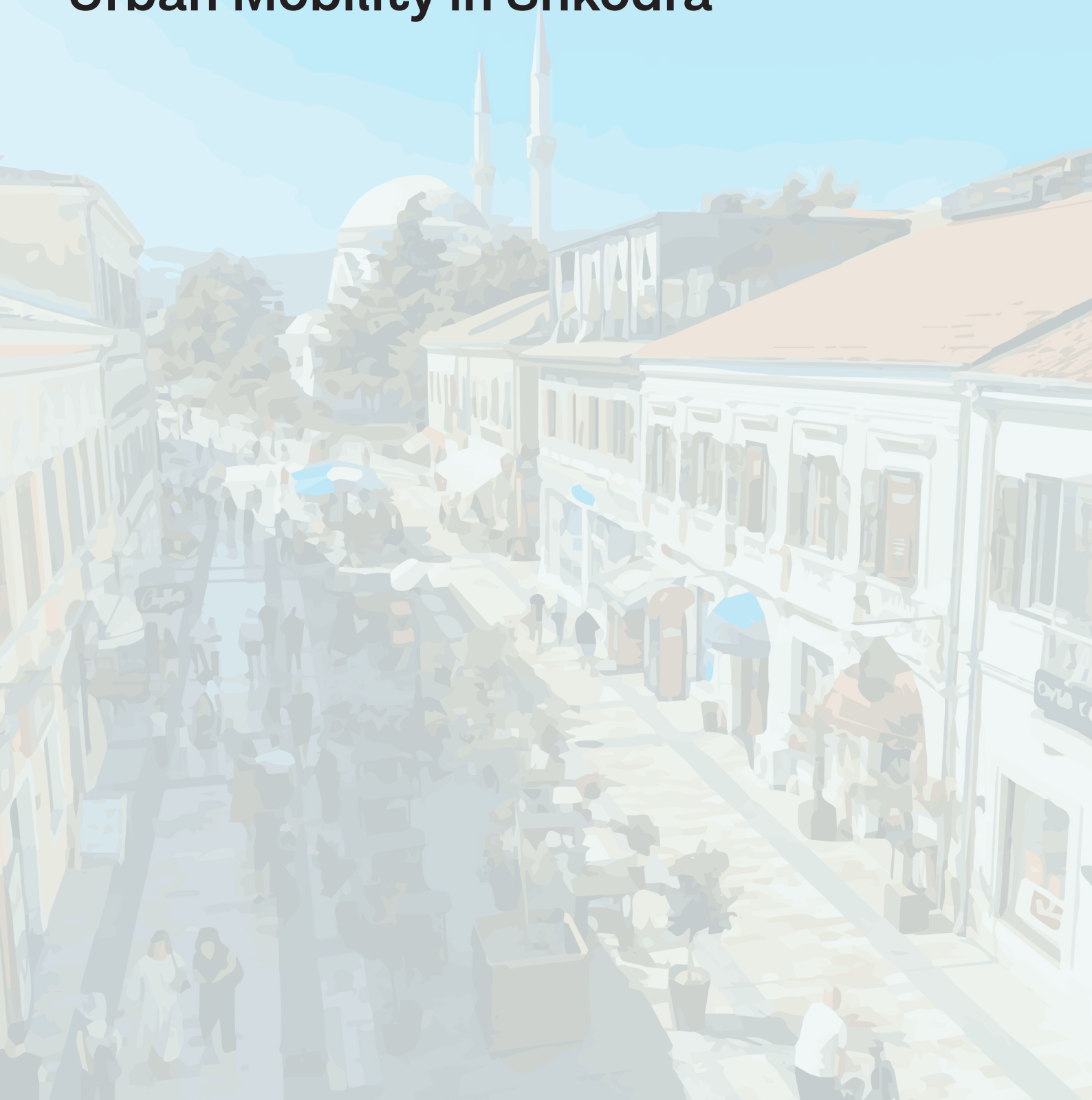


# Climate Risk Assessment of Urban Mobility in Shkodra



This Climate Risk Assessment (CRA) provides a rigorous, data-driven evaluation of the current and projected climate risks threatening the urban mobility ecosystem of Shkodra, Albania. Developed under the regional project “Green Agenda: Climate Change Adaptation in the Western Balkans,” implemented by GIZ, this report establishes the empirical evidence base required to integrate climate resilience directly into Shkodra’s local climate action planning, future Sustainable Urban Mobility Plan (SUMP) updates, and municipal capital infrastructure procurement frameworks.

## Project Context

Funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and spanning six Western Balkan countries (2024–2026), this regional initiative aims to accelerate the implementation of the Green Agenda. The project focuses on improving decision-making foundations, boosting regional knowledge sharing, and implementing scalable climate adaptation strategies specifically within the agriculture and urban transport sectors.

### Disclaimer

The findings, interpretations, and conclusions expressed in this report are entirely those of the authors and do not necessarily reflect the official views or policies of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, its commissioning federal ministries, or any other public or private entity mentioned herein.

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## EXECUTIVE SUMMARY

This Climate Risk Assessment (CRA) provides a rigorous, data-driven evaluation of the current and projected climate risks threatening the urban mobility ecosystem of Shkodra, Albania. Developed under the regional project Green Agenda: Climate Change Adaptation in the Western Balkans (WB Adapt) implemented by GIZ, this report establishes the empirical evidence base required to integrate climate resilience directly into Shkodra's local climate action planning, future Sustainable Urban Mobility Plan (SUMP) updates, and municipal capital infrastructure procurement frameworks.

Shkodra combines a highly compact urban form, a unique active-mobility paradigm (with walking and cycling representing nearly two-thirds of daily trips), and an unreliable public transit network. Its highly complex hydrological location at the confluence of the Buna, Drin, and Kir rivers, paired with flat plain geography and climate-driven precipitation shifts, makes it one of the most climate-exposed urban centres in the region, with risks directly impacting the safety, comfort, and structural continuity of daily movement patterns.

The assessment strictly follows the risk-based methodological framework outlined in the GIZ Climate Risk Sourcebook (2023), utilizing the standard core risk paradigm:

Risk = Hazard x Exposure x Vulnerability

To ground the risk profile in local, empirical evidence, the framework normalizes and integrates multi-source geospatial, climatic, and socio-demographic indicators into a standardized five-class scoring system (20% increments) across three core pillars:

- Hazard Identification: Derived from the Western Balkans Climate-Proofing Platform (historical baseline 1981–2010)<sup>1</sup>, GIZ Flood Risk Management Plan for the Shkodra Region and the Flood Risk Management Plan for the Drin–Buna Area 2023–2028<sup>2</sup>, Albania's Fourth National Communication on Climate Change, and Copernicus ERA5 urban downscaling datasets. Long-term climate projections are modeled under the high-emissions RCP 8.5 scenario up to the year 2100. Additional inputs were drawn from Municipal Energy and Climate Action Plan (MECAP) Shkodra<sup>3</sup>, which provides a local energy and climate action planning context.
- Spatial Exposure Mapping: Processed in a GIS environment by overlaying calculated climate hazard layers over transport network vectors provided by Shkodra Municipality (comprising 54.49 km of primary roads, 278.12 km of walking paths, 5.11 km of cycling routes, and 51 bus stops). This was aligned with planned developments as identified in the Sustainable Urban Mobility Plan (SUMP) 2025–2034<sup>4</sup> shared by representatives from the Municipality of Shkodra.

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<sup>1</sup> <https://test.wb-ccp.com/home>

<sup>2</sup> [https://konsultimipublik.gov.al/documents/RENJK\\_646\\_Projekt\\_Plani\\_i\\_Menaxhimit\\_te\\_Rrezikut\\_nga\\_Permbytjet\\_per\\_disa\\_zona\\_te\\_Basent\\_Drin\\_Bune.pdf](https://konsultimipublik.gov.al/documents/RENJK_646_Projekt_Plani_i_Menaxhimit_te_Rrezikut_nga_Permbytjet_per_disa_zona_te_Basent_Drin_Bune.pdf)

<sup>3</sup> Municipal Energy and Climate Action Plan of the Municipality of Shkodër (2023-2040), submitted by Shkodra Municipality

<sup>4</sup> prepared by ERI-ITA, EIB, ADF, and Shkodër Municipality and approved by the Council of Shkodra Municipality <https://bashkiashkoder.gov.al/wp-content/uploads/Vendim-Nr-72-date-27.11.2025-Plani-i-mobilitetit.pdf>

- Vulnerability Metric Integration: Rooted in municipal databases and downscaled socioeconomic metrics, tracking populations with reduced physiological or socioeconomic adaptive capacity to withstand transit disruptions (including low-income households [22–25%] and elderly cohorts [15–17%]).

The analytical results identify specific structural and operational vulnerabilities across Shkodra's transport network, categorized by their systemic risk levels:

### **Critical Tier: Urban Heat Islands (UHI) & Extreme Heatwaves**

Extreme summer heat waves intersect with intense UHI effects to form the city's most critical mobility threat. Driven by a regional warming trend of 0.4–0.6°C per decade, the historical baseline of 70–90 days/year exceeding 30°C is projected to expand to 100–120 days/year by late century under RCP 8.5.

Thermal remote sensing confirms intra-urban temperature variations up to 6.5°C compared to surrounding rural baselines, heavily concentrating heat across the dense urban core and primary axes. Physical exposure mapping tracks significant systemic vulnerabilities: 100% of traffic lights, 77.1% of parking surfaces, 66.7% of bus stops, and 53.6% of cycling tracks sit within high-heat zones. This causes asphalt softening and rutting along high-volume arterials (e.g., the North–South corridor), compromises active transit comfort, and triggers structural degradation of electronic municipal signaling.

### **Moderate Tier: Pluvial (Urban) Flooding & Precipitation Extremes**

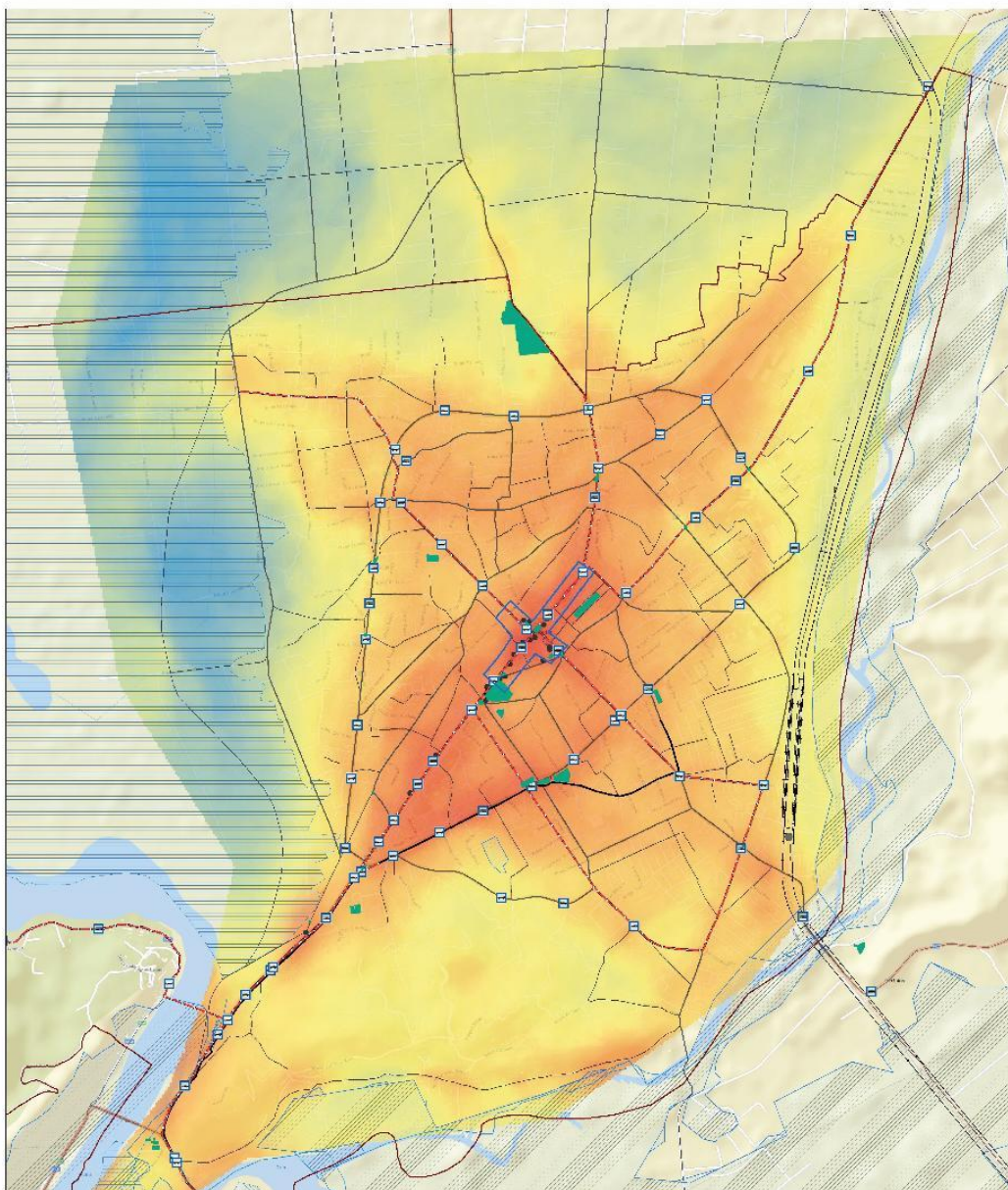
While total annual precipitation is high but variable, short-duration, high-intensity storms exceeding 20 mm/hour are projected to increase to 15–20% of all rainfall events by late century. Under the RCP 8.5 pathway, 99.9th percentile daily rainfall events (125–175 mm accumulations) will rise, contributing 8–10% of total annual precipitation. High surface sealing and an undersized stormwater grid create localized pluvial flooding sinks. The highest exposure is concentrated at critical transit links: 17.3% of cycling tracks, 14.8% of surface parking zones, 20% of traffic signaling nodes, and 6.7% of the total road network flood regularly, causing severe active mobility restrictions and traffic congestion.

### **Strategic Tier: Riverine and Coastal Flooding**

The Drin–Buna–Lake Shkodra hydrological system defines the city's most catastrophic structural hazard. Under RCP 8.5, peak river discharge is projected to increase by 15–25% by mid-century due to intensified winter precipitation and accelerated snowmelt. Though affecting a geographically localized urban footprint by length (2.8% of the road network and 3.2% of public transport routes), 100% of municipal road bridges (3 out of 3 major spans) and 13.6% of the rail infrastructure sit directly within high-risk flood zones. Overchannelling and river overtopping directly threaten to sever the city's entry points and main southbound corridor, crippling regional connectivity, freight logistics, and emergency services.

To shift from reactive maintenance to proactive climate risk management, Shkodra must prioritize green infrastructure, including planting dense tree canopies, constructing bioswales, and replacing 52,056 m<sup>2</sup> of heat-exposed surface parking lots with permeable pavers. Concurrently, the municipality must mandate climate-resilient engineering standards by elevating traffic signaling electronics at key river junctions, procuring transit fleets equipped with heavy-duty HVAC cooling systems, and launching a cross-sectoral IoT monitoring database to integrate real-time climate metrics into future SUMP updates and procurement frameworks.

*Figure 1. Map of urban mobility components and climate hazards. Please refer to Annex for the maps in original size*



## SHKODRA PROFILE

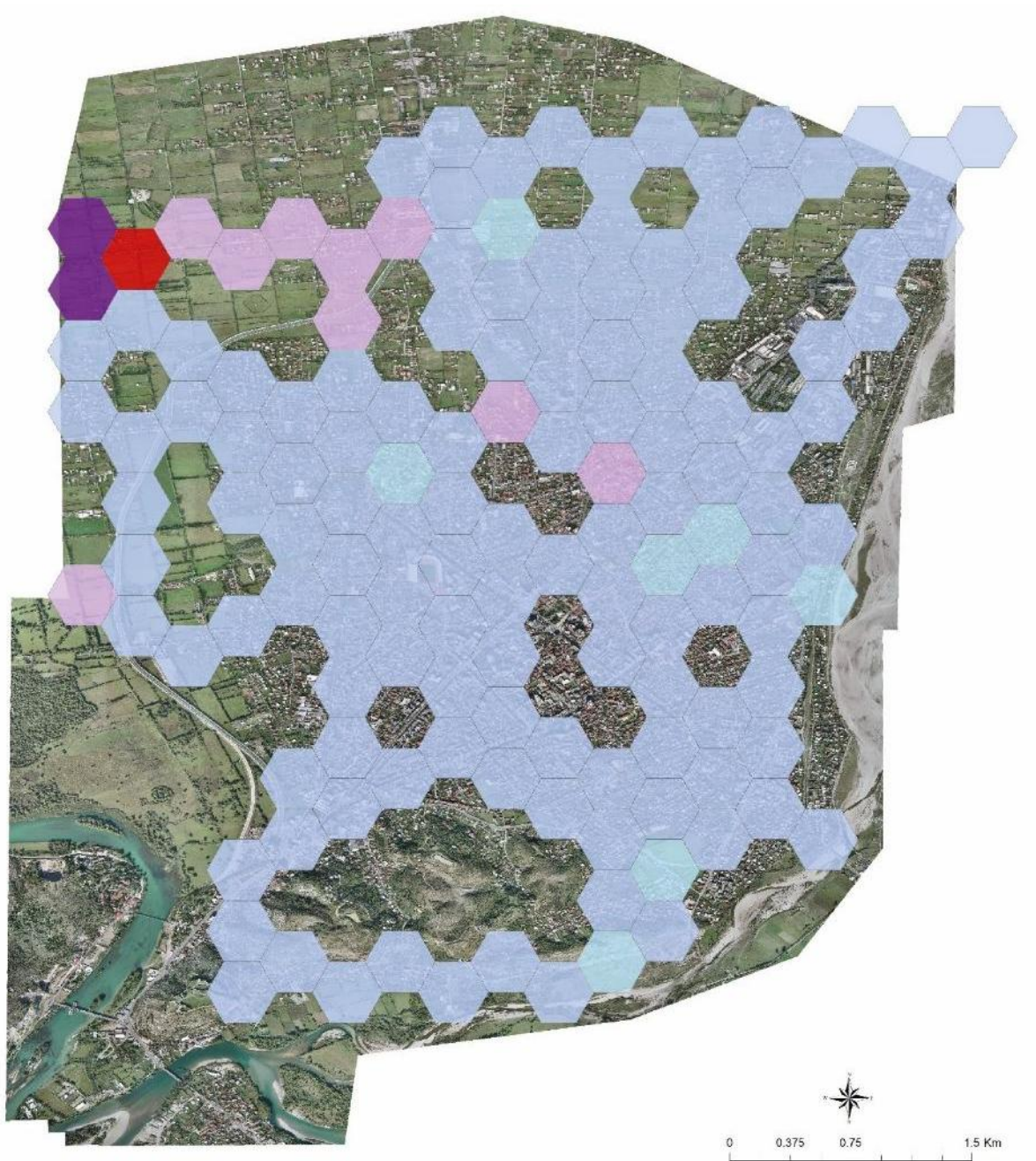
### Baseline Environmental and Air Quality Context

The Municipality of Shkodra features a specialized Mediterranean climate, sitting within a highly complex hydrological basin framed by the Drin, Buna, and Kir rivers, and the shores of Lake Shkodra—the largest freshwater body in the Balkans. Rapid urban expansion has reduced open agricultural land, increasing pressure on soil permeability and local water management. The flat terrain of the central urban basin contrasts sharply with the upland zones and the Albanian Alps to the northeast, making the downstream flat plains highly reactive to upstream mountain runoff and seasonal snowmelt.

Ambient air quality is a major public health and environmental issue, displaying severe diurnal variations driven by traffic density and microclimatic trapping. Longitudinal monitoring indicates substantial temporal pollution fluctuations:

- **Particulate Matter Diurnal Trends:** Median concentrations range from 20  $\mu\text{g}/\text{m}^3$  in the morning and 15  $\mu\text{g}/\text{m}^3$  in the evening down to 9  $\mu\text{g}/\text{m}^3$  during peak afternoon dispersion hours.
- **Localized Peak Events:** Morning rush hours exhibit the highest concentrations due to traffic peaks and stable atmospheric layers, with localized single-point maximum reads reaching up to 738  $\mu\text{g}/\text{m}^3$  in the morning and 306  $\mu\text{g}/\text{m}^3$  in the afternoon. These intense peaks exceed healthy safety thresholds, establishing severe pollution hotspots along unshaded, traffic-heavy urban corridors.

Figure 2. Map of PM2.5 averages in Shkodra



Map of Mean MP2.5 Hexagons  
Legend

- Good 0.1 - 12.0  $\mu\text{g}/\text{m}^3$
- Moderate 12.1-35.4  $\mu\text{g}/\text{m}^3$
- Unhealthy for sensitive group 35.5-55.4  $\mu\text{g}/\text{m}^3$
- Unhealthy 55.5-150.4  $\mu\text{g}/\text{m}^3$
- Very Unhealthy 150.5-250.5  $\mu\text{g}/\text{m}^3$

SHKODRA MUNICIPALITY

Green Agenda: Climate Change Adaptation in the  
Western Balkans – WB Adapt

Assignment: Development of Risk Assessment  
Methodology with Focus on Sustainable Transportation  
Consulting company: EU Bridge & Tregema



During the Heat Watch Albania campaign<sup>5</sup>, mobile measurements of particulate matter (PM<sub>2.5</sub>) were collected along the same routes used for temperature traverses, providing a snapshot of urban air quality conditions in Shkodra. PM<sub>2.5</sub> particles, those smaller than 2.5 micrometres, are among the most harmful air pollutants due to their ability to penetrate deep into the respiratory system.

In Shkodra, the median PM<sub>2.5</sub> concentrations recorded were 20 µg/m<sup>3</sup> in the morning, 9 µg/m<sup>3</sup> in the afternoon, and 15 µg/m<sup>3</sup> in the evening, while maximum values reached 738 µg/m<sup>3</sup>, 306 µg/m<sup>3</sup>, and 152 µg/m<sup>3</sup>, respectively. These values indicate substantial temporal variation, with morning hours exhibiting the highest particulate concentrations, likely influenced by traffic and daily activity peaks.

The median levels correspond to moderate air quality, suggesting that sensitive individuals, such as children, the elderly, and people with respiratory conditions, could experience mild respiratory symptoms outdoors. However, the maximum values recorded at specific points exceeded thresholds for “Unhealthy” to “Hazardous” conditions, highlighting localized pollution hotspots within the city.

Overall, the data reveal that air quality in Shkodra fluctuates significantly during the day, with short-term exposure to high PM<sub>2.5</sub> peaks posing potential health risks. These findings underline the need for targeted interventions in traffic-dense areas and continued monitoring to support local air quality management.

## Demographic and Social Vulnerability Matrix

The metropolitan core of Shkodra (comprising Shkodra city and the urbanized administrative unit of Rrethina) accommodates over two-thirds of the municipality's 213,000 residents<sup>6</sup>, with 116,593 individuals residing strictly within the urban core<sup>7</sup>. The remaining population is distributed across the predominantly rural administrative units such as Shalë, Shosh, Pult, Dajç, and Velipojë, where settlement density is lower and access to services and infrastructure is more limited. Pockets of socio-demographic vulnerability significantly amplify the impact of transport network disruptions.

Table 1. Quantification of social vulnerability indicators

Indicator	Estimated %	Basis for Estimate
Elderly population (65+)	15–17%	INSTAT population structure for Shkodra region
Children population (<14)	18–20%	INSTAT demographic distribution

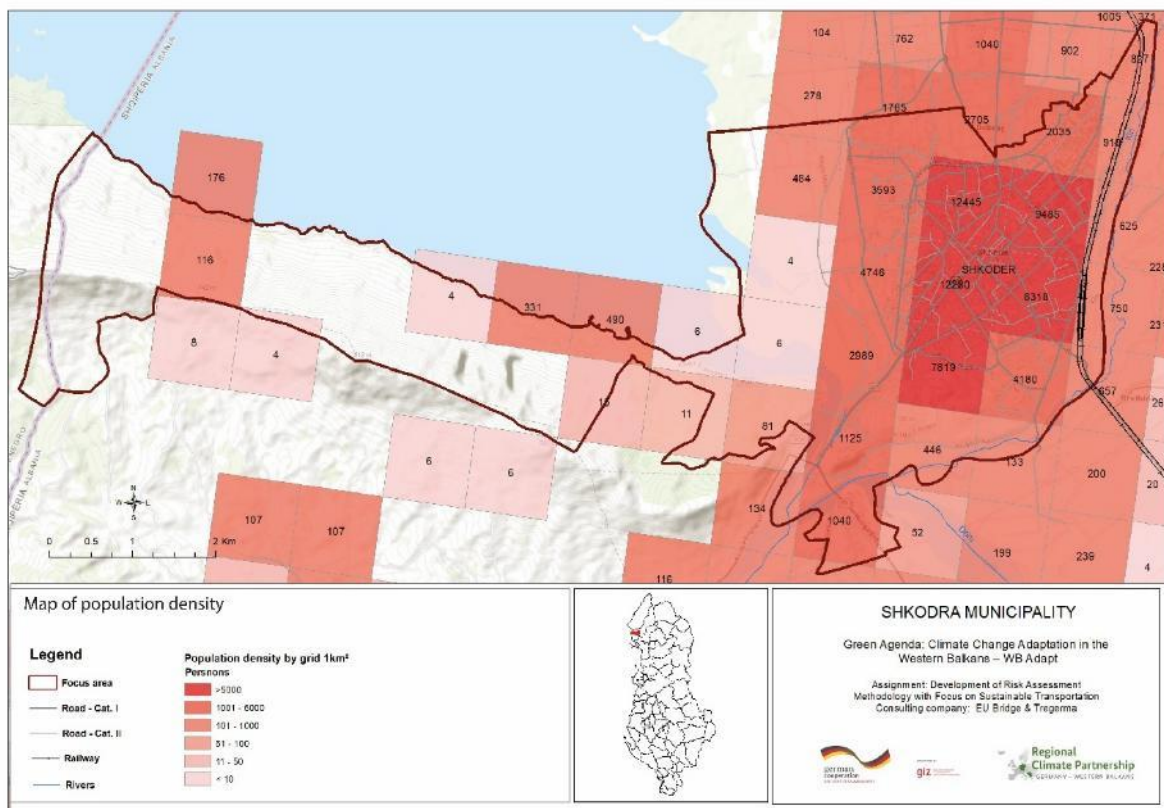
<sup>5</sup> <https://storymaps.arcgis.com/stories/0acc8804f35e4ca9b907bb93e0f1d11c>

<sup>6</sup> Bashkia Shkodër në shifra – Bashkia Shkoder

<sup>7</sup> Note that the data from the population census of 2023 from the Institute of Statistics (INSTAT) show a significantly lower number of inhabitants both in the city and the municipality.

Low-income households	22–25%	LSMS poverty indicators; Shkodra above national average poverty
Chronically ill cohorts	12–15%	Public Health Institute (ISHP) chronic disease prevalence
Single-parent households	7–9%	Census pattern for household composition
Disabled populations	6–8%	INSTAT disability data (regional level)
Informal settlements	5–7%	AKPT + municipal data on peri-urban informal housing (Drin–Buna lowlands)

Figure 3. Map of population density (1 km grid)



## Modal Split

Shkodra’s mobility framework is characterized by a compact urban form and a flat geography, which has sustained a unique culture of active mobility that represents the highest modal split share for non-motorized transport in the Western Balkans. The road network radiates from Democracy Square, intersecting along main boulevards and a series of inner rings. The Western Bypass (a four-lane corridor) offers some relief from through-traffic, but critical structural bottlenecks persist, notably at the Buna Bridge.

The 2024 Sustainable Urban Mobility Plan (SUMP) baseline modal split highlights this unique environmental baseline:

- **Cycling:** Accounts for 35–40% of all daily urban trips, serving as the primary backbone of everyday mobility across genders and generations.
- **Walking:** Accounts for 25–30% of daily travel behavior, heavily concentrated within the 1.4 km pedestrianized historical center (comprising Kolë Idromeno, Gjuhadol, 13 Dhjetori, and 28 Nëntori).
- **Private Motorized Vehicles:** Represent 20–25% of trips, though short-distance car use (< 3 km) is growing rapidly, causing severe parking pressure across 2,200 on-street surface spaces.
- **Public Transit (Bus):** Tracks below 10% of total trips, operating as a fragile, underfunded system consisting of a single primary north–south city line (L1) and two minor connections to Shiroka and Zogaj. Headways are erratic, oscillating from 15 minutes during peaks to over 60 minutes off-peak. Most bus stops lack protective shelters, real-time information displays, or intermodal alignment.

Parking dominates much of the street space: the SUMP recorded roughly 2,200 on-street and 850 off-street spaces, all at surface level. Informal parking and the system of “reserved” kerbside spaces constrain pedestrian access, erode public space, and create visual and functional clutter.

## Strategic Directions of the SUMP

The Sustainable Urban Mobility Plan (SUMP) for Shkodra provides a ten-year strategic roadmap to consolidate the city's active transport identity while adapting infrastructure to modern environmental strains. It translates this vision into eleven interlinked strategies and fifty-four measures built around four overarching goals: healthy, sustainable, efficient, and fair mobility. Key strategic priorities include:

- **Multimodal Boulevards:** Restructuring the primary north–south and east–west axes into linear green corridors that combine priority public transport, protected cycling tracks, and tree-lined pedestrian lanes.
- **Expanded Limited Traffic Zones (LTZ):** Enlarging traffic restrictions across the historic core, using narrower vehicular lanes, play-streets, and advanced access controls to encourage safe civic coexistence.
- **Protected Cycling Upgrades:** Upgrading Shkodra's active transit network with continuous protected lanes, secure parking hubs at key terminal nodes, and bike-sharing infrastructure.
- **Public Transit & Parking Overhaul:** Restructuring municipal bus service contracts, introducing electric fleets, constructing an intermodal hub at the railway station, and replacing informal street parking with regulated off-street resident zones and park-and-ride facilities.
- **Safety and accessibility as cross-cutting measures:** reducing accident black spots, redesign of junctions, installation of accessible pavements, and the design and implementation of “School Streets” programme, ensuring safe daily access for children.

## CLIMATE HAZARD DEEP-DIVE AND EXPOSURE METRICS

Table 2 Quantification of hazard indicators

Component	Score (%)	Explanation
<b>EXTREME HEAT &amp; UHI</b>		
% of days exceeding average summer temperature	76%	76% of summer days exceed the average summer temperature (24–26°C) for Shkodra. Source WB-CCP
% of days exceeding heat threshold (≥30°C)	25%	70–90 days/year (25% of the year) for Shkodra. Source WB-CCP
% of city area with elevated UHI	30%	Heat Watch Albania 2023; UHI mapping
<b>URBAN FLOODING</b>		
% annual heavy rainfall	8%	The 99.9th percentile precipitation intensity is in the range of 125–175 mm per event. In the Shkodra region, such high-intensity events typically account for 8% of total annual precipitation. Source WB-CCP "Precipitation intensity" observation
% of rainfall events exceeding 20 mm/hr	15%	Frequent in winter/autumn; estimated 15% of rainfall days. Derived from CCP intensity categories (60–100 mm/day events)
<b>COLD &amp; STORMS</b>		
% of days below freezing	2%	Minimum temperature, below 0°C. WB-CCP "Minimum temperature" observation
% of winter precipitation falling as snow	5%	CCP precipitation & temperature range
% of days with ice formation	1%	Temperature rarely falls below freezing
<b>LANDSLIDES</b>		
% of land cover classified as unstable	15%	Albanian Geological Survey (Geological Risk Map, Shkodra District <a href="http://geoportal.asig.gov.al">geoportal.asig.gov.al</a> )
% of area with recorded historical landslides	10%	Albanian Geological Survey (Geological Risk Map, Shkodra District <a href="http://geoportal.asig.gov.al">geoportal.asig.gov.al</a> )
<b>RIVER/COASTAL FLOODING</b>		

<b>% increase in peak river discharge</b>	10%	extreme peaks recorded in 2010 & 2021, ≈10% increase in peak river discharge
<b>% of city area in 100-year flood zone</b>	45%	Flood zoning maps
<b>% increase in storm surge events</b>	40%	Extreme wind speed, WP CCP

Figure 4. Map of land use in Shkodra municipality



## Urban Heat Islands and Extreme Heatwaves

### Climate Trends and Projections

Shkodra represents one of the most heat-exposed urban environments in Albania. Historical records track a rapid increase in heat severity, with 37 multi-day heatwaves documented between 1982 and 2012<sup>8</sup>; approximately 74% of these events occurred after 1996. Observed baseline data indicates over 80–90 days per year already exceed 30°C. Under the high-emissions RCP 8.5 scenario for the 2036–2065 period, the frequency of hot days is projected to rise to 100–120 days/year. Minimum night-time temperatures are projected to consistently exceed 14°C, significantly reducing nocturnal cooling. Combined with extended dry periods exceeding 120 consecutive days, summer microclimates will undergo extreme thermal amplification.

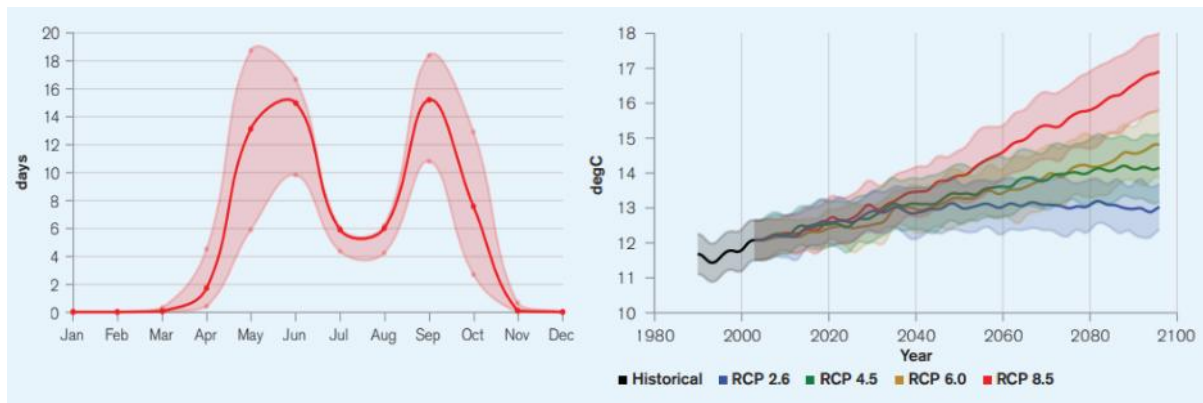


Figure 5: Projected change in summer days ( $T_{max} > 25^{\circ}\text{C}$ )      Figure 6: Historical and projected average

temperature for Albania from 1986 to 2099, from the World Bank's Climate Knowledge Portal for the Western Balkans

### Spatial Extents and Urban Hotspots

Thermal remote sensing confirms a high-intensity UHI profile across Shkodra's built footprint, with central land surface temperatures (LST) reaching up to 6.5°C higher than adjacent rural zones during afternoon peaks. The most severe thermal anomalies track along the primary commercial core and wide asphalt transport links. Conversely, open green spaces and the expansive margins of Lake Shkodra and the Buna River act as the city's primary microclimatic cooling reservoirs.

Table 3 Quantified hazard indicators for extreme heat & urban heat islands (uhi) in Shkodra

Indicator	Quantification (Current State)	Projection (RCP 8.5 scenario)	Source
% of days exceeding heat	<b>70–90 days/year</b> (20–25% of the year)	≈100–120 days/year (≈27–33% of the year),	WB-CCP Observation: "Heat

<sup>8</sup> Porja, T. (2013). Heat Waves Affecting Weather and Climate over Albania. Earth Science & Climatic Change, 4(4). <https://www.omicsonline.org/heat-waves-affecting-weather-and-climate-over-albania-2157-7617.1000149.php>

threshold (≥30°C)		with several exceeding 120 days/year by late century	days (30°C)" shows Shkodra grid cells in 70–90 days range
% of days exceeding average summer temperature	Approx. <b>54–76%</b> of summer days exceed the average summer temperature (24–26°C) (Average summer temp: 24–26°C)	≈75–90% of summer days exceed the historical average summer temperature, indicating near-continuous above-average heat conditions	WB-CCP "Average temperature" observations
% of city area with elevated UHI	<b>25–30%</b> of built-up urban core shows ≥6°C surface temperature contrast	≈35–45% of built-up urban area likely to experience ≥6°C surface temperature contrast, with intensification of UHI hotspots	Heat Watch Albania 2023; UHI mapping

Table 4. Quantified exposure indicators for urban heat island (UHI) for Shkodra urban area

Elements	Unit	Total Area	Affected Area	Percentage of affected area
Nr of traffic lights	number	5	5	100%
Number of parking spaces (including parking lots and on-street parking)	m <sup>2</sup>	67,535.90	52,056.70	77.10%
Number of bus stops	number	51	34	66.70%
Nr of EV charging stations	number	3	2	66.60%
Length of cycling roads	km	5.11	2.74	53.60%
Length of public transport routes	km	31.6	13.3	42.10%
Length of the road network	km	54.49	21.51	39.50%
Length of walking roads (total of walking roads, and pedestrian areas like Pedonale)	km	278.12	14.47	5.20%

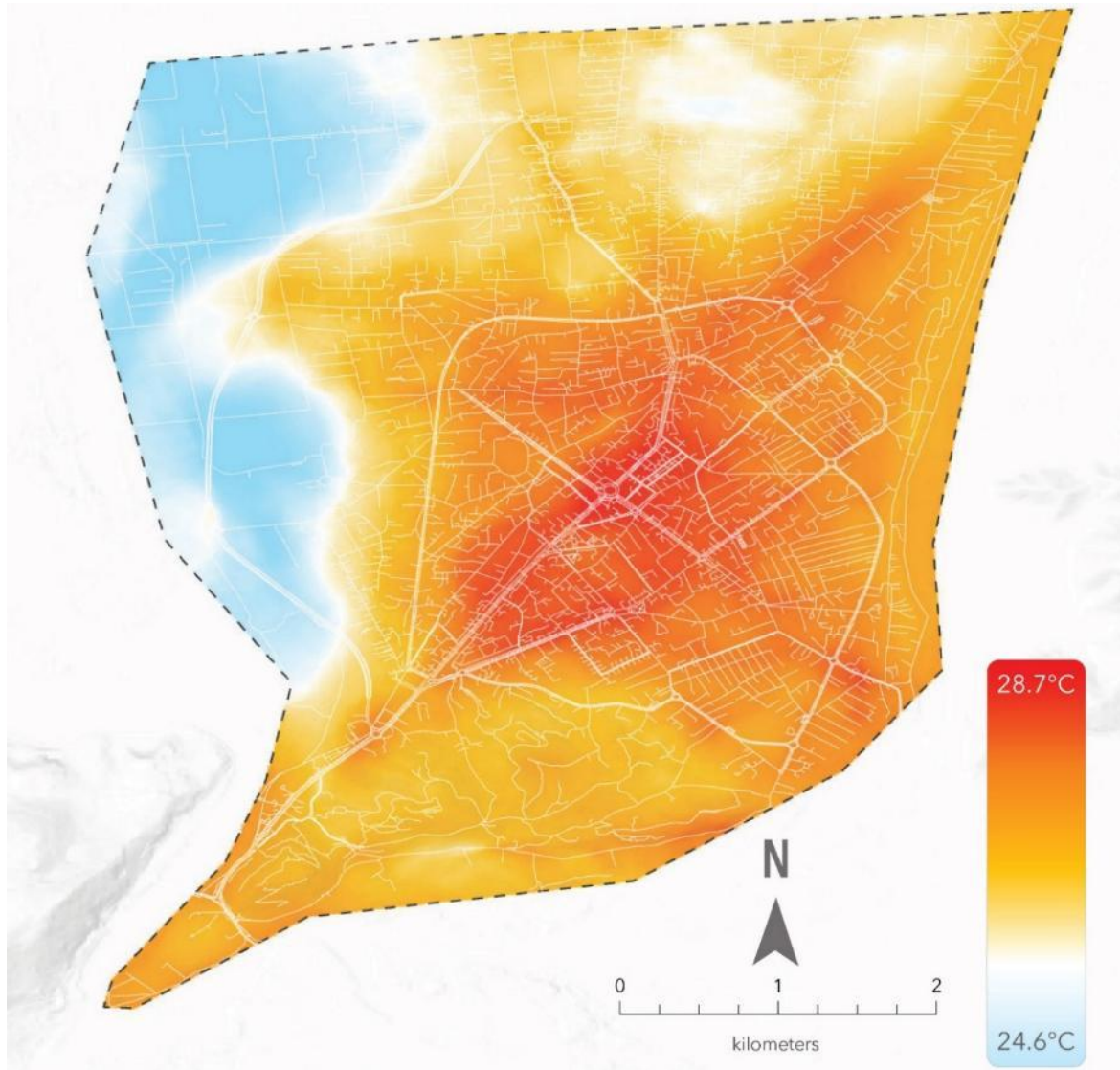
Measurements from the Heat Watch Albania campaign in August 2023<sup>9</sup> recorded intra-urban temperature differences of up to 6.5°C during peak afternoon hours, with the highest values observed around the city centre. These findings indicate that Shkodra's compact built form,

<sup>9</sup> World Bank & GFDRR (2023). Heat Watch Albania: Urban Heat Mapping Campaign: <https://documents1.worldbank.org/curated/en/099052825225387202/pdf/P177209-930133c5-204d-445e-968b-150cbfdd9e44.pdf>

lack of cooling corridors, and thermally dense materials intensify heat retention, particularly during calm, dry summer days when night-time cooling is minimal.

Copernicus ERA5 urban downscaling models<sup>10</sup> further suggest that if current patterns of surface sealing and limited greening persist, Shkodra's UHI intensity could increase by an additional 1–1.5°C by the 2040s relative to surrounding rural areas.

Figure 7: Urban Heat Island Patterns in Shkodra, Urban Heat Watch Report<sup>11</sup>



<sup>10</sup> [High-resolution climate projections | Copernicus](#)

<sup>11</sup>

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## Systemic Mobility Risk Analysis

- **Logistics & Microclimatic Loops:** Surface parking infrastructure is heavily exposed, with 77.1% of all spaces situated within intense UHI boundaries. Paved surface arrays become structural heat traps, forcing intense vehicle cooling loads at startup, which drives up localized emissions. Freight and commercial logistics face constrained delivery windows due to severe driver heat exhaustion.
- **Active Mobility Deterioration:** Shkodra's critical cycling infrastructure faces massive strain, with 53.6% of routes exposed to high-heat anomalies. Key links along the primary North–South corridor and commercial avenues lack tree shade and use dark, high-absorbency paving, causing heat glare and thermal discomfort that discourage the city's dominant cycling mode.
- **Public Transport Operational Failures:** Public transit operations are highly compromised, with 42.1% of routes and 66.7% of bus stops directly exposed to intense summer heat. Passengers wait at unsheltered locations lacking benches or canopies, creating high health risks for vulnerable cohorts, while older transit fleets suffer frequent engine overheating and diminished air-conditioning efficiency.
- **Infrastructure Asset Degradation:** Extreme summer heat softens asphalt binders across 39.5% of primary urban roads, leading to deep rutting and cracking under heavy vehicular traffic. Electronic components are highly vulnerable, with 100% of municipal traffic lights and 66.6% of EV charging stations operating within unshaded, thermally stressed environments.

Figure 8: Map of population density and heat map

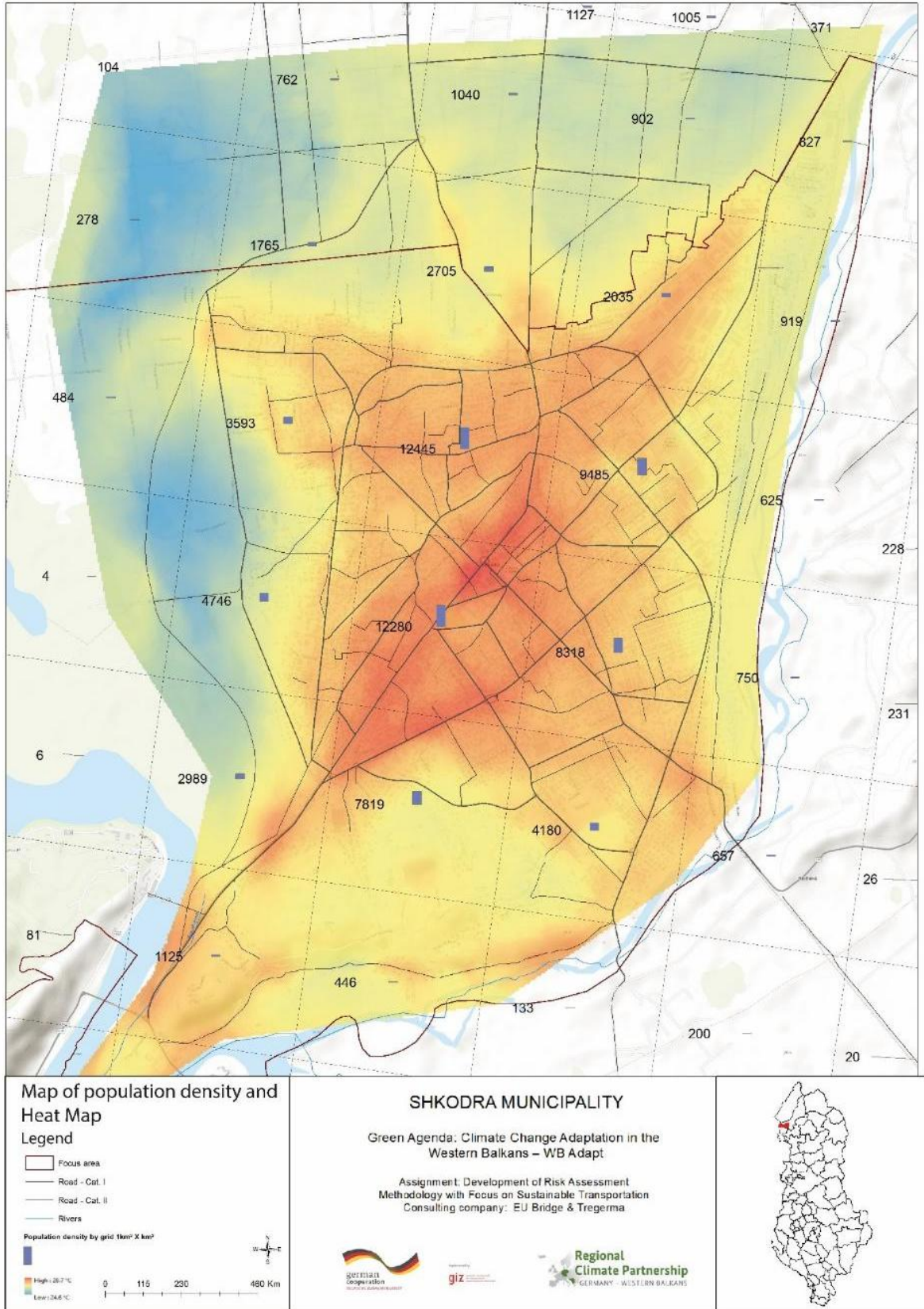
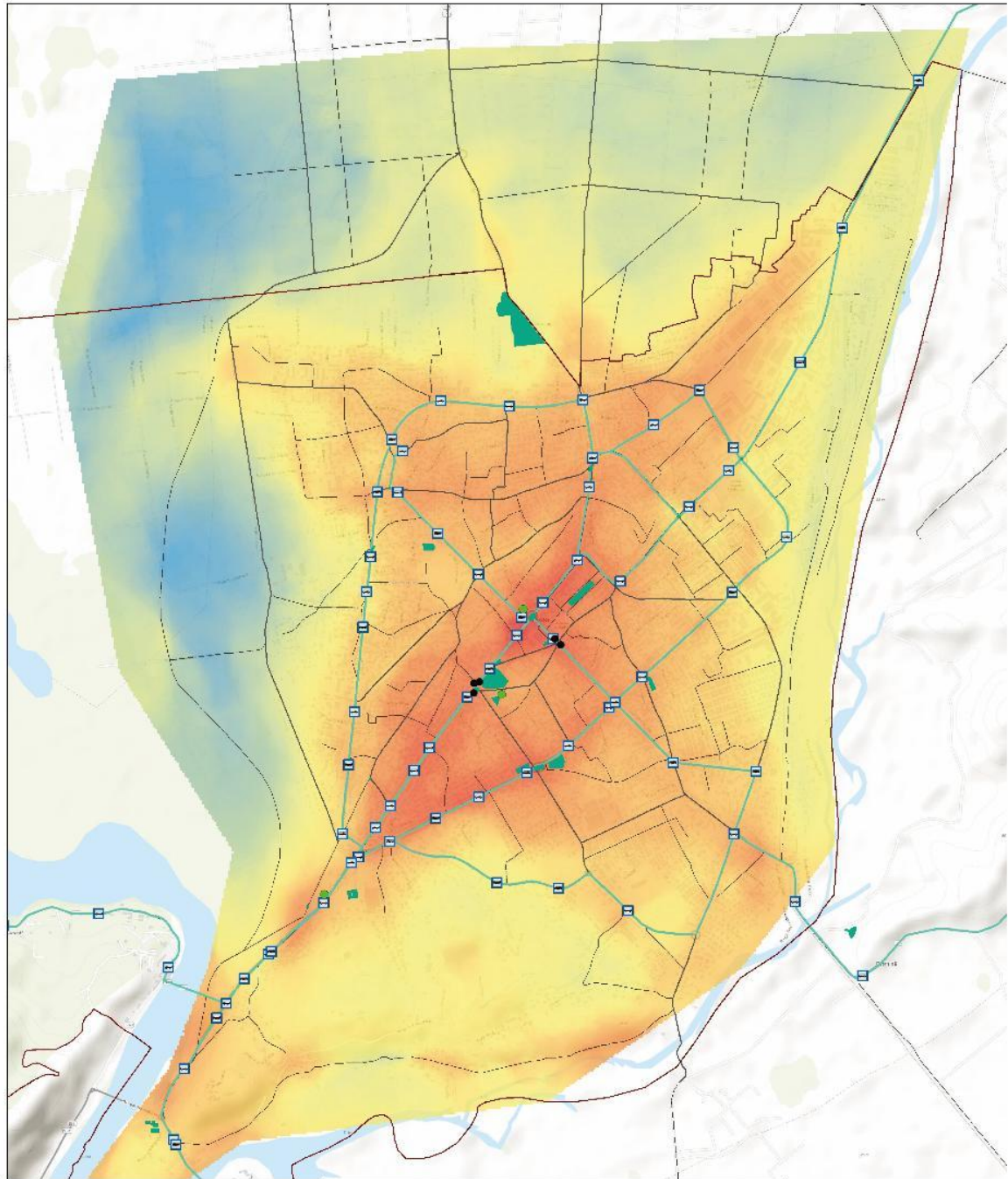
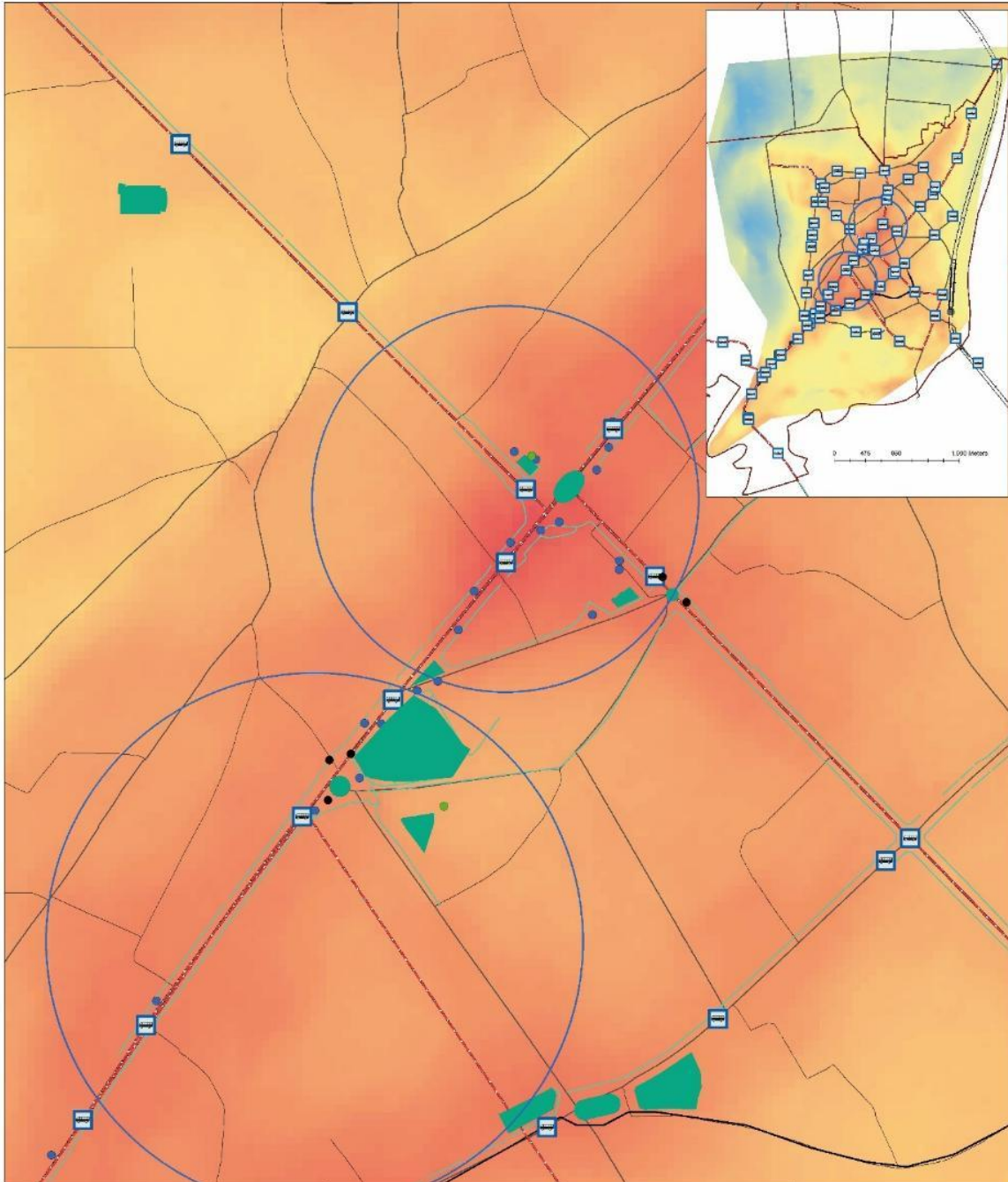


Figure 9: Hot spots of UHI



<p><b>Map of bus stops and parks overlaying UHI</b></p> <p>Legend</p> <ul style="list-style-type: none"> <li><span style="color: green;">●</span> EV charging stations</li> <li><span style="color: black;">●</span> Traffic lights</li> <li><span style="color: green;">■</span> Recreational area</li> <li><span style="border: 1px solid black; width: 10px; height: 10px; display: inline-block;"></span> Bus stop</li> <li><span style="border: 1px solid black; width: 10px; height: 10px; display: inline-block;"></span> I zeus area</li> <li><span style="color: red;">■</span> High &gt; 26.7 °C</li> <li><span style="color: orange;">■</span> Low &lt; 24.6 °C</li> <li><span style="color: green;">—</span> Dc's line</li> <li><span style="color: grey;">—</span> Roac Cat. I</li> <li><span style="color: grey;">—</span> Roac Cat. II</li> </ul> <p style="text-align: center;">W N E S</p> <p style="text-align: center;">0 0.25 0.5 1 km</p>	<p><b>SHKODRA MUNICIPALITY</b></p> <p>Green Agenda: Climate Change Adaptation in the Western Balkans – WB Adapt</p> <p>Assignment: Development of Risk Assessment Methodology with Focus on Sustainable Transportation Consulting company: EU Bridge &amp; Tregema</p> 	
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Figure 10: Map of bus stops and parks overlaying urban heat findings



Map of Urban Heat Island (UHI)

Legend

- |                       |                      |
|-----------------------|----------------------|
| <b>Celsius Degree</b> | Walking path         |
| High : 28.7           | Bicycle route        |
| Low : 24.6            | Road - Cat. I        |
| UHI hotspots          | Road - Cat. II       |
| Bus stop              | EV charging stations |
| Public parking        | Traffic lights       |
| Bus route             | Recreational area    |

SHKODRA MUNICIPALITY

Green Agenda: Climate Change Adaptation in the Western Balkans – WB Adapt

Assignment: Development of Risk Assessment Methodology with Focus on Sustainable Transportation  
Consulting company: EU Bridge & Tregema



## Pluvial (Urban) Flooding and Intense Precipitation Runoff

### Climate Trends & Projections

Long-term climate modelling for Shkodra, observed from the Western Balkans Climate-Proofing Platform (WB-CCP), indicates a shifting precipitation regime characterized by an increase in short-duration, high-intensity cloudburst events. While overall annual precipitation totals may trend slightly lower, high-percentile precipitation intensity (99.9 percentile) under the high-emissions RCP 8.5 scenario will rise into the 80–125 mm/day range. The historical return period for a severe 150mm/day storm event is projected to shorten from 50 years down to 34 years by late century, while high-intensity cloudbursts exceeding 20 mm/hour will expand to represent 15–20% of all rainy days.

Table 5. Quantified hazard indicators for urban flooding

Indicator	Quantification (Current State)	Projection (RCP 8.5 scenario)	Source
% annual heavy rainfall	The 99.9th percentile precipitation intensity is in the range of 125–175 mm per event. In the Shkodra region, such high-intensity events typically account for about <b>5–8%</b> of total annual precipitation	Under RCP 8.5, the contribution of extreme rainfall to annual totals is projected to increase to approximately <b>8–10%</b> , driven by faster intensification of high-percentile events relative to mean precipitation. The return period of extreme daily rainfall ( $\approx 150$ mm/day) shortens to $\sim 34$ years, increasing the likelihood of repeated pluvial flooding.	WB-CCP "Precipitation intensity" observation
% of rainfall events exceeding 20 mm/hr	Frequent in winter/autumn; estimated 10–15% of rainfall days	Under RCP 8.5, the share of high-intensity rainfall events is projected to rise to approximately <b>15–20%</b> of rainfall days, reflecting more frequent short-duration, cloudburst-type storms capable of overwhelming urban drainage systems.	Derived from CCP intensity categories (60–100 mm/day events)

## Riverine and Coastal Flooding

### Climate Trends and Projections

The lower Shkodra basin features high hydrological sensitivity due to the convergence of the Drin, Buna, and Kir rivers. Saturated lowland soils and backwater effects from Lake Shkodra frequently restrict drainage, causing catastrophic riverine floods (as seen during the baseline

disasters of 2010, 2018, and 2023<sup>12</sup>). Climate projections under the high-emissions RCP 8.5 scenario indicate that a 10–20% increase in winter precipitation intensity and accelerated alpine snowmelt will drive a 15–25% increase in peak river discharge by mid-century. The spatial extent of the 100-year flood zone is projected to expand from 40–45% up to 45–55% of the municipal territory.

### Spatial Extents and Urban Hotspots

Riverine flood hazards are concentrated along the low-lying plains flanking the Buna and Drin rivers, extending into southern and western urban neighborhoods (such as Xhabije and Bahçallek). While the spatial footprint across the urban core is constrained, river overtopping regularly impacts critical peripheral access roads and structural border links.

Table 6. Quantified hazard indicators for river / coastal flooding

Indicator	Quantification (Current State)	Projection (RCP 8.5 scenario)	Source
% peak river discharge	extreme peaks recorded in 2010 & 2021, ≈ <b>10%</b> increase in peak river discharge	Under RCP 8.5, peak river discharge is projected to increase by approximately <b>15–25%</b> by mid-century, driven by higher winter precipitation, more intense rainfall events (>50 mm/day), and accelerated snowmelt.	River Basin Authority; Fourth National Communication (2023); Regional Climate Models
% of population in floodplain	35–40%	Without additional flood protection measures, the exposed population is projected to increase to approximately <b>40–45%</b> , due to higher flood extents, more frequent flood events, and continued settlement and activity within flood-prone areas.	Shkodra Flood Risk Management Plan; Fourth National Communication (2023)
% of city area in 100-year flood zone	40–45%	Under RCP 8.5, the effective 100-year flood zone is projected to expand to approximately <b>45–55%</b> of the urban area, as the return period of major floods shortens from ~25 years to 10–15 years, effectively increasing the spatial extent and recurrence of severe flooding.	Flood zoning maps; Fourth National Communication (2023); Regional Climate Models

<sup>12</sup> KESH sh.a. (2018). Climate Risk Management Plan. Internal report prepared by the Albanian Power Corporation (Korporata Elektroenergjitiqe Shqiptare, KESH sh.a.) in collaboration with national and international experts. Tirana, Albania. (Personal communication / internal document shared by author)

Table 7. Quantified exposure indicators for riverine flooding

Elements	Unit	Total Area	Affected Area	Percentage of affected area
Nr of road bridges	number	3	3	100%
Length of cycling roads	km	5.11	1	19.60%
Railway Length	km	4.4	0.6	13.60%
Number of bus stops	number	51	3	5.90%
Length of public transport routes	km	31.6	1	3.20%
Length of the road network	km	54.49	1.5	2.80%
Length of walking roads (total of walking roads, and pedestrian areas like Pedonale)	km	278.12	1	0.40%

### Systemic Mobility Risk Analysis

- **Isolation of Critical Entry Gateways:** The core systemic threat to Shkodra lies in its structural gateways. 100% of the city's primary road bridges (3 out of 3 major spans) are directly exposed to riverine flood hazards. High-velocity river overtopping and bed scouring threaten bridge abutments, with the potential to isolate the city from the main southbound corridor toward Lezhë and Tirana.
- **Active Corridor Inundation:** Active transport networks along river margins face severe disruption, with 19.6% of the city's cycling tracks and 1.00 km of walking promenades inundated during flood stages. Overchannelling deposits thick river mud and debris across lakeside trails, interrupting active transport and recreational loops.
- **Strategic Rail and Transit Closures:** River overflows directly impact 13.6% of local rail tracks, 3.2% of public transport routes, and 5.9% of bus stops. Subfacing track structures suffer ballasting erosion, forcing complete service cancellations that disrupt intercity travel and freight logistics.

Figure 11: Map of riverine and coastal flooding

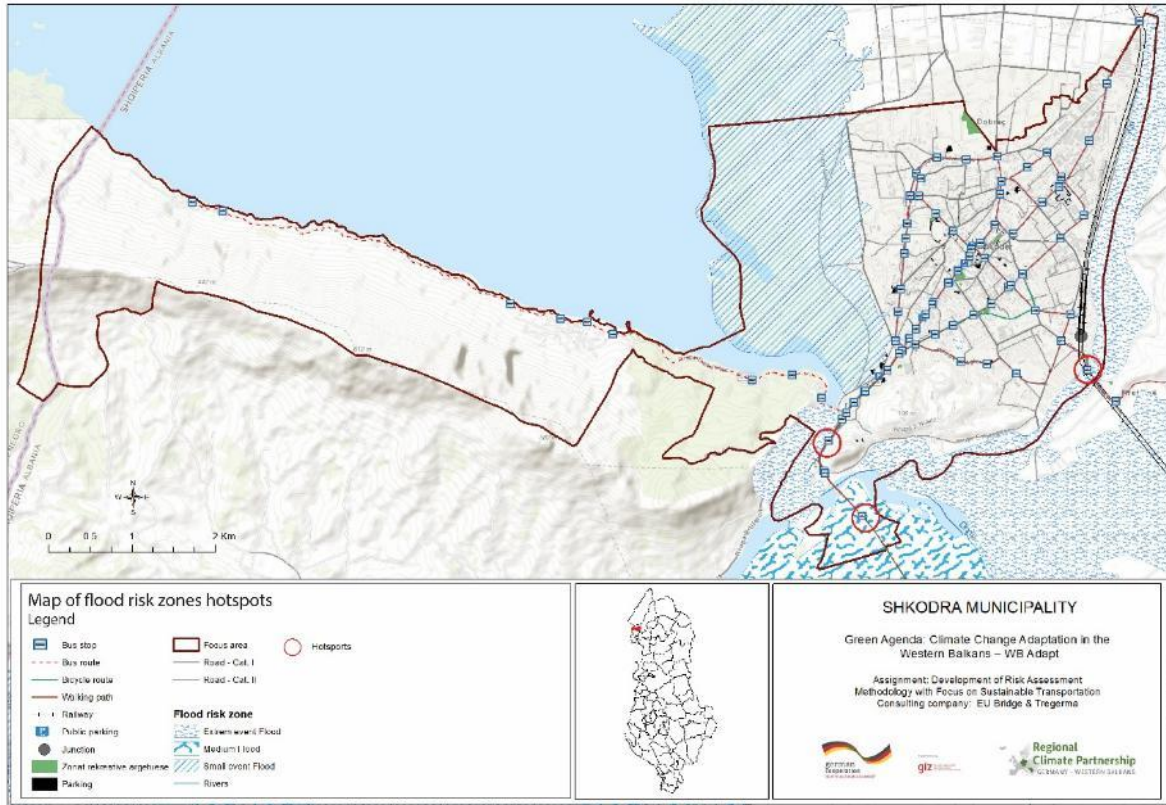


Figure 12: Hot spots of Riverine Flooding



Map of riverine flooding hot-spots

Legend

-  Bus stop
-  Bus route
-  Public parking
-  Junction
-  Focus area
-  Recreational area
- 
  -  Extrem event Flood
  -  Medium Flood
  -  Small event Flood
-  Riverine flooding hotspots
-  Walking path
-  Bicycle route
-  Railway
-  Road - Cat. I
-  Road - Cat. II



SHKODRA MUNICIPALITY

Green Agenda: Climate Change Adaptation in the  
Western Balkans – WB Adapt

Assignment: Development of Risk Assessment  
Methodology with Focus on Sustainable Transportation  
Consulting company: EU Bridge & Tregema



## CONCLUSIONS AND WAY FORWARD

Based on the empirical findings of the **Shkodra Climate Risk Assessment (CRA)**, developed under the regional project *Green Agenda: Climate Change Adaptation in the Western Balkans (WB Adapt)*, the following conclusions synthesize the core systemic risks facing the city's unique, active-mobility ecosystem:

### The Risk Paradigm & Methodological Core

The assessment establishes a rigorous baseline for integrating climate resilience into Shkodra's urban development frameworks. By applying the risk-based paradigm from the **GIZ Climate Risk Sourcebook (2023)**, the report provides an empirical foundation for future updates to Shkodra's Sustainable Urban Mobility Plan (SUMP) and Municipal Energy and Climate Action Plan (MECAP). It specifically highlights how Shkodra's specialized flat geography and compact form intersect with extreme vulnerabilities.

### Systemic Hazard Hierarchies

- **The Critical Tier (Urban Heat Islands & Extreme Heatwaves):** Extreme summer heat waves intersect with intense intra-urban UHI variations of up to 6.5°C to form the city's most critical mobility threat. Driven by a regional warming trend of 0.4–0.6°C per decade, hot days ( $\geq 30^{\circ}\text{C}$ ) are projected to expand from 70–90 days/year to **100–120 days/year under the RCP 8.5 scenario**. Physical exposure mapping tracks high systemic vulnerabilities: **100% of traffic lights, 77.1% of parking surfaces, 66.7% of bus stops, and 53.6% of cycling tracks** sit within high-heat zones, causing severe asphalt rutting along the core North–South corridor and compromising active transit comfort.
- **The Moderate Tier (Pluvial Flooding & Precipitation Extremes):** Short-duration, high-intensity cloudbursts exceeding 20 mm/hour are projected to increase to **15–20% of all rainfall events**. Extreme daily accumulations (125–175 mm) will regularly overwhelm Shkodra's undersized stormwater network. Localized pluvial sinks directly impact key infrastructure nodes: **20% of traffic signaling nodes, 17.3% of cycling tracks, 14.8% of surface parking zones, and 6.7% of the total road network flood regularly**, disrupting daily active commutes.
- **The Strategic Tier (Riverine and Coastal Flooding):** The highly complex convergence of the Buna, Drin, and Kir rivers alongside Lake Shkodra represents a catastrophic structural threat. Under RCP 8.5, peak river discharges are projected to increase by **15–25% by mid-century** due to intense winter precipitation and accelerated snowmelt. While geographically concentrated by network length (**2.8% of roads and 3.2% of public transport routes**), river overtopping exposes **13.6% of rail tracks and 100% of primary municipal road bridges (3 out of 3 major spans)**, threatening to completely sever regional connectivity, freight logistics, and southbound emergency corridors.

## Vulnerability as a Risk Multiplier

Shkodra's socio-demographic matrix significantly amplifies these physical hazards. The city maintains a dominant active mobility paradigm where **cycling accounts for 35–40% and walking represents 25–30% of daily trips**. However, a substantial portion of the population exhibits high vulnerability, including **22–25% low-income households and 15–17% elderly cohorts**. Because active transport infrastructure lacks tree shading, heat-resilient pavements, or elevated shelters, these non-motorized users face disproportionate health risks (compounded by microclimatic air quality peaks reaching up to 738 µg/m<sup>3</sup> of PM2.5), deepening spatial and social inequities during climate events.

## Action Plan Conclusions & Priority Interventions

To operationalize these findings, the Shkodra Action Plan employs a Multi-Criteria Analysis (MCA) evaluating infrastructure impact, vulnerable group protection, urgency, and cost-effectiveness. The strategic priorities are finalized across two structural pillars:

### Cross-Cutting System Actions (Capacity & Policy)

To support structural capital investments, institutional and operational frameworks are systematically fortified via low-cost, high-yield interventions:

- **Climate-Responsive Institutional Mainstreaming:** Prioritizing intensive training of municipal staff to draft climate-aware Terms of Reference (ToRs) for future mobility contracts, update local regulations, and monitor climate-informed interventions.
- **Preventive Maintenance Protocols:** Establishing clear municipal schedules for active tree pruning (to optimize thermal shading) and rapid drainage/culvert upkeep to mitigate intense stormwater runoff ahead of cloudburst seasons.

### Infrastructure Priority Projects (Top 5 Projects Roadmap)

The Action Plan prioritizes five foundational infrastructure interventions designed to weave nature-based solutions (NBS), green spaces, and sustainable transit directly into Shkodra's urban landscape:

Table 8. Priority projects and their climate adaptation potential

Priority Project	Key Climate Adaptation Effects
South-North Linear Garden & Multimodal Axis (Phase 2)	Reallocates wide car boulevards into single mixed lanes; deploys broad-canopy trees and permeable paving to manage stormwater runoff and lower core surface temperatures.
Quality Bus Stop & Interchange Node Upgrades	Rehabilitates bus shelters with green vegetated sedum roofs to lower localized heat, retain rainwater, and improve passenger thermal comfort during extreme heatwaves.
South-North Linear Garden & Multimodal Axis (Phase 1)	Backed by EIB funding; prioritizes pavement rehabilitation, integrated green networks,

	and light-colored, heat-absorbing materials to secure active transit resilience.
East-West Linear Garden & Multimodal Axis	Expands the green belt network toward the railway station; introduces temporary tensile fabrics and modular shade sails to protect active commuters and pedestrians.
Sector-Based Limited Traffic Zone (LTZ) Implementation	Implements traffic restrictions across 5 urban center sectors; uses climate-appropriate materials and greenery to reduce traffic-related heat and enhance civic spaces.

**Strategic Outlook:** By leveraging the strategic alignments of the SUMP (2025–2034) and the MECAP (2023–2040), the Municipality of Shkodra shifts from a reactive maintenance posture to an actionable, climate-resilient engineering and procurement paradigm