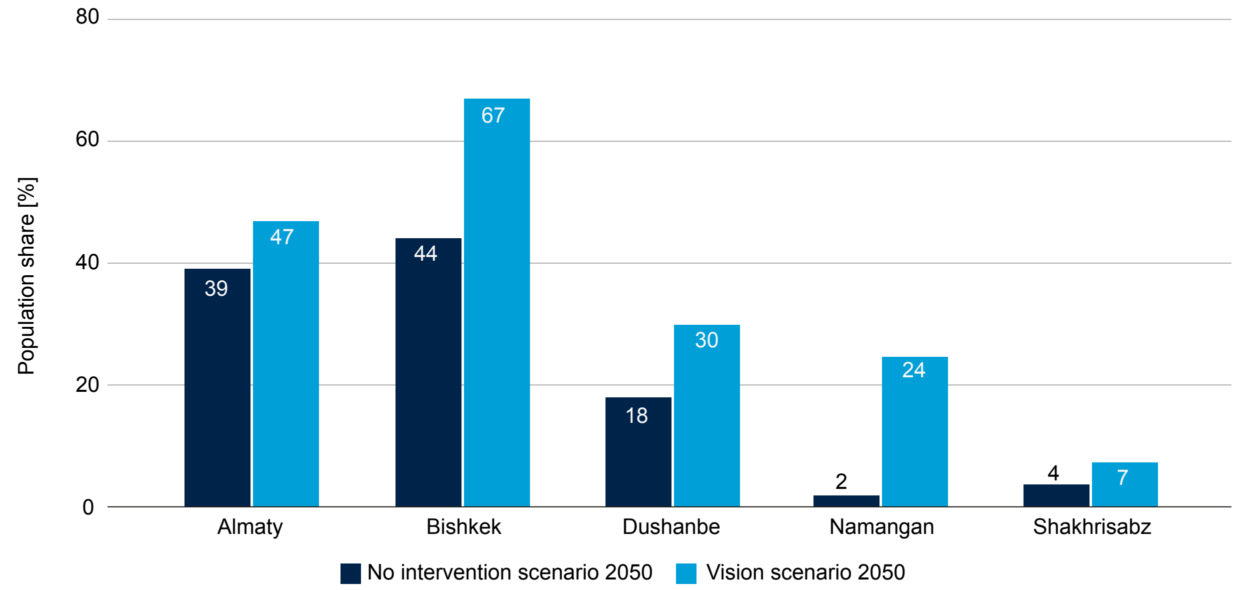
Source: CARL-cities 2024. Based on Urban Performance Modeling.

Urban Mobility

Proximity to Bus Stops

Investing in strategic public transportation corridors improves accessibility. Figure 3.8 shows that proposed investments in new infrastructure and public transportation corridors are estimated to enhance accessibility to bus stops by an average of 45 percent across the five cities. Namangan stands out with a projected 22-fold increase in accessibility under the Vision scenario, due to investments in key corridors connecting surrounding villages (Uyci, Unkhayat, and Turakurgan) to major activity centers and the development of an inner-city bus rapid transit (BRT) corridor. Shakhrisabz and Dushanbe also show significant improvements. Shakhrisabz is expected to see an 80 percent increase in accessibility, while Dushanbe is projected to improve by almost 60 percent. These expansions target areas currently lacking sufficient public transport options. Bishkek and Almaty would experience improvements of 51 percent and 20 percent, respectively. While these gains are more modest, they still represent significant steps toward enhanced public transportation accessibility.

Figure 3.8 Expected Proximity Levels to Bus Stops



Source: CARL-cities 2024. Based on Urban Performance Modeling.

Urban Environment

Exposure to Hazards

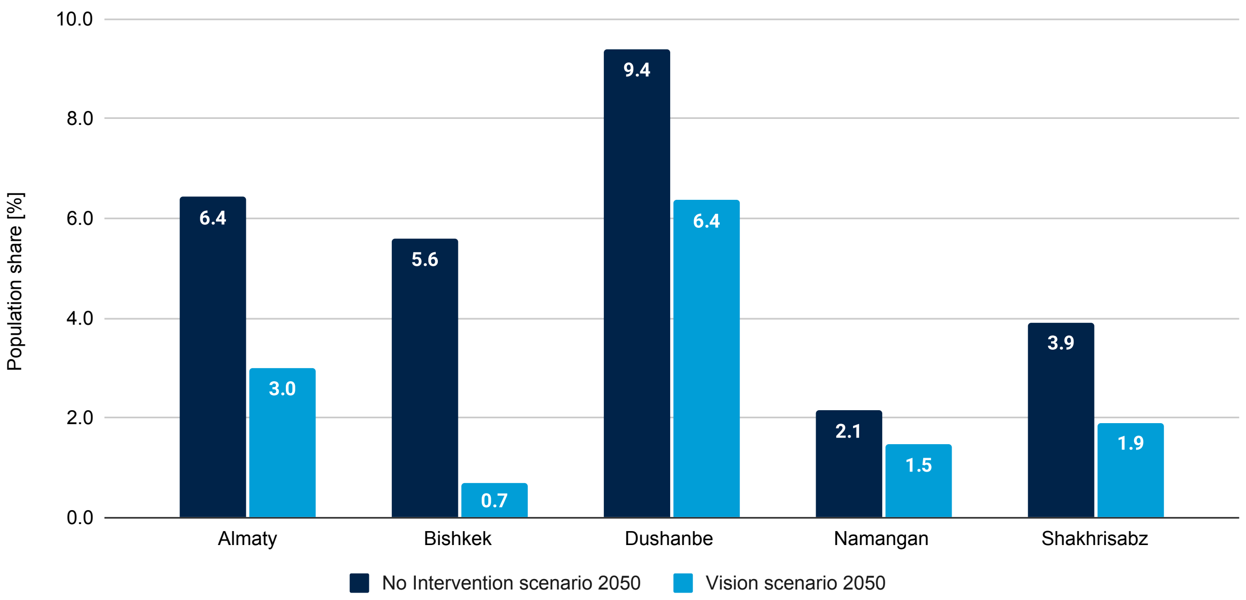
Reducing exposure to climate-related hazards can be achieved through nature-based solutions and resilient urban expansion. In the No Intervention scenario, exposure to natural hazards is projected to increase due to settlements in hazard-prone areas and lack of preventive investment. Figures 3.9 and 3.10 show that all five cities project a decrease in population at risk under the Vision scenario. Flood exposure is reduced by implementing nature-based solutions to retain excess rainwater and discouraging development in hazard-prone areas. The UHI effect is mitigated by nature-based solutions and reflective roofs. Bishkek exemplifies the benefits of minimizing flood risk, reducing the population in flood-prone areas from 5.6 percent to 0.7 percent under the Vision scenario. Dushanbe and Almaty also show significant progress, with reductions of 53.3 percent and 32.6 percent, respectively. Shakhrisabz can halve its flood-exposed population, while Namangan sees a reduction from 2.1 percent to 1.5 percent.

Bishkek leads in combating urban heat, achieving the most significant reduction under its Vision scenario. In the No Intervention scenario, 5.3 percent of Bishkek's population is expected to live in UHI-prone areas, but the Vision scenario reduces this to 0.2 percent, a 95 percent decrease. Shakhrisabz and Namangan also show significant progress, with reductions of 52 percent and 69 percent, respectively. Dushanbe and Almaty see more modest improvements of 29 percent and 20 percent. These improvements highlight the effectiveness of nature-based solutions and resilient urban planning, including green areas, corridors, reflective roofs, and overall resilient practices in mitigating UHI exposure.

Greenhouse Gas Emissions

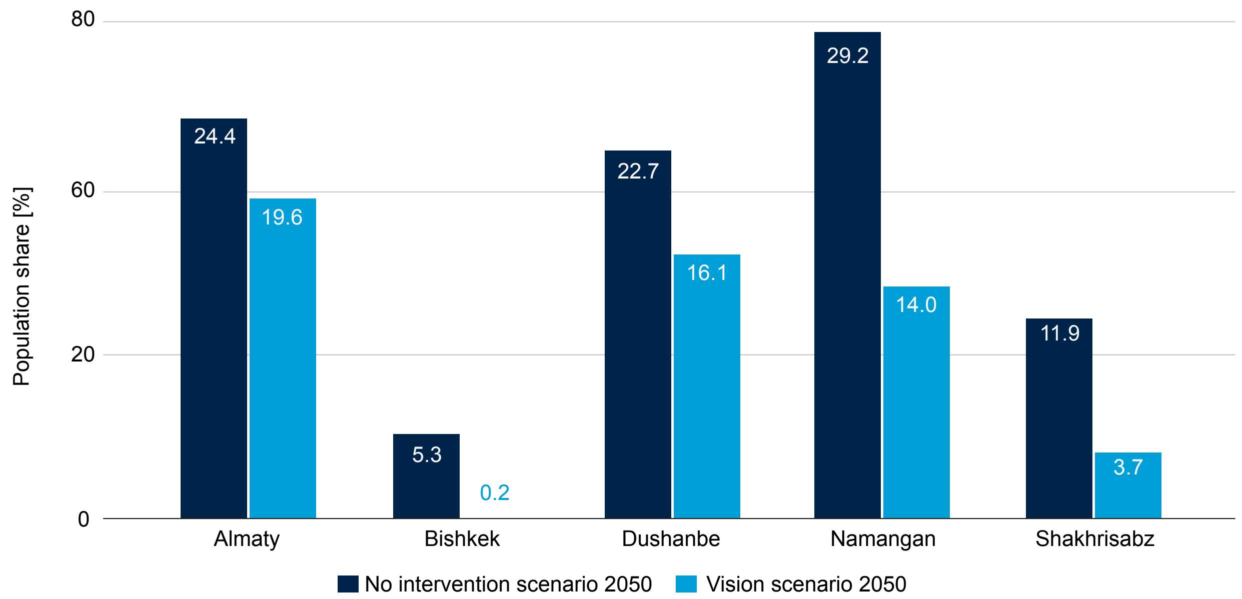
A strategic commitment to reducing greenhouse gas (GHG) emissions through a multisectoral approach can significantly cut local emissions. Figure 3.11 shows the projected reductions under the Vision scenario, with Almaty and Namangan seeing the largest decreases of 88 percent and 73 percent, respectively, compared to the No Intervention scenarios. Dushanbe is projected to reduce emissions by nearly 64 percent, while Shakhrisabz and Bishkek show more moderate reductions of 30 percent and 25 percent. Almaty aims for net-zero GHG emissions, targeting a nearly 90 percent reduction under the Vision scenario. Remaining emissions would be offset through nature-based solutions and market mechanisms. The strategy includes investments in

Figure 3.9 Flood Hazard Exposure



Source: CARL-cities 2024. Based on SFRARR Population Layer and Hazard Maps (Scaini 2022).

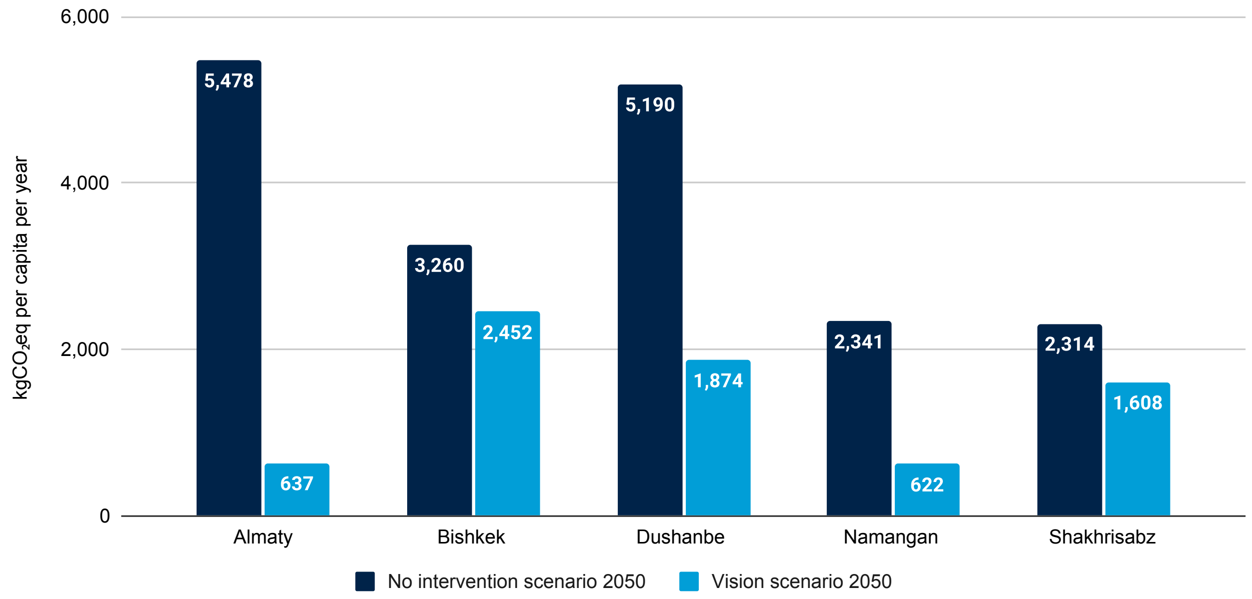
Figure 3.10 UHI Hazard Exposure



Source: CARL-cities, 2024. Based on SFRARR Population Layer and Hazard Maps (Scaini 2022).

clean urban mobility, reduced energy consumption, comprehensive solid waste management, and local solar energy generation. Without intervention, Almaty would produce 5,478 kgCO_2eq per capita, but the Vision scenario aims to reduce this to 637 kgCO_2eq per capita before offsets.

Figure 3.11 Comparison of Projected Per Capita GHG Emissions



Source: CARL-cities 2024, Based on Urban Performance Modeling.

Particulate Matter Emissions[40]

Local efforts to shift urban transportation, power generation, buildings, and waste management away from fossil fuels can significantly reduce $PM_{2.5}$[41]. Policies and investments in energy-efficient buildings, improved public transportation, low-carbon energy sources, and carbon capture technologies in the power industry[42] can decrease particulate matter emissions. Figure 3.12 shows that the Vision scenarios[43] could reduce $PM_{2.5}$ emissions by an average of 66 percent compared to the No Intervention scenarios, leading to a healthier environment.

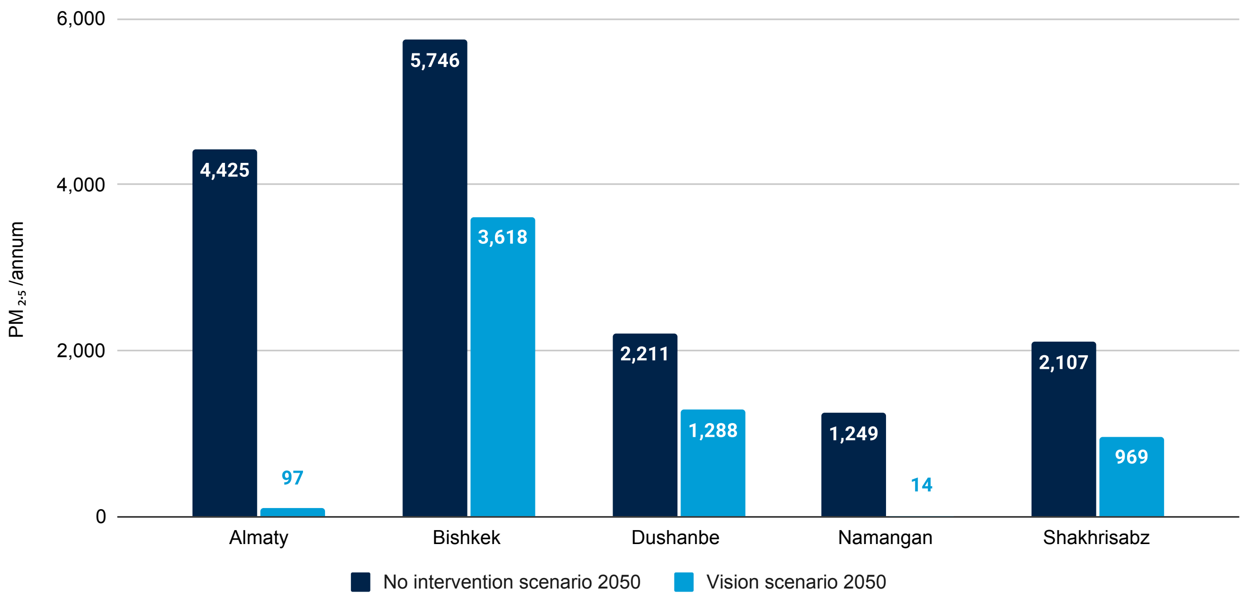
Almaty and Namangan are projected to achieve the most significant declines in $PM_{2.5}$ emissions, with reductions of 97 percent and 98 percent, respectively. This translates to decreases from 4,425 tons to 97 tons annually in Almaty, and from 1,249 tons to 14 tons annually in Namangan. Shakhrisabz is projected to reduce emissions by 54 percent, while Dushanbe and Bishkek show reductions of 42 percent and 37 percent, respectively. These improvements represent substantial steps toward cleaner air and lower-carbon development.

Energy Consumption

The five selected cities can reduce their energy consumption by an average of one-third through strategic densification, distributed photovoltaic systems, and stricter energy efficiency standards for buildings and appliances. Almaty and Namangan have the greatest potential, with projected reductions of 38 percent and 62 percent, respectively, reaching 6,601 kWh and 1,753 kWh per capita annually. These improvements result from a policy toolkit and investment package focusing on compact urban growth, walkability, and reduced reliance on diesel vehicles. Stricter energy efficiency standards for buildings and appliances are crucial. Almaty will benefit from renewable energy investments, while Namangan's energy demand reduction will be driven by enforcing green building codes and standards.

40 Since there is no local emission inventory, this estimation is based on the EDGAR database.
41 This indicator measures the amount of air pollutants sent to the atmosphere; it is not a measurement of air quality (concentration).
42 The model considered an incineration waste-to-energy (WtE) plant with a capacity of 40,000 tons per annum (tpa) (Namrata Joshi 2021).
43 Including public lighting, wastewater treatment, water supply, household electricity and heating, public transportation, private vehicle commuting, and solid waste management.
44 This section examines the energy consumption of public lighting, wastewater treatment, water supply, household electricity, public transportation, private vehicle commuting, and solid waste management.

Figure 3.12 Comparison of Projected Per Capita $PM_{2.5}$ Emissions



Source: CARL-cities 2024, Based on Urban Performance Modeling.

Water Consumption

Implementing and enforcing water-saving standards for buildings and household appliances could reduce Almaty's water consumption by nearly half by 2050. Under the Net Zero scenario (figure 3.13), per capita consumption is projected to drop from 47,000 liters to 26,000 liters annually, a 44 percent decrease. This results in an annual savings of approximately 21,350 liters per capita. Without these interventions, water consumption would remain much higher.

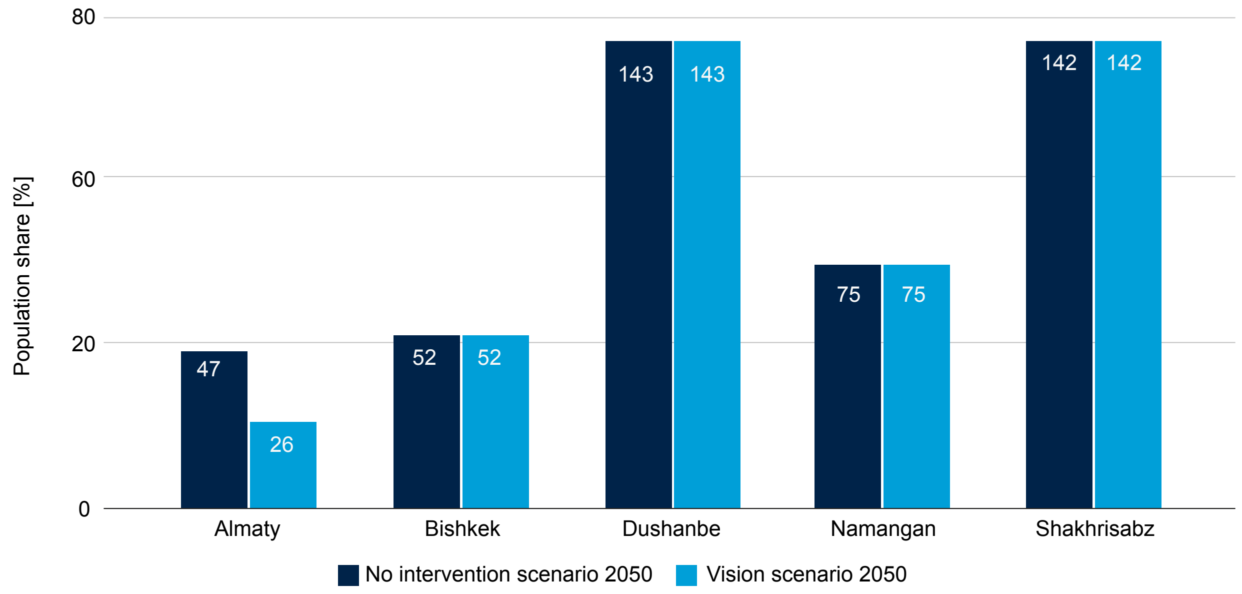
Wastewater Treatment

The Vision scenario anticipates strategic improvements in wastewater treatment across Central Asian cities. Figure 3.14 shows that only Namangan and Shakhrisabz increase their treatment capacity compared to the No Intervention scenario, thanks to key investments in wastewater treatment plants. Namangan's treatment capacity could increase by 61 percent, allowing it to treat 58 million cubic meters of wastewater annually, up from 36 percent in the No Intervention scenario. Shakhrisabz would also see significant improvements, with new plants treating 58 percent of its wastewater, or 48 million cubic meters per year. These investments would enhance environmental performance and reduce energy use, yielding cost savings and minimizing environmental impact.

Solid Waste Management

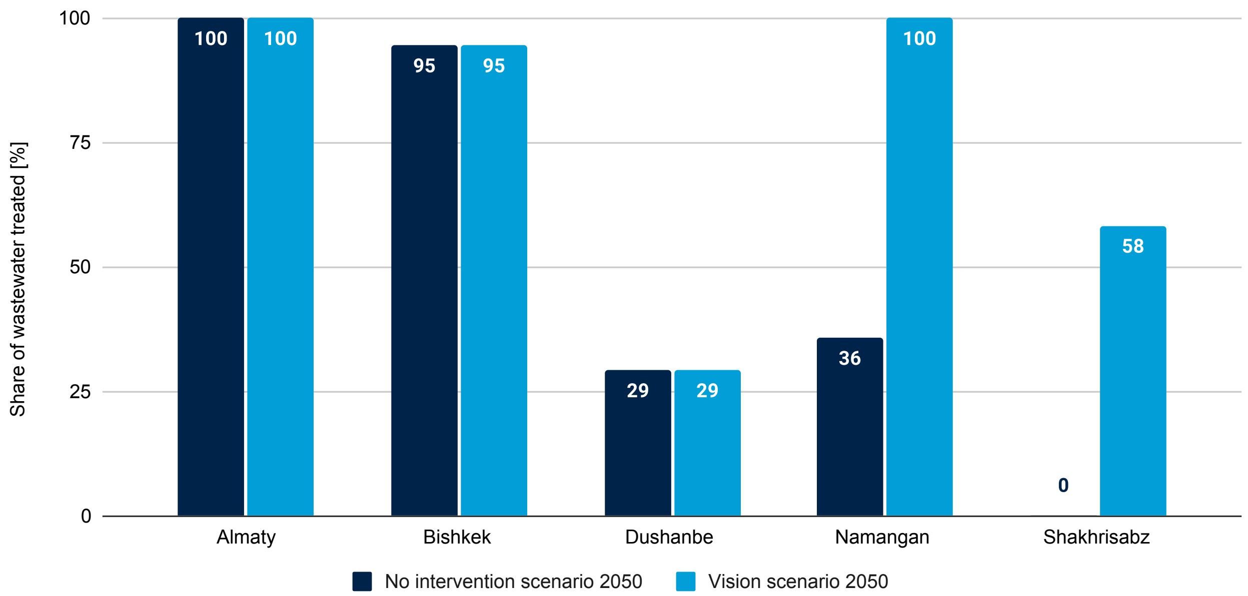
Renovating the collection truck fleet and densifying neighborhoods can improve waste coverage and reduce emissions (figure 3.15). The solid waste collection indicator measures the proportion of waste effectively collected by a city. The Vision scenario aims to enhance solid waste management by modernizing truck fleets and densifying strategic areas, significantly improving collection coverage and reducing emissions. Almaty, Namangan, and Dushanbe provide compelling examples. Almaty could increase collection coverage from 17 percent to 100 percent with 180 new low-carbon trucks. Namangan could achieve 100 percent collection by expanding its fleet with 48 new trucks, up from 44.5 percent. Dushanbe is projected to reach 100 percent coverage, up from 68 percent, under the Vision scenario.

Figure 3.13 Comparison of Projected Water Consumption



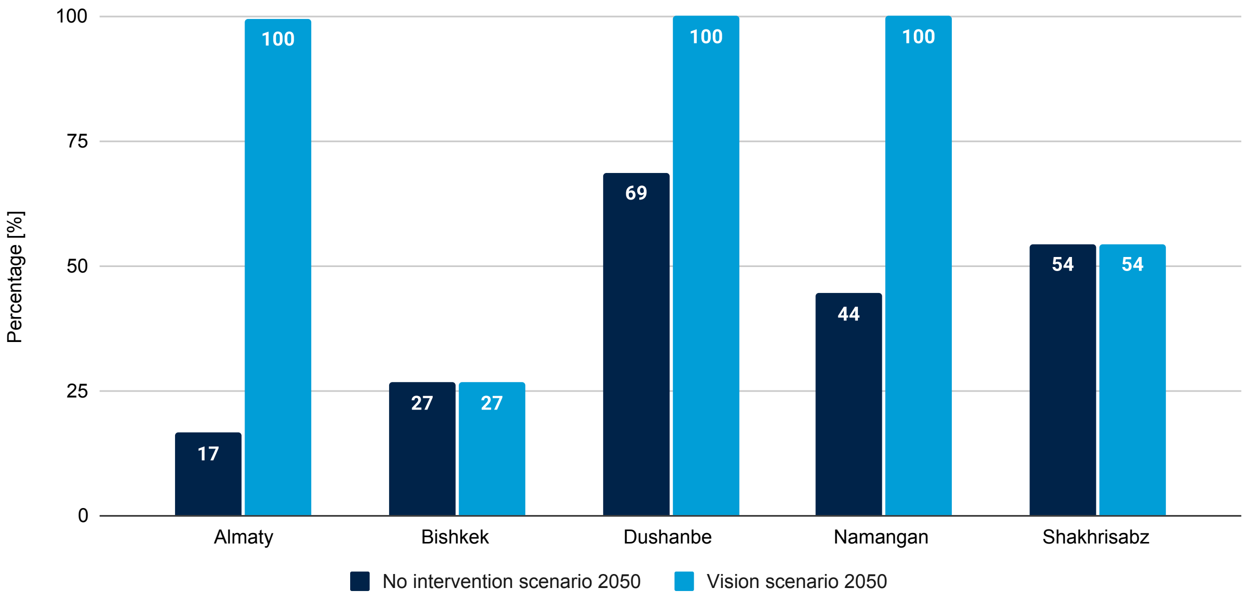
Source: CARL-cities 2024, Based on Urban Performance Modeling.

Figure 3.14 Comparison of Projected Share of Wastewater Treatment



Source: CARL-cities 2024, Based on Urban Performance Modeling.

Figure 3.15 Estimated Solid Waste Collection Coverage



Source: CARL-cities 2024, Based on Urban Performance Modeling.

Budget

Basic Infrastructure Costs

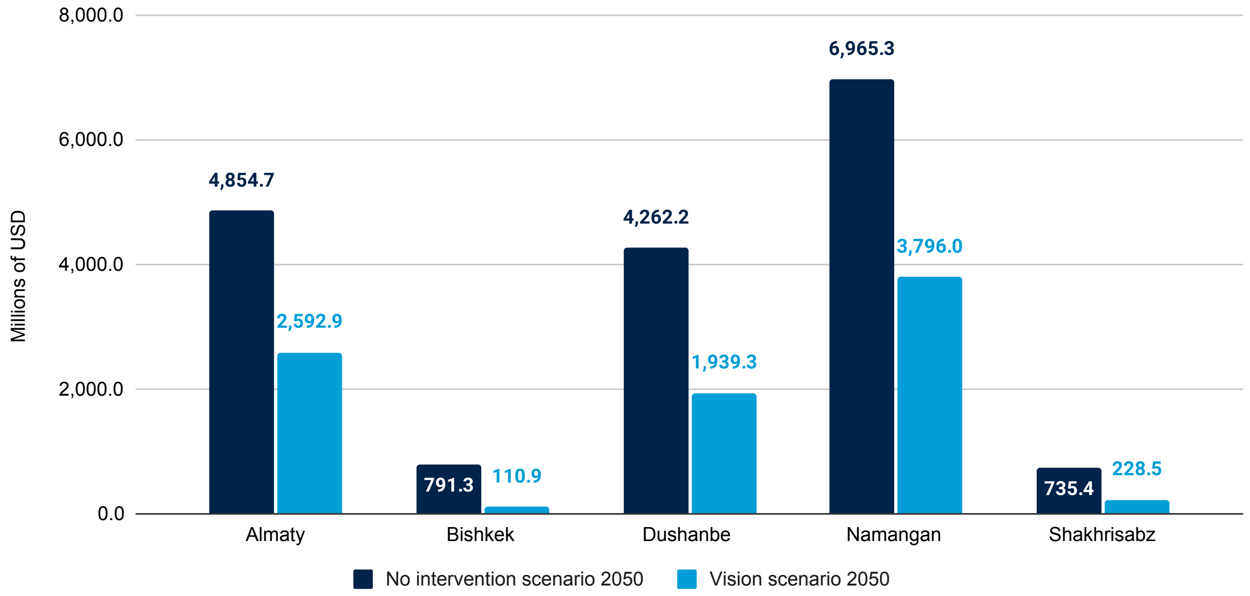
The Vision scenario's promotion of compact urban development results in substantial cost savings and additional funds for social infrastructure (figure 3.16). Basic infrastructure costs are projected to be 43 percent higher on average under the No Intervention scenario compared to the Vision scenario. This means basic infrastructure consumes 68 percent of the local budget under No Intervention, but only 25 percent under the Vision scenario. This shift not only delivers environmental benefits but also frees up significant capital for other strategic initiatives. Bishkek and Shakhrisabz would achieve the most significant cost savings, with potential reductions of up to 86 percent and 68 percent, respectively. Dushanbe, Almaty, and Namangan also see substantial savings, with reductions of 54.5, 46.6, and 45.5 percent, respectively.

Capital Investment Costs

The Vision scenario focuses on capital-intensive interventions in energy, transportation, and urban sectors to achieve long-term sustainability goals (figure 3.17). These costs include specific policy interventions beyond basic infrastructure. For example, Almaty's goal of carbon neutrality by 2050 requires an estimated $15.79 billion investment ($16.65 billion with offsets), with renewable energy initiatives comprising 44 percent, urban infill 9 percent, and energy efficiency measures 7 percent.

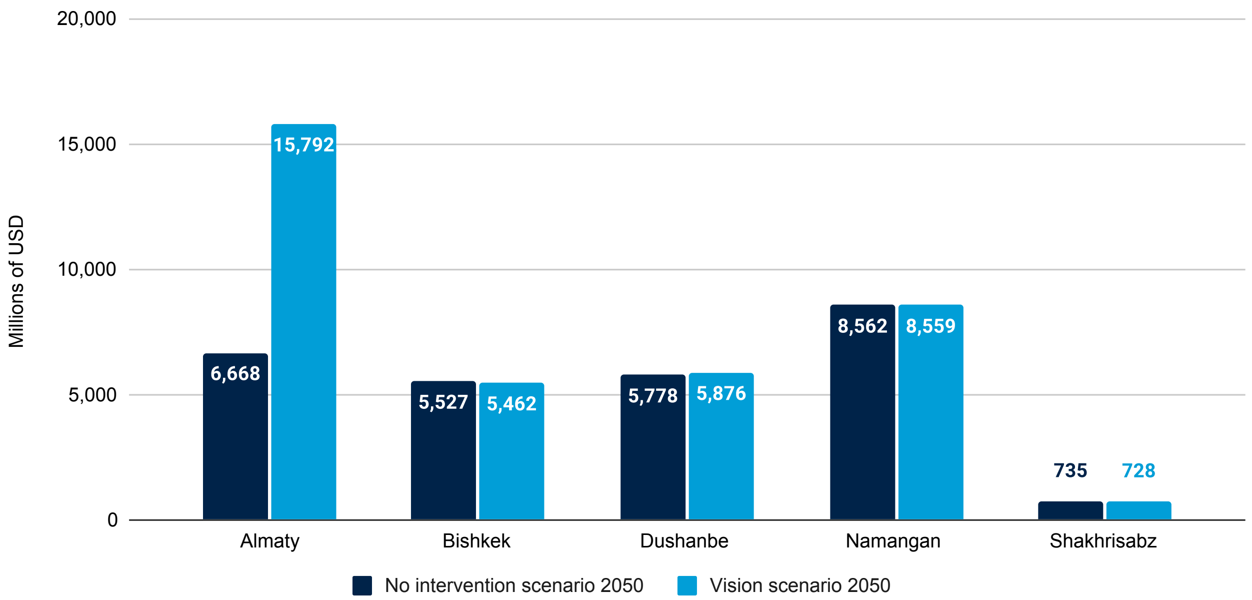
Similar trends are seen in other cities. Bishkek's Vision scenario prioritizes infill development and public transportation, allocating 90 percent of the budget to these areas. Dushanbe's interventions in infill development, public transportation, and energy efficiency account for 86 percent of its budget. Namangan allocates 40 percent of its resources to urban retrofit and renewable energy. In Shakhrisabz, the focus is on energy efficiency, wastewater treatment, and emissions control, which make up 67 percent of the budget.

Figure 3.16 Estimated Share of Basic Infrastructure Costs



Source: CARL-cities 2024, Based on Urban Performance Modeling.

Figure 3.17 Estimated Capital Investment Costs for Implementing Recommended Interventions



Source: CARL-cities 2024, Based on Urban Performance Modeling.

Source: CAPSUS, 2023, Almaty [Photograph]

4 Lessons Learned from the Deep- Dive Analysis

The deep-dive analysis revealed that each city's path to low-carbon, resilient development is shaped by its unique context and resource management. A comparative analysis of five cities showed both commonalities and differences, offering valuable lessons. Integrating these insights helps understand current conditions, potential future scenarios, and derive key takeaways for the region. These lessons can guide policy recommendations, aiding in navigating urban development complexities and fostering sustainable growth.

Common Challenges and Shared Realities

The deep-dive analysis identified common challenges in all five cities, including unsustainable urbanization, high carbon intensity, air pollution, vulnerability to natural hazards, and limited access to social infrastructure. These issues result in traffic congestion, longer commutes, loss of natural habitats, high GHG emissions, poor air quality, and social inequalities.

Compact urban development offers a solution to these challenges. It reallocates resources from expansion costs to sustainable interventions, reducing hazard exposure and improving access to urban amenities and public services. For example, nature-based solutions like green corridors can mitigate floods and heat effects, while efficient public transportation reduces reliance on motorized vehicles.

Another key lesson is the need for specialized urban data. The lack of standardized and complete data hampers reliable insights and effective policies. Improving urban data infrastructure is essential for accurate monitoring, identifying improvement areas, and anticipating future trends, enabling evidence-based decision-making for low-carbon, resilient urban planning.

Different Interventions for Common Challenges

While cities share common urban concerns, the impact on development varies, necessitating different priorities based on each city's unique situation. For example:

- **Bishkek** faces challenges from a carbon-intensive power industry and rapid urban expansion, straining infrastructure and services.
- **Shakhrisabz** struggles with energy scarcity and high building-related GHG emissions, impacting power demand and contributing to climate change.
- **Dushanbe** has significant transportation-related carbon challenges, with heavy reliance on fossil fuels causing high GHG emissions and air pollution.
- **Namangan** deals with limited green urban areas and high residential energy demand emissions.

Policies and investments emphasize low-carbon and renewable energy generation but vary by city context. For instance:

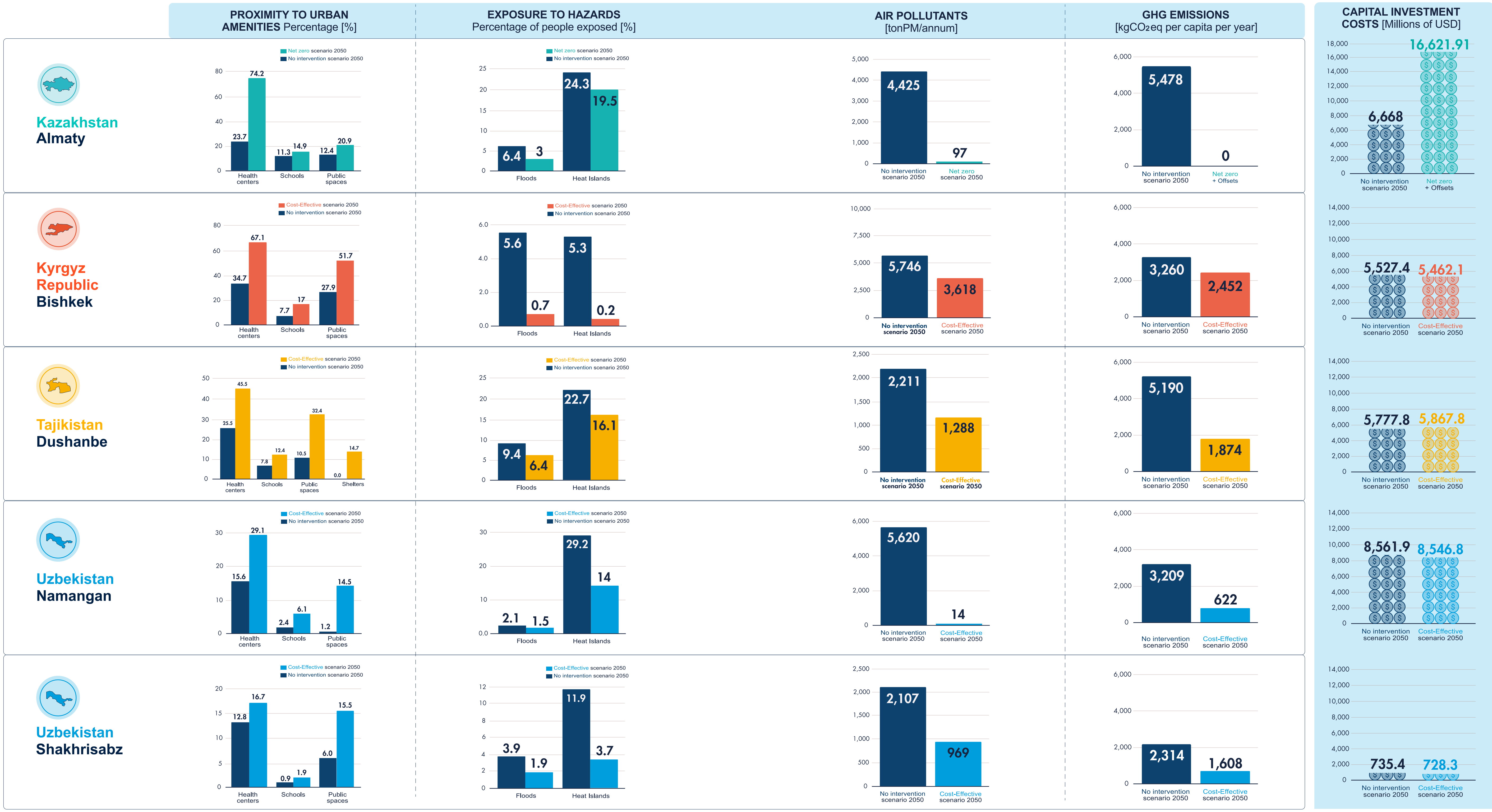
- **Bishkek** focuses on retrofitting CHP1 and using gas, with investments in distributive renewable sources.
- **Dushanbe** prioritizes carbon capture and storage technologies, with future solar power considerations.
- **Shakhrisabz** emphasizes solar grid upgrades, storage solutions, and phasing out carbon energy sources.
- **Almaty** integrates solar technologies to reduce reliance on fossil fuels, aiming for net-zero emissions by 2050.
- **Namangan** and **Shakhrisabz** focus on energy efficiency in residential areas and renewable investments.

Urban growth scenarios also differ:

- **Almaty** adopts a net-zero scenario aiming for net-zero emissions by 2050, incurring higher costs but yielding significant benefits.
- The **other cities** adopt a cost-efficient scenario, using current budgets and savings from compact growth for sustainable improvements.

These tailored approaches highlight the importance of context-specific interventions for effective and sustainable urban development, enhancing energy efficiency, and diversifying energy sources to achieve cleaner, more sustainable practices. Figure 4.1 summarizes the key differences in results yield between the two scenarios.

Figure 4.1 Summary of Selected Indicators and Results from Scenario Modeling



Source: CAPSUS, 2023, Uzbekistan [Photograph]

5 Key Recommendations

This section builds on the study's findings to propose recommendations addressing regional and urban challenges, aiming to achieve ambitious objectives. These challenges include urban development, infrastructure access, natural hazards, GHG emissions, and environmental concerns. The recommendations are organized by key objectives (table 5.1):

1. Becoming livable and green cities
2. Improved access to infrastructure and services
3. Adapting to natural hazards and climate risks
4. Mitigating GHG emissions and environmental concerns
5. Enhanced access to jobs

This section also highlights best practices from Central Asia and globally, demonstrating how these recommendations can be implemented. By combining local needs with international best practices, it aims to guide and support low-carbon, resilient urban development in the region.

Figure 5.1 Key Recommendations and Actionable Items in Five Key Dimensions

Key Dimension	Key Objective	Policy Levers	Specific Actions
1 Urban Form	Livable and green cities	People-centered urban design	- Develop and implement urban planning and design guidelines for compact and people-oriented urban forms.
		Sustainable urban growth	- Promote infill growth and contiguous peri-urban growth. - Encourage appropriate densification through updating urban plans and guidelines. - Establish urban limits where appropriate.
		Land use planning for resilience and equity	- Prevent construction and urban development in hazard-prone areas. - Update relevant building and construction codes to be seismic and climate-resilient. - Promote affordable housing in central areas. - Be sensitive and respond to market forces while safeguarding the public interest. - Adopt Transit-Oriented Approach (TOD)
2 Urban services and amenities	Easy access to infrastructure and services	Urban regeneration and multifunctional community facilities	- Redevelop and repurpose brownfield sites and underutilized plots. - Facilitate the construction and upgrade of housing units in well-served areas and neighborhoods. - Transform single-use public buildings into multifunctional community buildings.

Key Dimension	Key Objective	Policy Levers	Specific Actions
2 **Urban services and amenities**	Easy access to infrastructure and services	Urban regeneration and multifunctional community facilities	- Create a network of cultural and sports facilities. - Improve coverage and access to quality health care services. - Establish public spaces and buildings as shelters and disaster response centers.
3 **Urban mobility**		Low-carbon personal mobility	- Create and maintain safe paths for children and adults to walk and bike to schools and other urban amenities. - Build complete streets for a better walking and cycling experience.
		Efficient public transport	- Update and expand the public transportation network. - Decarbonize public transportation.
		E-mobility	- Invest in charging stations for electric vehicles. - Gradually disincentivize the use and ownership of private vehicles.
4 **Urban environment**	Adapt to natural hazards and climate risks	Green infrastructure and nature-based solutions	- Restore and enhance urban green areas and nature in public spaces. - Increase access to consolidated urban green areas of at least 0.5 hectare within a 5-minute walk from residential areas.
		Wastewater management	- Build pollutant-specific wastewater treatment plants in industrial parks. - Modernize and rehabilitate water and sewage infrastructure. - Explore replacing or complementing gray water and waste infrastructure with green ones.
	Mitigate GHG emissions and environmental concerns	Energy and water efficiency	- Implement and update building regulations and norms to meet energy-efficient standards. - Incentivize the purchase and use of green appliances.
		Efficient heating provision	- Decarbonize cooking and heating systems in residential buildings.
		Renewable energy	- Promote the installation of renewable microgrid technology in residential units and commercial buildings.
		Decarbonize the power industry	- Modernize the CHP plants within cities to efficiently transition from coal to natural gas as the main fuel source. - Invest in carbon capture and storage in the manufacturing and industry sectors.
		Effective solid waste management	- Consolidate municipal waste management. - Implement integral "Waste-to-Energy" facilities.
		Enhanced air pollution control	- Develop local emission inventories of criteria air pollutants and GHGs. - Invest in an automatic pollution monitoring network. - Establish a vehicle verification program.

Key Dimension	Key Objective	Policy Levers	Specific Actions
5 **Economic activity**	Enhanced access to jobs	Mixed-use and densification	- Incentivize mixed-use densification projects in existing urban areas and consolidated neighborhoods. - Promote new residential developments to allocate 25-30 percent of the constructed area to nonresidential uses (and job-generating uses).

Source: CARL-Cities 2024.

Dimension 1: Livable Green Cities

The development of cities in the region should embrace compact urban growth.

Urban development in the region should promote adequate population density and access to public services and social infrastructure. Currently, many Central Asian cities face rapid urbanization and inefficient land use, leading to low-density development. This issue is particularly severe in medium and small-sized cities in Tajikistan, the Kyrgyz Republic, and Kazakhstan. Extensive low-density development increases infrastructure costs by an average of 60 percent. Therefore, local authorities should encourage compact urban development, focusing on dense populations and walkable neighborhoods near basic services and jobs, accessible by nonmotorized, clean transport options.

Urban data is essential for developing effective evidence-based policies to promote low-carbon, resilient urban development.

Cities in Central Asia need to improve data production, management, and use to accurately assess performance and deliver effective policies. The study's findings and proposals rely on the best available, though often limited, information. Establishing robust city data infrastructure is crucial for managing urban data systematically, supporting evidence-based decision-making, and implementing targeted policies. Developing local emission inventories for GHG emissions and air pollutants (such as their types, quantities, and sources) is essential for crafting effective strategies and public policies for healthy, low-carbon development.

Suggested specific actions (SAs) for livable and green cities include:

1 **People-Centered Urban Design**

SA1. Develop and implement guidelines for compact, dense, and people-oriented urban forms, ensuring better quality of life and compatibility with existing neighborhoods. Strategies include investing in critical infrastructure, promoting higher urban density, mixed land use, energy efficiency, and balanced streetscapes. By creating people-oriented urban design guidelines, cities in CA can ensure that new developments--whether new construction or the renewal of existing infrastructure-- promote adequate densification, sustainability, and social development in the long term.

2 People-Centered Urban Design

SA2. Promote infill and contiguous peri-urban growth. Expanding a city's urban footprint requires funds for new infrastructure and increases travel time. Cities should utilize unused or underused land within or near the city with good access to social infrastructure, public services, goods, and jobs. This approach saves budgetary resources and improves environmental performance in Central Asian cities.Promote infill growth and contiguous peri-urban growth.

SA3. Encourage appropriate densification by updating urban plans and guidelines. Strategic densification aims to increase urban density sustainably, enhancing the city's livability, sustainability, and resilience. Key elements include energy efficiency, green spaces, public transportation access, and infrastructure resilience. These guidelines should promote a mandatory framework for citywide implementation and foster evidence-driven decision-making in urban planning.

SA4. Establish urban limits to control sprawl and protect natural areas providing ecosystem services. Tailor containment boundaries to each city's unique circumstances, as existing regulations may differ. Local governments should periodically review and adjust these boundaries to protect significant areas and allow for peri-urban growth. Regulations could prohibit land-use changes or construction permits outside the urban perimeter.

3 Land-Use Planning for Resilience and Equity

SA5. Prevent construction in hazard-prone areas by addressing urban sprawl. This region is highly vulnerable to earthquakes, floods, and landslides. Unplanned expansion increases risk. Urban growth in Central Asia should consider natural risk factors. Strategies include increasing fines for illegal construction and establishing a public-private monitoring system where the private sector receives a percentage of the fines.

SA6. Update relevant building and construction codes to be seismic and climate-resilient. This action minimizes disaster risks and ensures urban infrastructure safety and sustainability. Key strategies include: (i) ensuring building codes withstand seismic forces; (ii) integrating climate resilience for impacts like increased temperatures and rising sea levels; (iii) conducting risk assessments to identify hazard-prone areas and design local responses; (iv) investing in capacity-building programs to train construction professionals; and (v) fostering public awareness and engagement on the importance of updated building codes.

SA7. Promote affordable housing in new residential developments and central areas to ensure inclusive economic development and adequate housing for all. This policy aims to mitigate gentrification and reduce rental prices, providing housing for low-income residents. By encouraging densification and accessible social services, cities can enhance spatial justice in the region.

3 Land-Use Planning for Resilience and Equity

SA8. Balance housing market forces with public interest to ensure equitable access to housing and promote economic development. Cities should prioritize affordable housing in new developments and integrate regulatory measures. Key actions include: (i) using market-based solutions like inclusionary zoning and PPPs for affordable housing projects; (ii) encouraging development in both low-income and mixed-income areas to prevent segregation and promote social cohesion; (iii) establishing a regulatory framework that promotes public participation in housing provision; and (iv) involving communities and the private sector in decision-making for new housing developments.

SA9. Adopt a Transit Oriented Development (TOD) approach. Cities should develop new housing within walking distance of transit stations and create transport hubs in dense neighborhoods. Affordable housing near transit benefits low-income households by providing access to jobs, education, and services, and increases return on investment for local governments in transit infrastructure.

Regional Best Practices

Kazakhstan's national efforts to promote agglomeration development and support urban priorities are commendable. This includes investing in infrastructure, connectivity, and strategic densification to combat urban sprawl. The Green City Action Plan (GCAP) for Almaty 2022 exemplifies sustainable urban growth, aligning with national goals and addressing climate change and resilience.

The Kyrgyz Republic uniquely incorporates a vision for green cities in its long and midterm national development plans. The next step is to create local urban planning documents for cities and towns.

Tajikistan's Green Economy Development Strategy (GEDS) 2023-2037 and Dushanbe's Green City Action Plan (GCAP) promote sustainable development and empower local agencies.

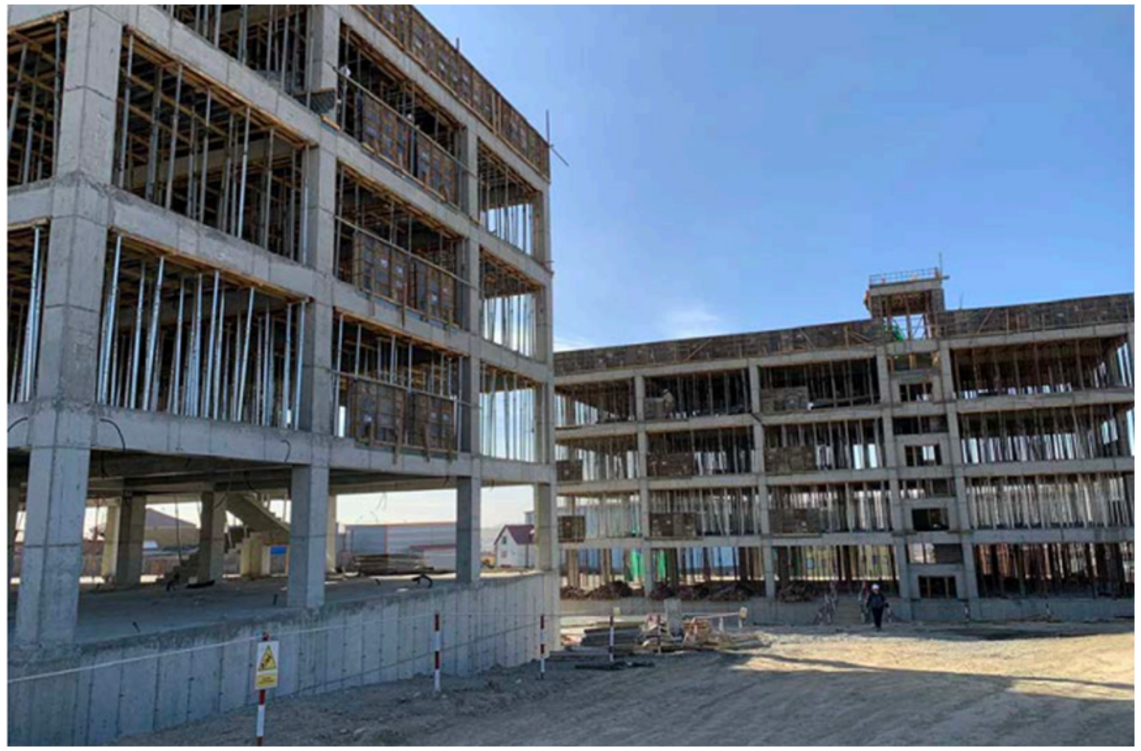
Uzbekistan emphasizes the role of cities in environmentally conscious socioeconomic development through the Green Economy Transition Strategy 2019-2030 and the Green Economy and Green Growth Transition Program 2030. These frameworks aim to enhance urban environmental sustainability and decentralize power to support sustainable growth, providing a pathway for the sustainable development of cities by 2050.

International Best Practice: Ulaanbaatar, Mongolia (AHURP)

The Affordable Housing and Resilient Urban Renewal Sector (AHURP) project in Mongolia aims to enhance Ulaanbaatar's climate resilience by investing in low-cost urban infrastructure, public facilities, and social housing (photo 5.1). By developing self-sufficient ecodistricts in city subcenters, AHURP seeks to improve urban quality and reduce traffic congestion.

The project will transform climate-vulnerable and polluting ger districts[45] into climate-resilient ecodistricts with low-carbon affordable housing. Designed with community input, these neighborhoods will offer accessible services and amenities. Housing units will cater to diverse incomes: 15 percent for social green housing, 55 percent for affordable green housing, and 30 percent for market-rate green housing. AHURP plans to build 10,000 housing units in a 100-hectare area between 2022 and 2027, increasing density in new ger areas and providing housing, social infrastructure, and public services to low- and middle-income families.

Photo 5.1 AHURP Building Site in Ulaanbaatar, Mongolia



Source: Asian Development Bank. (2024).

45 "Ger" districts are residential areas in Mongolia. They usually consist of parcels with one or more detached traditional mobile dwellings or gers (hence the name) and are usually informal and in the peri-urban areas of cties.

Dimension 2: Easy Access to Infrastructure and Services

To increase livability and reduce carbon intensity, cities in CA should improve accessibility to social infrastructure and urban amenities.

Over 90 percent of Central Asian city residents lack convenient access to urban amenities like parks and healthcare facilities, increasing carbon emissions from commuting. Local authorities could address this by increasing urban amenities and social infrastructure, upgrading existing facilities, and promoting their use in well-served areas. New facilities should be built in underserved areas, and existing ones modernized. Improving the built environment for safer walking and cycling, and increasing population density near amenities, will reduce energy consumption and transport emissions while enhancing accessibility.

Cities could also improve access to public transportation and nonmotorized alternatives. The macro assessment reveals a significant lack of accessibility to public transportation, with only 7 percent of residents living near a bus stop. Local governments could promote sustainable mobility by expanding the public transportation network, adding new routes, and enhancing infrastructure like right-of-way lanes. Redesigning streets to prioritize walking and cycling safety, balancing space for pedestrians and vehicles, and providing protected pedestrian and cycling infrastructure will encourage healthier, low-carbon transportation options.

The specific actions suggested for achieving the key objective of easy access to infrastructure and services are:

4 **New Social Infrastructure**

SA10. Redevelop and repurpose brownfield sites and underused urban plots by promoting mixed-use development and creating more public spaces. Facilitate building permits in central areas and provide economic and fiscal incentives for infill development and renovation projects that comply with local green building codes.

SA11. Facilitate the construction and upgrading of housing in well-served neighborhoods. Local authorities could invest in revitalizing these areas by upgrading basic services and infrastructure, improving public buildings and spaces, and increasing energy- and water-efficient housing units.

SA12. Transform single-use public buildings into multifunctional community spaces. Most Central Asian residents lack convenient access to urban amenities and social infrastructure. Cities should extend the hours of public facilities and integrate compatible activities within them. This will improve accessibility, strengthen community ties, and reduce social service costs. Adapt existing buildings to accommodate various activities, such as libraries, community centers, and childcare facilities.

SA13. Create a network of cultural and sports facilities to promote cohesive, resilient, and inclusive communities. Cities could invest in constructing or upgrading community centers, public parks, and shared spaces. These investments strengthen social ties and increase the city's social capital.

4 New Social Infrastructure

SA14. Improve coverage and access to quality health care services. The assessment reveals spatial injustice in proximity to health facilities. Creating new facilities is essential, but their location is critical. Focus on building medical centers and clinics in densely populated areas far from existing public health facilities. This will enhance health outcomes and improve spatial equality.

SA15. Designate public spaces and buildings as shelters and disaster response centers. To enhance city resilience and ensure quick disaster response, these shelters should be disaster-resistant and capable of autonomous operation, providing safe refuge and serving as coordination points for relief efforts.

5 Low-Carbon Personal Mobility

SA16. Create and maintain safe walking and biking paths to schools and urban amenities. Enhancing street and sidewalk safety improves access to public facilities and supports social mobility. This could be achieved by widening sidewalks, adding crosswalks, planting trees, providing shade, and installing traffic calming measures and lighting. Safe routes encourage walking and biking, reduce air pollution, and lower GHG emissions. Implement road safety measures around these facilities and public spaces.

SA17. Build complete streets to enhance walking and cycling. While many cities support active mobility, local authorities should design environments that promote nonmotorized transport, especially near public transportation stations and social infrastructure (within 1,000 meters). This involves redesigning streets to allocate safe spaces for walking and cycling, creating safe cycle parking, and bike lanes, and protecting pedestrian and cycling infrastructure from motorized traffic.

6 Efficient Public Transport

SA18. Update and expand the public transportation network. Efficient options like trolleybuses and buses are well-known in Central Asia. To attract more riders, cities should prioritize funding to expand coverage and implement transport-priority corridors. This will reduce traffic congestion, air pollution, and GHG emissions.

SA19. Decarbonize public transportation. Cities could adopt energy-efficient, low-emission vehicles to reduce fossil fuel dependency, GHG emissions, and air and noise pollution. Modernize bus fleets to battery-electric, hydrogen, or natural gas units. For electric vehicles, reduce the carbon intensity of the national grid by introducing pollution controls, cleaner fuels, and renewable energy sources.

7 E-Mobility

SA20. Invest in charging stations for public and private electric vehicles (EVs) to reduce GHG emissions and improve air quality in CA cities. Transitioning from fossil-fueled to electric vehicles can significantly lower the carbon footprint. Key strategies include promoting subsidies for charging infrastructure, exploring public-private partnerships (PPP) for installation and maintenance, and providing fleet conversion incentives for private vehicles, businesses, taxi companies, and public transportation agencies.

SA21. Gradually disincentivize private vehicle use and ownership to promote sustainable urban mobility. Measures could include congestion pricing, car-free zones, vehicle-emissions fines, and increased parking fees. Reducing private vehicle use decreases traffic congestion and carbon emissions. Ensure sustainable alternatives like public transportation, cycling, and pedestrian pathways are available, enhancing social equity by providing affordable transportation for all residents.

International Best Practice: Open Schools in Tirana, Albania[46]

Tirana's innovative Open Schools program transforms educational facilities into vibrant community hubs. These spaces function as traditional schools on weekdays and become accessible to the community on evenings, weekends, and holidays, serving as recreational areas, meeting places, and emergency shelters, fostering community life.

The Tirana 2030 masterplan incorporates this concept to address the city's growing population and revitalize suburban areas. By opening public schools beyond traditional hours, Open Schools integrates education into residents' lives. The plan envisions 17 new schools by 2030, starting with three in Don Bosko, Köder-Kamëz, and Shqiponja, inaugurated in 2021. These schools offer canteens, multipurpose halls, libraries, and sports facilities, accessible from both inside and outside the buildings.

46 See Stefano Boeri Architetti – Open Schools | Tirana.

Dimension 3: Adapt to Natural Hazards and Climate Risks

To enhance resilience against climate-driven hazards, cities can leverage the power of nature-based solutions and adopt resilient urban development practices.

Cities should prevent construction in hazard-prone areas, as the region is vulnerable to earthquakes, floods, and landslides. Unplanned expansion increases the number of vulnerable people. To ensure resilient development, cities must prioritize urban planning with hazard risk assessments. Additional measures include early warning systems, retrofitting existing structures in moderate-risk areas, and developing a risk atlas to identify unsuitable areas for urbanization.

Cities can improve resilience to weather events by expanding multifunctional green spaces[47], reducing exposure to UHI and flooding. Implementing green corridors and reducing heat absorption in built-up areas are key strategies. Local authorities could invest in tree trenches along sidewalks and roads, and revitalize underused plots and degraded public spaces with vegetation and water features to manage stormwater and regulate temperature. Additionally, supporting green roofs, white roofs, and vertical gardens can further reduce heat absorption.

CA cities should prioritize climate-smart policies to protect public health and reduce GHG emissions. They face challenges like air quality, water pollution, and flood exposure. While local governments have strategies to mitigate these issues, most lack a climate change vision. For example, Kazakhstan plans to introduce natural gas and electric buses, Uzbekistan aims for 80 percent electric or natural gas-powered public transit by 2030, the Kyrgyz Republic targets 80 percent of urban passenger volume with these vehicles, and Tajikistan promotes electric vehicles to reach a 55 percent share by 2037. However, these investments focus on reducing pollutant emissions rather than specific GHG reductions. Cities that design climate-smart policies can better protect public health, reduce carbon intensity, and build resilience.

The specific actions suggested for achieving the key objective of adapting to natural hazards and climate risks are:

8 Green Infrastructure and Nature-Based Solutions (NBS)

SA22. Restore and enhance urban green areas and nature in public spaces. Environmental degradation negatively impacts biodiversity, ecosystem services, and public health. Cities could increase access to green areas and restore degraded spaces with native species to counteract the UHI effect. To fund these efforts, cities could seek national and international green funds, public income, and public-private partnerships, and evaluate instruments like tax-increment financing, carbon bonds, and value-capture taxes.

SA23. Ensure access to urban green areas of at least 0.5 hectares within a 5-minute walk from residential areas. These green spaces offer social and environmental benefits, including flood management, temperature regulation, biodiversity sheltering, air quality improvement, soil protection, and water runoff prevention.

9 Wastewater Management

SA24. Build pollutant-specific wastewater treatment plants in industrial parks. Industrial wastewater requires different treatment than household waste. Cities in CA could form public-private partnerships to develop these facilities, funded by wastewater fees on industries and higher taxes or fines for untreated discharges. Investing in advanced monitoring technologies will ensure accurate measurement of wastewater quantity and quality. Fees, taxes, and fines based on discharge volume and pollutant content will incentivize sustainable practices. Revenue from these measures could enhance local sewage systems and build new treatment facilities.

SA25. Modernize and rehabilitate water and sewage infrastructure. These systems are essential for community well-being and public health. Cities in this region struggle to meet demand due to outdated Soviet-era infrastructure and urban sprawl. Aligning urban containment measures with water infrastructure retrofits can help prioritize areas for improvement and allocate resources efficiently, allowing for the repair and upgrade of existing networks to handle increased demand.

Regional Best Practices

Most countries in the region have set ambitious targets for urban environment and risk management. The Kyrgyz Republic's National Development Strategy 2018-2040 (NDS-2040) guides policy and investments, emphasizing the expansion of green areas to mitigate climate change risks. Uzbekistan's New Uzbekistan Development Strategy 2022-2026 coordinates with every region in the country and set city-level urban environment targets, including planting millions of trees to improve air quality.

Regional climate change frameworks promote a low-carbon, resilient approach in CA cities. All countries participate in the Sendai Framework for Disaster Risk Reduction and aim to incorporate its principles into domestic policies. Transboundary cooperation, such as the Regional Center for Emergency Situations and Disaster Risk Reduction (CESDRR) established by Kazakhstan and the Kyrgyz Republic, supports regional resilience. Continuing these frameworks will significantly aid the region's resilient pathway.

47 According to WHO (2017) the population should be able to access consolidated urban green areas of at least 0.5 hectare within a 5-minute walk from residential areas.

International Best Practice: La Quebradora Park, Iztapalapa, Mexico City

La Quebradora (Vargas Lara 2018) is a 4-hectare public park in one of Mexico City's densest districts, offering cultural and recreational activities (photo 5.2). The park addresses water management issues like drinking water scarcity, flood hazards, sinking ground, and reduced aquifer recharge. Using Water Sensitive Urban Design (WSUD), the park captures rainwater and infiltrates it into the aquifer, benefiting up to 28,000 residents. It increases public space per capita from 1.1 to 2.9 m², improves water capture and infiltration, and reduces flood hazards in surrounding streets. The park features a skate park, swimming pool, basketball courts, open-air gym, and multifunctional classrooms. It includes a wastewater treatment plant, bioswales for water demand, and solar panels for electricity.

Photo 5.2 La Quebradora Park, Mexico City

Source: © Elprimoshere, Licensed under CC0 1.0 Universal.

International Best Practice: Little Sugar Creek, Charlotte, North Carolina (USA)

The Little Sugar Creek Greenway (LandDesign n.d.) spans 800 acres and serves as a vital city corridor (photo 5.3). Completed in 2012, this multifunctional green space connects neighborhoods, parks, civic facilities, schools, and open areas, attracting thousands of visitors monthly. The waterfront has seen significant retail and residential growth, creating picturesque landscapes. Once a neglected and polluted waterway, Little Sugar Creek's transformation began in 1990 by Mecklenburg County.

Photo 5.3 Little Sugar Creek, Charlotte, North Carolina

Source: Institute for Transportation Research and Education. (2015). Little Sugar Creek Greenway Urban Section Pedestrian Downtown [Graphic]. Licensed under CC by 2.0.

Integrating green infrastructure in this dense urban area faced challenges like property acquisition, business relocation, flood-resilient design, and freeway proximity. Ecologically, the main goal was to restore the creek's health, requiring robust public involvement through stakeholder interviews and community open houses. The transformation began in 2002 with the removal of the concrete cap, followed by replanting native vegetation and restoring creek banks. These efforts brought back wildlife and changed community perception, with residents valuing the creek's beauty and ecological benefits. The project's success relied on public-private partnerships.

Dimension 4: Mitigate Greenhouse Gas Emissions and Environmental Concerns

Low-carbon development requires clean local energy generation, and a set of energy-efficiency measures in existing residential buildings.

Achieving low-carbon urban development requires transitioning to clean local energy sources. Analyses show the power industry is a major carbon emitter, responsible for nearly one-third of regional emissions. In cities like Aktau, Osh, and Temirtau,[48] power generation emissions can exceed 50 percent of their carbon footprint. This is mainly due to coal-fired CHP plants. To reduce emissions, the region could decrease reliance on solid fuels and increase clean energy production, such as solar, wind, hydro, and geothermal power. Additional measures include investing in renewable energy, setting incentives for distributed generation, and implementing abatement technologies.

48 EDGAR data (Monforti Ferrario et al. 2021) reveals that the power industry is a significant contributor to carbon emissions in Aktau (71 percent), Osh (65 percent), and Temirtau (64 percent).

Energy-efficient strategies and local green building codes can significantly reduce carbon and air pollutant emissions. By updating building regulations to meet energy-efficient standards, local governments can lower per capita GHG and particulate matter emissions from the construction sector. Analysis shows potential reductions in air pollution and carbon emissions, with $PM_{2.5}$ emissions decreasing by 14-97 percent and GHG emissions by 2-40 percent. Cities in CA could enforce higher energy-efficiency standards for buildings and appliances, and incentivize energy-efficient technologies in existing buildings through fiscal incentives and grants. Governments could also partner with international financing institutions and banks to offer green mortgages for environmentally efficient housing and buildings.

Decarbonizing residential cooking and heating is crucial for low-carbon development. This involves renovating building envelopes to improve insulation and upgrading heating systems to modern, energy-efficient alternatives like heat pumps and eco-friendly stoves. These measures reduce heat loss, lower energy demand, and cut air pollutants. Analysis shows that retrofitting heating technology and using energy-efficient stoves can reduce annual household energy consumption per capita by up to 30 percent under the Net Zero scenario and 23 percent under a Cost-Efficient scenario. Carbon emissions could decrease by up to 31% with strong retrofitting efforts, while fine particulate matter could drop by 56 percent under the Net Zero scenario. To achieve these reductions, it is essential to improve insulation, phase out polluting fuels, and adopt modern heating and cooling technologies.

To curb transportation-related CO_2 emissions, CA cities should prioritize sustainable transportation by reducing the use of diesel and gasoline-fueled vehicles. This can be achieved through regulations limiting these vehicles, promoting low-carbon public transport, and encouraging non-motorized modes of transport. Key actions include limiting obsolete vehicle imports, conducting environmental checks on public transport, phasing out older vehicles, and offering incentives for low-carbon and electric vehicles. Additionally, promoting public transport can involve implementing low-emission and car-free zones, expanding public transport infrastructure, and developing safe pedestrian and cycling paths. Analysis shows that reducing motorized vehicle use and expanding public transport, combined with strategic densification, can significantly cut commuting-related greenhouse gas emissions.

The specific actions suggested for achieving the key objective of Mitigating GHG Emissions and Environmental Concerns are:

10 **Energy and Water Efficiency**

SA26. To reduce per capita GHG emissions in the construction sector, cities should implement and update building regulations to meet energy-efficient standards. This includes enforcing higher energy-efficiency standards for buildings and household appliances, as well as new commercial and office buildings. For existing buildings, cities can incentivize energy-efficient technologies and low-scale renewable energy systems through fiscal incentives and grants. Additionally, governments can partner with international financing institutions and banks to offer lower-rate green mortgages for environmentally efficient housing and buildings.

10 **Energy and Water Efficiency**

SA27. Incentivize the purchase and use of green appliances through rebates and tax breaks to make them more affordable and attractive, accelerating the transition to sustainable energy efficiency. Prioritize high-efficiency refrigerators, washing machines, dryers, energy-efficient stoves, LED light bulbs, and smart thermostats. Slow adoption hinders energy goals and increases GHG emissions; thus, incentivizing green appliances complements other energy-efficient and low-carbon initiatives.

11 **Efficient Heating**

SA28. Decarbonize cooking and heating systems in residential buildings by focusing on combined renovations of building envelopes and heating systems. Enhance insulation of windows and doors to minimize heat loss in winter and reduce cooling needs in summer. Upgrade heating systems to energy-efficient alternatives like heat pumps, which can significantly reduce emissions when paired with low-carbon electricity. For cooking, update equipment regulations and consider programs for improved stoves, fuel switching (coal to gas if feasible), and better solid fuels.

12 **Renewable Energy**

SA29. Promote renewable microgrid technology in residential and commercial buildings. Access to clean, reliable electricity is essential for economic development and quality of life. Implement distributed renewable solutions like photovoltaic panels on roofs and facades to generate solar energy for buildings, social facilities, and street lights. This transition reduces carbon intensity, promotes community resilience, diversifies energy sources, and lowers GHG emissions. Cities can offer economic incentives and capacity-building programs to accelerate this shift.

13 **Decarbonization of the Power Industry**

SA30. Modernize CHP plants in cities to transition from coal to natural gas. Cities in CA face power sector pollution but lack control over operations. National governments should modernize CHP plants to boost efficiency and cut emissions. Additionally, CA can expand renewable energy, both utility-scale and distributed, and invest in carbon capture and storage where fuel substitution isn't feasible.

SA31. Invest in carbon capture and storage (CCS) in manufacturing and industry. Incorporating CCS technologies can significantly reduce GHG emissions by capturing CO_2 at the source and preventing its release. This involves capturing, compressing, and securely storing CO_2 in carbon sinks.

14 Effective Solid Waste Management

SA32. Consolidate municipal waste management to mitigate environmental degradation, improve public health, and enhance resource efficiency. In CA, challenges include incomplete collection, inadequate landfill space, and insufficient recycling systems. Cities need to develop infrastructure for waste collection, treatment, and recycling. Addressing these needs will help mitigate GHG emissions through sorting and recycling, waste-to-energy solutions, and pollutant control at disposal sites.

SA33. Implement "Waste-to-Energy" facilities as part of a low-carbon waste management strategy. Use biodigesters to treat organic material and capture biogas for generating electricity and heat in areas with significant biodegradable waste. Assess and define the best technological options suited to each city's local context.

15 Enhanced Air Pollution Control

SA34. Develop local emission inventories of criteria air pollutants and GHGs. These reports list all sources of pollutants in an area, detailing types, amounts, and sources. This data informs public policies to improve air quality and monitor progress. Major metropolitan areas should regularly monitor GHGs and air quality, updating inventories at least every two years.

SA35. Invest in an automatic pollution monitoring network. These systems help identify air quality issues, track policy performance, and pinpoint pollutant sources and their interaction with weather. They support evidence-based policy design, inform the public about air quality, activate contingency programs for extreme pollution, and protect public health. In many cities, these networks are essential for air quality and public health initiatives.

SA36. Establish a vehicle verification program with mandatory inspections for private cars, motorcycles, trucks, and buses to test safety and emissions. This will reduce highly polluting vehicles and improve urban air quality. The program could be linked to initiatives like "day without a car" or ecozones. Design the policy to reward low-carbon technologies (hybrids, electric, natural gas) and discourage high-carbon options through fines, use restrictions, and enforcement.

Regional Best Practices

Central Asian countries are committed to reducing energy intensity. Kazakhstan aims for a 30 percent reduction by 2030 and 50 percent by 2050, while Uzbekistan targets a 30 percent reduction by 2030. The Kyrgyz Republic aims for a 4.5 percent reduction by 2023.[49] All countries plan to reduce energy consumption in housing, public, and industrial sectors by introducing resource-efficient technologies, reducing transmission and distribution losses, and enhancing building energy efficiency.

Energy efficiency in housing and infrastructure is a priority for Central Asian countries. Kazakhstan leads in building energy efficiency, setting clear consumption targets, encouraging retrofitting, and enhancing subnational control and monitoring. The Kyrgyz Republic has introduced energy efficiency certification for buildings and developed "green" technical passports for construction.

Transportation strategies promote electric vehicles and invest in charging infrastructure. Kazakhstan considers natural gas and electric buses, Uzbekistan aims for 80 percent electric or natural gas public transport by 2030, the Kyrgyz Republic targets 80 percent clean-powered public transport in major cities, and Tajikistan promotes electric vehicles for both private and public use. Most countries offer tax and fee benefits on electric vehicle imports, boosting their popularity. Tajikistan is implementing an electric taxi project, the Kyrgyz Republic is considering electric official vehicle fleets, and Kazakhstan is expanding electric vehicle infrastructure in large cities.

International Best Practice: Green Mortgage Program, Mexico

Mexico's Green Mortgage Program, initiated by Infonavit, offers extra loans at lower rates for purchasing energy- and water-efficient homes (photo 5.4). It includes incentives for developers and is linked to public subsidies and housing credit rules. The program achieves nearly one ton of CO_2e savings per household annually, with monthly savings of $13, seven cubic meters of water, and over 200 kWh. Recently, private banks in Mexico have implemented similar programs to promote efficient homes.

Photo 5.4 Photovoltaic System for Residential Use

Source: © CAPSUS. Used with the permission of CAPSUS. Further permission required for reuse.

49 At the time of writing, there was no report available on the achievement of this goal.

International Best Practice: Low-Emission Zone, Jakarta, Indonesia

A Low-Emission Zone (LEZ) restricts high-emission vehicles to reduce air pollution, improve air quality, and promote public transportation and low-emission transport. Jakarta's LEZ, implemented in Kota Tua on February 8, 2021, covers 14 hectares with six closed road sections. Only pedestrians, cyclists, public transportation, residents, and vehicles with low-emission stickers are allowed. The LEZ aims to limit traffic and protect the cultural heritage of the old town, as part of the Kota Tua Old City master plan. It includes the following strategies:

- Reduce the number of vehicles on the road.
- Protect the physical structures and historical character of Kota Tua.
- Improve air quality.
- Create a more pleasant and healthy environment for residents and visitors.
- Encourage people to use public transportation and walk more, which will help reduce traffic and air pollution.

Photo 5.5 Jakarta Old Town, Kota Tua

Source: © Hari W. Agung. Licensed under CC by-SA 2.0 Attribution-Share alike 2.0 Generic.

Due to improvements in air quality, safety, and social inclusion, Jakarta plans to expand the LEZ to other areas. The Kota Tua LEZ improved the Air Pollution Standard Index (ISPU) from 58 to 49 points. Authorities aim for full pedestrianization and integrated public transportation access by 2027.[50]

50 DKI Jakarta Governor Special Climate Envoy Team. (2021). Jakarta Climate Resilient City. Best Practices Compilation 2021. Jakarta.

Dimension 5: Enhanced Access to Jobs

Mixed-Use Development Is Key for Thriving Low-Carbon Cities

Central Asian cities should prioritize mixed-use development to improve job access, shorten commutes, and reduce carbon emissions. Currently, these cities have monofunctional urban areas with few residents near job centers. Integrating residential areas with workplaces, shops, and amenities can attract businesses, create jobs, and foster entrepreneurship. Prioritizing mixed-use development and compact growth strategies increases proximity to job centers and reduces vehicle-kilometers traveled. Policy interventions include zoning reforms to incentivize mixed-use developments and programs to support entrepreneurship and start-ups.

The specific actions suggested for achieving the key objective of access to jobs are:

16 **Accessible Jobs**

17 **Land Use Planning**

SA37. Incentivize mixed-use densification in urban areas by offering tax breaks, density bonuses, quick permitting, and public real estate assets. These incentives encourage developers to invest in energy-efficient buildings and renovations. This strategy promotes infill development, reducing carbon intensity and climate vulnerability. Code amendments can support new buildings with commercial ground floors and residential upper floors, enhancing sustainability. Densely mixed-use neighborhoods foster interaction, reduce commuting times, promote diversity, and lower GHG emissions.

SA38. Encourage new residential developments to allocate 25-30 percent of the constructed area to nonresidential (and job-generating) uses. This mix promotes sustainable development by enabling walking to destinations and reducing service provision costs. According to UN-Habitat (2023), this strategy is effective but may need local adjustments. Cities should use regulations and economic incentives, like property tax breaks for mixed-use buildings, to bring jobs and services closer to residents.

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Appendixes

Appendix A:
Macro-Assessment Report with Methodology and References

Appendix B:
Five City Reports

Appendix C:
Institutional Full Gap Analysis

Appendix D:
Summary Fact Sheet

Appendix E:
Technical Analysis Report on Proposed Investments for the Five Cities

Appendix F:
Country-Level Summaries With Relevant Recommendations

REIMAGINING CENTRAL ASIAN CITIES FOR A RESILIENT AND LOW-CARBON FUTURE

Kazakhstan
Kyrgyz Republic
Tajikistan
Turkmenistan
Uzbekistan

City Resilience Program
GFDRR Global Facility for Disaster Reduction and Recovery
CSF CLIMATE SUPPORT FACILITY
Since 1948 AUSTRIA 75 YEARS WORLD BANK
SURGE Sustainable Urban and Regional Development