Interreg Danube Region

Co-funded by the European Union

Be Ready

Urban heat islands vulnerability and risk assessment

City of Niš

Specific objective 1	Provide assessment and operational instruments to cities to better understand UHI drivers & effects
Activity 1.3.	Testing the methodology and tools: conducting vulnerability and UHI risk assessments in the partner cities
Deliverable 1.3.1	City reports from UHI risk assessment
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List of Abbreviations

BCR	Building Coverage Ratio
CLC	Copernicus Land Cover
CORINE	Coordination of Information on The Environment
FAR	Floor Area Ratio
GDP	Gross Domestic Product
GIS	Geographic Information System
OLED	Office for Local Economic Development
IPCC	Intergovernmental Panel on Climate Change
NGOs	Non-Governmental Organizations
UHI	Urban Heat Island
VI	Vulnerability Index

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Introduction

ABOUT THE PROJECT

Urban heat islands (UHI) are the common challenge of the project that 19 partners and 9 ASPs from 12 countries will tackle with the aim to strengthen the preparedness and adaptive capacity of the society to cope with impacts of climate change and foster resilience at city level. The project approach will allow partners, to take targeted, small powerful, context-based measures to deal with UHI in critical urban areas. City pilots will test solutions in three areas: “green acupuncture” (vegetation-based interventions); “white acupuncture” (based on innovative surfaces and materials); and “blue acupuncture” (novel uses of water resources). The approach of jointly developing, testing and evaluating solutions contributes to most effective use of shared expertise for better understanding the effects of UHI in and building institutional capacity at local/regional level, for policy development and practical interventions.

ABOUT THE REPORT

The main aim of the document Deliverable 1.3.1 City reports from UHI risk assessment is to test the join methodology and tools developed for 4 vulnerability elements (Figure 1): exposure, sensitivity, preparedness and adaptive capacity and risk groups (Deliverable 1.1.1. Shared methodology and tools for UHI vulnerability and risk assessment).

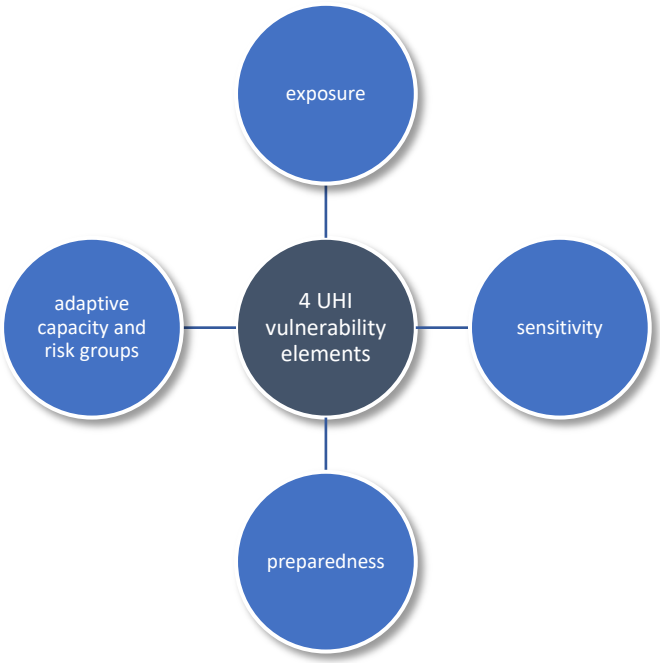


Figure 1. 4 UHI vulnerability elements

The project partner cities publish a UHI risk assessment for their cities as a preparatory activity for the implementation of pilot actions as part of Specific Objective 2 Co-creating, testing and validating jointly developed solutions to mitigate the effects of UHI in cities. Accordingly, the City of Niš, as a project partner, conducted a risk assessment for the pilot zone. The assessments relied on historical data and statistics, as well as other information and data from various sources. The risk assessment was carried out with the support of local coalitions (Activity 1.3), which enabled community engagement and raising awareness across the city about the project objectives and expected results. As a project partner, the City of Niš selected the city zone that was included in the risk assessment. To ensure comparability of results and applicability and usability of the tool, the UHI assessment refers to a part of the central city zone, characterized by high population density, and a high degree of built-up and occupation.

The task leaders are the partner cities (conducting the risk assessment and drafting the resulting report; knowledge partners provide consultations and feedback). Accordingly, the city of Niš has drafted this city report by engaging the knowledge partners. The city report includes an analysis of the usability of the tool and recommendations for adapting the methodology, where needed. The reports feed into the City Climate Sandbox concept and pilots. The reports feed into the concept and pilots for the City Climate Sandbox.

AREA OF THE INTERVENTION

Territorial context	**Serbia**
City	City of Niš
Municipality	City municipality Medijana
Region	South and East Serbia (territorial-statistical unit)
State	/
Country	Serbia

Statistical data:	**City of Niš** (Census 2022)
Surface Area (km^2)	596.71 km^2
Population	250091
Density	420 inh per sq. km
GDP per capita (€)	12 281.51 USD (2023)[1]
Minimum Wage (€/year)	480480 din/year (approx. 4000 €/year)[2]

Statistical data:	**City Municipality Medijana** (Census 2022)
Surface Area (km^2)	10.0 km^2
Population	83275
Density	8328 inh. per sq. km
GDP per capita (€)	/
Minimum Wage (€/year)	/

Statistical data:	**Pilot zone/Study area within City Municipality Medijana**
Surface Area (km^2)	0.063 km^2
Population	2098 inh (assessment)
Density	33,25 inh. per sq km
GDP per capita (€)	/
Minimum Wage (€/year)	/

[1] Data is available on national level (Source: World Bank)
[2] Data is available at the national level (Source: https://www.ipc.rs/statisticki_podaci/2025/minimalna-zarada-2025)

ABOUT THE CITY OF NIŠ

The city of Niš is the third largest city in the Republic of Serbia and one of the oldest cities in the Balkans. It is located in the south eastern part of Serbia (237 km southeast from the capital Belgrade) (Figure 2). In terms of geographical position, the territory of the City of Niš occupies the area between 43°15′ and 43°30′ north latitude and 21°49′ and 22°13′ east longitude. The city is located in the Nišava valley, bordered by the slopes of the Svrljiške Mountains, Suva Planina and Jastrebac Mountains, along the confluence of the Nišava River and the South Morava River. Niš has a temperate continental climate, with warm summers and moderately cold winters[3].

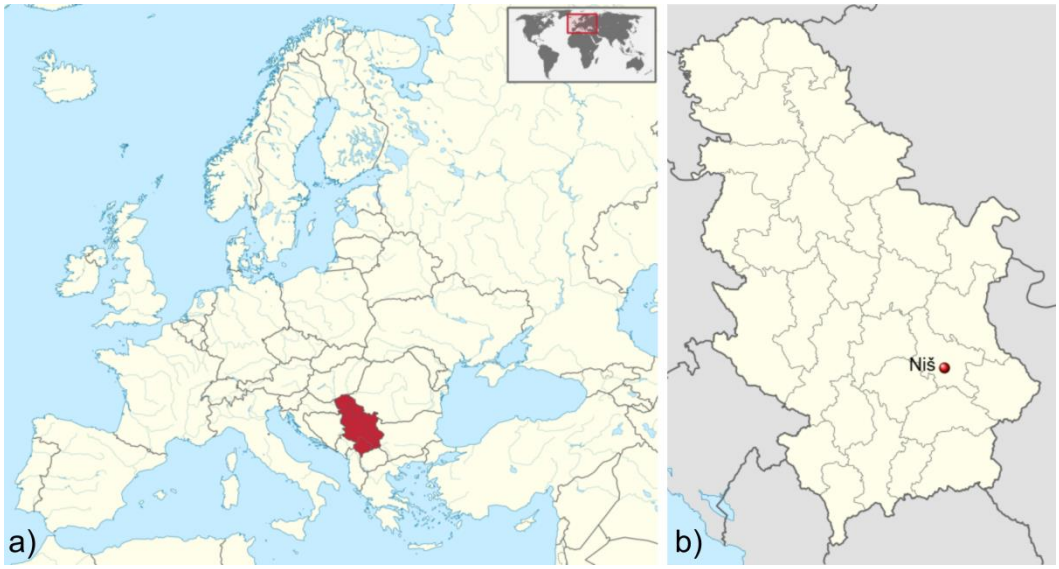


Figure 2. Position of the City of Niš. a) Location of Republic of Serbia in Europe. b) Location of the City of Niš in Serbia

Source: TUBS - This vector image includes elements taken or adapted from the file: Georgia location map.svg (by NordNordWest)., CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=14630050

Niš is a modern university city and an educational, industrial, economic and tourist center of national importance, as well as one of the largest healths, cultural and sports centers in Serbia. With the Science and Technology Park and the University of Niš, the city is a center of information technologies, while the International Airport "Constantine the Great", intended for passenger and cargo air traffic (the second largest airport in Serbia), as well as its reliance on Corridor 10 makes city of Niš easily accessible and a transport hub of road, rail and air connections.

In the area of present-day Niš, in ancient Nais, the Roman emperors Constantine the Great and Constantius III were born. Throughout its rich history, Niš has been an administrative, military and trade center of various states and empires. Thanks to its favourable geographical position, Niš has always been a strategically important and attractive city for many conquerors. The roads in the Niš territory have served since ancient times as routes connecting Europe with the Middle East and were an integral part of the *Via Militaris* during the time of Ancient Rome and Byzantium, or the *Constantinople Road* during the Ottoman Empire[4].

[3] Plan razvoja grada Niša za period od 2021. do 2027. godine ("Official List of the City of Niš", no. 36/2021). Available on: https://www.eupropisi.com/dokumenti/NI_036_2021_003.pdf

[4] *Ibid.*

Throughout history, the territory of present-day Niš has been visited by: Dardanians, Thracians, Illyrians, Celts, Romans, Huns, Avars, then Byzantines, Bulgarians and Ottomans. On several occasions, the city was also occupied by Hungarians and Austrians. It was liberated from the Turks in 1878 and has since been part of Serbia again, with short interruptions during the First and Second World Wars, when it was under occupation.

Due to its rich history, diverse urban heritage and abundant natural resources, Niš is also an important regional tourist destination. The natural and cultural heritage includes a diverse natural landscape surrounded by Niška Banja, many natural resources and rich biodiversity, as well as architectural heritage, monuments, landmarks (Figure 3), traditional manifestations and cultural events (Figure 3).

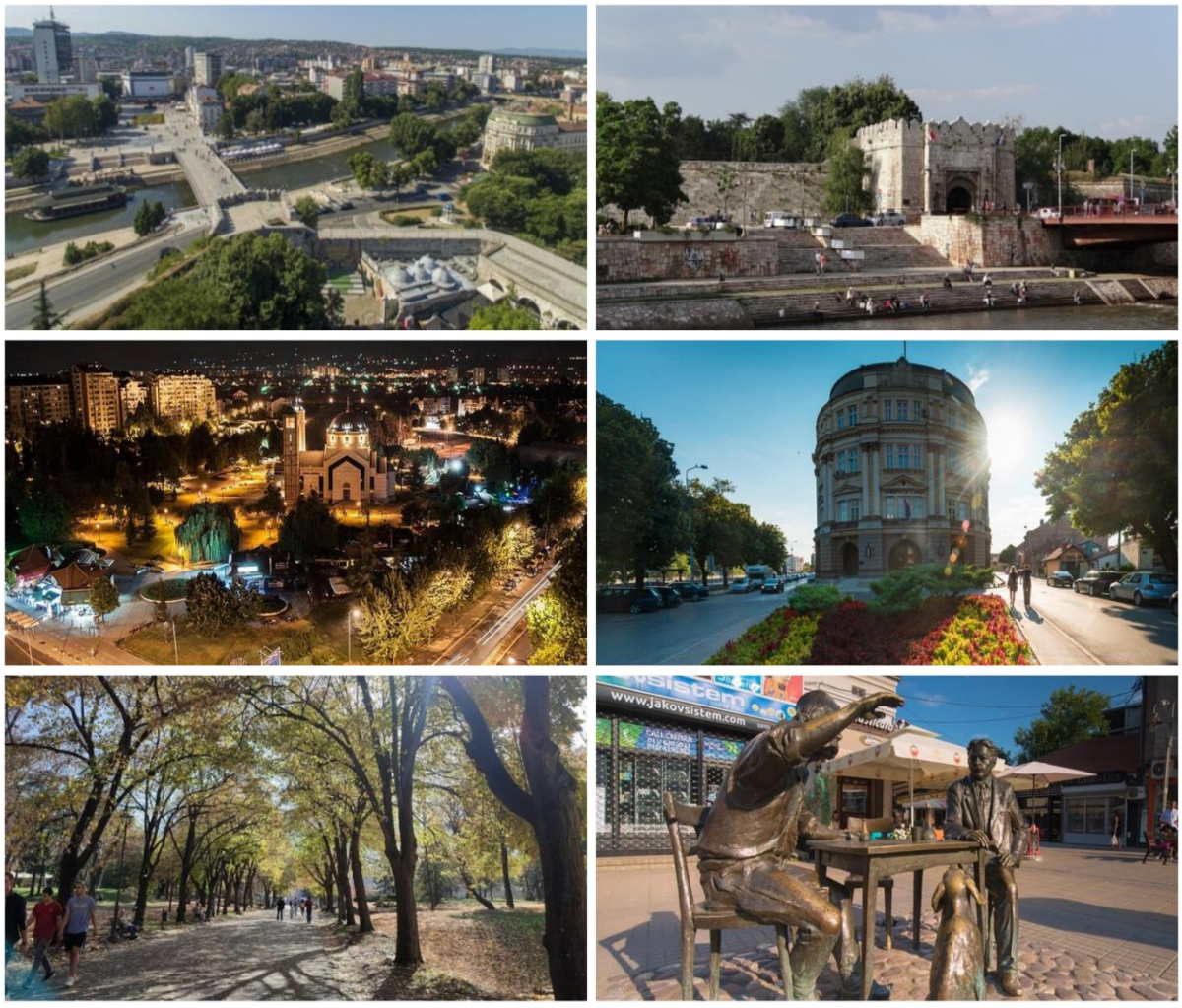


Figure 3. Landmarks of Niš

Source: https://conventa.si/try-before-you-buy/; https://www.tripadvisor.com/AttractionProductReview-g295110-d13181265-Skopje_Nis_ Serbia _One_day_tour-Skopje_Skopje_Region.html#/media/13

In the administrative sense, Niš is a largest city of the region of South and East Serbia (NUTS 2; code RS22), one of the five territorial-statistical units in Serbia,[5] and the seat of the Nišava Administrative District (Nišava Development Area - NUTS 3; code RS225)[6] (Figure 4).

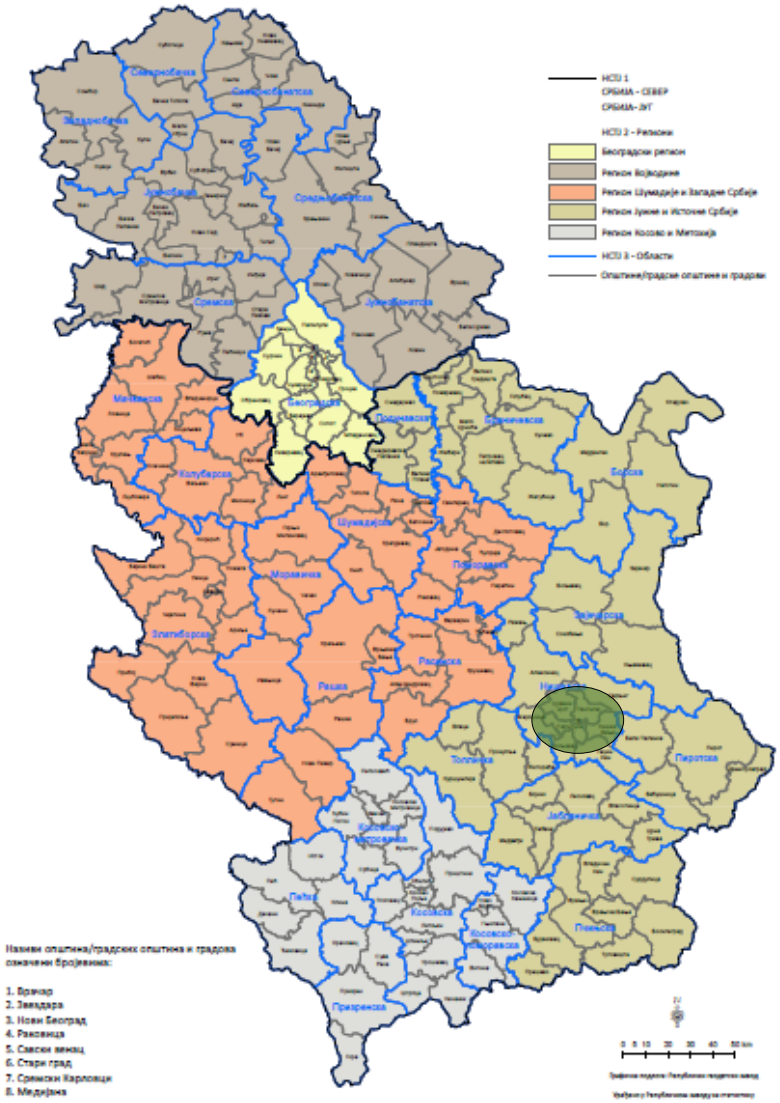


Figure 4. City municipalities and cities in the Republic of Serbia, by administrative districts and regions (Status on 1 January 2023): Position of the City of Niš

Source: Opštine i regioni u Republici Srbiji 2023. Republički zavod za statistiku. Available on: https://publikacije.stat.gov.rs/G2023/Pdf/G202313050.pdf

[5] *Regulation on the Nomenclature of Statistical Territorial Units* (Official Gazette of the Republic of Serbia, No. 109/09, and 46/10) (Uredba o nomenklaturi statističkih teritorijalnih jedinica (Službeni glasnik RS, br. 109/09, i 46/10). Available on: https://www.stat.gov.rs/sr-Latn/oblasti/registar-prostornih-jedinica-i-gis/administrativno-teritorijalna-podela-i-nstj-nivoi-1-2-3

[6] *Law on Territorial Organization and Local Self Government of the Republic of Serbia* from 1991*;* Law on The Territorial Organization of the Republic Of Serbia ("Official Gazette of the RS", no. 129/2007, 18/2016, 47/2018 and 9/2020 - other laws).

The Nišava Administrative District/Nišava Administrative District/Nišava development area includes the municipalities of Ražanj, Aleksinac, Svrljig, Merošina, Doljevac, Gadžin Han and the City of Niš (Figure 5a). Since 2004, the City of Niš has been administratively divided into five city municipalities: Medijana, Niška Banja, Palilula, Pantelej and Crveni Krst (Figure 5b). In this sense, the City of Niš consists of urban settlements of Niš and Niška Banja, as well as 69 villages (Igić et al., 2023). Medijana city municipality covers only the central part of the urban settlement of Niš, while the remaining parts of the urban settlement of Niš, as well as the urban settlement of Niška Banja and the villages are located within the other four city municipalities. Although the smallest in its surface area, city municipality Medijana has the largest population and it is the most densely populated municipality (Table 1).

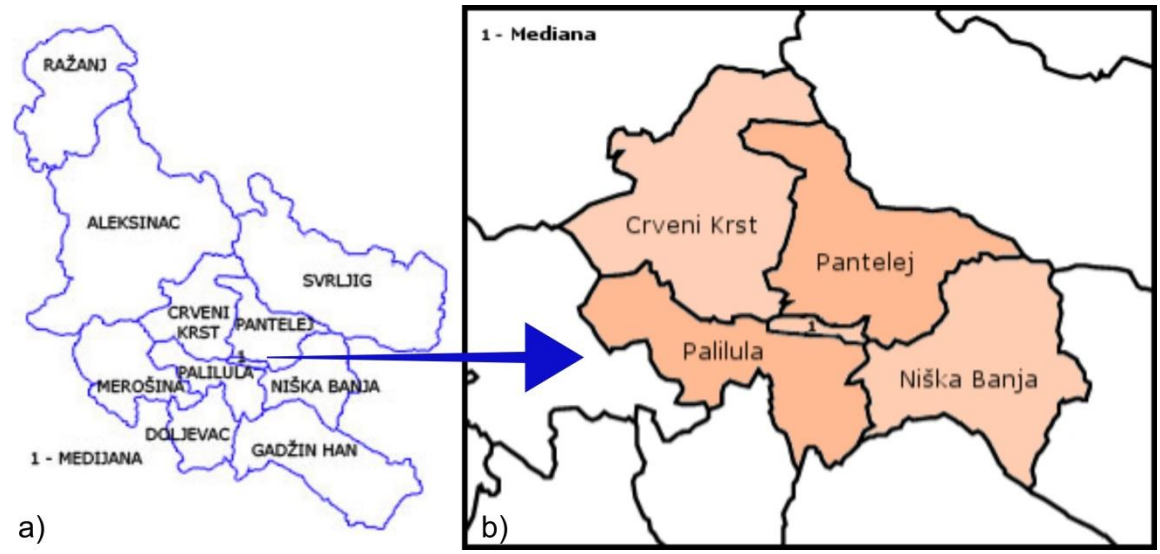


Figure 5. City municipalities of the City of Niš. a) Municipalities in Nišava Administrative District (including the city municipalities of the City of Niš. b) Spatial distribution of the city municipalities within administrative area of the City of Niš

Source: https://www.381info.com/nisavski-okrug; https://sr.wikipedia.org/Категорија:Нишке општине

Table 1. Surface area, number of settlements, number of inhabitants and population density – City of Niš and city municipalities

City/ city municipality	Surface area (km^2)	Number of settlements	Population (inhabitants)	Population density (inh/km^2)
City of Niš	**596**	**71**	**250091**	**420**
Medijana	10	1	83275	8328
Niška Banja	146	18	13003	89
Palilula	117	15	69985	598
Pantelej	141	13	54180	384
Crveni Krst	182	23	29648	163

Source: Opštine i regioni u Republici Srbiji 2023. Republički zavod za statistiku. Available on: https://publikacije.stat.gov.rs/G2023/Pdf/G202313050.pdf

In terms of demographics, City of Niš has a relatively old population and a balanced gender structure (see Tool 4).

Niš is a typical former socialist city of Central and Eastern Europe, which was a strong industrial center during the former Yugoslavia, based on labour-intensive mechanical, electronic and tobacco industries. After the collapse of the socialist system, the political and economic crisis of the 1990s and the civil war, Niš went through a period of transition, which resulted in its economic decline, the dissolution of large businesses, a high unemployment rate and a political crisis (Vasilevska et al, 2014; Vranić et al, 2016; Đekić, 2022). Despite the significant presence of the industrial socialist heritage, which is seen as a potential for the development of complex and innovative industrial technologies, Niš's industry has not yet managed to fully recover from the collapse of socialism. Nevertheless, the City of Niš represents a favourable investment environment for both domestic and international investors and is recognized as a champion of local economic development[7].

In the post-socialist period, major urban transformations occurred that affected the physical and functional characteristics of the urban fabric. The transition to a market-oriented economy in the 1990s led, among other things, to major changes in urban planning. With the introduction of new actors and market forces, urban planning was no longer guided by the public interest. In this sense, the balance between urban planning and market forces (which has yet to be established) is seen as a one of the greatest challenges.

Some of the implications of post-socialist development on the urban landscape include deindustrialization, suburbanization, spontaneous expansion of building land, illegal construction, densification of the central city zone and inherited areas of multi-family housing, traffic congestion, and the reduction of public open spaces and green areas. The aforementioned urban changes, which also pose risks, have raised some important and current environmental issues, such as the city's ecological footprint, pollution, noise, stormwater management (Slavković, 2024) and urban heat islands (UHI).

[7] *The Financial Times fDi* magazine ranked the City of Niš in a high 5th place among small European cities of the future 2020/2021 in the category of attracting foreign direct investment. Available on: https://investnis.rs/en/

1. Methodology of the assessment

SUMMARY OF THE PROCESS

The UHI assessment methodology set the stage for local workshops with stakeholders and UHI experts in the City of Niš, which enabled shared learning about UHI drivers and effects, building predictive scenarios and simulations to address UHI. The City of Niš carried out a UHI risk assessment, testing the shared methodology and developed tools for 4 elements of vulnerability: 1) exposure, 2) sensitivity, 3) preparedness and adaptive capacity, and 4) risk groups.

The methodology and actual UHI assessments at the city zone level led to one of the key results of the Be Ready project, namely the online UHI vulnerability assessment tool for cities, an open-access instrument that will enable other cities to conduct guided UHI risk assessments as well as to request methodological assistance and mentoring from the project partners. The core elements of the methodology are integrated into the Be Ready virtual training program, which aims to provide knowledge and skills to city-level experts on UHI. The main aim of the methodology of the assessment is to describe the process and approaches used for the assessment.

Before drafting this document, a **needs analysis** was conducted among the partner cities through an online survey. The results indicated **a general lack of strategic planning to address UHI**. A preliminary analysis at the level of the city of Nis also indicated this lack, as well as the absence of relevant data, dedicated budgets for addressing UHI, etc. When it comes to motivations for strengthening the capacity of cities to address UHI, the City of Nis listed the need for climate change adaptation and mitigation, public health concerns, disaster preparedness and energy savings. It also, like most partner cities, indicated that it would need expert assistance in collecting, analyzing and using data for policy formulation. The input from the city partners served as a basis for the scientific and methodological partners in developing the methodology and tools for self-assessment.

PREPARATORY PHASE

At the initial phase key stakeholders were identified from civil and business sectors and the academic community, and external team of experts engaged for project implementation.

EVENTS/ ACTIVITIES

Several events/activities were organised for the assessment.

The first event was **Local Methodological Workshop - Urban Heat Islands** organised on **29.10.2025**. with the main aim to:

- inform the public, civil and business sectors and the academic community about the project and objectives;
- initiate the development of a model for a comprehensive analysis of patterns and effects of urban heat islands;
- identify relevant vulnerability indicators, as well as to familiarize with the methodology that will be applied in subsequent project activities.

More than 30 participants were present. The main result of the workshop was exchange of information about past experiences and available data in the field of combating climate change. Additional information is provided in Annex A.

The second event was **Local participative event** held on **05.12.2025**.

The event consisted of two activities:

Signing the Local Coalition Agreement.

The agreement was signed by 19 institutions in the city, including public (7), civil (5), business (4), and academic (3) sector. The goal of this agreement was to establish strong and strategic cooperation in efforts to mitigate the effects of UHI. The participants took part in the survey, later used for assessment within methodology tool 3. Additional information is provided in Annex B.

Workshop for students of architecture.

The event was attended by 16 students and 5 teaching staff. Students analyzed a specific location identified as an urban heat island, and focused on proposals for white, blue, and green interventions and on all four tools of the methodology, which were specially considered during the workshop for the given location. The students also took part in the survey, later used for assessment within methodology tool 3. Additional information is provided in Annex B.

TIMELINE OF THE PROCESS

Project activities performed so far by the City of Niš and external team of experts are shown in Table 2. Please note that March 2025 is the fifth month of our external team of experts engagement.

Table 2. Timeline of activities, month 1 = November 2024

Activity, Task /month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	St*
1. UHI methodology workshop for local application and testing																					
1.1. Lectures																					●
1.2. Analytical report on available data																					●
2. Methodology and tool testing: conducting vulnerability assessments and UHI risk assessments																					
2.1. Data collection																					●
tools																					●
2.3. Local participatory event																					●
2.4. Preliminary risk assessment report																					●
3. Identification of good practices and models for sustainable management of UHI																					
3.1. Collection of material from SRB																					●
3.2. Mapping																					●
3.3. Report																					●
4. Workshop for co-design and implementation of pilot actions in cities																					
4.1. Organization of the CS workshop																					●
4.2. Report on the implementation of the workshop																					●
4.3. Local road map for implementation of the pilot project																					●
4.4. Development of application guides																					●
5. Collegial evaluation and validation of tested pilot initiatives																					
5.1. Valuation																					●
5.2. Creation of infographics/visualization of the pilot																					●
5.3. Evaluation and validation report																					●
6. Development of the UHI management plan																					●
6.1. Action plan proposal																					●
6.2. Consultative meeting																					●
6.3. Local action plan for management																					●

*Status key:

- ● completed
- ● ongoing
- ● preparation
- ● not started

2. Urban climate

GENERAL INFORMATION ABOUT URBAN CLIMATE TRENDS

he City of Niš, situated in the Nišava River valley and surrounded by mountains such as Suva Planina and Svrljiške Planine, experiences significant urban heat island (UHI) effects due to its geographical setting. The mountains act as natural barriers, limiting wind penetration and reducing ventilation, which allows heat to accumulate in built-up areas, especially during warm and windless periods. Unlike cities in open plains where airflow can help dissipate heat, Niš experiences weaker cooling effects from natural winds, though occasional local winds like Košava can provide temporary relief. The city's high number of sunny days further intensifies the UHI effect by increasing solar radiation absorption, while cloudy and windy conditions, though less frequent, help suppress excessive heating. This combination of factors makes Niš particularly vulnerable to urban overheating, emphasizing the need for urban planning strategies that enhance natural ventilation, increase green spaces, and incorporate heat-reflective materials.

Over the past decade, the City of Niš, has experienced weather trends characterized by increasing average temperatures and variable precipitation patterns. Summers have become warmer, with August typically being the hottest month, with average air temperature around 22.3 °C. Winters remain cold, with January average air temperature approximately 0.6 °C. These trends align with broader regional climate patterns, suggesting a shift towards warmer conditions with irregular precipitation patterns. Climate data for the City of Niš is shown in Table 3.

Table 3. Mean monthly, annual and extreme values of the climate elements observed and gauged at the meteorological observatory Niš in the period 1981-2010.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
TEMPERATURE (°C)													
Mean maximal	5,0	7,5	13,0	18,4	23,8	27,1	29,8	30,1	25,0	19,3	11,9	6,1	18,1
Mean minimal	-2,2	-1,4	2,3	6,4	11,0	13,8	15,4	15,4	11,5	7,4	2,6	-0,8	6,8
Mean daily	0,6	2,4	7,0	12,2	17,1	20,4	22,5	22,3	17,4	12,3	6,4	2,1	11,9
Absolute maxima	21,7	23,5	26,5	33,0	34,7	40,3	44,2	42,2	37,2	32,6	29,0	22,2	44,2
Absolute minima	-23,4	-19,3	-12,2	-5,6	0,8	4,9	4,1	4,6	2,5	-6,8	-14,0	-15,8	-23,4
Mean no. frost days	22	18	10	2	0	0	0	0	0	2	9	18	80
Mean no. tropical days	0	0	0	0	3	9	15	17	5	0	0	0	49
RELATIVE HUMIDITY (%)													
Average	80	74	66	63	65	65	61	61	69	73	77	81	70
SUNSHINE DURATION													
Average (h)	64,5	93,3	147,8	171,5	220,9	251,2	286,7	274,3	201,9	150,5	85,9	49,4	1997,7
No. clear days	3	4	4	4	4	7	11	13	9	7	4	3	73
No. cloudy days	15	12	11	9	8	5	4	3	6	9	12	15	109
PRECIPITATION (mm)													
Mean monthly sum	38,8	36,8	42,5	56,6	58,0	57,3	44,0	46,7	48,0	45,5	54,8	51,5	580,3
Max. daily sum	24,2	28,8	27,9	33,2	41,5	56,8	46,7	50,6	52,6	32,8	37,4	33,0	56,8
Mean no. days >= 0.1 mm	13	13	12	13	12	11	9	8	9	9	11	14	134
Mean no. days >= 10.0 mm	1	1	1	2	2	2	1	2	1	2	2	1	17
PHENOMENA (no. days with....)													
snow	10	9	5	1	0	0	0	0	0	0	3	8	37
snow cover	13	10	4	0	0	0	0	0	0	0	4	10	41
fog	3	1	0	0	0	0	0	0	0	1	2	3	11
hail	0	0	0	0	0	0	0	0	0	0	0	0	1

Source: Republic Hydrometeorological Service of Serbia.
https://www.hidmet.gov.rs/latin/meteorologija/stanica_sr.php?moss_id=13388

Most data shown in this report section are based on the data records from Meteorological observatory Niš (Table 4) and Digital Climate Atlas of Serbia[8] launched in 2023. Spatial resolution in the Atlas is 10 km.

[8]Ministry for environmental protection, 2022, Digital climate and climate change atlas of the republic of Serbia. Project „Advancing medium and long-term adaptation planning in the republic of Serbia ", https://atlas-klime.eko.gov.rs

Available climatological point data (meteorological observatory) and coarse-resolution spatial data do not allow for a detailed analysis of the urban climate. Such an analysis requires data from multiple measurement locations across the city, but no such network currently exists. Publicly available remote sensing products can offer some improvement in this regard; however, their spatial resolution is approximately 1 km, which is still insufficiently detailed for a city of the considered size and intended analysis of UHI hotspots.

Table 4. Meteorological Observatory: Niš (founded in 1889).

OBSERVATORY	**Niš**
COORDINATES	
Longitude:	21°54E
Latitude:	43°20N
Altitude:	202 m
EXTREME VALUES OF CLIMATE ELEMENTS:	
Maximum temperature:	44.2 °C
Maximum temperature date:	24.07.2007
Minimum temeprature:	-23.7 °C
Minimum temperature date:	25.01.1963
Maximum precipitation:	76.6 mm
Maximum precipitation date:	5.11.1954
Maximum snow cover:	62 cm
Maximum snow cover date:	23-25.02.1954

Source: Republic Hydrometeorological Service of Serbia.
https://www.hidmet.gov.rs/eng/meteorologija/stanica_moss1.php?moss_id=13388

Air Temperature

Air temperature is a crucial parameter for the UHI effect. In cities, air temperature can be much higher because of the concentration of buildings, roads, and other heat-retaining structures. Comparing air temperature data from urban and rural areas helps determine the temperature difference and assess the UHI effect.

Air temperature data is generally measured using weather stations in different parts of the city, using mobile temperature sensors to measure at specific points to close data gaps or carry out measurements during specific times and can be determined using citizen science including the personal datasets from inhabitants. Based on the definition of UHI it is key to also establish a dataset in the rural area around the city and in multiple parts of the city. As the negative effects on humans come also during the nighttime, it is not just important, but urgent to not only have daytime but also nighttime data, underlining the critical nature of our research.

The rise of the mean daily temperature for the municipality of Medijana is illustrated in Figure 6.

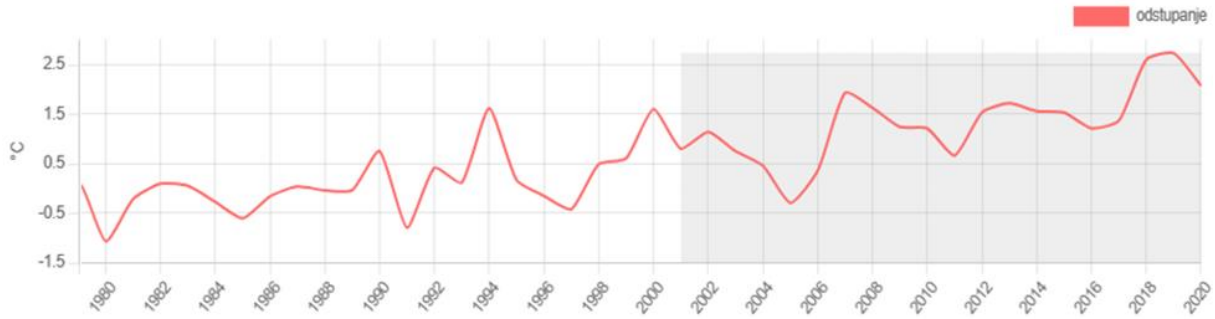


Figure 6. Mean daily temperature deviation in the period 1980-2020 compared to 1971-2000, for the municipality of Medijana.

Source: https://atlas-klime.eko.gov.rs/lat/files

Surface Temperature

The surface temperature helps us understand how much heat is absorbed by different materials. Infrared camera measurements can be done using satellites, drones, and handheld devices. Urban surfaces like asphalt and concrete tend to absorb more heat during the day and release it slowly at night. This data helps identify hot spots within a city and evaluate solutions like green roofs and reflective pavements. The surface temperature map for the city of Niš is shown in Figure 7, while day and night surface temperature for the Medijana municipality is shown in Figure 8.

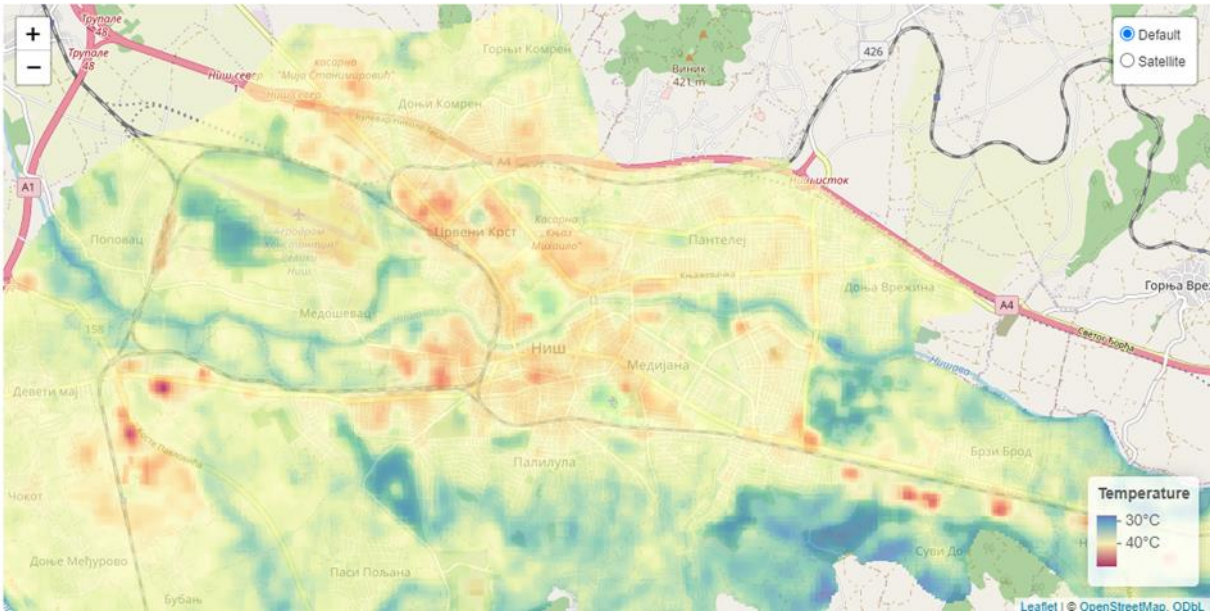


Figure 7. Surface temperature for the City of Niš

Source: https://wbcrp.shinyapps.io/crc_workshop_western_balkans/

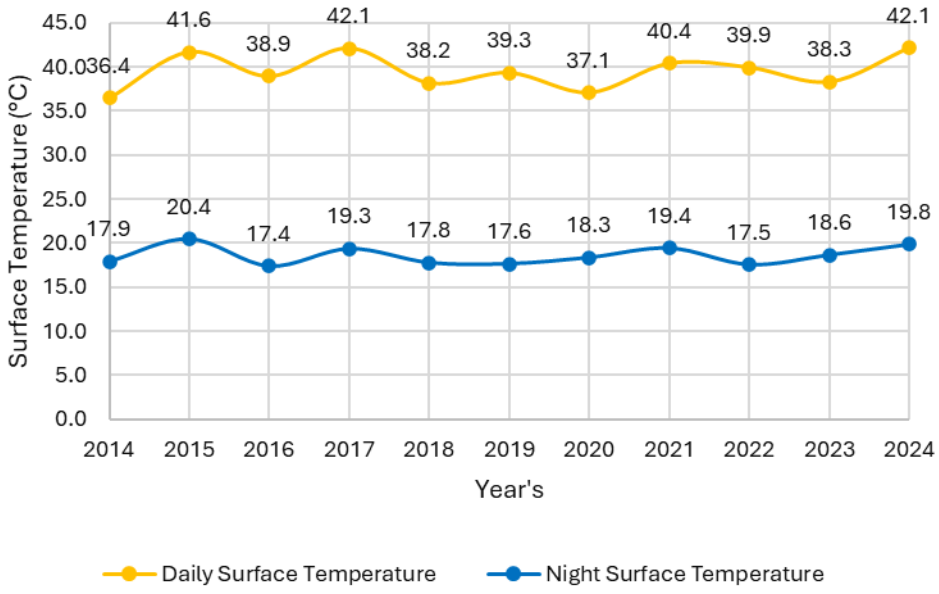


Figure 8. Daily/Night average surface temperature for the period 15.7.-15.08. in the period 2014-2024 in the municipality of Medijana

Source: https://search.earthdata.nasa.gov/search

Solar Radiation

Solar radiation is the main source of heat in urban areas. It is measured using pyranometers, providing the amount of solar energy reaching the surface. Urban materials absorb and reflect this radiation, affecting surface and air temperatures. Understanding solar radiation patterns helps identify areas with high heat accumulation and develop shading strategies to reduce heat absorption.

The graph of solar radiation for the Medijana municipality is shown in Figure 9.

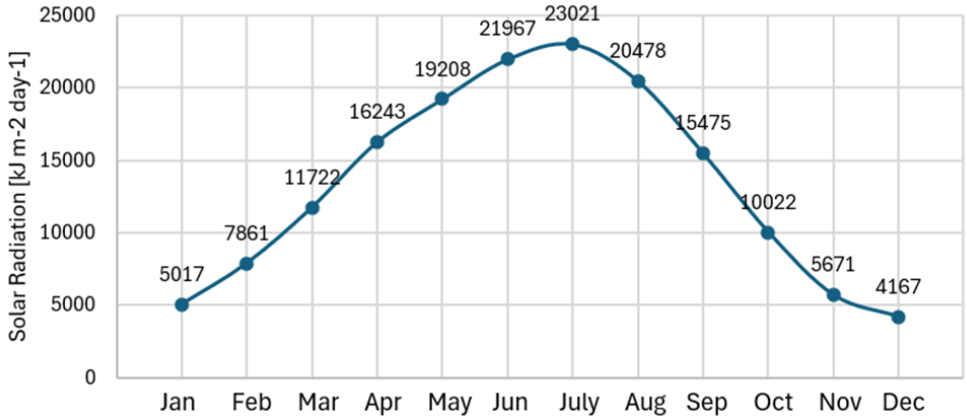


Figure 9. Mean monthly solar radiation in the period 1970-2000 for the municipality of Medijana.

Source: https://www.worldclim.org/

Humidity

Humidity refers to the amount of water vapor present in the air. It impacts thermal comfort and the overall heat balance in an environment. High humidity levels make the air feel hotter and increase the perceived temperature. Humidity is typically measured using a hygrometer, which can be part of a weather station or a standalone portable device. Hygrometers measure the relative humidity, indicating the percentage of moisture in the air relative to the maximum amount it can hold at a given temperature.

According to the data on relative humidity (%) shown in Table 3, the least humid months are July and August, while the most humid is December.

Wind Speed and Direction

Wind speed and direction are key parameters for heat and pollutant transport. Wind speed measures how fast the air is moving, while wind direction indicates the wind vector. Together, they influence the cooling effect and ventilation of an area. These parameters are typically measured using anemometers often integrated in weather stations.

Wind speed data is shown in graphical (Figure 10) and tabular form (Table 5), while wind direction is illustrated by windrose in Figure 11.

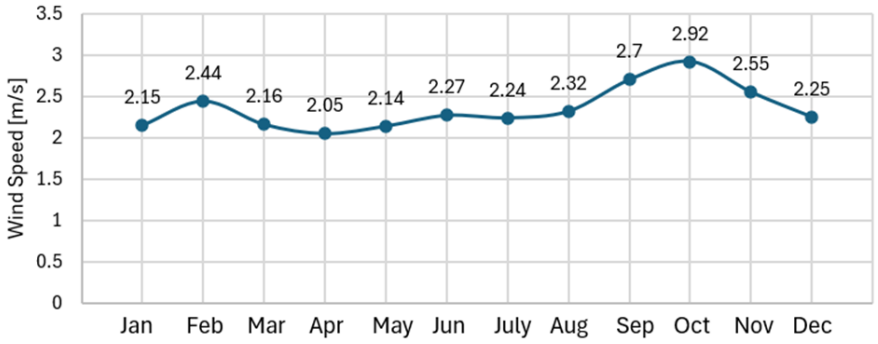


Figure 10. Mean monthly wind speed for the period 1970-2000 in the municipality of Medijana

Source: https://www.worldclim.org/

Table 5. Relative wind frequency for directions and silence, and mean wind speed at the meteorological observatory Niš in the period 1981-2010.

Direction	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**C**
Rel. Frequency (‰)	24	20	32	117	67	33	15	16	23	19	17	24	27	50	105	98	313
Mean wind speed (m/s)	1.4	1.8	2.1	2.1	2	1.7	1.6	2.2	2.6	2.1	1.9	1.3	1.4	1.9	2.8	2.3	

Source: Republic Hydrometeorological Service of Serbia.

https://www.hidmet.gov.rs/latin/meteorologija/stanica_sr.php?moss_id=13388

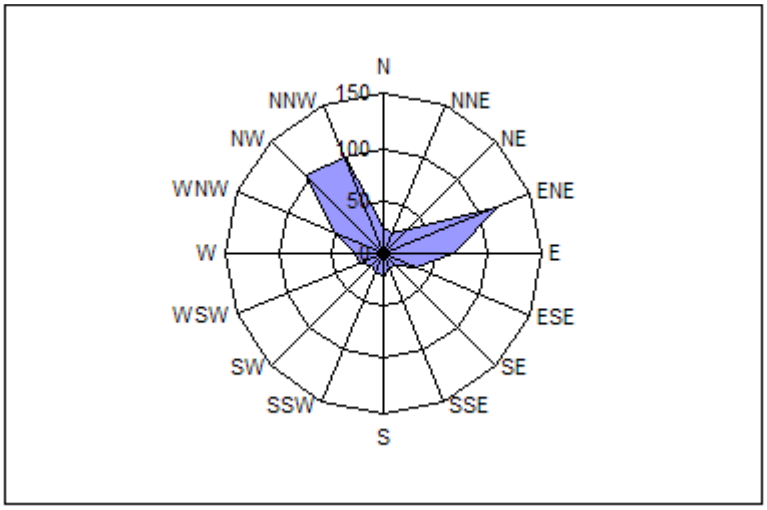


Figure 11. Windrose at the meteorological observatory Niš in the period 1981-2010.

Source: Republic Hydrometeorological Service of Serbia.
https://www.hidmet.gov.rs/latin/meteorologija/stanica_sr.php?moss_id=13388

Precipitation

Precipitation affects the cooling of surfaces and the overall heat balance. Rain can temporarily cool both surfaces and the air, mitigating the UHI effect. Data on rainfall intensity, duration, and frequency is collected using rain gauges and weather radars. Knowledge on past precipitation events supports planning for rainwater harvesting and reuse in irrigation of green infrastructure for UHI mitigation.

The annual precipitation data sums for the Medijana municipality are shown in Figure 12, and a % difference of annual precipitation data between two periods in Figure 13.

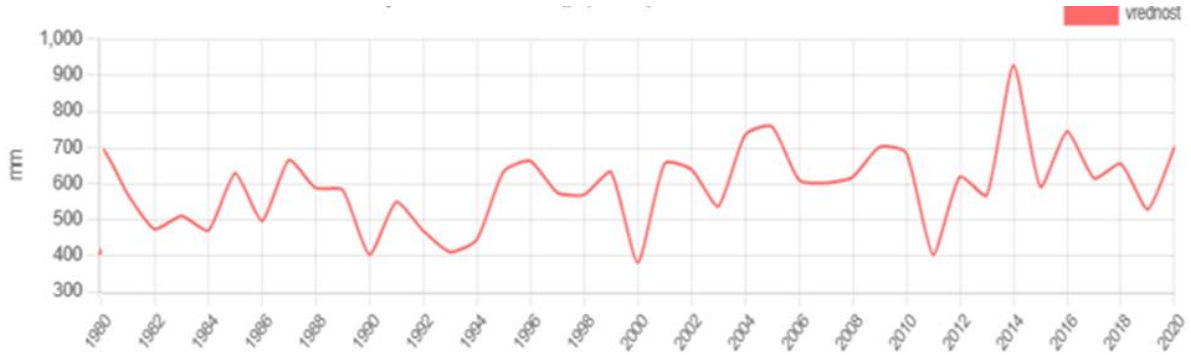


Figure 12. The annual sum of Precipitation in the period 1980-2020 for the municipality of Medijana

Source: https://atlas-klime.eko.gov.rs/lat/files

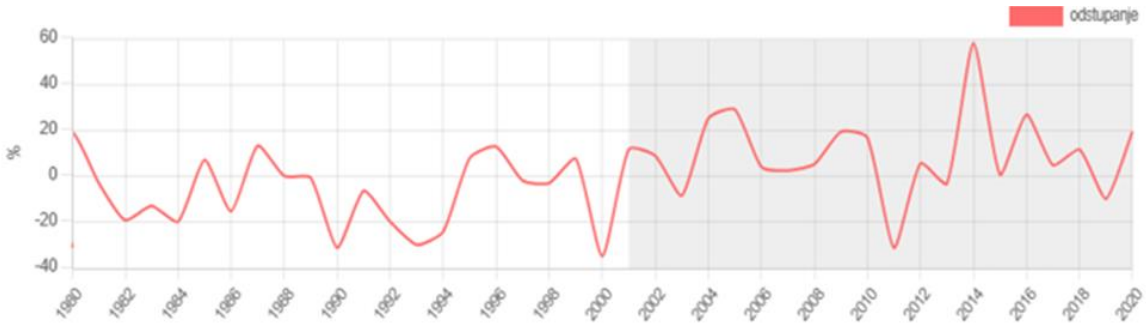


Figure 13. The annual sum of Precipitation % deviation in the period 1980-2020 compared to 1971-2000, for the municipality of Medijana

Source: https://atlas-klime.eko.gov.rs/lat/files

3. Assessment of the city based on 4 vulnerability elements, exposure, sensitivity, preparedness and adaptive capacity and risk groups

The City of Niš conducted a UHI vulnerability assessment for the selected urban area in the central city zone, testing a common methodology and developing tools for **4 elements** of vulnerability: 1) **exposure**, 2) **sensitivity**, 3) **preparedness and adaptive capacity**, and 4) **risk groups**.

Selected city area/pilot zone – urban brief

The City of Niš selected a zone in the central part of the city for the UHI risk assessment on the smaller spatial scale (Figure 14, Figure 15). The risk assessment at this level was carried out for the elements and indicators for which it was possible.

Selected zone includes the central city square – King Milan square, part of Obrenovićeva Street – the main pedestrian street in the city, part of Voždova Street - one of the primary city street, as well as adjacent, mixed-use blocks (Figure 14, Figure 15). This zone was chosen because it represents a densely built-up area, with a high population density and a large share of paved surfaces, which are key prerequisites for the occurrence of UHI and the possible negative effects it brings with it.

Figure 14. City of Niš and position of the selected pilot zone
Source: GeoSrbija

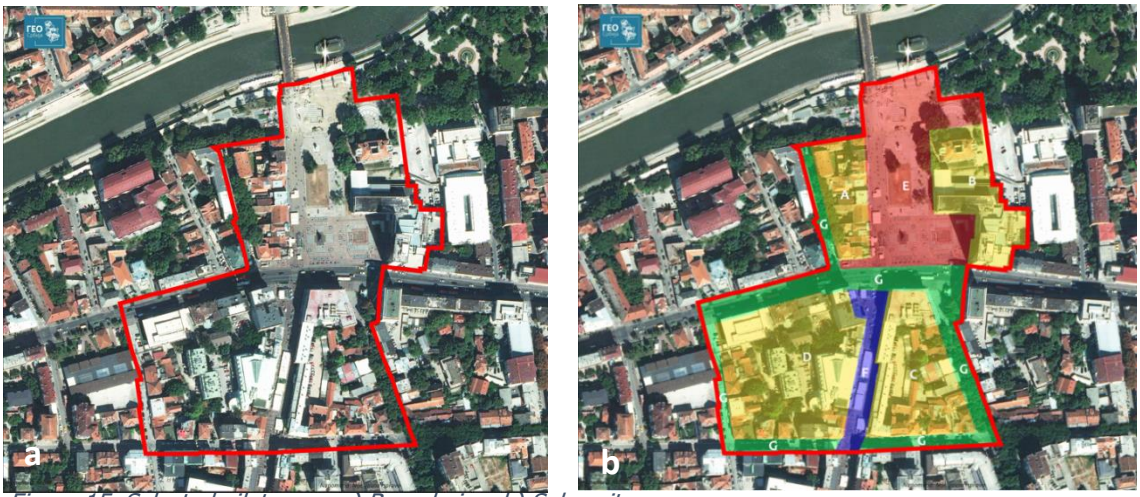


Figure 15. Selected pilot zone. a) Boundaries; b) Sub-units
Source: GeoSrbija

EXPOSURE OF BUILDINGS AND SURROUNDINGS

Key criteria for the assessment of **Tool 1** are the following: 1) **urban morphology/urban form**; 2) **green urban spaces and vegetation**; 3) **permeability of surfaces**; and 4) **human activities**.

Urban morphology/urban form

1A) Indicator: Building coverage ratio (BCR)

Building coverage ratio (BCR) reflects the relationship between the ratio of the site occupied by the building and the site area (plot/parcel or larger area).

City level

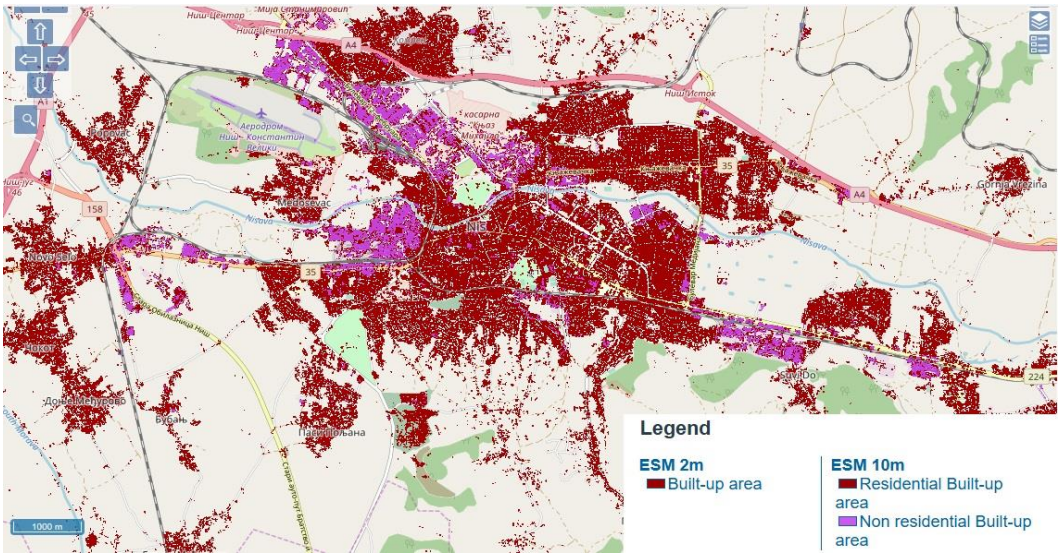


Figure 16. Built-up area – city level
Source: https://human-settlement.emergency.copernicus.eu/

Pilot zone

The pilot zone is located within a densely built urban fabric with an impermeability of 50-100% (Figure 1.1).

Current BCR values for the selected pilot zone are:
Sub-unit A: 83.44% (net value); Sub-unit B: 59.72% (net value)
Sub-unit C: 65.90% (net value); Sub-unit D: 64.41% (net value)
Sub-unit E: - ; Sub- unit F: -; Sub-unit G: -
Pilot zone: 36.65% (gross value)

The highest BCR value (83.44%) is present in sub-unit A which consists of a large number of small, almost fully built-up cadastral plots. The pilot zone includes large undeveloped areas (central city square, main city road and pedestrian street), thus the BCR value (36.65%) is much lower than the values for individual sub-units. Thus the average BCR value for sub-units can be considered as relevant (68.37%).

Building coverage ratio (BCR):
36.65% (gross value for pilot zone); 68.37% (average net value)

BCR values are defined in urban plans for the city area (plans of general regulation and plans of detailed regulation), but those values refer to future, planned construction. According to the Plan of General Regulation of the City Municipality of Medijana, the pilot zone belongs to the "business-residential zone". For this area the plan foresees a maximum BCR of 60% to 70%, depending on the plot area.

Current Building Coverage Ratio (BCR) is calculated as follow:
BCR=building area (B) /area of the plot (P) *100 [%]
Building area (B) and area of the plot (P) for each plot were obtained by measuring from Geosrbija and GIS Niš maps.

BCR for sub-units (A,B,C,D) is expressed as a net value, i.e. the ratio of the total area under the objects in the sub-unit to the net surface area of the sub-unit.
Total pilot zone BCR is expressed as a gross value, i.e. the ratio of the total area under the objects to the gross surface area of the pilot site.

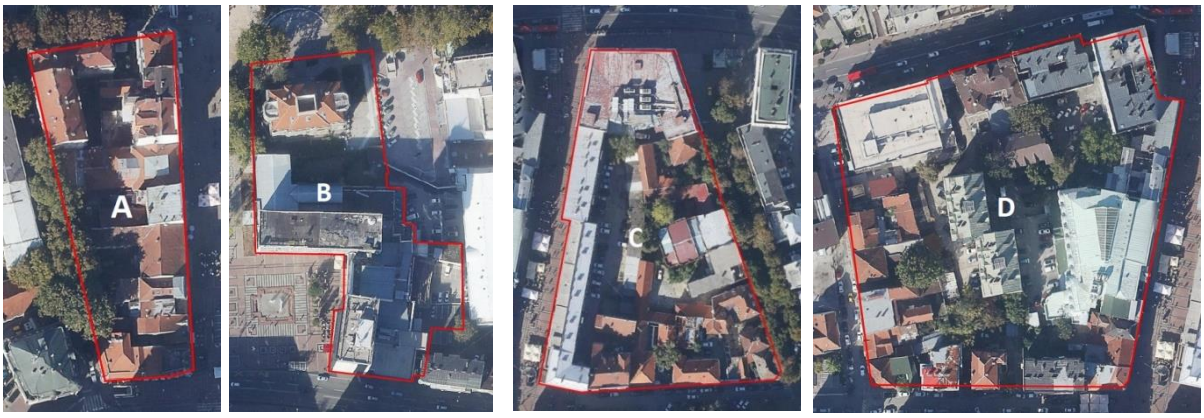


Figure 17. Building coverage – subunits A, B, C, D
Source: GIS Niš

Limitation of the analysis:

The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of building coverage ratio at the grid level. The available data provides surface area information only on the level of the city municipality. Population census data or any other open source data in a form of a grid/spatial cell data do not exists. This limits the analysis of the indicator, as well as the possibility of its application in urban planning for the purpose of detecting and assessing UHI effects. Namely, the value of the indicator can be determined only by analytical calculation of data that must be separately taken from GeoSrbija and GIS Niš (often accompanied with the observation), which is time-consuming and calls into question the the efficiency and applicability of the indicator in urban planning.

Source of data for the assessment:

GeoSrbija (https://a3.geosrbija.rs/)
GIS Niš (https://gis.ni.rs/smartPortal/gunisPublic)
World Bank (https://wbcrp.shinyapps.io/crc_workshop_western_balkans/)

1B) Indicator: Floor area ratio (FAR)

Floor area ratio (FAR) (also floor space ratio - FSR; floor space index – FSI; site ratio or plot ratio) is a measure describing how much land is covered by a building. It is a relationship between the total floor area of land covered by buildings and the whole area where the buildings stand. A higher FAR allows for more intensive development.

City level

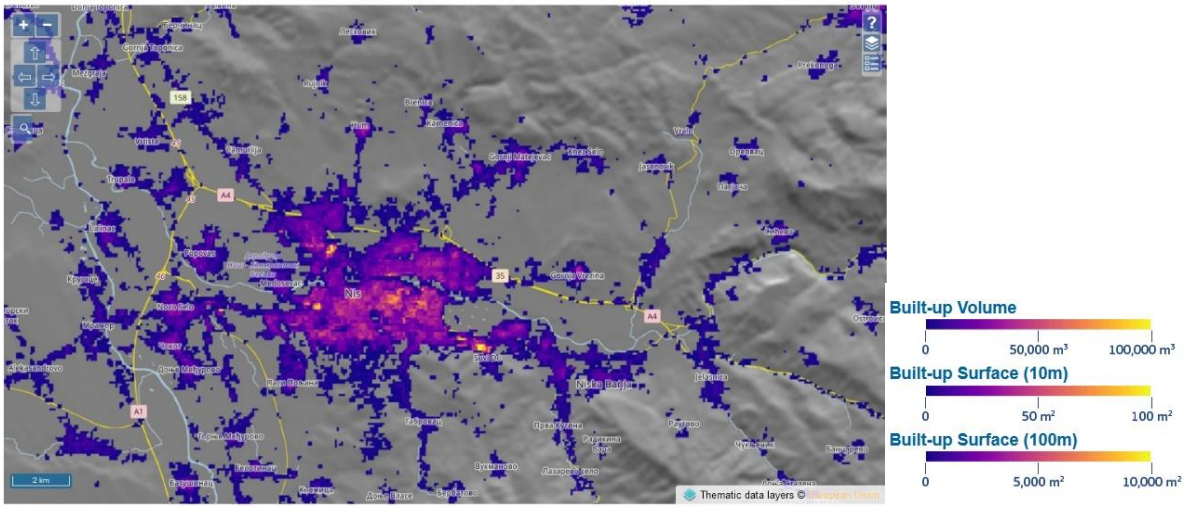
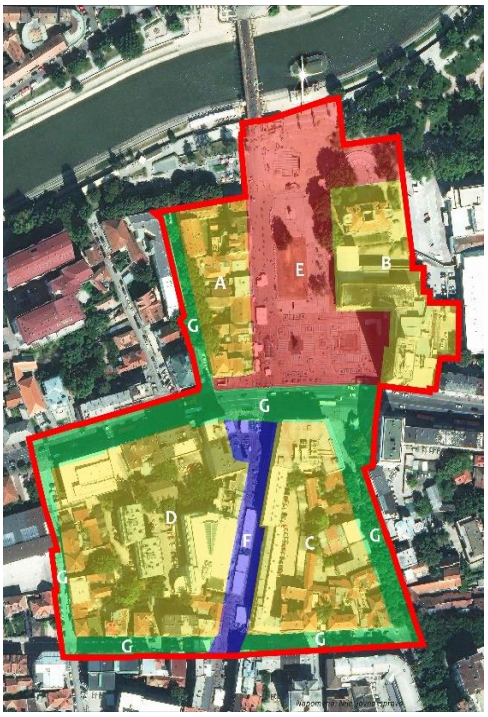


Figure 18. Built-up volume of buildings – city level

Source: https://human-settlement.emergency.copernicus.eu/

Pilot zone



Current FAR values for the selected pilot zone are:

Sub-unit A: 2.52 (net value)
Sub-unit B: 2.48 (net value)
Sub-unit C: 1.94 (net value)
Sub-unit D: 2.88 (net value)
Sub-unit E: -
Sub-unit F: -
Sub-unit G: -
Pilot zone FAR: 1.39 (gross value)

FAR value is the highest in the sub-unit D, which includes low-rise single-family housing but also high-rise multi-family housing (seven- to thirteen-story buildings) (Figure 22).
The lowest FAR value is present in the sub-unit C, with predominantly low-rise single- and multi-family buildings (Figure 21).

Floor area ratio (FAR): 1.39

FAR values are defined in urban plans for the city area (plans of general regulation and plans of detailed regulation), but those values refer to future, planned construction. According to the Plan of General Regulation of the City Municipality of Medijana, the pilot zone belongs to the "business-residential zone". For this area the plan foresees a maximum FAR of 2.4 to 4.2, depending on the plot area.

Current FAR is calculated as follow: FAR= gross floor area (sum of all F) / area of the plot (P)

FAR for sub-units (A,B,C,D) is expressed as a net value, i.e., the ratio of the total floor area in the sub-unit to the net surface area of the sub-unit. Total FAR is expressed as a gross value, i.e the ratio of the total floor area to the gross surface area of the pilot site.

Figure 19. Sub-unit A
Source: authors

Figure 20. Sub-unit B
Source: authors

Figure 21. Sub-unit C
Source: authors

Figure 22. Sub-unit D
Source: authors

Limitation of the analysis:

The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of floor area ratio at the grid level. The available data provides surface area information only on the level of the city municipality. Population census data or any other open source data in a form of a grid/spatial cell data do not exists. This limits the analysis of the indicator, as well as the possibility of its application in urban planning for the purpose of detecting and assessing UHI effects. Namely, the value of the indicator can be determined only by analytical calculation of data that must be separately taken from GeoSrbija and GIS Niš, which is time-consuming and calls into question the efficiency and applicability of the indicator.

Source of data for the assessment:

GeoSrbija (https://a3.geosrbija.rs/)
Copernicus (https://human-settlement.emergency.copernicus.eu/)
Observation

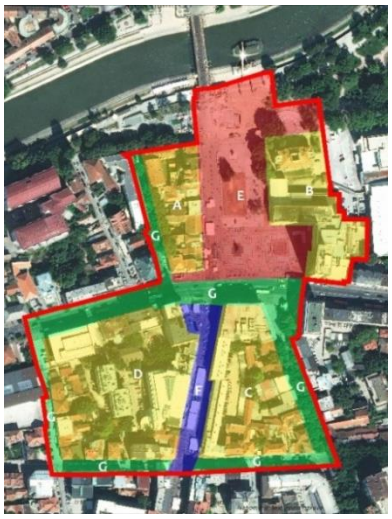
1C) Indicator: Street canyon aspect ratio

Street canyon is a narrow street with tall buildings along the street on both sides of it. It can be measured as an aspect ratio of average building height along the street and street width.

City level

Figure 23. Building height – city level
Source: https://www.copernicus.eu/en

Pilot zone



The pilot site is characterized by the presence of buildings of various heights and typologies.

In parts where a continuous series of buildings on opposite sides of the street form a street canyon, the ratio of the height of the buildings to the street width ranges from 0.8 to 1.3 (Figure 24).

The highest value (H/W = 1.3) occurs in the northern part of Balkanska street (Fig. 25). However, Balkanska Street is rich in high greenery, which helps mitigate the effects of the street canyon. In other streets the H/W ratio is lower than 1 (Fig. 24).

The effects of street canyons are minimal in parts of the pilot zone where detached single-family homes predominate (the perimeter edges of subdivisions C and D) as well as in the central city square.

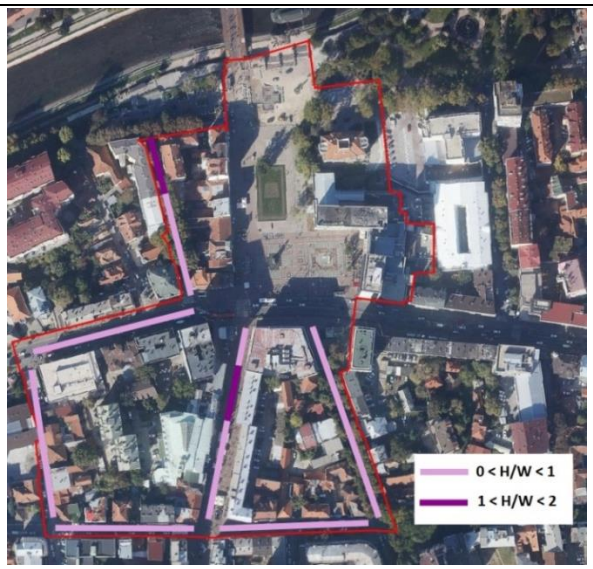
Street canyon aspect ratio: H/W = 0.8 – 1.3

The values of the H/W ratio were calculated based on:

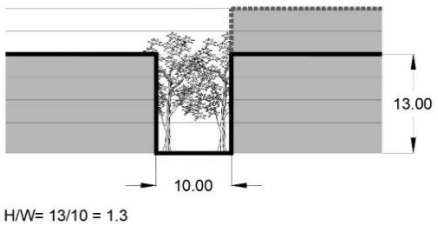
- street width measured from GeoSrbija and GISNišmaps;
- building's heights obtained through the field observation and analytical calculation (number of floors of buildings multiplied by the average floor height).

In the case of an asymmetric street canyon, the average height of the buildings was used for the calculation.

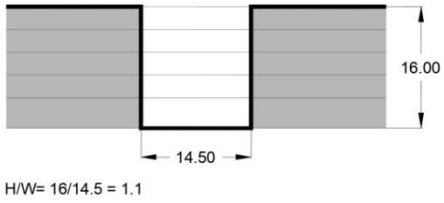
Results of the analysis are presented graphically on the map (Figure 24).



a)



b)



c)

Figure 24. a) Street canyon aspect ratio – pilot zone; b), c) Cross sections of the street canyons in Balkanska and Nade Tomić street (respectively)
Source: authors

Figure 25. Street canyon in Balkanska Street.
Source: authors

Figure 26. Street canyon in Obrenovićeva Street
Source: authors

Limitation of the analysis:
The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of street canyon aspect ratio at the grid level. Moreover, the available data do not exist. The value of the indicator can be determined only by observation and analytical calculation of data that must be separately taken from available sources (GeoSrbija and GIS Niš) and observation findings, which is time-consuming and calls into question the efficiency and applicability of the indicator in in urban planning for the purpose of detecting and assessing UHI effects.

Source of data for the assessment:
GeoSrbija (https://a3.geosrbija.rs/)
Copernicus (https://www.copernicus.eu/en)
Observation

Green urban spaces and vegetation

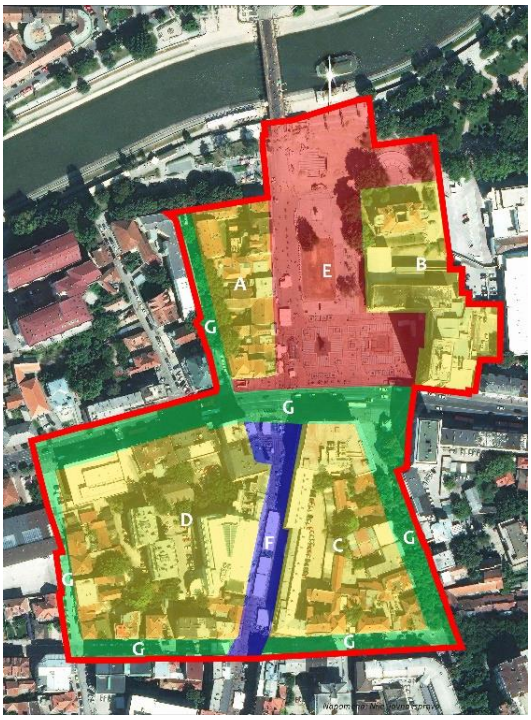
2A) Indicator: Green coverage ratio

Green urban spaces are open spaces in cities and towns defined by a certain degree of vegetation and other natural features, regardless of ownership, function and position in space (Spatial Planning Decree of Slovenia, 2004, National Spatial Order of Slovenia, 2023).

City level

Figure 27. Grassland – city level
Source: https://land.copernicus.eu/

Pilot zone



Green coverage ratio (GCR) in the central city zone, which is the subject of the analysis, is very low, and it amounts to:

Sub-unit A: 4.45%
Sub-unit B: 10.2%
Sub-unit C: 5.12%
Sub-unit D: 3.6%
Sub-unit E: 8.45%
Sub-unit F: 0%
Sub-unit G: 1.67%
Pilot zone: 5 %

The largest share of greenery is present in sub-unit B, and it amounts to 10.2%. The share of green areas in the other mixed use sub-units (A, C, D) is half as much (3.6% to 5.12%). The lowest share of green areas is expected within zone G, which includes streets and associated spaces. However, the lowest GCR value is present in the pedestrian zone (subzone F) and it is 0%, which indicates a complete absence of grassland (Figure 28).

Green coverage ratio: 5%

GCR values for sub-units represent the ratio of the sum of all green areas in a sub-unit to the net area of the sub-unit. GCR values for pilot zone represent the ratio of the sum of all green areas to the gross area of the pilot zone.

The GCR values were calculated based on measurements from GeoSrbija and GISNiš maps and field observation. Following the tree canopy cover classification scale proposed in the Methodology, a scale for the green cover ratio was formed. Since the analysis showed that the highest share of greenery in the pilot zone is 10.2%, the scale was modified to display the results in more detail. GCR classification scale consists of three values: < 5%; 5% - 10%; > 10%. Lower values are demonstrated in lighter colour and higher in darker colour (Figure 28).

Figure 28. Green coverage ratio – pilot zone
Source: authors

Figure 29. Greenery within the sub-unit C
Source: authors

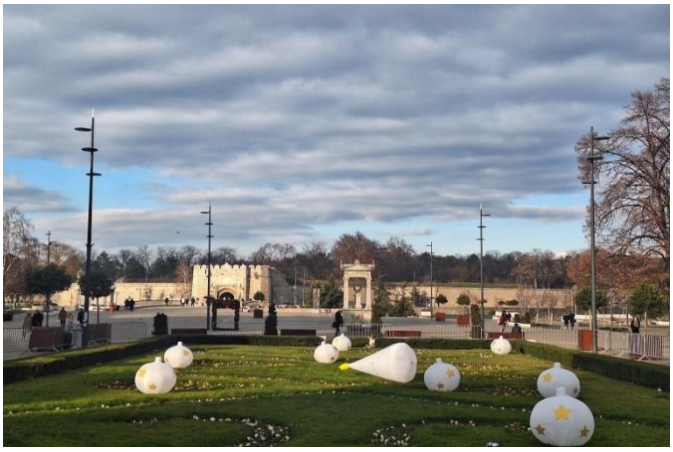


Figure 30. Green area at the central city square
Source: authors

Limitation of the analysis:

The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of green coverage ratio at the grid level. Moreover, the available data do not exist, which limits the analysis of the indicator. The value of the indicator can be determined only by analytical calculation of data that must be separately observed from GeoSrbija, GIS Niš and General or Detailed Urban Plan(s), which is time-consuming and calls into question the efficiency and applicability of the indicator.

Source of data for the assessment:

GeoSrbija (https://a3.geosrbija.rs/)
GIS Niš (https://gis.ni.rs/smartPortal/gunisPublic)
Observation

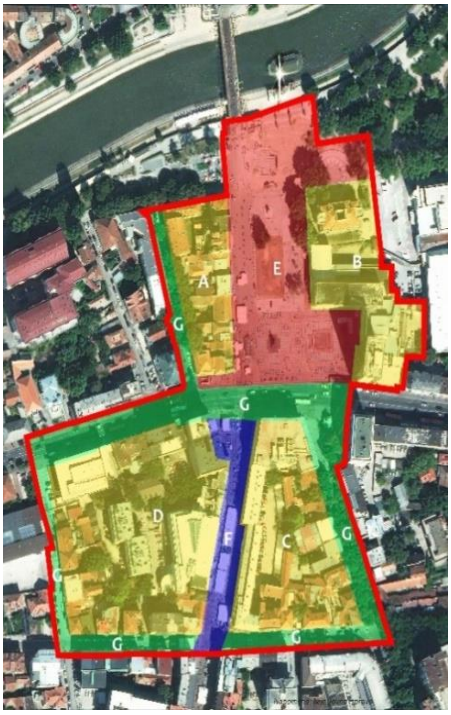
2B) Indicator: Tree canopy coverage

Tree canopy coverage is a ratio of tree canopy coverage on the entire city level and a city unit (neighborhood, district, city level).

City level

Figure 31. Tree covers density – city level
Source: https://www.copernicus.eu/en

Pilot zone



Tree canopy coverage (TCC) for the pilot zone:
Sub-unit A: 13.87%; Sub-unit B: 3.31%; Sub-unit C: 9.62%
Sub-unit D: 14.68%; Sub-unit E: 11.31%; Sub-unit F: 0%
Sub-unit G: 22.62% (Nade Tomić Street: 70.26%, Balkanska Street: 79.49%, other streets: 0%)
Pilot zone: 12.84%
Unexpectedly, the highest TCC value (22.62%) is present in sub-unit G, which includes all streets in the pilot zone, while TCC in sub-unit F (pedestrian street) is the lowest (0%). These results are due to the fact that two streets—Balkanska and Nade Tomić—have tree-lined avenues on both sides and TCC of more than 70%. Other streets, including pedestrian streets, are missing trees, i.e., the TCC value is zero. TCC values for mixed-use sub-units range from 3.31% in the sub-unit B to 14.68% in the sub-unit D. TCC at the main city square (sub-unit E) is also very low (11.31%) (Figure 32, Figure 33). In order to improve the condition, new tree rows and trees in boxes have been planted, but they are still not significant in terms of tree canopy coverage.

Tree canopy coverage: 12.84%

TCC values for sub-units represent the ratio of the tree canopy projection in a sub-unit to the net area of the sub-unit. TCC values for pilot zone represent the ratio of the tree canopy projection to the gross area of the pilot zone.

The TCC values were calculated based on measurements from GeoSrbija and GISNiš maps and field observation. The positions and canopies of trees, as well as TCC values, are presented graphically (Figure 32, Figure 33).

TCC classification scale, proposed in the methodology, includes the following values: 0% - 20%; 21% - 35%; 36% - 52%; 53% - 75%; 76% - 100%. Having in mind that TCC values for most of the pilot zone are lower than 20%, except for two streets with TCC values higher than 70%, the graphic display contains four categories: 0%; 0-10%; 10-20%; >70%. Lower values are demonstrated in lighter colour and higher in darker colour.

Figure 32. Position of trees within the pilot zone
Source: authors

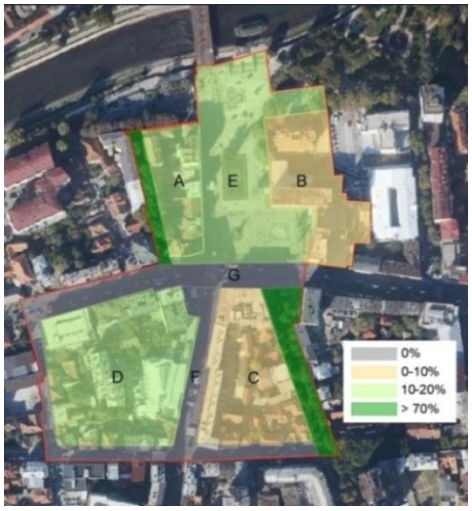
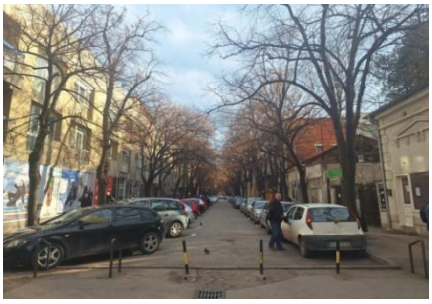


Figure 33. Tree coverage ratio
Source: authors



Tree rows in Nade Tomić street
Source: authors

Newly planted tree rows and tree boxes in the central city square
Source: authors

Limitation of the analysis:
The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of tree canopy coverage at the grid level. Moreover, the available data do not exist at all. The value of the indicator can be only determined by observation in the field or analytical calculation (counting the trees) of data from GeoSrbija and GIS Niš, whichh is time-consuming and calls into question the efficiency and applicability of the indicator.

Source of data for the assessment:
GeoSrbija (https://a3.geosrbija.rs/)
GIS Niš (https://gis.ni.rs/smartPortal/gunisPublic)
Copernicus (https://www.copernicus.eu/en)
Observation

Permeability of surfaces

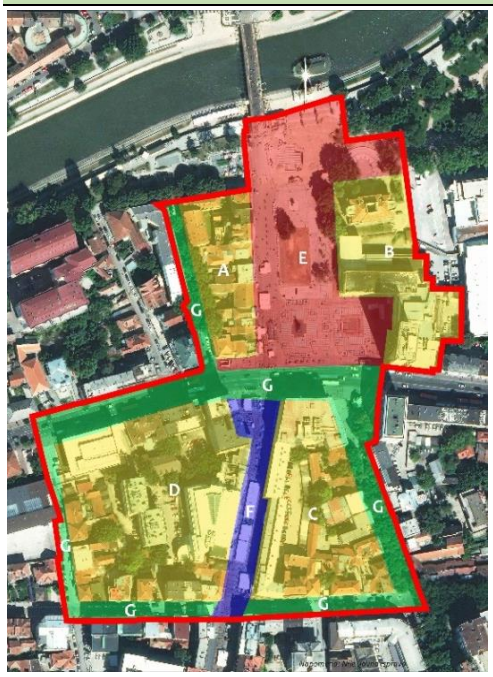
3A) Indicator: Share of permeable surfaces related to impermeable surfaces

A ratio of impermeable surfaces is the relation between permeable and impermeable surfaces. Three categories for permeability are defined: permeable surfaces (green spaces); semi-permeable surfaces (green roofs and green walls); impermeable surfaces (e.g. roads, pavements, parking spaces; covered by hard construction materials like asphalt).

City level

Figure 34. Imperviousness of surfaces - city level
Source: https://www.copernicus.eu/en

Pilot zone



The pilot zone is characterized by high BCR values within business and residential blocks, as well as a large share of areas intended for pedestrians (pedestrian street and main town square) and vehicular traffic (streets and paved/unpaved parking spaces). In order to increase the share of greenery, the current Plan of General Regulation of the City Municipality of Medijana provides for green roofs and facades for future construction. However, these provisions are not binding for existing buildings, therefore no semi-permeable surfaces are present in the subject area.

The share of permeable, semi-permeable and impermeable surfaces within the pilot zone are: 1) Permeable surfaces (PS): 6.9%; 2) Semi-permeable surfaces (SPS): 0%; 3) Impermeable surfaces (IS): 93.1% (Figure 34).

The analysis showed a very high proportion of impermeable surfaces compared to permeable ones. Namely, permeable surfaces make up only 6.93% of the total area of the pilot zone, while the remaining 93% are impermeable surfaces.

Share of permeable surfaces related to impermeable surfaces: PS/ IS= 0.07; IS/PS= 13.5

In line with the proposed methodology, the following areas have been identified within the pilot zone:
Total area: 62,743 m^2
Buildings: 22,996 m^2
Unbuilt space: 39,747m^2
Permeable surfaces (grassland): 2,745 m^2
Impermeable surfaces (streets, pavement, parking): 37,002 m^2 The graphic display shows five categories of surfaces: **buildings, streets**, **pavement**, **parking** and **grass** (Figure 35).

Figure 35. Permeability of surfaces – pilot zone
Source: authors



Figure 36. Impermeable surfaces: a) main city square; b) main street; c) inner courtyard
Source: authors

Limitation of the analysis:
The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of tree canopy coverage at the grid level. Moreover, the available data do not exist at all. The value of the indicator can be only determined by observation in the field and analytical calculation of data (measuring surfaces) from GeoSrbija and GIS Niš, whichh is time-consuming and calls into question the efficiency and applicability of the indicator.

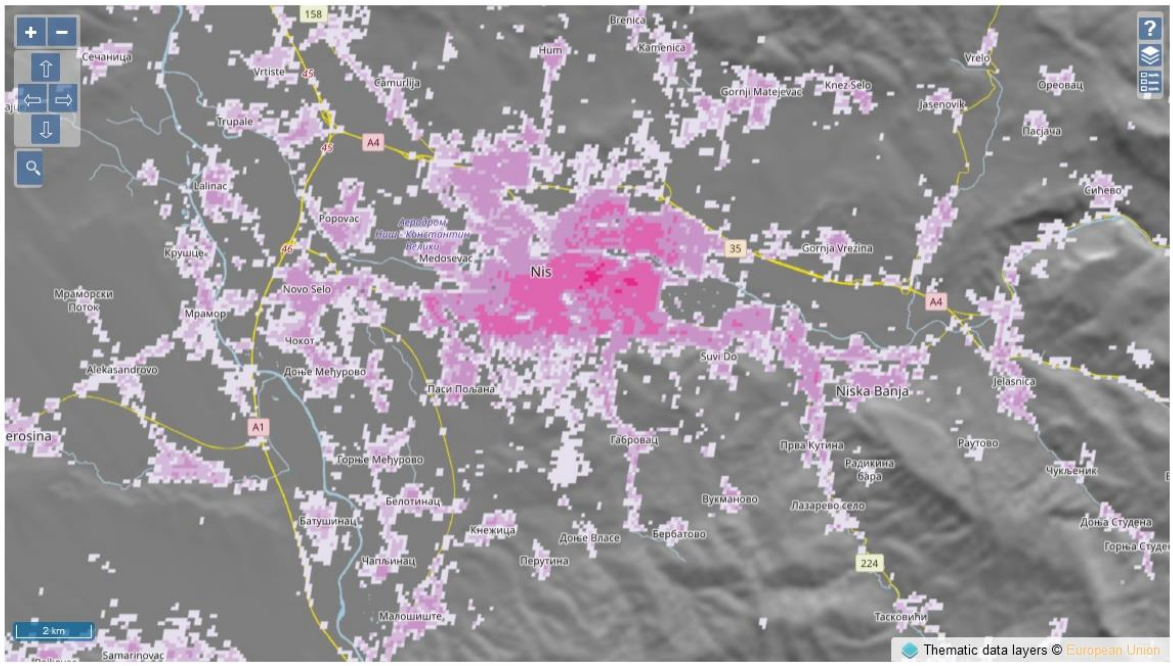
Source of data for assessment:
GeoSrbija (https://a3.geosrbija.rs/)
GIS Niš (https://gis.ni.rs/smartPortal/gunisPublic)
Copernicus (https://www.copernicus.eu/en)
Observation

Human activities

4A) Indicator: Population density

Population density is a measurement of the number of people in an area (inhabitants per hectare or inhabitants per m^2).

City level



Population
- no data (transparent)
- 0 - 5
- 6 - 20
- 21 - 100
- 101 - 300
- 301 - 500
- 501 - 1,000
- 1,000 - Max

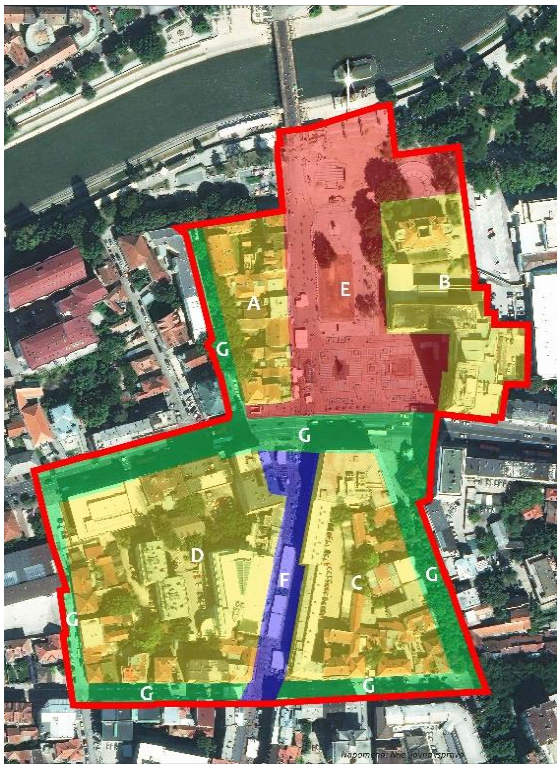
The central city municipality of Medijana is the most densely populated with 83,073 inhabitants per 10 km², i.e., a population density of 83 inhabitants per ha.

Figure 37. Population - number of inhabitants per ha
Source: https://human-settlement.emergency.copernicus.eu/

Basic data for the pilot zone and sub-units

Sub-unit	Area (m2)	Area (km2)	Population assessment (inh)
A	4355	0.004355	238
B	7252	0.007252	170
C	8712	0.008712	346
D	14424	0.014424	1344
E	12393	0.012393	0
F	2991	0.002991	0
G	12616	0.012616	0
Sum	62743	0.062743	2098

Pilot zone



Being a part of central city municipality, the pilot zone is densely built and populated. Population densities for sub-units and the pilot zone are:
Sub-unit A: 546 inh. per ha (net value)
Sub-unit B*: 234 inh. per ha (net value)
Sub-unit C: 397 inh. per ha (net value)
Sub-unit D: 932 inh. per ha (net value)
Sub-unit E: -
Sub-unit F: -
Sub-unit G: -
Pilot zone: 335 inh. per ha (gross value)
Sub-unit D is the most densely populated, due to the high-rise, multi-family housing with a large number of residents.
Population densities are significantly lower in sub-units with predominant single-family and low-rise multi-family housing (sub-unit C) as well as in sub-units with a higher share of business and administration in relation to housing (sub-unit B).

Population density: 335 inh. per ha (33,500 inh. per sq. km)

Since there are no available data for a level lower than the municipality, the population density for the sub-units was calculated based on observation (number of dwellings) and average number of inhabitants per dwelling.
Within the sub-unit B*, city hotel "Ambasador" was taken into account as a special type of housing. The number of residents corresponds to the full accommodation capacity of the hotel.

Limitation of the analysis:

The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of population density at the grid level. The available data provides population distribution information in terms of people count/number and surface area only on the level of the city municipality. Population census data or any other open source data in a form of a grid/spatial cell data do not exists. This limits the analysis of the indicator, as well as the possibility of its application in urban planning for the purpose of detecting and assessing UHI effects. Namely, the value of the indicator can be determined only by analytical calculation of data that must be separately taken from available sources, which is time-consuming and calls into question the efficiency and applicability of the indicator.

Source of data for the assessment:

GeoSrbija (https://a3.geosrbija.rs/)
DevInfo (http://devinfo.stat.gov.rs/SerbiaProfileLauncher/)
Copernicus (https://human-settlement.emergency.copernicus.eu/)

4B) Indicator: Land use

Land use is related to the use of land for the needs of human activities like agricultural, residential, industrial, mixed use, recreational and other.

City level

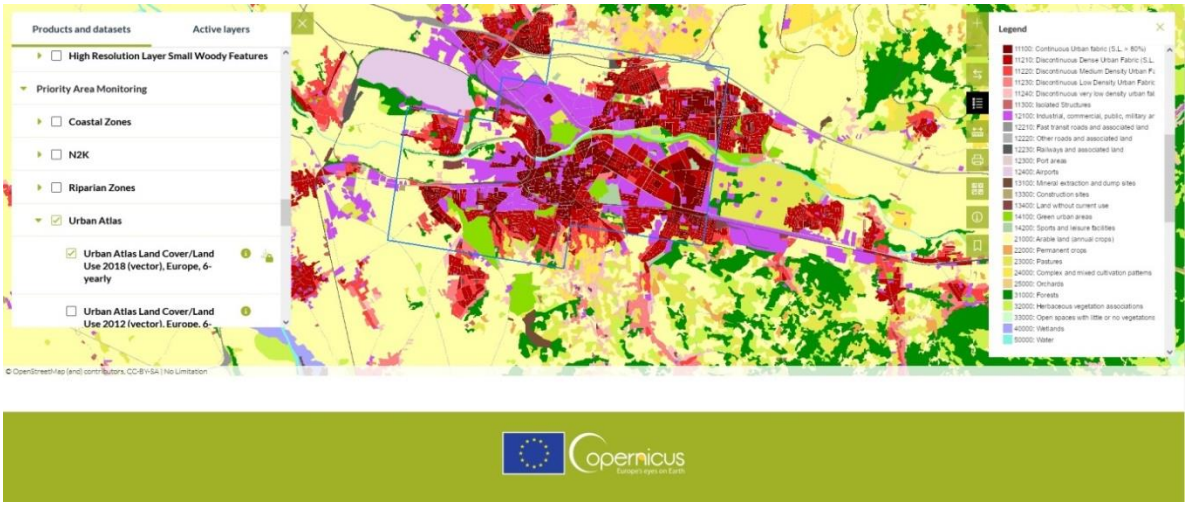
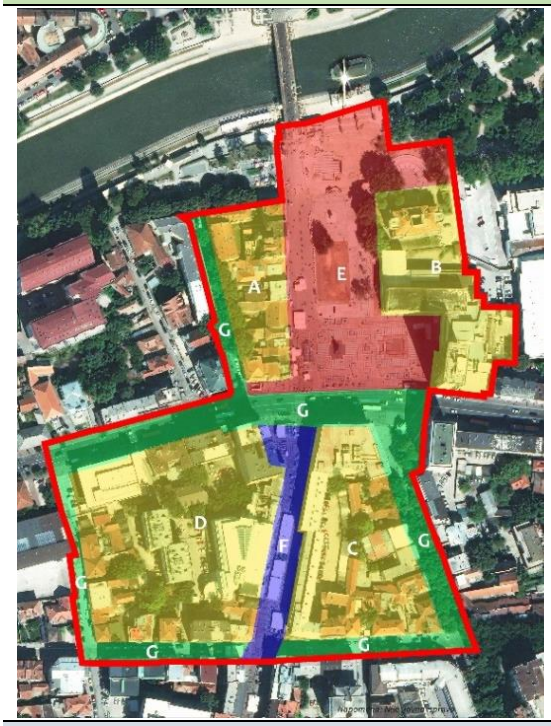


Figure 38. Land use – city level
Source: https://www.copernicus.eu/en

Pilot zone



The pilot zone is divided into sub-units corresponding to different land-uses, as follows:

1) Sub-units A, B, C, D: Mixed use (residential, commercial, cultural, institutional, and other) 34,743 m^2 (55.37%)
2) Sub-unit G : Streets 12,616 m^2 (20.11%)
3) Sub-unit F – pedestrian street 2,991m^2 (4.77%)
4) Sub-unit E – main city square 12,393m^2 (19.75%)

Land use:
Mixed-use (A,B,C,D): 55.37%
Streets (G): 20.11%
Pedestrian surfaces (E,F): 24.52%

According to the current Plan of General Regulation of the City Municipality of Medijana, sub-units A, C, and D are designated as "business-residential zones" (Figure 39).
In addition to housing and business, this zone also includes commercial services, trade, administration, health, education, childcare, culture, social institutions, etc., which corresponds to the "mixed-use.". For the sub-unit B, the plan distinguishes administration, business, and tourism as separate land uses. Since these land uses also occur to a lesser or greater extent in other sub-units (A, C, and D), the sub-unit B is also marked as "mixed-use.".
Land uses in sub-units E, F, and G correspond to those defined in the plan.

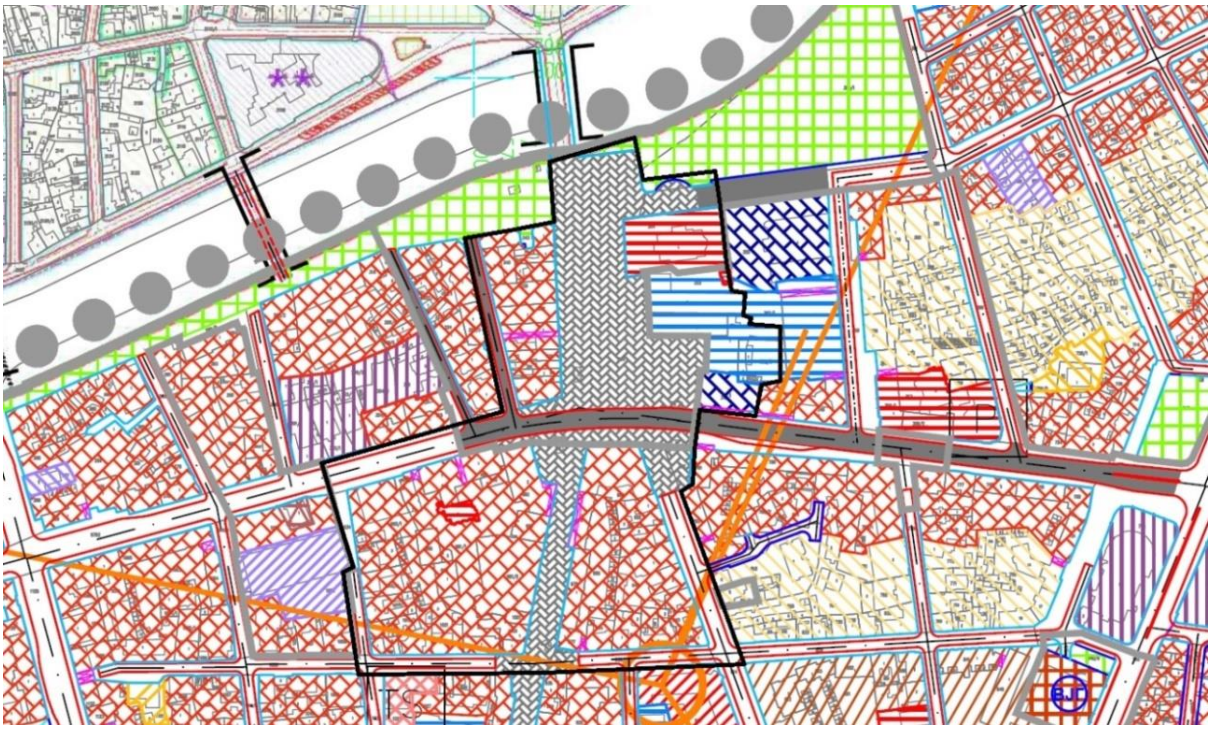


Figure 39. Plan of General Regulation of the City Municipality of Medijana - Land use

Source: http://www.eservis.ni.rs/urbanistickiprojekti/

Limitation of the analysis:

The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of land use at the grid level. The available data provides land use information only on the level of the Spatial plan, General Urban plan and Detailed urban plans, while in a form of a grid/spatial cell data do not exists. This limits the analysis of the indicator, as well as the possibility of its application in urban planning for the purpose of detecting and assessing UHI effects. Namely, the value of the indicator can be determined only by analytical calculation of data that must be separately taken from available sources, which is time-consuming and calls into question the efficiency and applicability of the indicator.

Source of data for the assessment:

GeoSrbija (https://a3.geosrbija.rs/)
Copernicus (https://www.copernicus.eu/en)
http://www.eservis.ni.rs/urbanistickiprojekti/
Observation

4C) Indicator: Energy consumption of buildings

Energy consumption of building is the amount of energy consumed by buildings for residential, commercial, industrial and other purposes.

City level

Figure 40. CO_2 emissions caused by buildings – city level

Source: https://climatetrace.org/

Табела 20. Енергетски биланс града Ниша по секторима и категоријама за 2020. годину (вредности су исказане у MWh)

	Категорија / Сектор	Општинске зграде, опрема и друге просторије	Терцијалне зграде, опрема и друге просторије	Зграде за индивидуално становање	Јавна расвета	Индустрије (изузев оних које су укључене у EU ETS)	Збирно зграде, опрема, простор. и индустрија	Општински возни парк	Јавни транспорт	Приватни и комерцијални транспорт	Збирно саобраћај	Укупно
Финална потрошња енергије [MWh]	Електрична енергија	9.271,6	20.561,	605.344,8	13.414,0	95.276 6	**743.868,0**	-	-	-	-	743.868,0
	Грејање / хлађење	19.695,6	578,	179.009,6	-	29.892.6	**229.176,8**	-	-	-	-	229.176,8
	Фосилна горива — Природни гас	67,6		5.762,8	-	874.6	**6.705,0**	-	-	-	-	6.705,0
	Фосилна горива — Течни гас	27,8		-	-	4.2	**31,9**	131,2	-	16.853,4	**16.984,6**	17.016,6
	Фосилна горива — Лож уље и мазут	-		1.469,1	-	220 4	**1.689,5**	-	-	-	-	1.689,5
	Фосилна горива — Дизел гориво	3.718,8	749,	-	-	670 2	**5.138,3**	6.841,3	37.161,9	187.179,2	**231.182,4**	236.320,7
	Фосилна горива — Бензин	-		-	-	-	-	690,4	-	39.067,2	**39.757,6**	39.757,6
	Фосилна горива — Лигнит	94,1		-	-	14.1	**108,2**	-	-	-	-	108,2
	Фосилна горива — Угаљ	666,5	320,	53.372,1	-	8.153.9	**62.512,9**	-	-	-	-	62.512,9
	Фосилна горива — Друго фосилно г.	-		-	-	-	-	-	-	-	-	-
	Обновљива енергија — Уље	-		-	-	-	-	-	-	-	-	-
	Обновљива енергија — Биогориво	-		-	-	-	-	-	-	-	-	-
	Обновљива енергија — Биомаса	295,4	47,	330.266,6	-	49.591 5	**380.201,3**	-	-	-	-	380.201,3
	Обновљива енергија — Пасивно соларно грејање	-		-	-	-	-	-	-	-	-	-
	Обновљива енергија — Геотермална	-		-	-	-	-	-	-	-	-	-
	Укупно	**33.837,3**	**22.257,**	**1.175.224,9**	**13.414,0**	**184.698,0**	**1.429.431,8**	**7.662,9**	**37.161,9**	**243.099,9**	**287.924,7**	**1.717.365,5**

Figure 41. Energy consumption by sectors and categories in the City of Niš: marked column - energy consumption in residential buildings

Source: Local Economic Development Office, Niš

Pilot zone

-

Limitation of the analysis:

Energy consumption data at the city level is not up-to-date (the latest data provided by the Local Economic Development Office is from 2020). There is no data available for municipalities or parts of the city. Therefore it is not possible to assess energy consumption of buildings for the pilot zone or sub-units.

Source of data for the assessment:

Climate Trace (https://climatetrace.org/)

Local Economic Development Office, Niš (https://investnis.rs/en/)

4D) Indicator: Energy consumption of transportation

Energy consumption of transportation is the amount of energy consumed by transport vehicles.

City level

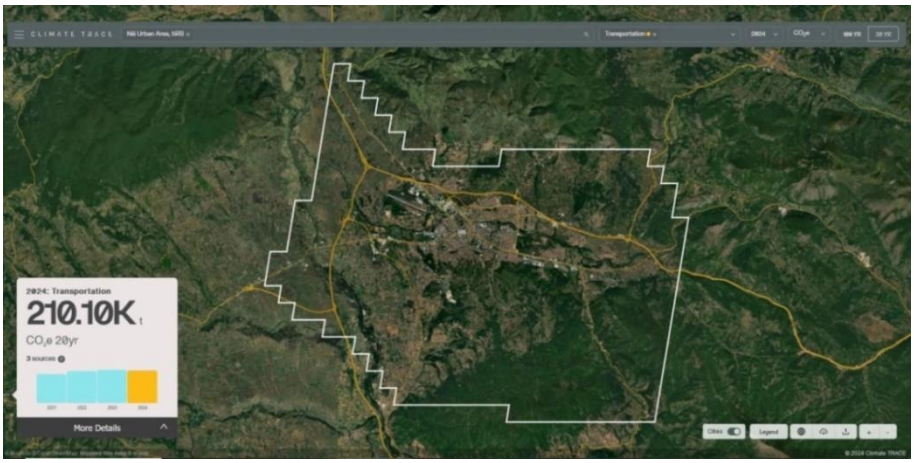


Figure 42. CO_2 emissions caused by transportation – City level

Source: https://climatetrace.org/

Табела 20. Енергетски биланс града Ниша по секторима и категоријама за 2020. годину (вредности су исказане у MWh)

	Категорија / Сектор	Општинске зграде, опрема и друге просторије	Терцијалне зграде, опрема и друге просторије	Зграде за индивидуално становање	Јавна расвета	Индустрије (изузев оних које су укључене у EU ETS)	Збирно зграде, опрема, просторије и индустрија	Општински возни парк	Јавни транспорт	Приватни и комерцијални транспорт	Збирно саобраћај	Укупно
Финална потрошња енергије [MWh]	Електрична енергија	9.271,6	20.561,1	605.344,8	13.414,0	95.276 6	743.868,0	-	-	-	-	743.868,0
	Грејање / хлађење	19.695,6	578,9	179.009,6	-	29.892 6	229.176,8	-	-	-	-	229.176,8
Фосилна горива	Природни гас	67,6	-	5.762,8	-	874 6	6.705,0	-	-	-	-	6.705,0
	Течни гас	27,8	-	-	-	4 2	31,9	131,2	-	16.853,4	16.984,6	17.016,6
	Лож уље и мазут	-	-	1.469,1	-	220 4	1.689,5	-	-	-	-	1.689,5
	Дизел гориво	3.718,8	749,3	-	-	670 2	5.138,3	6.841,3	37.161,9	187.179,2	231.182,4	236.320,7
	Бензин	-	-	-	-	-	-	690,4	-	39.067,2	39.757,6	39.757,6
	Лигнит	94,1	-	-	-	14.1	108,2	-	-	-	-	108,2
	Угаљ	666,5	320,4	53.372,1	-	8.153 9	62.512,9	-	-	-	-	62.512,9
	Друго фосилно г.	-	-	-	-	-	-	-	-	-	-	-
Обновљива енергија	Уље	-	-	-	-	-	-	-	-	-	-	-
	Биогориво	-	-	-	-	-	-	-	-	-	-	-
	Биомаса	295,4	47,8	330.266,6	-	49.591 5	380.201,3	-	-	-	-	380.201,3
	Пасивно соларно грејање	-	-	-	-	-	-	-	-	-	-	-
	Геотермална	-	-	-	-	-	-	-	-	-	-	-
	Укупно	33.837,3	22.257,6	1.175.224,9	13.414,0	184.698,0	1.429.431,8	7.662,9	37.161,9	243.099,9	287.924,7	1.717.365,5

Figure 43. Energy consumption by sectors and categories in the City of Niš: marked column - energy consumption in transportation

Source: Local Economic Development Office, Niš

Pilot zone

-

Limitation of the analysis:

Energy consumption data at the city level is not up-to-date (the latest data provided by the Local Economic Development Office is from 2020). There is no data available for municipalities or parts of the city. Therefore it is not possible to assess energy consumption in transportation for the pilot zone or sub-units.

Source of data for the assessment:

Climate Trace (https://climatetrace.org/)

Local Economic Development Office, Niš (https://investnis.rs/en/)

Identification of the most vulnerable areas to UHI - City level

Based on the overlap of available data and information at the city level, it is possible in general to identify the areas most vulnerable to UHI. Based on the overlap of data related to population density (Indicator 4A) and land use (Indicator 4B), the following areas can be identified as potentially most vulnerable to UHI (Figure 44): 1) the central city area (where the pilot zone is also located), especially the parts south of the Nišava River and Nikole Pašića Street; 2) inherited multi-family residential areas from the socialist past (for example, Boulevard Nemanjića, the largest residential area), that are exposed to constant densification and loss of green spaces; and 3) newly built multi-family residential areas (Somborska neighbourhood, for example) where the share of greenery is very low.

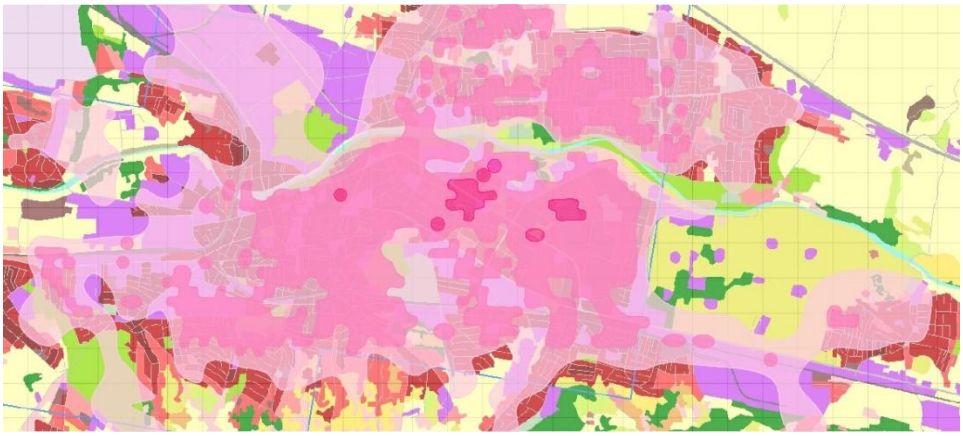


Figure 44. Potentially most vulnerable areas to UHI at city level based on population density and land use (pink shades)

In addition to the central city zone, based on the overlap of data related to share of permeable surfaces (Indicator 3A) and land use (Indicator 4B), the industrial zones Sever and Sever-2, the railway junction, and the communal-warehouse zone to the east (towards Niška Banja) are also recognized as potentially vulnerable areas to UHI (Figure 45).

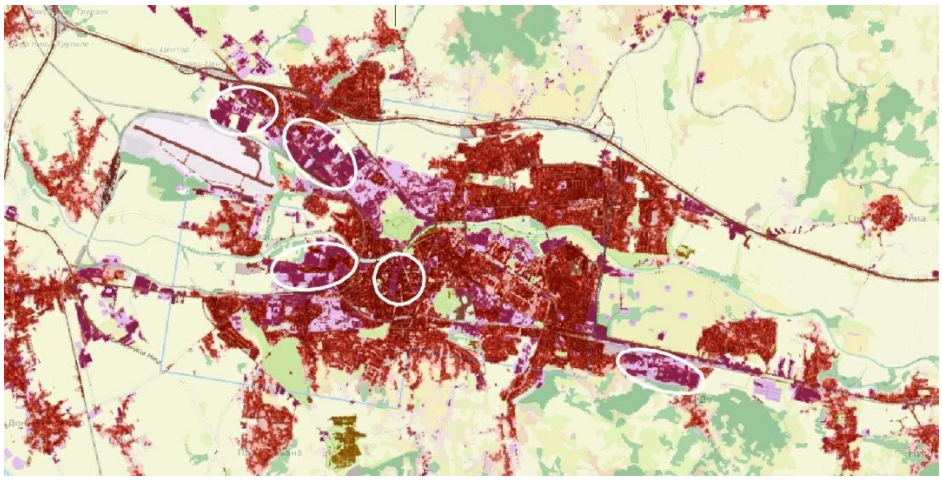


Figure 45. Potentially most vulnerable areas to UHI at city level based on share of permeable surfaces and land use

SENSITIVITY OF EQUIPMENT AND MATERIALS

Understanding the properties of surface materials is important for assessing their impact on local thermal dynamics. Different materials affect temperature and comfort in urban environments by varying heat absorption and reflection. This information helps identify materials that exacerbate or reduce the UHI effect and is important for documenting street and roofing materials, their condition, and thermal properties. This data helps identify key drivers of UHI, assess mitigation materials, develop strategies and policies, engage the community, and support urban planners with data for informed decision-making.

The pilot zone in the Medijana municipality of the City of Niš is located within the coordinates (latitude and longitude) shown in Figure 46. The data for Tool 2, Material Sensitivity, were collected and analyzed from November 2024 to January 2025.

Figure 46. Coordinates for the pilot zone
Source: https://www.wekeo.eu/data

To effectively identify and assess the impact of materials on the UHI effect the key indicators for Tool 2 were defined. Below is an explanation of each metric and its relevance to UHI evaluation (summarized in Table 6).

Albedo (reflectivity) coefficient is a measure of how much sunlight a surface reflects. It is expressed on a scale from 0 to 1, where 0 indicates no reflection (all light is absorbed) and 1 indicates total reflection (no light is absorbed). High-albedo surfaces, like white roofs, reflect more sunlight and stay cooler, while low-albedo surfaces, such as asphalt, absorb more heat, contributing to higher temperatures and the UHI effect.

Thermal conductivity is the rate at which a material conducts heat. It is measured in watts per meter per Kelvin (W/m•K). Materials with high thermal conductivity transfer heat quickly, influencing rapid temperature changes in urban environments, and understanding thermal conductivity helps in choosing materials that reduce heat retention and transfer.

Heat capacity is the amount of heat required to raise the temperature of a material by one degree Celsius (or Kelvin). It is measured in joules per kilogram per Kelvin (J/kg•K). Materials with high heat capacity store large amounts of heat, leading to prolonged elevated temperatures in urban areas, and evaluating this property is important for understanding how different materials affect heat retention.

Surface temperature is the temperature of a material's surface, typically measured in degrees Celsius (°C) or Fahrenheit (°F). High surface temperatures indicate a material's heat retention and emission properties, and monitoring them helps identify hot spots and areas that contribute significantly to the UHI effect.

Emissivity is a measure of a material's ability to emit infrared radiation. It is expressed on a scale from 0 to 1, where 0 indicates no emission and 1 indicates perfect emission. Materials with high emissivity release absorbed heat efficiently, while those with low emissivity retain it, and understanding this property aids in selecting materials that dissipate heat effectively.

Material condition is a qualitative assessment of the state of a material, typically categorized as good, fair, or poor. The condition of materials affects their thermal properties (e.g. deteriorated surfaces may absorb more heat and have reduced reflectivity). Assessing material condition is essential for accurate evaluation of their impact on UHI.

Coverage area refers to the extent of a surface or material, measured in square meters (m^2). The larger the coverage area of a heat-contributing material, the greater its impact on the UHI effect. Quantifying coverage area helps in understanding the spatial distribution of heat sources.

Vegetative cover is the percentage of an area covered by vegetation. Vegetation plays a crucial role in cooling urban environments through shading and evapotranspiration, and increasing green spaces helps mitigate the UHI effect.

Table 6: Indicators for the assessment of the influence on materials and UHI

Indicators - materials	Measurement unit
Albedo (reflectivity) coefficient	Scale from 0 to 1
Thermal conductivity	Watts per M Kelvin [W/(m*K)]
Heat capacity	Joules per KG Kelvin [J/(kg*K)]
Surface temperature	Degrees Celsius [°C]
Emissivity	Scale from 0 to 1
Material condition	Qualitative assessment (good, fair, poor)
Coverage area	Square meters [m^2]
Vegetative cover	Area covered by vegetation [%]

Notes: Since the observation period was during the winter, it was not possible to apply the recommended thermal imaging method using a thermal camera to collect data on the surface temperatures of materials within the pilot zone. Therefore, for the purposes of analyzing identifiers within Tool 2, open-source surface temperature data from the World Bank website was used as a basis (Figure 47).

For the purposes of this assessment, and in accordance with the relevant legislative and regulatory framework, the assessment and value of each indicator are given in relation to the characteristics of the materials represented in the pilot zone.

Surface temperatures

City level

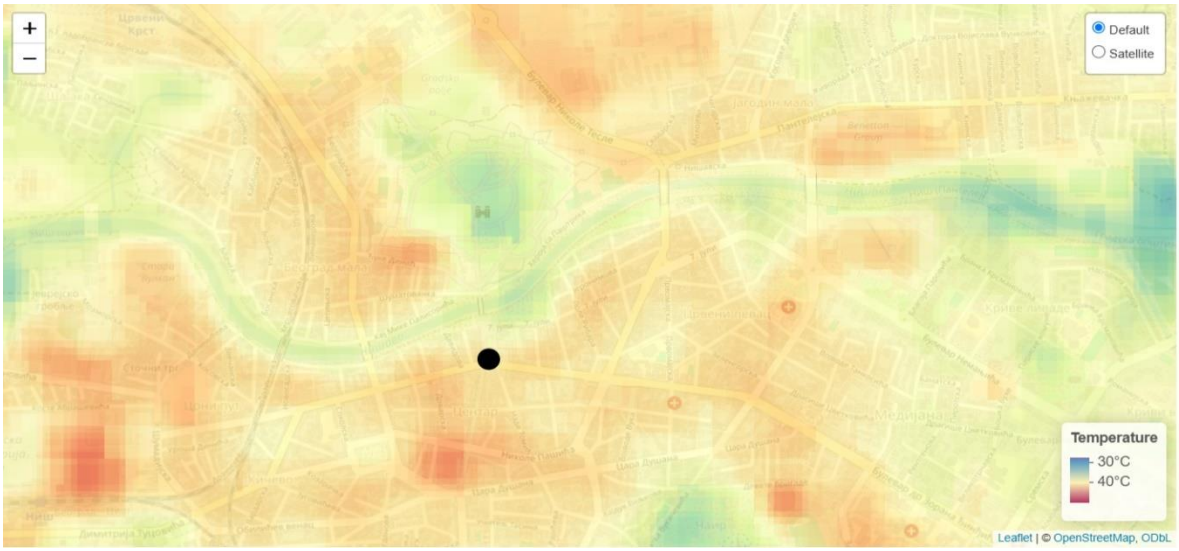


Figure 47. Surface temperatures for the City of Niš with a position of the pilot zone

Source: https://wbcrp.shinyapps.io/crc_workshop_western_balkans/

Pilot zone

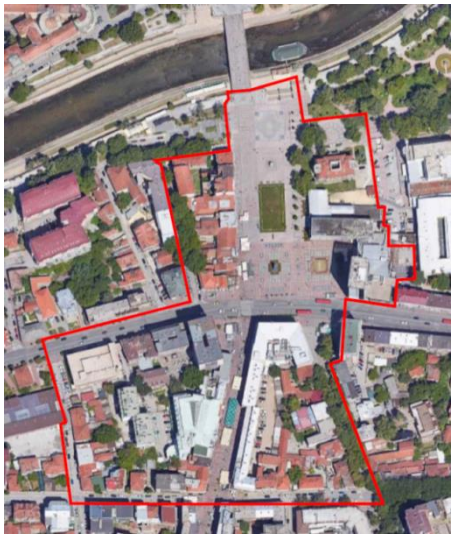


Figure 48. Surface materials for pilot zone

Source: Google Earth

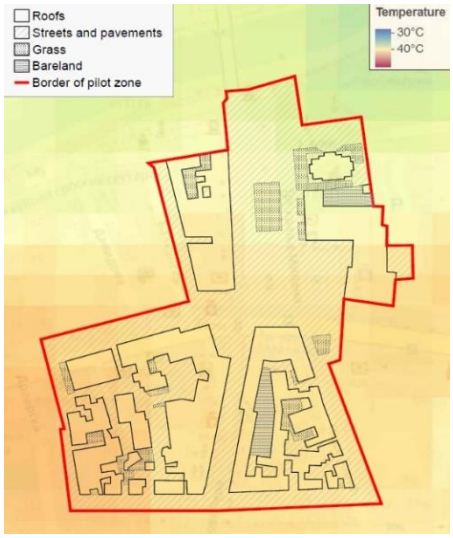


Figure 49. Surface temperature as a function of material position for the pilot zone

Source: Authors with the background from https://wbcrp.shinyapps.io/crc_workshop_western_balkans/

Surface materials – Pilot zone

The data for indicators shown in Table 6 were collected for streets and pavements, and roofs within the boundaries of selected pilot zone (62 743 m^2), as defined in the Methodology.

Street, pavements, and open spaces: 39 747 m^2

- Permeable surfaces (grass and bareland): 2 745 m^2
- Impermeable surfaces: 37 002 m^2

The identified materials are: asphalt, stone slabs, concrete, and concrete paving slabs (Figure 48).

Area covered by vegetation (grass and bareland) is 6,90%, or 4,37% from total area pilot zone.

Roofs: 22 996 m^2

The identified materials are ceramic roof tiles, metal sheets, bitumen membranes, and EPDM white (light) waterproofing membranes (Figure 49). Within a plot zone, there is no roof area covered with systems for green roofs, so the area covered by vegetation is 0%.

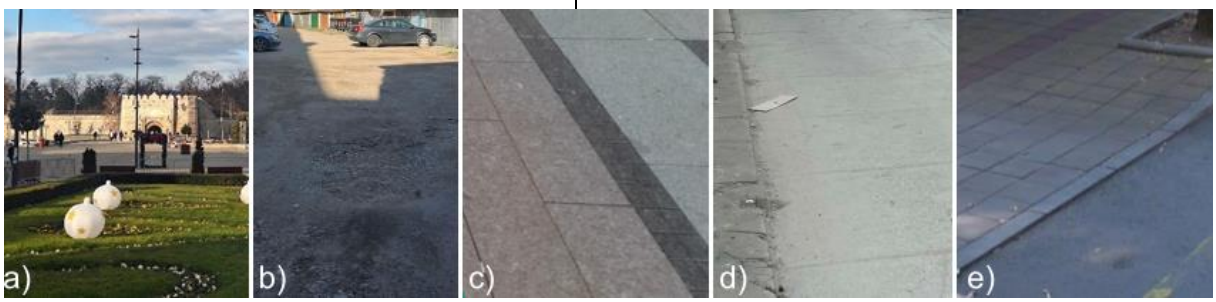


Figure 50. Street, pavements, and open spaces: a) grass, b) bareland, c) stone, d) concrete, and e) asphalt and concrete slabs
Source: Authors

Figure 51. Roofs materials - Subunits A, B, C, and D
Source: Google Earth

Indicators of Materials for Streets and Pavements

Asphalt

Figure 52. Coverage area of asphalt

Source: Authors

Indicators	
Albedo (reflectivity) coefficient	0.05 – 0.10
Thermal conductivity	0.70 [W/(m*K)]
Heat capacity	1 050 [J/(kg*K)]
Surface temperature	/
Emissivity	0.85 – 0.95
Material condition	Fair
Coverage area	14 092 m^2

Asphalt is the finishing layer for main city road, parking areas, and sidewalks. It is a material with a large coverage area within a pilot zone. It contributes to the UHI effect due to its low albedo coefficient, which increases surface temperatures. Additionally, its high heat capacity causes the asphalt to absorb and retain heat during the day, slowly releasing it at night and contributing to the rise in ambient temperatures, thereby increasing the UHI effect.

Stone slabs

Figure 53. Coverage area of stone slabs

Source: Authors

Indicators	
Albedo (reflectivity) coefficient	0.05 – 0.20
Thermal conductivity	3.5 [W/(m*K)]
Heat capacity	920 [J/(kg*K)]
Surface temperature	/
Emissivity	0.85 – 0.95
Material condition	Good
Coverage area	16 970 m^2

Stone slabs with a large coverage area are the finishing layer for public open spaces (central city square, and pedestrian street) in the pilot zone. Even with a slightly lower heat capacity compared to asphalt, this material contributes to the UHI effect due to its low albedo coefficient, which increases surface temperatures, as well as its large coverage area.

Concrete

Figure 54. Coverage area of concrete

Source: Authors

Indicators	
Albedo (reflectivity) coefficient	0.20 – 0.40
Thermal conductivity	0.93 – 2.33 [illegible]
Heat capacity	960 [J/(kg*K)]
Surface temperature	/
Emissivity	0.90 – 0.95
Material condition	Bad
Coverage area	3 942 m^2

Compared to asphalt and stone slabs, concrete covers a smaller area of the pilot zone, and as a result, it has less impact on the UHI effect. It is a surface material for semi-private spaces (such as parking lots) and private open spaces within individual residential buildings. Although it has a higher albedo coefficient, its higher heat capacity still contributes to the UHI effect. It is important to note that semi-private spaces with concrete surfaces also include vegetation (e.g., trees), which helps reduce the UHI effect.

Lightweight concrete paving slabs

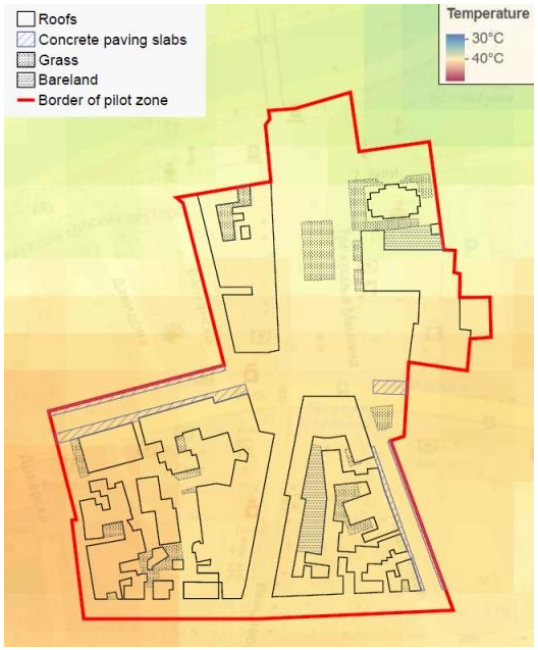


Figure 55. Coverage area of lightweight concrete paving slabs

Source: Authors

Indicators	
Albedo (reflectivity) coefficient	0.20 – 0.40
Thermal conductivity	0.47 [W/(m*K)]
Heat capacity	920 [J/(kg*K)]
Surface temperature	/
Emissivity	0.90 – 0.95
Material condition	Good
Coverage area	1 998 m^2

Lightweight concrete paving slabs, used as a surface material for sidewalks, cover the smallest area of the pilot zone and have no significant impact on the UHI effect. Indicators suggest that lightweight concrete paving slabs have better characteristics (thermal properties and albedo coefficient) compared to the other three surface materials recognized within the pilot zone. At the city level, in order to improve sidewalk conditions, existing asphalt is being replaced with lightweight concrete paving slabs.

Indicators of Roof Materials

Ceramic roof tiles

Figure 56. Coverage area of ceramic roof tiles

Source: Authors

Indicators	
Albedo (reflectivity) coefficient	0.20 – 0.35
Thermal conductivity	0.99 [W/(m*K)]
Heat capacity	880 [J/(kg*K)]
Surface temperature	/
Emissivity	0.85 – 0.95
Material condition	Good
Coverage area	7 311 m^2

Ceramic roof tiles are one of the dominant roof materials within a pilot zone. It is characteristic for the individual housing buildings within a pilot zone, and less than 2% is not in good condition. Although characteristics such as the albedo coefficient and heat capacity are unfavorable, ceramic roof tiles, due to their high emissivity, efficiently release absorbed heat, reducing their impact on the UHI effect.

Metal sheets

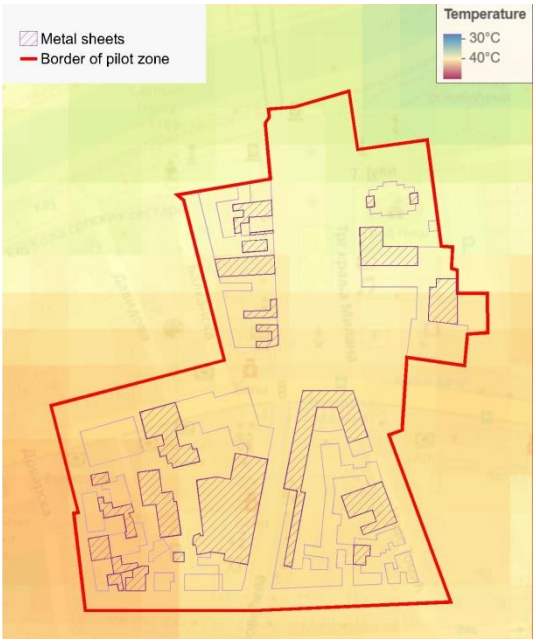


Figure 57. Coverage area of metal sheets

Source: Authors

Indicators	
Albedo (reflectivity) coefficient	0.10 – 0.25
Thermal conductivity	110 [W/(m*K)]
Heat capacity	390 [J/(kg*K)]
Surface temperature	/
Emissivity	0.10 – 0.30
Material condition	Fair
Coverage area	9 329 m^2

Metal sheet roofs with a large coverage area are characteristic of public buildings (shopping malls that diverge from the central city square and pedestrian street), low-rise single-family, and high-rise multi-family housing. Observations have shown that the metal roofs on individual residential buildings are made in darker colors and have been degraded. On the other hand, public buildings and multi-family residential buildings feature white/light roofs. Light-colored materials have higher albedo and can help mitigate some of the UHI effects.

Bitumen waterproofing membranes

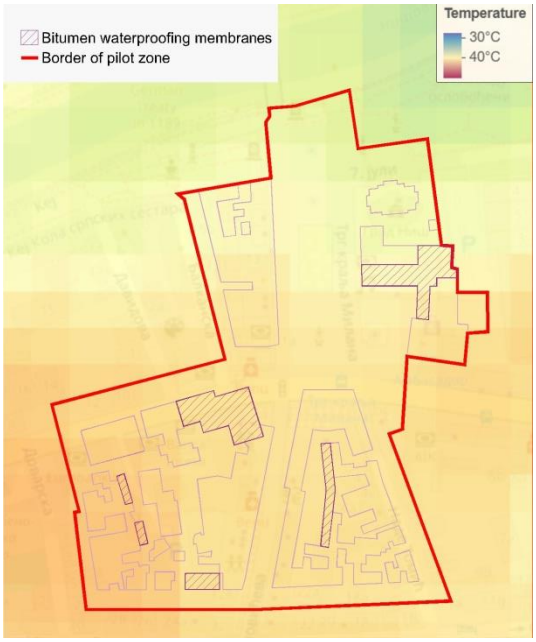


Figure 58. Coverage area of bitumen waterproofing membranes

Source: Authors

Indicators	
Albedo (reflectivity) coefficient	0.05 – 0.15
Thermal conductivity	0.19 [W/(m*K)]
Heat capacity	1 460 [J/(kg*K)]
Surface temperature	/
Emissivity	0.85 – 0.95
Material condition	Bad
Coverage area	3 400 m^2

Bitumen waterproofing membranes are traditional flat roofing materials observed on public buildings, high-rise multi-family housing, as well as on private garages within residential areas. With a low albedo coefficient and high heat capacity, this material contributes to the increase in the UHI effect. All roofs with bitumen waterproofing membranes within the pilot zone have deteriorated surfaces, and because of that, they may absorb more heat and have reduced reflectivity.

EPDM white (light) waterproofing membranes

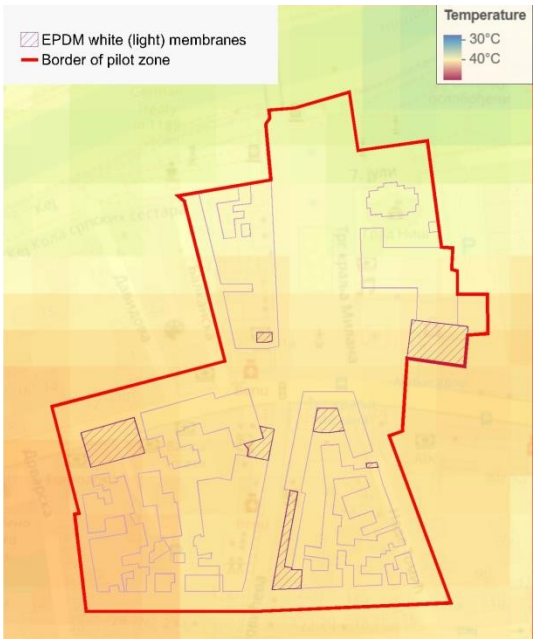


Figure 59. Coverage area of EPDM white (light) waterproofing membranes

Source: Authors

Indicators	
Albedo (reflectivity) coefficient	0.60 – 0.85
Thermal conductivity	0.30 [W/(m*K)]
Heat capacity	1 040 [J/(kg*K)]
Surface temperature	/
Emissivity	0.85 – 0.95
Material condition	Good
Coverage area	2 956 m^2

EPDM light-colored waterproofing membranes were applied during the renovation of existing flat roofs. This roofing material is the least common in the pilot zone. With high emissivity and a good albedo coefficient, these roofs help reduce the impact of UHI. Surfaces with high albedo reflect more sunlight and, as a result, stay cooler. The use of EPDM light-colored waterproofing membranes in the renovation of existing flat roofs with bitumen waterproofing membranes can be an effective solution in reducing UHI effects.

Limitation of the analysis:

The City/city municipality do not have a usable georeferenced (i.e., which can be elaborated in GIS) spatial assessment/mapping of green coverage, and materilas for streets and pavements at the grid level. The value of the coverage area indicator can be determined only by analytical calculation of data that must be separately observed from GeoSrbija, GIS Niš and General or Detailed Urban Plan(s), which is time-consuming and calls into question the efficiency and applicability of the indicator.

Source of data for the assessment:

https://www.wekeo.eu/data

Google Earth

https://wbcrp.shinyapps.io/crc_workshop_western_balkans/

GeoSrbija (https://a3.geosrbija.rs/)

Republika Srbija, Ministarstvo životne sredine, rudarstva i prostornog planiranja, „Pravilnik o energetskoj efikasnosti zgrada" (Regulations on energy efficiency of buildings), Službeni glasnik Republike Srbije br. 61/2011.

Observation

VULNERABLE GROUPS

Heat waves in combination with UHI pose severe health risks to vulnerable populations including children, elderly persons, individuals with pre-existing health conditions, and inhabitants in socioeconomically disadvantaged areas. The elderly population is especially susceptible due to their reduced ability to regulate body temperature and the presence of chronic health issues. Children, with their developing bodies and higher surface-area-to-mass ratio, are also at greater risk of heat-related illnesses. Individuals with cardiovascular, respiratory, and other chronic conditions may experience exacerbated symptoms during heat waves, leading to increased morbidity and mortality rates.

This tool provides a Vulnerability Index (VI) for quantitative assessment that measures overall vulnerability related to risk groups. VI is calculated using multiple indicators based on the population of a defined area.

This tool analyzes three different criteria: **Socio-economic**, **Health conditions**, and **Infrastructures**. Every criterion has a set of indicators that are showcased through diagrams, charts, tables, and maps. This visual presentation enhances understanding and engagement.

For testing this tool, we applied weights either based on survey results (Annex B), or data quality. Under data quality we considered spatial scale of the corresponding data source (Table 7).

Table 7. Indicator weights (wi) used in the VI assessment.

Source data for the indicator assessment	***wi***
Country	0.1
Region	0.2
City	0.3
Municipality	0.4
Sub-unit/building	0.5

Socio-economic indicators

Indicator: Population density

Population density is shown under human activities in tool 1. Here we will present the procedure for calculating the normalized values of this indicator and its weight.

Population density – the normalized value of this indicator and its corresponding weight

Table 8. Calculation of the normalized value of the population density indicator and its corresponding weight

i=	1	**Population density (inh./ha)**			
j	Sub-unit	Indexi,j	NormIndexi,j	*wi*	*wi*NormIndexi,j*
1	A	**546**	0.586	**0.5**	0.293
2	B	**234**	0.251		0.126
3	C	**397**	0.426		0.213
4	D	**932**	1.000		0.500
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Indicator: Young people

Young people are children under five and infants. Children under the age of 5 get dehydrated faster due to difficulties regulating their metabolism. For this indicator, we calculate the proportion of children under the age of 5 over the total population of the municipality of Medijana.

Municipality level

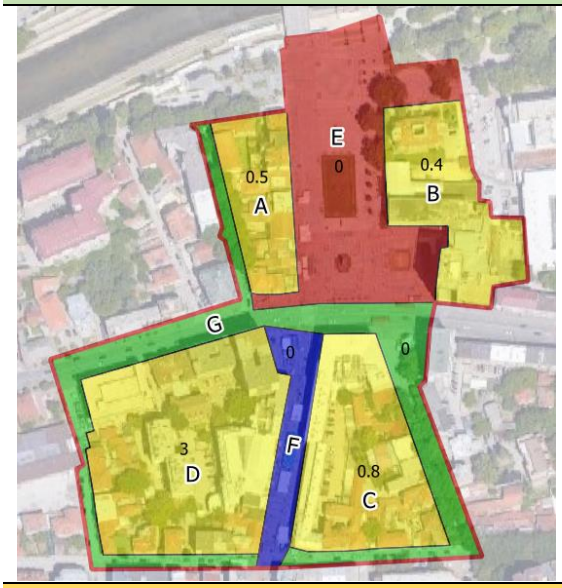
Table 9. Population at the municipality level according to age

Region **Area** City-municipality	Gender	Total	0-4 years
Nišava region	**S**	**343950**	15369
	M	**168367**	7795
	F	**177583**	7574
City of Niš	S	249501	11510
	M	120792	5837
	F	128709	5673
Medijana	S	83113	3928
	M	38728	2022
	F	44385	1906
Niška Banja	S	12940	507
	M	6471	251
	F	6469	256
Palilula	S	69811	3093
	M	34782	1592
	F	35029	1501
Pantelej	S	54119	2615
	M	26170	1302
	F	27949	1313
Crveni krst	S	29518	1367
	M	14641	670
	F	14877	697

Source: https://www.stat.gov.rs/

The total number of young people is 3928, which amounts to 4.7 % of the entire population in the municipality of Medijana.

Pilot zone



Percentage participation of young people in the entire population of the pilot zone:

Sub-unit A: 0,5%

Sub-unit B: 0,4%

Sub-unit C: 0.8%

Sub-unit D: 3.0%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Young People – the normalized value of this indicator and its corresponding weight

Table 10. Calculation of the normalized value of the Young people indicator and its corresponding weight

i=	2	**Young People (% over population)**			
j	Sub-unit	Indexi,j	NormIndexi,j	*wi*	*wi*NormIndexi,j*
1	A	**0.5**	0.167	**0.4**	0.067
2	B	**0.4**	0.133		0.053
3	C	**0.8**	0.267		0.107
4	D	**3**	1.000		0.400
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data are available only at the level of the city/municipality, so the weight of the indicator was assigned accordingly, based on the quality of the data, which in this case is 0.4. Also, following the available data, the number of young people by sub-unit was obtained proportionally to the population density over the pilot zone.

Source of data for the assessment:

RZS (https://www.stat.gov.rs/)

Indicator: Elderly people

Population over the age of 65. Like children, elderly people are more rapidly dehydrated because of their difficulty in regulating their metabolism. For this indicator, we calculate the proportion of people over the age of 65 over the total population of the municipality of Medijana.

Municipality level

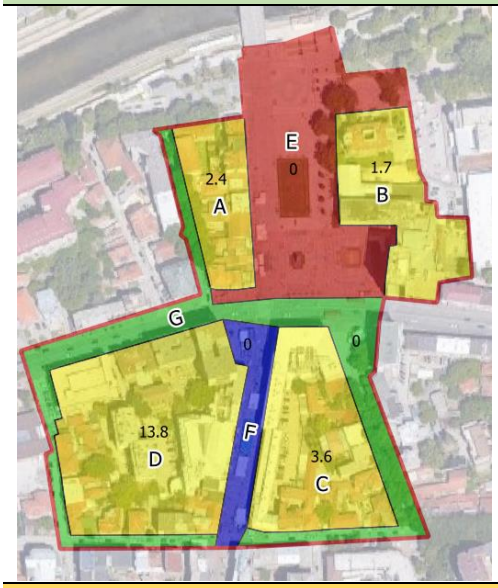
Table 11. Population at the municipality level according to age

Region / **Area** / City-municipality	Gender	Total	65-69	70-74	75-79	80-84	85 and more
Nišava region	**S**	**343950**	**24933**	**22987**	**13413**	**10353**	**6713**
	M	**168367**	**11603**	**10439**	**5803**	**4419**	**2647**
	F	**177583**	**13330**	**12548**	**7610**	**5934**	**4066**
City of Niš	S	249501	16897	15441	9112	6788	4358
	M	120792	7674	6795	3843	2865	1764
	F	128709	9223	8646	5629	3923	2594
Medijana	S	83113	**5465**	**5402**	**3130**	**2335**	**1596**
	M	38728	2330	2248	1235	930	620
	F	44385	3135	3154	1895	1405	976
Niška Banja	S	12940	1012	895	538	462	2687
	M	6471	491	431	253	212	111
	F	6469	521	464	285	250	157
Palilula	S	69811	4614	4206	2475	1818	1129
	M	34782	2121	1824	1079	763	487
	F	35029	2493	2382	1396	1055	642
Pantelej	S	54119	3646	3116	1886	1407	868
	M	26170	1666	1439	808	630	356
	F	27949	1980	1677	1078	777	512
Crveni krst	S	29518	2160	1822	1083	766	497
	M	14641	1066	853	468	330	190
	F	14877	1093	969	615	436	307

Source: https://www.stat.gov.rs/

The total number of elderly people is 17928, which amounts to 21.6 % of the entire population in the municipality of Medijana.

Pilot zone



Percentage participation of elderly people in the entire population of the pilot zone:

Sub-unit A: 2.4%

Sub-unit B: 1.7%

Sub-unit C: 3.6%

Sub-unit D: 13.8%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Elderly People – the normalized value of this indicator and its corresponding weight

Table 12. Calculation of the normalized value of the Elderly people indicator and its corresponding weight

i=	3	**Elderly People (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**2.4**	0.177	**0.4**	0.071
2	B	**1.7**	0.126		0.051
3	C	**3.6**	0.257		0.103
4	D	**13.8**	1.000		0.400
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data are available only at the level of the city/municipality, so the weight of the indicator was assigned accordingly, based on the quality of the data, which in this case is 0.4. Also, following the available data, the number of elderly people by sub-unit was obtained proportionally to the population density over the pilot zone.

Source of data for the assessment:

RZS (https://www.stat.gov.rs/)

Indicator: Gender

Part of the population of females. Women are disadvantaged compared to males in heat-stress situations because of physiological differences, even more so for pregnant women. For this indicator, we calculate the proportion of females over the total population.

Municipality level

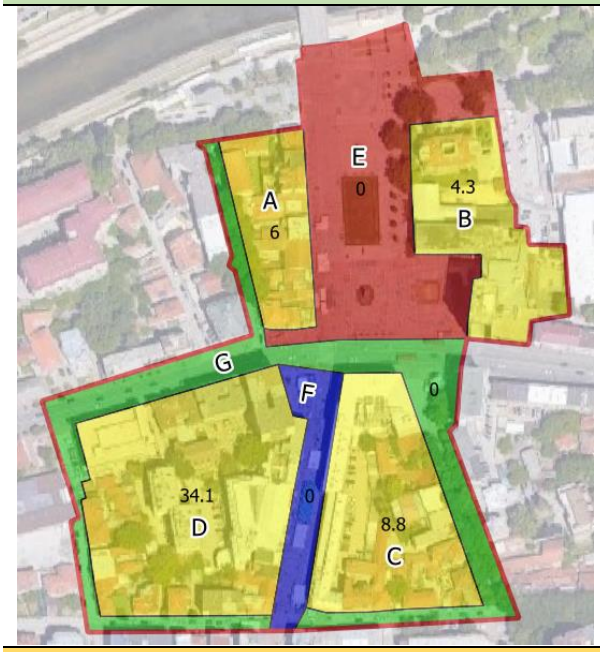
Table 13. Population at the municipality level by gender

Region **Area** City-municipality	Gender	Total
Nišava region	**S**	**343950**
	M	**168367**
	F	**177583**
City of Niš	S	249501
	M	120792
	F	128709
Medijana	S	83113
	M	38728
	F	**44385**
Niška Banja	S	12940
	M	6471
	F	6469
Palilula	S	69811
	M	34782
	F	35029
Pantelej	S	54119
	M	26170
	F	27949
Crveni krst	S	29518
	M	14641
	F	14877

Source: https://www.stat.gov.rs/

The total number of females is 44385, which amounts to 53.4 % of the entire population in the municipality of Medijana.

Pilot zone



Percentage participation of females in the entire population of the pilot zone:

Sub-unit A: 6.0%

Sub-unit B: 4.3%

Sub-unit C: 8.8%

Sub-unit D: 34.1%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Gender (female) – the normalized value of this indicator and its corresponding weight

Table 14. Calculation of the normalized value of this indicator and its corresponding weight

i=	4	**Gender-Female (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**6.0**	0.177	**0.6**	0.106
2	B	**4.3**	0.126		0.076
3	C	**8.8**	0.257		0.154
4	D	**34.1**	1.000		0.600
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Based on the available data, the number of females by sub-unit was obtained proportionally to the population density over the pilot zone. The indicator's weight was assigned based on the conducted survey and 35 answers, where 62.9 percent of women answered that they considered themselves particularly sensitive to heat.

Source of data for the assessment:

RZS (https://www.stat.gov.rs/)
KLER – Survey

Indicator: Poverty rate

The proportion of people living below the risk-of-poverty threshold over the total population. People living below the risk-of-poverty threshold don't have the financial resources to deal with overheating.

Municipality level

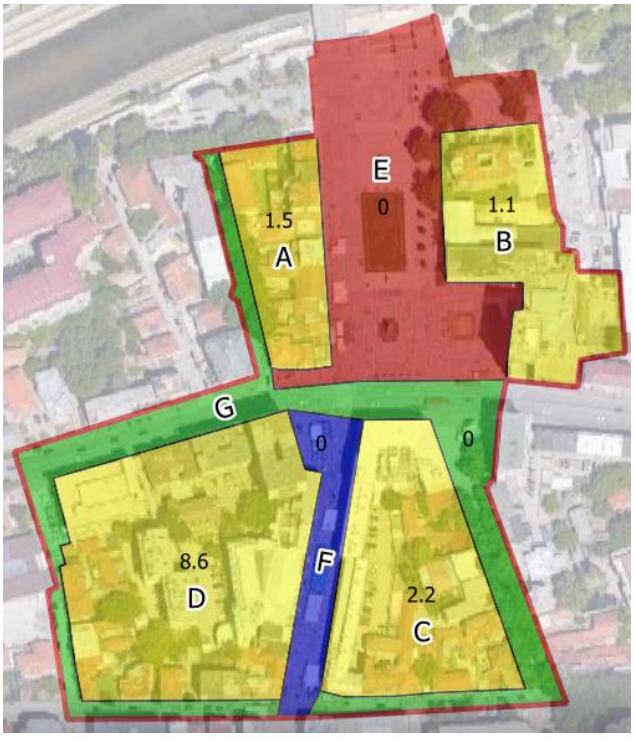
Table 15. Poverty risk rate at the level of the municipality of Medijana

Poverty estimates using the poverty mapping method, 2013.	
Poverty risk rate %	13.4
Poverty risk rate - ranking of municipalities	12.0
Gini coefficient (interval from 0 to 100)	32.2
Relative poverty risk gap %	3.8

Source: http://devinfo.stat.gov.rs/diSrbija/diHome.aspx

For this indicator, we use the poverty risk rate of the municipality of Medijana, which amounts to 13.4 %.

Pilot zone



Percentage participation of people who live below the risk of poverty threshold in the entire population of the pilot zone:

Sub-unit A: 1.5%

Sub-unit B: 1.1%

Sub-unit C: 2.2%

Sub-unit D: 8.6%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Poverty density – the normalized value of this indicator and its corresponding weight

Table 16. Calculation of the normalized value of this indicator and its corresponding weight

i=	5	**Population density (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**1.5**	0.177	**0.7**	0.124
2	B	**1.1**	0.126		0.089
3	C	**2.2**	0.257		0.180
4	D	**8.6**	1.000		0.700
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data is available only at the municipal level. In this case, to determine the weight of the parameter, we used a survey in which 25% of respondents answered that they do not own an air conditioner in their home.

Source of data for the assessment:

Devinfo (http://devinfo.stat.gov.rs/diSrbija/diHome.aspx)
KLER - Survey

Indicator: Unemployment rate

People with low incomes don't have the financial resources to deal with overheating. For this indicator, we calculate the proportion of unemployed people over the total population.

Municipality level

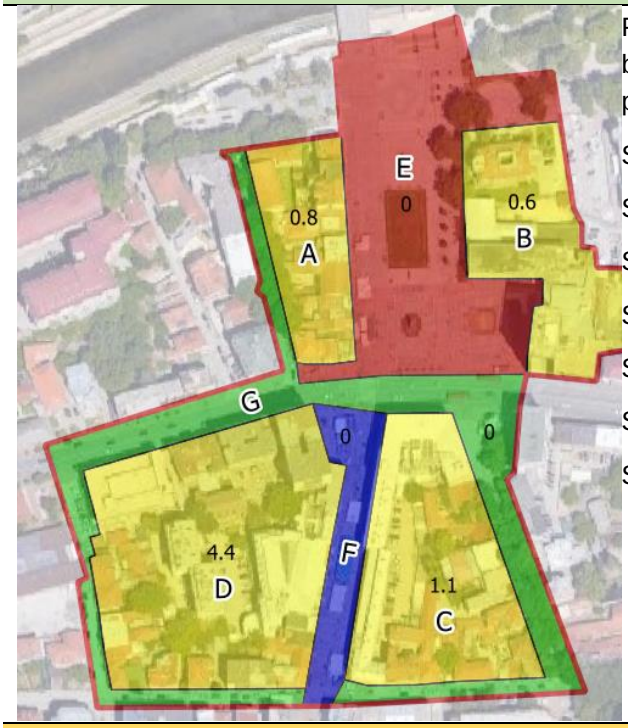
Table 17. Unemployment rate at the level of the municipality of Medijana

Region **Area** City-municipality	**Total**
Nišava region	28528
City of Niš	19074
Medijana	**5690**
Niška Banja	1247
Palilula	5659
Pantelej	3796
Crveni krst	2682

Source: https://www.stat.gov.rs/

The proportion of unemployed people over the total population is 6.8 %.

Pilot zone



Percentage participation of people who live below the risk of poverty threshold in the entire population of the pilot zone:

Sub-unit A: 0.8%

Sub-unit B: 0.6%

Sub-unit C: 1.1%

Sub-unit D: 4.4%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Unemployment rate – the normalized value of this indicator and its corresponding weight

Table 18. Calculation of the normalized value of this indicator and its corresponding weight

i=	6	**Unemployment rate (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**0.8**	0.177	**0.4**	0.071
2	B	**0.6**	0.126		0.051
3	C	**1.1**	0.257		0.103
4	D	**4.4**	1.000		0.400
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data is available only at the municipal level.

Source of data for the assessment

RZS (https://www.stat.gov.rs/)

Indicator: Immigrated people

Immigrated people can be linguistically isolated and live in poor insulated buildings. For this indicator, we calculate the proportion of immigrated people over the total population.

Data not found yet. The data provider interpreted this indicator as internal population migration.

Indicator: Low-skilled jobs

Low-skilled jobs offer less financial opportunity to face the heatwave events and they are often in extreme conditions like for outdoor workers. For this indicator, we calculate the proportion of people with low-skilled jobs over the employed population.

Municipality level

Table 19. Employment and earnings in the municipality of Medijana

Employment and earnings	
Registered employees	
according to the municipality of work	41066
according to the municipality of residence	32450
Registered employees according to the municipality of residence in relation to the number of residents (%)	39
Average wages without taxes and contributions (RSD)	93269
Registered unemployed	5207
Registered unemployed per 1000 inhabitants	63

Source: http://devinfo.stat.gov.rs/diSrbija/diHome.aspx

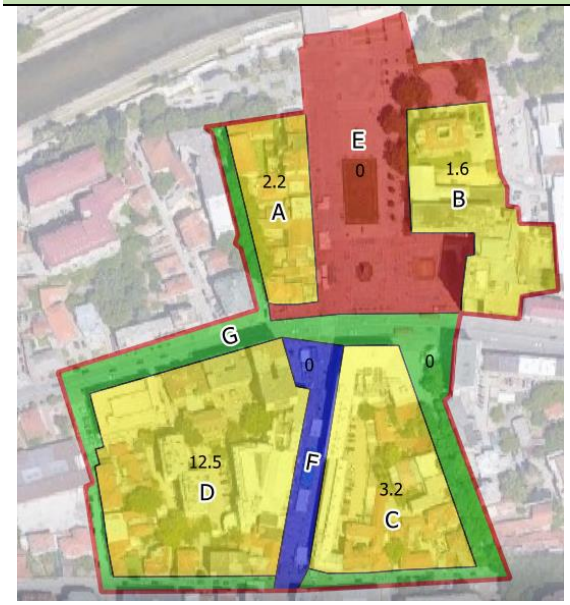
Table 20. Salary in Serbia in 2024

Salary amount May 2024.	**Number of employees**	**Share in the number of employees**
minimum salary up to RSD 49,864	114.064	5,5271%
between minimum and median salary RSD 49,864 - RSD 77,571	917.798	44,4729%
Median earnings 77,571 RSD	-	-
between the median and average salary RSD 77,571 - RSD 100,170	412.656	19,9957%
average earnings	9	0,0004%
more than the average salary of more than 100,170 RSD	619.197	30,0039%
TOTAL	2.063.724	100%

Source: https://www.stat.gov.rs

The total number of employees according to the municipality of residence amounts to 32450.

Pilot zone



Percentage participation of people with low-skilled jobs in the entire population of the pilot zone:

Sub-unit A: 2.2%

Sub-unit B: 1.6%

Sub-unit C: 3.2%

Sub-unit D: 12.5%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

People with low-skilled job – the normalized value of this indicator and its corresponding weight

Table 21. Calculation of the normalized value of this indicator and its corresponding weight

i=	8	**People with Low-skilled jobs (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**2.2**	0.177	**0.35**	0.062
2	B	**1.6**	0.126		0.044
3	C	**3.2**	0.257		0.090
4	D	**12.5**	1.000		0.350
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Since there is no financial data available to accurately determine the number of employees in low-skilled jobs, this indicator is based on the percentage of residents earning either the minimum wage or a salary that falls between the minimum and median wage. In Serbia, this percentage is 50%.

Source of data for the assessment:

RZS (https://www.stat.gov.rs/)
DevInfo (http://devinfo.stat.gov.rs/diSrbija/diHome.aspx)

Indicator: Social housing

Social housing in not present in the pilot zone.

Indicator: Retired people

The number of retired people indicates more about the number of elderly people. For this indicator, we calculate the proportion of retired people over the total population.

Municipality level

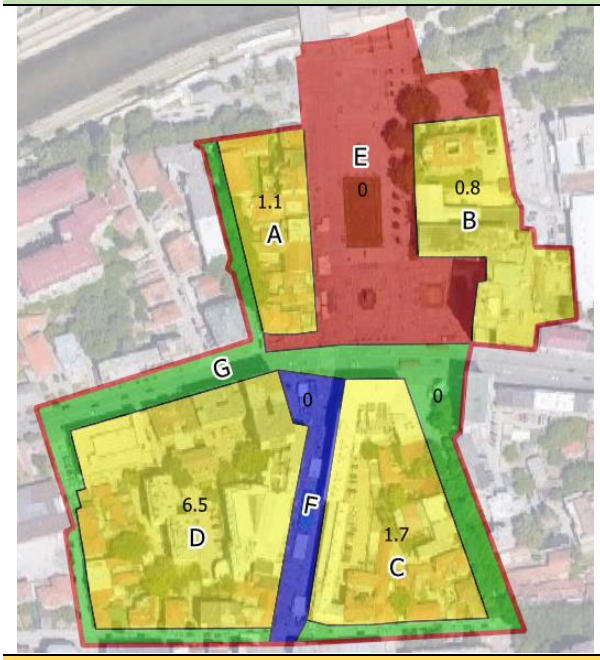
Table 22. Retired people in the municipality of Medijana

Branch office Municipality	Total
Total branches in Nis	90046
12 N I Š	75978
City of Niš	61672
Niš	4313
Niš Crveni krst	3414
Niš Pantelej	4630
Niš Palilula	36993
Niš Medijana	**8390**
Niška Banja	3932
Gadzin Han	2478
Svrljig	4665
Merošina	3028
Doljevac	4135

Source: https://www.pio.rs/

The total number of retired people according to the municipality of Medijana amounts to 8390.

Pilot zone



Percentage participation of retired people in the entire population of the pilot zone:

Sub-unit A: 1.1%

Sub-unit B: 0.8%

Sub-unit C: 1.7%

Sub-unit D: 6.5%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Retired people– the normalized value of this indicator and its corresponding weight

Table 23. Calculation of the normalized value of this indicator and its corresponding weight

i=	9	**Retired people (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**1.1**	0.177	**0.4**	0.071
2	B	**0.8**	0.126		0.051
3	C	**1.7**	0.257		0.103
4	D	**6.5**	1.000		0.400
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data is available only at the municipal level.

Source of data for the assessment:

Fond PIO https://www.pio.rs/

Health conditions

Indicator: Ill people

People with chronic illnesses take medication that can affect thermoregulation by reducing their ability to sweat. For this indicator, we calculate the proportion of people with illnesses like diabetes, asthma, hypertension, and obesity over the total population.

Region level

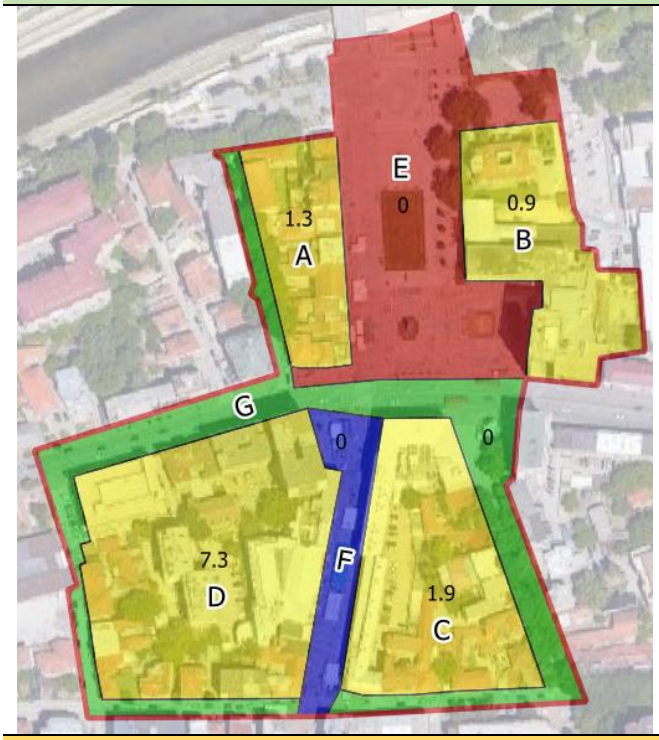
Table 24. Number of people with illnesses like diabetes, asthma, South region, 2023

No.	Chronic illness	No. ill	Population total Serbia	% ill in population
1	Obesity	6578	5014541	0.13
2	Chronic rheumatic heart disease	1057		0.02
3	Hypertension	524064		10.45
4	Asthma	40447		0.81

Source: Izveštaj o zdravstvenoj zaštiti na primarnom nivou na teritoriji Republike Srbije, 2023

The percentage of ill people in the entire population is 11.4%.

Pilot zone



Percentage participation of ill people in the entire population of pilot zone:
Sub-unit A: 1.3%
Sub-unit B: 0.9%
Sub-unit C: 1.9%
Sub-unit D: 7.3%
Sub-unit E: -
Sub-unit F: -
Sub-unit G: -

Ill people– the normalized value of this indicator and its corresponding weight

Table 25. Calculation of the normalized value of this indicator and its corresponding weight

i=	10	**Ill people (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**1.3**	0.177		0.035
2	B	**0.9**	0.126		0.025
3	C	**1.9**	0.257		0.051
4	D	**7.3**	1.000	**0.2**	0.200
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data is available only at the region level.

Source of data for the assessment:

Izveštaj o zdravstvenoj zaštiti na primarnom nivou na teritoriji Republike Srbije, 2023

Indicator: Disabled people

People receiving Adult Disabled Benefit (ADB) are dependent on other people and services. For this indicator, we calculate the proportion of people receiving ADB over the total population.

Municipality level

Table 26. Citizens according to disability status

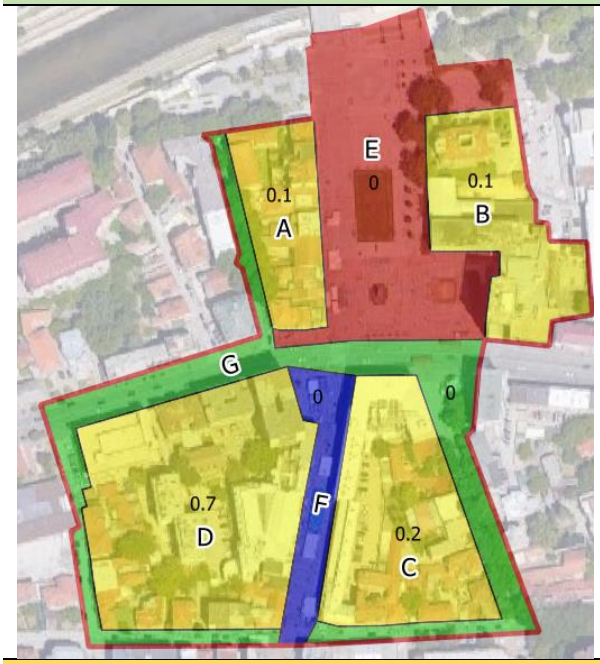
	Total population			People with disabilities		
	total	male	female	total	male	female
City of Niš	260237	126645	133592	19190	8184	11006
GO Medijana	85969	40350	45619	**5617**	**2192**	**3425**
GO Niška Banja	14680	7413	7267	1512	662	850
GO Palilula	73801	36410	37391	4924	2172	2752
GO Pantelej	53486	26267	27219	3724	1609	2115
GO Crveni krst	32301	16205	16096	3413	1549	1864

		Problem with						
	Total	**vision**	**hearing**	**walk**	**memory**	**independence**	**communi-cation**	**three or more than three problems**
City of Niš	19190	7830	4994	11513	3669	3007	2377	3289
GO Medijana	5617	2182	1424	3562	896	965	609	944
GO Niška Banja	1512	660	410	933	302	215	142	282
GO Palilula	4924	2087	1327	2905	878	794	578	846
GO Pantelej	3724	1548	1033	2244	631	586	377	636
GO Crveni krst	3413	1353	800	1869	962	447	671	581

Source: http://www.eservis.ni.rs/

The number of ADB people in the entire population is 965.

Pilot zone



Percentage participation of disabled people in the entire population of the pilot zone:

Sub-unit A: 0.1%

Sub-unit B: 0.1%

Sub-unit C: 0.2%

Sub-unit D: 0.7%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Disabled people– the normalized value of this indicator and its corresponding weight

Table 27. Calculation of the normalized value of this indicator and its corresponding weight

i=	11	**Disabled people (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**0.1**	0.143	**0.4**	0.057
2	B	**0.1**	0.143		0.057
3	C	**0.2**	0.286		0.114
4	D	**0.7**	1.000		0.400
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data is available at the municipality level.

Source of data for the assessment:

Eservis http://www.eservis.ni.rs/

Indicator: Mentally ill people

People with mental illness may be prone to cognitive impairment and medication side effects that can interfere respectively with awareness and thermoregulation. For this indicator, we calculate the proportion of people receiving mental health services over the total population.

Municipality level

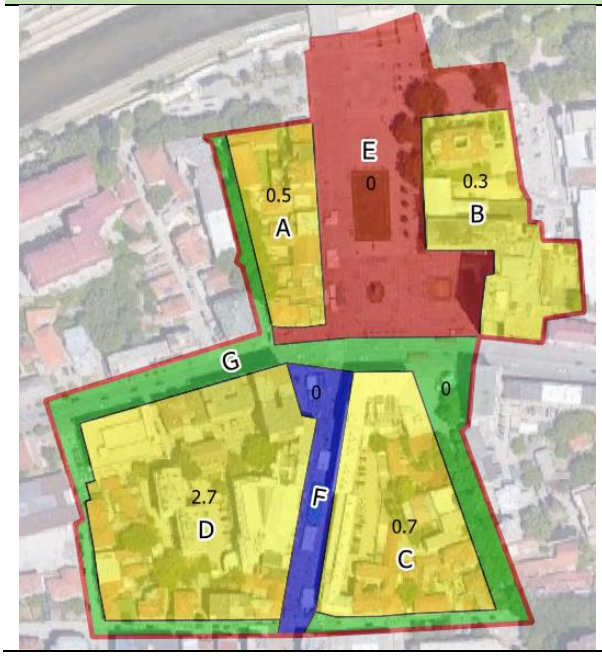
Table 28. Number of mental and behavioural disorders, South region, 2023

Mental and behavioural disorders	**210313**
Dementia	10767
Mental and behavioural disorders due to use of alcohol	4202
Menatl and behavioural	5468
Schizophenia, schizotypaln, and delusional disorders	18824
Mood (affective) disorders	70672
Neurotic, stress-related, and somatooform disorders	79915
Mental retardation	3877
Other mental and behavioural disorders	16588

Source: Izveštaj o zdravstvenoj zaštiti na primarnom nivou na teritoriji Republike Srbije, 2023

The proportion of people receiving mental health services over the total population is 4.2%.

Pilot zone



Percentage participation of mentally ill people in the entire population of the pilot zone:

Sub-unit A: 0.5%

Sub-unit B: 0.3%

Sub-unit C: 0.7%

Sub-unit D: 2.7%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Mentally ill people– the normalized value of this indicator and its corresponding weight

Table 29. Calculation of the normalized value of this indicator and its corresponding weight

i=	12	**Mentally ill people (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**0.5**	0.185	**0.2**	0.035
2	B	**0.3**	0.111		0.025
3	C	**0.7**	0.259		0.051
4	D	**2.7**	1.000		0.200
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data is available only at the municipality level.

Source of data for the assessment:

Izveštaj o zdravstvenoj zaštiti na primarnom nivou na teritoriji Republike Srbije, 2023

Indicator: Mortality rate

The mortality rate can indicate deteriorated health and thus vulnerability to high temperatures. For this indicator, we calculate the proportion of deaths in a year over the total population.

Municipality level

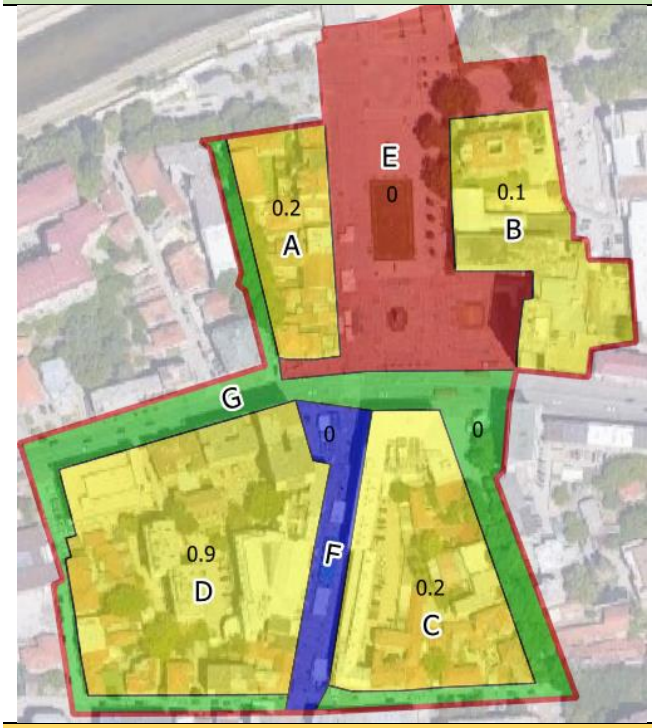
Table 30. Number of deaths for 2022

Region **Area** City-municipality	**Died**
Nišava region	5788
City of Niš	3763
Medijana	1215
Niška Banja	249
Palilula	987
Pantelej	667
Crveni krst	645

Source: https://www.stat.gov.rs

The proportion of deaths in a year over the total population is 1.5%.

Pilot zone



Percentage participation of deaths in the entire population of the pilot zone:

Sub-unit A: 0.2%

Sub-unit B: 0.1%

Sub-unit C: 0.2%

Sub-unit D: 0.9%

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Deaths– the normalized value of this indicator and its corresponding weight

Table 31. Calculation of the normalized value of Deaths indicator and its corresponding weight

i=	13	**Deaths (% over population)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**0.2**	0.222	**0.4**	0.071
2	B	**0.1**	0.111		0.051
3	C	**0.2**	0.222		0.103
4	D	**0.9**	1.000		0.400
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

Data is available only at the municipality level.

Source of data for the assessment:

RZS https://www.stat.gov.rs/

Infrastructure

Indicator: Hospital capacity

The hospital capacity indicates especially the preparedness of the city to manage heat-related diseases. For this indicator, we calculate the number of beds in hospitals per 1000 inhabitants.

Municipality level

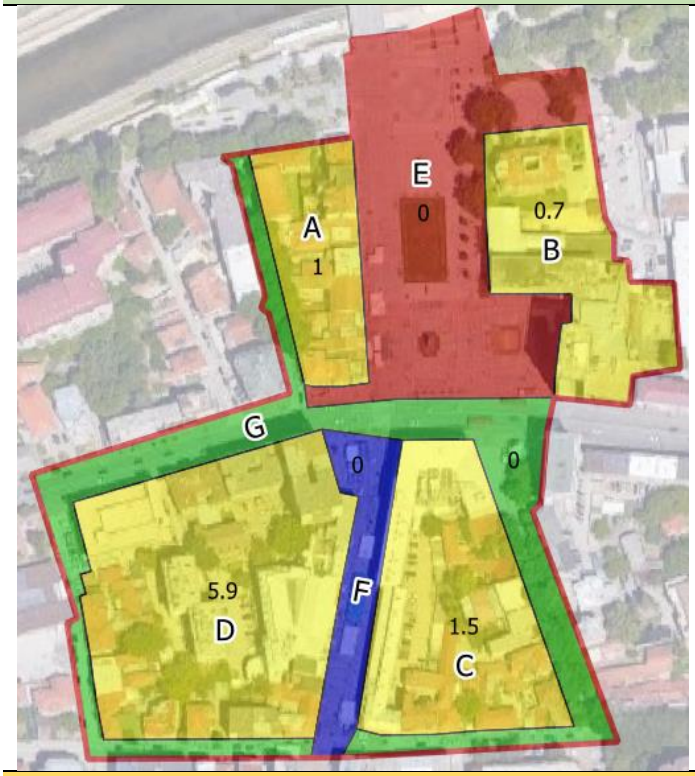
The Clinical Center in Niš is a republican institution founded on November 14, 1990. Year. It is the second largest in Serbia and serves the entire southeast and south of Serbia, with about three million inhabitants.
The institution is the teaching base of the Faculty of Medicine in Niš, where about 240 experts employed in the Clinical Center, who are teachers and associates at the faculty, participate in the teaching and training of new staff.

With its 28 clinics, institutes and institutes, along with supporting services, the Clinical Center represents a unique health-educational and scientific research system. The Niš Clinical Center has 1,525 beds and is the only healthcare organization in Serbia that does not have excess space or hospital beds.

Source: https://www.stat.gov.rs/

The number of beds in hospitals per 1000 inhabitants is 4.4.

Pilot zone



Beds in hospitals per 1000 inhabitants of the pilot zone:

Sub-unit A: 1

Sub-unit B: 0.7

Sub-unit C: 1.5

Sub-unit D: 5.9

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Hospital capacity – the normalized value of this indicator and its corresponding weight

Table 32. Calculation of the normalized value of hospital capacity indicator and its corresponding weight

i=	14	**Hospital capacity (beds per 1000 inhabitants)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**1.0**	0.177	**0.3**	0.053
2	B	**0.7**	0.126		0.038
3	C	**1.5**	0.257		0.077
4	D	**5.9**	1.000		0.300
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

It might be more efficient if the number of beds is shown as a number of vulnerable people at the location of hospital.

Source of data for the assessment:

RZS https://www.stat.gov.rs/

Indicator: Health centres

The number of health centres indicates how much the citizens have support and care in the event of a heat-related disease. For this indicator, we calculate the number of health institutions of all types (private or public) per 1000 inhabitants.

City Level

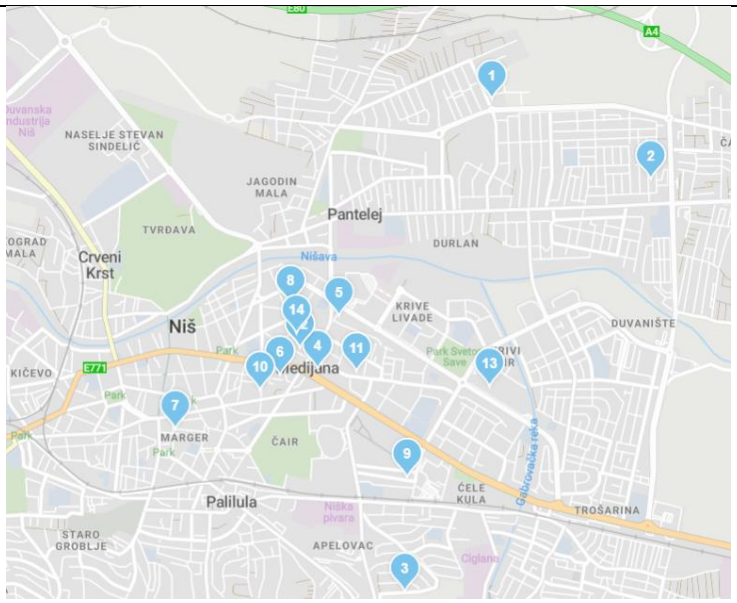


Figure 60. Locations of private health institutions of all types in the city of Niš

Source: https://www.planplus.rs/nis/privatne-poliklinike

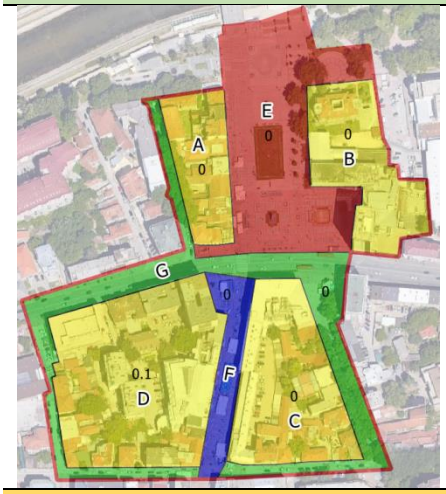
Table 33. Public health institutions of all types over the city of Niš

No.	Health center
1	Cental building
2	Contact offices in the central building
3	HC "BUBANJ"
4	HC "NOVO SELO"
5	HS "RASADNIK"
6	HC "ČAIR"
7	HC "RATKO PAVLOVIĆ"
8	HC "LIRA"
9	HC "DONJA VREŽINA"
10	□C"GORNJI MATEJEVAC"
11	HC "12. FEBRUAR
1	HC "TRUPALE"
13	HC "DELIJSKI VIS"
14	HC "DUVANIŠTE"
15	HC "BRANKO BJEGOVIĆ"
16	HC "GORNJA TOPONICA"
17	HC "JELAŠNICA"
18	HC "DUŠKO RADOVIĆ"
19	HC "NIŠKA BANJA"
20	HC "NIKOLA TESLA"

Source:https://www.domzdravljanis.co.rs

The total number of health institutions of all types is 34.

Pilot zone



Number of health institutions of all types (private or public) per 1000 inhabitants of the pilot zone:

Sub-unit A: 0

Sub-unit B: 0

Sub-unit C: 0

Sub-unit D: 0.1

Sub-unit E: -

Sub-unit F: -

Sub-unit G: -

Health centres – the normalized value of this indicator and its corresponding weight

Table 34. Calculation of the normalized value of Health centres indicator and its corresponding weight

i=	15	**Health centres (number per 1000 inhabitants)**			
j	Sub-unit	*Indexi,j*	*NormIndexi,j*	*wi*	*wi*NormIndexi,j*
1	A	**0.02**	0.154	**0.3**	0.053
2	B	**0.02**	0.154		0.038
3	C	**0.03**	0.231		0.077
4	D	**0.13**	1.000		0.300
5	E	**0**	0.000		0.000
6	F	**0**	0.000		0.000
7	G	**0**	0.000		0.000
wi assigned according to Survey/data quality.					

Limitation of the analysis:

The definition of this indicator might be revisited, because all types of health institutions include types of health institutions that are not adequate for support and care in the event of a heat-related disease.

Source of data for the assessment:

Dom Zdravlja Niš (https://www.domzdravljanis.co.rs/)

Planplus (https://www.planplus.rs/nis/privatne-poliklinike)

Retirement houses

Indicator: Retirement houses

The number of retirement houses in the area indicates the presence of elderly people. For this indicator, we calculate the number of retirement houses

City Level

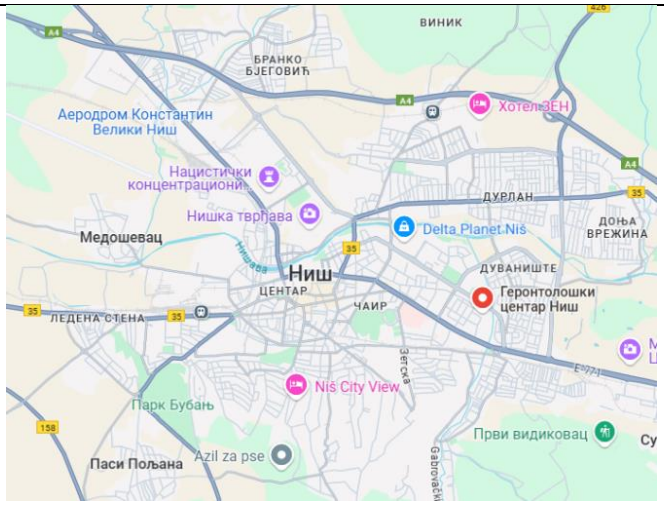


Figure 61. Locations of retirement houses over the city of Niš

Source:https://www.google.com/maps/search/domovi+za+penzionere+nis)

The total number of public retirement houses is 1.

Retirement houses – not located in the pilot zone

Source of data for the assessment:

Google Maps (https://www.google.com/maps/search/domovi+za+penzionere+nis)

Indicator: Social housing

Not present in the pilot zone.

Vulnerability Index

The vulnerability indices assessed for each sub-unit of the pilot zone are shown in Table 35 and Figure 62.

Table 35. Vulnerability index in six zones of the pilot area.

j	Sub-unit	*(Sum(wi*NormIndexi)),j*	VI	VI scale	VI qualitative
1	A	1.309	0.206	2	Low
2	B	0.877	0.138	1	Very low
3	C	1.733	0.273	2	Low
4	D	6.350	1.000	5	Very high
5	E	0.000	0.000	1	Very low
6	F	0.000	0.000	1	Very low
7	G	0.000	0.000	1	Very low

Figure 62. Vulnerability index plot for the pilot zone

Story mapping

Story mapping is a method for arranging user stories to create a more holistic view of how they fit into the overall user experience. In addition to calculating vulnerability indices, story mapping can provide valuable qualitative information about residents' perceptions of the effects of UTO in residential areas and different social groups.

Our story map was created based on a survey we conducted on December 5, 2024 at the Faculty of Civil Engineering and Architecture in Niš. To create the story map, we used ESRI Free Software. Annex B shows the questions and answers given by the survey participants. Our story map can be accessed via the QR code given below.

Figure 63. QR code of Story Map

PREPAREDNESS AND ADAPTIVE CAPACITY OF CITIES AND MUNICIPALITIES

Key factors for the assessment of **Tool 4** are the following: 1) **institutional factors**; 2) **social factors**; 3) **economic factors**; and 4) **technological factors and scientific knowledge**.

Institutional factors

1A) Indicator: Governance structures

Public administration of the City of Niš consists of eight sectors: 1) Local Economic Development and Investments; 2) City Bodies, Civil Status and Human Resources; 3) Common Affairs and Information and Communication Technologies; 4) Communal Activities, Inspection Affairs and Communal Militia; 5) Planning and Construction; 6) Finance and Local Public Revenues; 7) Social and Family Protection, Education, Culture and Sports; 8) Property, Economy and Environmental Protection.

Within the City Administration for Property, Economy and Environmental Protection, two sectors deal with environmental protection issues and protection against natural disasters. The Sector for Economy, Agriculture and Environmental Protection, among others, performs the tasks related to preparation and implementation of environmental protection programs and plans; development and implementation of action and remediation plans; protection of air, water, soil, protection from noise, ionizing and non-ionizing radiation; control and systematic monitoring of the state of the environment; information and publication of data on the state and quality of the environment.

The Sector for Joint Affairs performs, among others, tasks in the field of emergency management, protection from natural and other major disasters.

City's energy manager is responsible for energy-related matters, while issues related to emergency situations are under the jurisdiction of the Emergency Headquarters of the City of Niš.

Administrative area of the City of Niš, consists of five city municipalities: Medijana, Palilula, Pantelej, Crveni Krst and Niška Banja. Each municipality has its own assembly and administration.

The permanent working bodies of the City Municipality of Medijana are: Committee for Administrative and Mandate-Immunity Issues and four Commissions. Issues related to communal arrangements and environmental protection are under the competence of the Commission for Communal Issues and Urban Aesthetics and Commission for Sports and Education.

1B) Indicator: Legislative and regulatory regimes

The Law on Disaster Risk Reduction and Emergency Management of the Republic of Serbia ("Official Gazette of Republic of Serbia", No. 87/2018) defines natural disaster as a phenomenon of hydrological, meteorological, geological or biological origin, caused by the action of natural forces such as earthquakes, floods, torrents, storms, heavy rain, atmospheric discharges, hail, drought, landslides or landslides, snow drifts and avalanches, extreme temperatures air, accumulation of ice on watercourses, pandemics, epidemics of infectious diseases, epidemics of livestock infectious diseases and the appearance of pests and other large-scale natural phenomena which may threaten

the safety, life and health of a large number of people, material and cultural assets or the environment on a larger scale.

The terms of exposure, vulnerability and preparedness are also defined by this Law. Disaster risk reduction and emergency management are set as national and local priorities. Local self-government units have a primary role in disaster risk management and they are supported by all relevant state and provincial institutions.

The Law prescribes three types of documents (Disaster Risk Assessment, Disaster Risk Reduction Plan, Protection and Rescue Plan) for the territory of the Republic of Serbia (national), autonomous provinces (provincial) and local self-government units (local).

1C) Indicator: Policies

National policies and plans

Sustainable Urban Development Strategy until 2030, "Official Gazette of the Republic of Serbia", No. 47/2019. https://pravno-informacioni-sistem.rs/eli/rep/sgrs/vlada/strategija/2019/47/1/reg

Nature Protection Programme of the Republic of Serbia 2021-2023, "Official Gazette of the Republic of Serbia", No. 53/2021. https://pravno-informacioni-sistem.rs/eli/rep/sgrs/vlada/drugiakt/2021/53/1/reg

Spatial Plan of the Republic of Serbia 2021-2035 (Draft). https://www.mgsi.gov.rs/sites/default/files/PPRS%20Nacrt.pdf

City level policies and plans

Development Plan of the City of Niš 2021-2027, "Official Gazette of the City of Niš", No. 36/2021. https://investnis.rs/wp-content/uploads/2021/04/Plan-razvoja-GN-za-period-2021-2027.pdf

Development strategy of the urban area of the City of Nis and the municipalities of Svrljig, Merošina and Gadžin Han, "Official Gazette of the City of Niš", No. 42/2024.

https://www.eupropisi.com/dokumenti/NIS_042_2024_001.pdf

Spatial Plan of the City of Niš Administrative Area 2021, "Official Gazette of the City of Niš", No. 45/2011 and 85/2022. http://www.eservis.ni.rs/urbanistickiprojekti/

General Urban Plan of Niš 2010-2025, "Official Gazette of the City of Niš", No. 43/2011. http://www.eservis.ni.rs/urbanistickiprojekti/

General Urban Plan of Niš 2025-2040 (in preparation – in phase of early public insight) http://www.eservis.ni.rs/urbanistickiprojekti/

Strategy for Safety of the City of Niš for the period 2017-2020 (Draft). (2017). https://www.gu.ni.rs/wp-content/uploads/strategijabezb.pdf

Environmental Protection Programme of the City of Niš with Action Plan 2017-2027. (2017). Secretariat for Environmental Protection of the City of Niš. https://www.gu.ni.rs/wp-content/uploads/Program-zastite-zivotne-sredine-Grada-Ni%C5%A1a-2017-2027.pdf

Action Plan of Sustainable Energy Development of the City of Niš. (2014). https://www.gu.ni.rs/wp-

content/uploads/141224-seap.pdf

Air Quality Plan for the Agglomeration of Niš. (2020). Public Health Institute Niš. http://www.gu.ni.rs/wp-content/uploads/Plan-kvaliteta-vazduha-za-aglomeraciju-Nis.pdf

Program for using funds of the environmental protection budget fund of the city of Niš for the year 2024, "Official Gazette of the City of Niš", No. 22/2024.

http://demo.paragraf.rs/demo/combined/Old/t/t2024_03/NIS_022_2024_002.htm

Development Plan of the City of Niš 2021-2027 („Official Gazette of the City of Niš", No. 36/2021) defines four main directions for the development: 1) economic development; 2) territorial development and environmental protection; 3) social development; 4) management.

The goal of *Development direction 2 - Territorial development and environmental protection* - is the transition towards carbon neutrality of the continent by 2050, by introducing a strict climate policy, reforming the energy and transport sectors, strengthening mobility, with the commitment of the City of Niš to the transition from a linear to a circular economy, and reducing air, water and soil pollution as a general interest stemming from the primary concern for the health of our citizens, with the implementation of long-term measures to halt biodiversity loss, protect and restore ecosystems and rich biodiversity, and reduce the risks arising from the impact of climate change.

Within the framework of *Development direction 2* five priority objectives have been defined: 1) Improve the process of preparation and implementation of planning documents 2) Improve accessibility and quality of life of citizens by switching to sustainable mobility solutions 3) Accelerate energy transition towards low-carbon, climate-neutral development while ensuring energy security 4) Ensuring zero environmental pollution without toxic products, preservation and restoration of ecosystems and biodiversity 5) Preserving the potential of adaptation and mitigation measures, determined at the national level until 2030 by increasing resilience to climate change in priority sectors and establishing response in risky and disaster situations in urban and rural settlements. The priority objectives are further elaborated through a total of 42 measures for achieving the objectives, 8 of which relate to adaptation and mitigation to climate change.

In addition to priority objectives and measures, Development Plan of the City of Niš 2021-2027 also defines the responsibilities for the implementation of individual measures, as well as sources of financing. The implementation of measures related to climate change adaptation is largely the responsibility of the Property and Sustainable Development Administration and the Emergency Situations Sector. The financing of individual measures is planned from the Budget of the City of Niš, the Budget of the Republic of Serbia, line ministries, development assistance, EU funds, EU pre-accession assistance and structural funds, EIB, EBRD, World Bank, business community through corporate social responsibility.

https://investnis.rs/wp-content/uploads/2021/04/Plan-razvoja-GN-za-period-2021-2027.pdf

Development strategy of the urban area of the City of Nis and the municipalities of Svrljig, Merošina and Gadžin Han ("Official Gazette of the City of Niš", No. 42/2024)

The aim of the strategy is to contribute to the sustainable development of urban areas based on encouraging:

- the implementation of an integral and participatory approach to the development of society and economy, the development of landscapes, cultural and built heritage, natural heritage,

sustainable tourism and the strengthening of urban-rural links;
- the transition to clean and fair energy, green and blue investments, climate change mitigation and adaptation, risk prevention and management, sustainable and multimodal urban mobility;
- an innovative, smart, low-carbon and circular economy, with better use of the potential of digital technologies for innovation purposes;
- strengthening the social component by implementing the european pillar of social rights in the areas of employment, education, socio-economic inclusion and integration, housing, social and health care, culture, sport and recreation, creating an enabling environment for youth initiatives and activities, and social innovation

https://www.eupropisi.com/dokumenti/NIS_042_2024_001.pdf

Environmental Protection Programme of the City of Niš with Action Plan 2017-2027

The program, in accordance with the Law on Environmental Protection and the National Environmental Protection Program, includes: – description and assessment of the state of the environment; – assessment of trends and key problems in the environment; – defined basic goals that need to be achieved in terms of environmental protection with priority measures; – conditions for the application of the most favourable economic, technical, technological, economic and other measures for sustainable development and environmental protection management; – long-term and short-term measures for the prevention, mitigation and control of pollution; – carriers, method and dynamics of implementation; – framework funds for implementation.
The program identifies environmental factors, factors of development and impact on the environment, environmental risk factors and environmental quality factors, and defines instruments for the implementation and monitoring of the program.

The Action plan for implementation of the environmental protection program in the territory of the City of Niš clearly defines the tasks; activities, measures and projects, holders and partners in the implementation, and the implementation period, i.e. the deadline for each activity.

https://www.gu.ni.rs/wp-content/uploads/Program-zastite-zivotne-sredine-Grada-Ni%C5%A1a-2017-2027.pdf

In 2024 the City of Niš adopted the **Program for using funds of the environmental protection budget fund of the city of Niš for the year 2024** ("Official Gazette of the City of Niš", No. 22/2024). The program includes the distribution of funds in the previous year (2023), as well as planned funds for the current year (2024). Funds are allocated for the following program activities: air control and protection and suppression of inhaled allergens; waste management; surface and groundwater control and protection; control and protection of nature, biodiversity, public green spaces; soil control and protection; noise control and protection; non-ionizing radiation control and protection; information, education, promotion and popularization of environmental protection; and adaptation measures to climate change.

Compared to 2023, funds for certain program activities have been significantly increased in 2024 (waste management, noise and non-ionizing radiation control). However, no budget funds have been allocated for climate change adaptation in the last two years (2023, 2024).

(http://demo.paragraf.rs/demo/combined/Old/t/t2024_03/NIS_022_2024_002.htm)

The **Disaster Risk Assessment of the City of Niš** was prepared in 2021 as a basic document for the creation of an optimal protection and rescue system. The Disaster Risk Assessment is prepared

for the following hazards that were identified: earthquakes, landslides, floods, extreme weather events - hail, lack of drinking water, epidemics and pandemics, animal diseases, outdoor fires, and technical and technological accidents. This document also proposes measures for risk treatment, as defined for the Disaster Risk Reduction Plan (Dinić Branković, 2024).

1!D) Indicator: Plans

Urban plans

The area of the City of Niš as a local self-government unit is covered by the "Spatial Plan of the City of Niš Administrative Area 2021" (2011, with modifications and additions adopted in 2022). For the urban area of the City of Niš, which encompasses 44.7% territory of the total administrative area, the standing plan is the "General Urban Plan of Niš 2010-2025" (2011). This plan has undergone four subsequent modifications and additions, which were adopted in 2016, 2018, 2021 and 2024 (Dinić Branković, 2024).

The General Urban Plan of Niš 2025-2040 is currently in preparation, i.e. in the phase of early public review of the planning document. Green infrastructure, as one of the measures for climate change adaptation and mitigation, is integral part of the plan. The strategic goal of planning and developing green infrastructure is to achieve optimal living conditions for citizens through "healing the city" in an ecological, social and economic sense.

Other Plans

The City Administration for Property and Sustainable Development Niš also initiated the preparation of the Protection and Rescue Plan and the External Major Accident Protection Plan. The procedure for the development of these documents has started. The Protection and Rescue Plan is being drawn up based on the results of Disaster Risk Assessment. It is the basic planning document that enables protection and rescue entities to organize, prepare and participate in the execution of measures and tasks for the protection and rescue of the endangered population, cultural assets and environment. The City of Niš has operational plans for flood defence on small streams as watercourses of the second order, but the adopted solutions are not fully implemented due to a lack of financial resources (Dinić Branković, 2024).

Supporting documents

Roadmap for the adoption of the Climate Change Adaptation Plan with vulnerability assessment for the City of Nis

This document aims to facilitate the development of a Climate Change Adaptation Plan (CCAP) with vulnerability assessment for the City of Niš. The Roadmap is created by civil society organizations and it contains activities through precisely defined steps according to the Methodology proposed by the Standing Conference of Cities and Municipalities of Serbia. According to the Roadmap, the process of the adoption of the CCAP is divided into five phases: 1) Starting the process, 2) Analysis of vulnerability to changing climate conditions, 3) Selection and prioritization of adaptation measures, 4) Implementation of measures, and 5) Monitoring and evaluation.

The Roadmap includes a wide range of participants in different stages of the preparation of the Climate Change Adaptation Plan: city administration (Mayor, City Council, city administration body

responsible for environmental protection), civil society organizations, media, business community, academic community, citizens. The Roadmap is part of the NišClima2020 project, which is implemented by the Media and Reform Center Niš with the co-financing of the Ministry of Environmental Protection and the support of the City of Niš. (https://mediareform.rs/wp-content/uploads/2020/12/Mapa-puta-Nis-Klima-2020-spremno-za-stampu.pdf)

1E) Indicator: Institutions

Climate change adaptation and mitigation, as a comprehensive activity, involves a wide range of participants in preparation, implementation and monitoring, both on national and local level:

State level

- Government of the Republic of Serbia (establishes and conducts policy, executes laws and other general acts of the National Assembly, proposes laws and other general acts to the National Assembly, etc.)
- Ministry of Environmental Protection of the Republic of Serbia (with local offices) - performs state administration tasks related to the basics of environmental protection, the system of environmental protection and improvement, national parks, inspection supervision in the field of environmental protection; the application of the results of scientific and technological research and development research in the field of the environment; nature protection, air protection, ozone layer protection, climate change, establishing environmental protection conditions in spatial planning and construction of facilities, etc.

Local self-government level (city and/or municipalities)

- City administration (mayor, city council, city assembly, competent city administration)
- Municipal administration (the head of the municipality, municipal assembly, competent municipal commissions)
- Public enterprises (PE Institute for Urban Planning Niš- spatial and urban planning; PE Mediana - communal maintenance and arrangement and maintenance of green areas; PE Naissus - water supply and sewerage, etc.)
- Civil society organizations and non-governmental organizations
- Academic community
- Private socially responsible companies
- Citizens

The Directorate for Civil Protection and Risk Management is an organizational unit of the Emergency Situations Sector of the Ministry of Internal Affairs. Within its competences, the Directorate carries out activities aimed at establishing and implementing policies for reducing the risk of natural disasters or technical and technological accidents (disasters), rapid and adequate response to the occurrence of these threats, managing emergency situations, and mitigating the consequences caused by disasters.

The Directorate for Civil Protection and Risk Management consists of four departments with respective Sections:

Department for planning and risk assessment, with Section for Natural Disaster Risk Assessment and; Section for Development of a Natural Disaster Protection Plan

Department for coordination and emergency management, with Section for Coordination of Staff Work and Recording of Emergency Situations and Section for Preparation and Engagement of Subjects of Special Importance

Department of Civil Protection Units, with Section for Operational Organizational Affairs of Civil Protection Units and Section for Care and Technical Support.

Department for Unexploded Ordnance (UO), with Section for UO Operations, and Section for UO Design, Control and Reconnaissance.

(http://prezentacije.mup.gov.rs/svs/HTML/uprava%20za%20upravljanje%20rizikom.html)

The Russian-Serbian Humanitarian Center was established on the basis of the Agreement of October 20, 2009 between the Government of the Russian Federation and the Government of the Republic of Serbia on cooperation in the field of humanitarian response in emergency situations, prevention of natural disasters and technological accidents and elimination of their consequences. The Center was officially opened on April 25, 2012.

The activities and legal status of the center are defined by separate intergovernmental agreements. The center is under the joint jurisdiction of the Ministry of Civil Protection, Emergencies and Disaster Relief of the Russian Federation and the Ministry of Internal Affairs of the Republic of Serbia.

The Center is entrusted with the following basic tasks: preparation for preventing and eliminating the consequences of emergency situations; humanitarian assistance to the population affected by emergency situations; implementing programs and projects on humanitarian demining; assistance to Serbia and other countries in the region in extinguishing fires with the help of aviation assets; training, retraining and retraining of specialists in the field of preventing and eliminating the consequences of emergency situations; etc. The Center is an intergovernmental non-profit organization that enjoys the rights of a legal entity. The Center and its branches are located at the Niš airport, as well as in other areas of Serbia agreed upon by the Parties.

(http://ambasadarusije.rs/sr/rusko-srpski-humanitarni-centar)

Regional Chamber of Commerce of the Niš, Pirot and Toplica Administrative Districts

The activities of the Regional Chamber of Commerce Niš (RCC Niš), as a non-profit and non-political organization, are aimed exclusively at supporting the economy of the region and encouraging the development of the economy, entrepreneurship and entrepreneurial initiatives. The most important activities relate to organizing local events, conducting international activities, education, projects and dual education. RCC Niš: 1) provides support to local government bodies in attracting investors, defining and implementing development projects; 2) participates in organizing local, regional and cross-border business meetings and events; 3) launches initiatives to improve existing and develop new services, in accordance with the demands and needs of businesspeople; 4) provides businesspeople with services and professional assistance; 5) organizes education for business people. (https://nis.pks.rs/)

Regional Development Agency "SOUTH" (RDA SOUTH)

The primary role of RDA SOUTH is to help local actors to act in a certain way in order to fully utilize the potential of the region. RDA SOUTH was co-founded by ten municipalities, civil society

organizations/non-governmental organizations, and "Tigar" company. RDA's mission is to improve the quality of life of citizens in the region through participation in the process of strategic planning and development of the region; assistance to the private sector in the region and thereby creating new jobs; development and management of regional projects that encourage the socio-economic development of the region; creation of a "knowledge bank" on the matters related to the region, including a database of key local experts; and promotion of the region at the national and international level.

RDA SOUTH participated in development of Development strategy of the urban area of the City of Nis and the municipalities of Svrljig, Merošina and Gadžin Han.

(https://www.rra-jug.rs/o-nama/misija-i-ciljevi/)

Social factors

2A) Indicator: Social connections

Social connections in the context of UHI refer to the role that community networks, social networks, cooperation, and information sharing play in both mitigating UHI effects and adapting to the challenges posed by heat in cities. Communities that are well-connected can more effectively address the UHI effect through collaborative actions, informed decision-making, and mutual support, especially for vulnerable groups.

In the City of Niš, community awareness and collective actions, social networks and social support related to UHI risk reduction are in the initial stages of development and implementation.

Collective actions are implemented partially by residents or non-governmental organizations and are aimed at increasing the share of greenery within certain neighbourhoods, the arrangement of public open spaces (POS) etc., where UHI is observed indirectly (Figure 64).

Figure 64. Examples of social connections. a) NGO "Delijski Vis" and the association "Gorani grada Niša" in the campaign of planting greenery in the neighbourhood on the territory of Delijski Vis. b) Participatory-based project "Zelena oaza" – reclaiming of existing POS within Krive Livade Neighbourhood (City Municipality Medijana, NGO and citizens)

Sources: https://www.facebook.com/groups/707999849372648

2B) Indicator: Community cohesion

Community cohesion enhances a neighbourhood's ability to effectively respond to the challenges of

urban heat islands. By coming together, communities are not only able to better manage heat risks in the short term (such as during heat waves), but they can also influence long-term urban planning decisions and climate adaptation strategies. Social connections, mutual support, and shared action within cohesive communities are key to minimizing the impacts of UHI and building more resilient, sustainable urban spaces. Although there are certain initiatives and strategically expressed support (pp. 84-89), social cohesion in relation to UHI in city of Niš is still in the initial phases of development.

Strategic documents at the city level can, as well as on-going projects such as *Be Ready* and *Natured*, can help strengthen social awareness and mobilize the community.

2C) Indicator: Self-learning/self-organizing capacities of communities

The self-learning and self-organizing capacities of communities in the context of the Urban Heat Island (UHI) effect refer to the ability of a community to independently adapt to, respond to, and mitigate the heat-related challenges in urban areas without relying solely on external intervention. It involves communities developing the skills, knowledge, and resources necessary to take proactive measures to reduce UHI impacts and improve their own resilience. The ways in which capacities can manifest are shown in Table 36.

Table 36. Self-learning/self-organizing capacities in the city of Niš

Manifestation of self-learning	Components and current status
Self-Learning: Developing knowledge and awareness	▪ Education and Information Sharing ▪ Learning from Experience ▪ Adapting Practices
	In initial phases of implementation
Self-Organizing: Collaborative action for UHI mitigation	▪ Neighborhood Initiatives ▪ Community-Led Urban Design ▪ Local Resource Management
	In initial phase of preparation
Adaptive behaviour in response to heat waves	▪ Coping Strategies ▪ Heat Action Plans
	Not recorded
Leveraging Local Knowledge and Networks	▪ Local Expertise ▪ Social Networks and Communication
	In initial phase of implementation
Engaging with Local Policy and Decision-Makers	▪ Community Advocacy ▪ Participatory Decision-Making
	In initial phase of implementation
Building long-term UHI resilience	▪ Sustainable Practices ▪ Resilient Infrastructure
	In initial phase of preparation and implementation
Innovation and experimentation	▪ Pilot Projects ▪ Testing and Evaluating Solutions
	In initial phase of preparation and implementation

2D) Indicator: Available skills and knowledge

See criteria **Technological factors and scientific knowledge**

Economic factors

3A) Indicator: Public finansial resources

LOCAL GOVERNMENT BUDGET. Data on budget revenues and expenditures of municipalities and cities of the Republic of Serbia are collected and processed by the Ministry of Finance. Data on realized budget revenues and expenditures refer to the data of the final budget accounts collected from all cities and municipalities that make up the local government system. All direct and indirect users of the city or municipality budget that are mainly financed by local government funds are included. Total budget revenues consist of current (tax and non-tax) revenues, income from the sale of non-financial assets, as well as income from borrowing and the sale of financial assets. Receipts from the sale of non-financial assets include only income from the sale of capital goods (state-owned buildings, inventories and land) and capital transfers from non-governmental institutions. Budget revenues are used to cover budget expenditures. Current revenues finance the regular operating expenses of budget users. Total budget expenditures consist of both expenditures for the acquisition of non-financial assets and expenditures for the repayment of loans and the acquisition of financial assets.

Table 37. Budget revenues and receipts, 2022

City/ City Municipality	Budget income		Current income (thousands RSD)	Proceeds from the sale of non-financial assets, (thousands of RSD)	Proceeds from borrowing and sale of financial assets (thousands of RSD)
	Total (thousands RSD)	Per capita (thousands RSD)			
City of Niš	**12623718**	**50476**	**12563053**	**60665**	**-**
Medijana	200320	15406	200320	-	-

Source: Regioni i opštine u Srbiji 2023, RGZ ; https://www.ni.rs/budzet-grada/

Table 38. Budget expenditures, 2022

City/ City Municipality	Budget expenditures		Current expenses (thousands RSD)	Expenditures for the acquisition of non-financial assets (thousands of RSD)	Expenditures for loan repayment and acquisition of financial assets, (thousands of RSD)	Realized surplus or deficit (thousands RSD)
	Total (thousands RSD)	Per capita (thousands RSD)				
City of Niš	**788287**	**3152**	**737568**	**50719**	**-**	**11835431**
Medijana	204183	15703	179592	24591	-	-3863

Source: Regioni i opštine u Srbiji 2023, RGZ; https://www.ni.rs/budzet-grada/

EXPENDITURE OF BUDGET BENEFICIARIES. Data on budget revenues and expenditures of municipalities and cities of the Republic of Serbia are collected and processed by the Ministry of Finance. Data on realized budget revenues and expenditures refer to the data of the final budget accounts collected from all cities and municipalities that make up the local self-government system. All direct and indirect users of the city or municipality budget that are mainly financed by funds from the local government level are included. Total budget revenues consist of current (tax and non-tax)

revenues, income from the sale of non-financial assets, as well as income from borrowing and sale of financial assets. Receipts from the sale of non-financial assets include only income from the sale of capital goods (state-owned buildings, inventories and land) and capital transfers from non-governmental institutions. Budget revenues are used to cover budget expenditures. Current revenues finance the regular operating expenses of budget users. Total budget expenditures consist of both expenditures for the acquisition of non-financial assets and expenditures for the repayment of loans and the acquisition of financial assets.

Table 39. Expenditures of budget beneficiaries 2022

City/ City Municipality	Expenditure					
	Total (thousands RSD)	Education	Other activities (thousands of RSD)			
			Health and social protection	Public administration and compulsory social insurance	Arts, entertainment and recreation	Other activities
City of Niš	**53522402**	**12461448**	**22646448**	**15279359**	**1153290**	**1981858**
Medijana	41325073	6355041	20068884	12707885	839782	1353481

Source: Regioni i opštine u Srbiji 2023, RGZ

3B) Indicator: Household income

Data on average household income can be obtained indirectly, through: 1) number of households divided by the number of members, i.e. the average number of members (Table 40); 2) assumption that in a household with 2.5 members, 1.5 family members work (optimistic scenario), and 3) average earnings per employee (Table 41).

Table 40. Households by number of members, according to the 2022 census.

City/ City Municipality	Total	With 1 member	2	3	4	5	With 6 or more members	Average number of members
City of Niš	**100274**	**29436**	**28365**	**19730**	**15734**	**4679**	**2330**	**2,5**
Medijana	36042	11898	10297	7075	5239	1205	328	2,3

Source: Regioni i opštine u Srbiji 2023, RGZ

Table 41. Average earnings without taxes and contributions, per employee (in RSD)

Republic/ City/ City Municipality	2018	2019	2020	2021	2022
Republc of Serbia	49650	54919	60073	65864	74933
City of Niš	**46383**	**51009**	**57009**	**63239**	**71867**
Medijana	51552	56426	62907	70978	81574

Source: Regioni i opštine u Srbiji 2023, RGZ

Average household income in the city of Niš in 2022:
1.5 (employed) members x 71867 RSD = 107800 (approx. 898 euros)

Average household income in the city municipality Medijana in 2022:
1.5 (employed) members x 81574 RSD = 122361 (approx. 1019 euros)

3C) Indicator: Access to finansial resources

In UHI Risk Assessment, access to financial resources refers to the financial capacity of a city, city municipalities, businesses, and residents to implement adaptation and mitigation measures against UHI effects. It is an essential component of resilience and adaptive capacity, influencing how well an urban area can cope with and respond to heat-related risks.

Sub-indicators of access to financial resources in UHI risk assessment are shown in Table 42.

Table 42. Sub-indicators of access to financial resources in UHI risk assessment

Sub-indicator	**Existing condition, documents and plans**
Municipal Budget for Climate Adaptation – Funds allocated for UHI mitigation projects	Indirectly, through: ▪ Environmental Protection Programme of the City of Niš with Action Plan 2017-2027 ▪ Program for using funds of the environmental protection budget fund of the city of Niš for the year 2024 ("Official Gazette of the City of Niš", No. 22/2024).
Availability of Government Grants/Subsidies – Support for green infrastructure, energy efficiency, or cooling initiatives.	▪ Development Plan of the City of Niš 2021-2027, "Official Gazette of the City of Niš", No. 36/2021 ▪ Environmental Protection Programme of the City of Niš with Action Plan 2017-2027 ▪ Roadmap for the adoption of the Climate Change Adaptation Plan with vulnerability assessment for the City of Nis
Private Sector Investment in Climate Resilience – Participation of businesses in heat mitigation efforts.	No available data
Household Income Levels – Determines the affordability of cooling solutions for residents	No available data
Insurance Coverage – Availability of financial protection against heat-related damages (e.g., health costs, infrastructure damage)	No available data
Foreign and National Climate Funds – Access to external financial resources for urban adaptation projects	▪ Interreg IPA Adrion programme under the Interreg Funds, Project **Natured** - Nature-Based Solutions for a Just Resilience in the Adriatic-Ionian Cities ▪ Interreg Danube Region, Programme co-funded by European Union funds (ERDF, IPA, ENI), Project **Be Ready** - UrBan hEat islands REsilience, prepAreDness and mitigation strategY
Public-Private Partnerships (PPPs) – Collaborative financing mechanisms for heat risk reduction	No available data
Social Assistance Programs – Financial aid for vulnerable populations during extreme heat periods	No available data

3D) Indicator: Insurance contract

No available data.

Technological factors and scientific knowledge

4A) Indicator: Availability of technological, social, institutional, environmental and other innovations

Institutions

Science and Technology Park Niš

The Science and Technology Park Niš is an organization which, working closely with the University and the academic community, provides the infrastructure and services to assist innovative companies in realizing business success on the market, especially in the area of high technologies.

As a regional center for the accelerated development of innovative science-technological entrepreneurship and the international promotion of projects and companies, it provides the basis of reengineering the region's economy and strengthening its global competitiveness.

(https://ntp.rs/en/)

Green Technologies Research Group, University of Niš

The Green Technologies Research Group (GTR Group) consists of the University of Niš researchers from various fields of expertise (electrical and power engineering, applied physics, control engineering, information technologies, electronics, etc.) conducting the research in three laboratories - Laboratory for micro and smart grids, Solar Energy Laboratory, and Laboratory for PV technology, devices and systems. Laboratories are primarily intended for scientific research with modern equipment that allows researchers to work comfortably and enables students to practice with modern technologies in their areas of interest. The laboratory equipment was partly provided through participation in scientific projects and partly with donations from partner companies.

The activities of the GTR Group are in line of UN Sustainable Development Goals (7- Affordable and Clean Energy, 9 – Industry, Innovation and Infrastructure; 12- Responsible Consumption and Production; 13-Climate Action). Innovative solutions in collaboration with local stakeholders and companies make university researchers a key player in global transition.

(https://green.elfak.ni.ac.rs/sr/)

Past and on-going projects

Climate-Resilient Cities Regional Workshop in the Western Balkans

Established in June 2017, the World Bank's City Resilience Program (CRP) empowers cities to invest in climate and disaster resilience. The CRP has assembled a diverse range of World Bank sectoral expertise as a global technical support system to assist cities in integrating climate change and disaster risk into their upstream capital investment planning and access the financing needed for climate-smart investments to succeed. Rather than trade off between competing sectoral needs, the CRP helps cities tackle their most pressing development challenges through integrated, cross-sectoral, spatially-based priorities that capture the interaction between the natural and built environments.

(https://wbcrp.shinyapps.io/crc_workshop_western_balkans/)

Adaptation to the changed climatic conditions in Niš 2023- PIKU-NIS 2023

The aim of the Project led by Green network of the city of Nis is to contribute to improving the capacity of the local community for resilience and adaptation to the changed climatic conditions and to emphasize the importance of reform in the field of environmental protection. Activities are aimed to strengthen the visibility of the network, to raise awareness of the importance of changed climate conditions and the importance of developing a PIKU plan. All sectors, civil society organizations, activists and citizens participate in the adoption of the Adaptation Plan to the changed climatic conditions for the city of Niš. In order to strengthen all three sectors and improve sectoral and local planning processes, the network will carry out the necessary research and expert analysis, will support initiatives for mini-climate solutions, implemented education and exchange of practical knowledge in the field of legal advocacy procedures, and will promote the results and activities through the media and an online campaign. (https://ekosistem.mis.org.rs/podrzani-projekti-2023/)

NATURED – Nature-based Solutions for a Just Resilience in the Adriatic-Ionian Cities

The NATURED project aims to empower decision-makers in preventing the impact of climate change on different zones of urban environments, especially when it comes to flash floods and urban heat islands, through the application of nature-based solutions, of which the most vulnerable groups to benefit the most. The expected change is the promotion of equitable, safe and inclusive resilience, to ensure that no one is left behind in the process of adapting to climate change.

Project participant: Regional Development Agency "SOUTH" (RDA SOUTH) (https://www.rra-jug.rs/kategorija-projekata/projekti-u-toku/)

This project is supported through the Interreg IPA ADRION program within the Interreg funds (European Fund for Regional Development and IPA III (www.interreg-ipa-adrion.eu)

4B) Indicator: Ability to use the innovations, or availability of information on adaptation to climate change

Legal obligations to inform the public about the risks

The Law on Disaster Risk Reduction and Emergency Management of the Republic of Serbia ("Official Gazette of Republic of Serbia", No. 87/2018) obliges competent authorities to timely and fully inform the public about the risks of disasters, relevant data and measures to protect against their consequences, as well as about other measures taken for disaster risk management (Article 9: Principle of Public Information).

Availability of information

GIS portal Gradske uprave Niš (GIS portal of the City administration of Nis)

GIS portal Gradske uprave Niš is and application for viewing and managing data from the Niš General Directorate, organized in several logical units. The application contains planning data, data on investment potential, data important for tourism, and data important for agriculture and rural development.

(https://gis.ni.rs/smartPortal/gunisPublic)

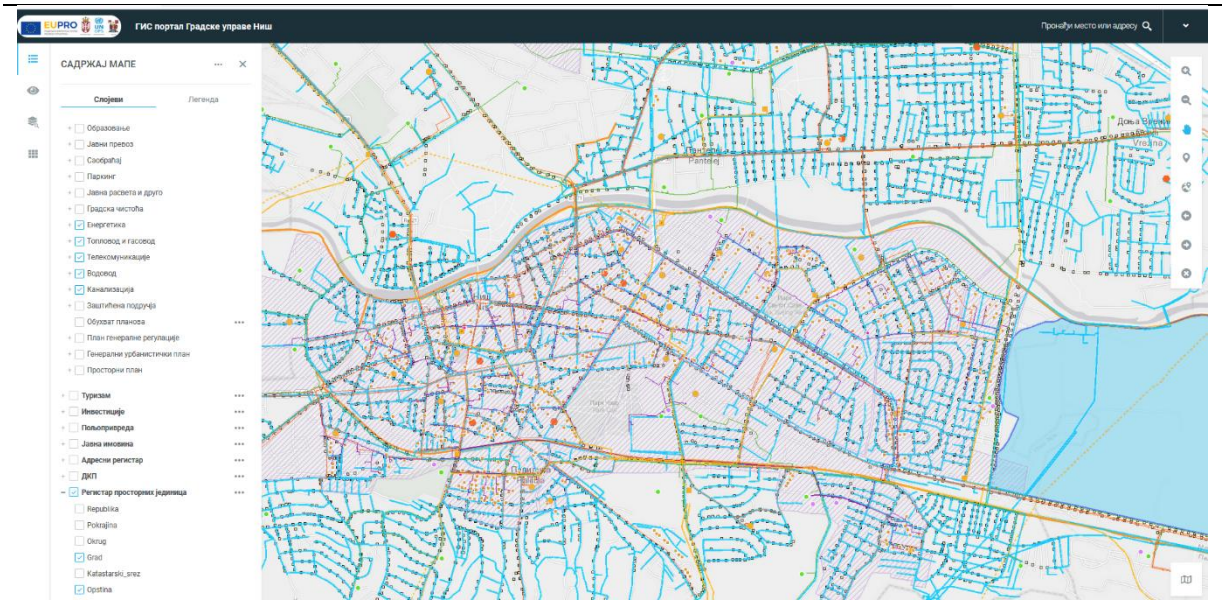


Figure 65. Layout of the electricity infrastructure, heating and gas infrastructure, water supply and sewage systems in the territory of the city of Niš

Source: https://gis.ni.rs/smartPortal/gunisPublic

Disaster Risk Register of the Republic of Serbia

Disaster Risk Register of the Republic of Serbia is an Interactive, electronic, geographic information database for the territory of the Republic of Serbia that contains data of importance in risk management.

It contains:

Web GIS – public Web GIS platform for data collection, sharing, and accessing geospatial and alphanumeric data and maps with information on disaster risk for decision support in natural disaster management.

Metadata catalogue – the national application which enables searching, creating, maintaining, and sharing metadata for spatial datasets, data series, and services.

(https://drr.geosrbija.rs/drr/home)

Digitalni atlas klime Srbije (Digital Climate Atlas of Serbia)

The Digital Climate Atlas of Serbia (web platform) was established within the NAP project (https://adaptacije.klimatskepromene.rs/en/about-the-project/). to provide the best available climate and socio-economic information necessary for decision-making and the integration of climate change adaptation into medium- and long-term planning. Beside climate data used for specific risk & vulnerability assessments, it contains:

climate datasets, including observation of the past, and regional climate model projections for the whole country, as well as at the sub-national and city/local level – the platform; and

on-line visuals - maps and charts for different seasonal and annual analysis and data.

All climate data presented in the Digital Climate Atlas of Serbia is publicly available and can be used by different stakeholders for vulnerability and risk assessments, as well as for identification of

adaptation options at sectoral, subnational and national levels, including for the priority areas/sectors (Agriculture & Water Management nexus, Energy, Transport and Construction infrastructure).

(https://atlas-klime.eko.gov.rs/lat/map?dataType=obs&visualization=pro&area=regions)

Climate TRACE is a non-profit coalition of organizations building a timely, open, and accessible inventory of exactly where greenhouse gas emissions are coming from. (https://climatetrace.org/)

People's ability to access information

Table 43. Population aged 15 and over by computer literacy in the City of Niš

	Total	Computer literate persons		Persons with partial computer skills		Computer illiterate persons		Unknown
		All	Share in total population %	All	Share in total population %	All	Share in total population %	All
City of Niš	214,404	119,930	55.9%	49,030	22.9%	44,619	20.8	825
Settlement Niš	153,353	95,151	62%	31,471	20.5%	26,044	17%	687
Medijana	71,338	47,892	67.1%	11,846	16.6%	11,397	16%	203

Source: Statistical Office of the Republic of Serbia, 2023

According to the 2022 census data, share of illiterates in total population (%) in the City of Niš is among the lowest in the country and it amounts: 0.31% (the City of Niš), 0.25% (Settlement Niš) and 0.12% (City Municipality of Medijana) . (Statistical Office of the Republic of Serbia. (2023).

Niš, Novi Sad and Belgrade are the areas with the highest share of computer literate population (more than 50%). This is even higher in the central city municipality of Medijana, where as many as two-thirds of the population is computer literate (67%).

The above data shows that residents are largely capable of using internet sources and interpreting available data.

Assessment of adaptive capacity

Adaptive capacity is not directly measurable. Indicators of adaptive capacity are more difficult to identify than indicators of risk. Physical risks associated with UHI impacts can be caused by specific events (extreme weather events, e.g. heat or waves), driven or associated with longer-term shifts predicated by the climate patterns (e.g., higher mean air temperatures, changing precipitation patterns, etc.), as well as with the institutional, socio-economic and technical-scientific knowledge of the city of Niš, its institutions and citizens to adapt and respond to climate change.

The assessment of the adaptive capacity of a city requires a detailed examination of various influencing factors. In addition to a detailed analysis of four groups of indicators - institutional, social, economic and technical-scientific knowledge, the assessment of their readiness and ability to respond to the risk of UHI and climate change was also carried out on the basis of a survey proposed in the methodology. 21 participants from the local government office structure and the academic community took part in the survey. The structure of the survey is shown in Table 44.

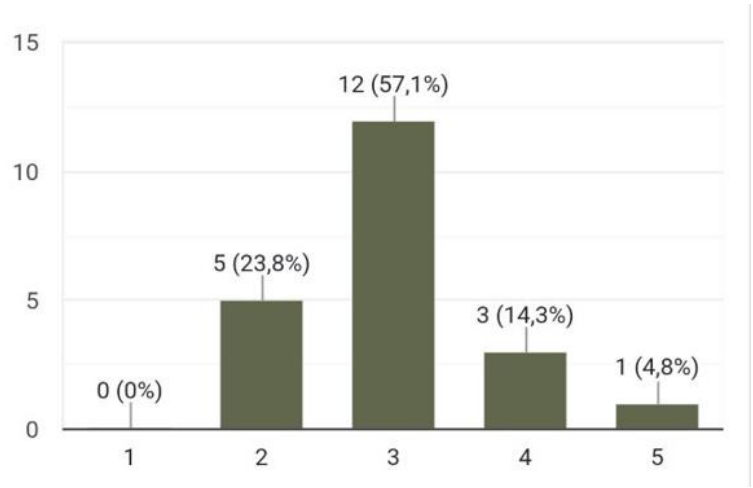
Table 44. Structure of the survey for assessment of adaptive capacity

A. Local government office structure
○ At what level is the disaster risk management department? (scale 1–5)
○ At what level is the environment, sustainability, or climate change department? (scale 1–5)
B. Responsibilities for disaster risk management and climate change management
○ Are responsibilities clearly specified in municipality? (scale 1–5)
○ Is responsibility for climate change management established? (scale 1–5)
○ At what level is the responsibility for disaster risk management established? (scale 1–5)
○ At what level is the existence, capacity, and effectiveness of a city's emergency and disaster response plan? (scale 1–5)
○ How is the response system set up in terms of comprehensive and equipment for all specified natural hazards? (scale 1–5)
○ At what level is the update of the disaster response system set in municipality? (scale 1–5)
Rating scale: 1= not set at all, non-existence of the system 2 = setup/equipment/preparedness at a very low level 3 = average level of setup/equipment/preparedness 4 = good level of setup/equipment/preparedness 5 = high (precise) level of setup/equipment/preparedness

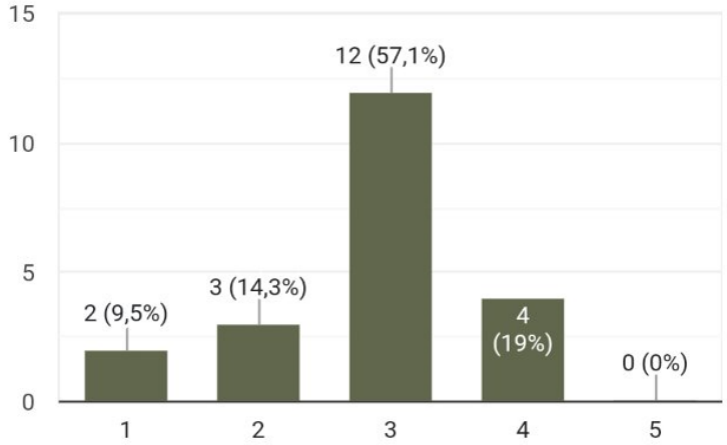
Note: The questions in section A and B follow the World Bank report (Dicson at al., 2012)

A. Local government office structure

To the question, **"At what level is the disaster risk management department?"** out of 21 respondents, 12 rated the level of the *disaster risk management department* with a score of 3, which represents 57,1% of the total sample, 5 responders gave a score 2 (23,8%), while 3 participants gave a score of 4, accounting for 14.39% of the total sample. Only one respondent gave a score 5.



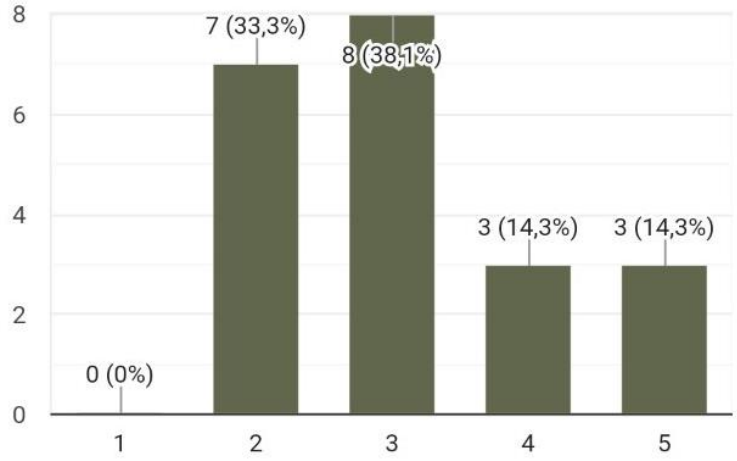
To the question, **"At what level is the environment, sustainability, or climate change department?"** out of 21 respondents, 12 rated the level of the *environment, sustainability, or climate change department* with a score of 3, which represents 57,1% of the total sample, 4 responders gave a score 4 (19,0%), 3 responders gave a score 2 (14,3%), while 2 responders gave a score of 4, accounting for 9,5% of the total sample.



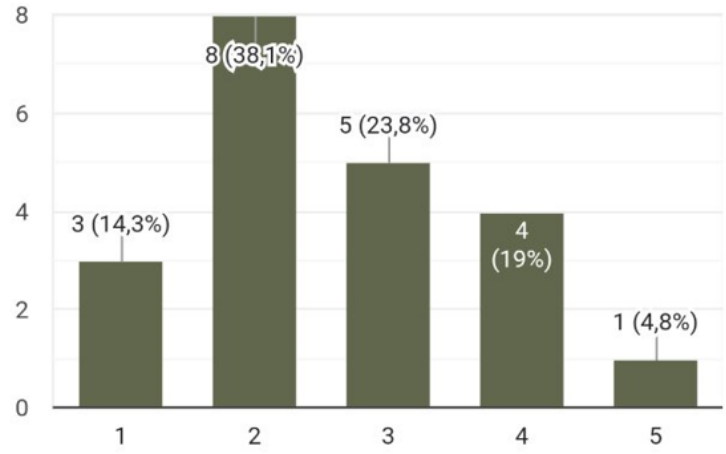
Part A_ Rate of the adaptive capacity of the local office structure in the city of Niš: More than 80% of respondents gave a score of 3 (average level) and 2 (very low level)

B. Responsibilities for disaster risk management and climate change management

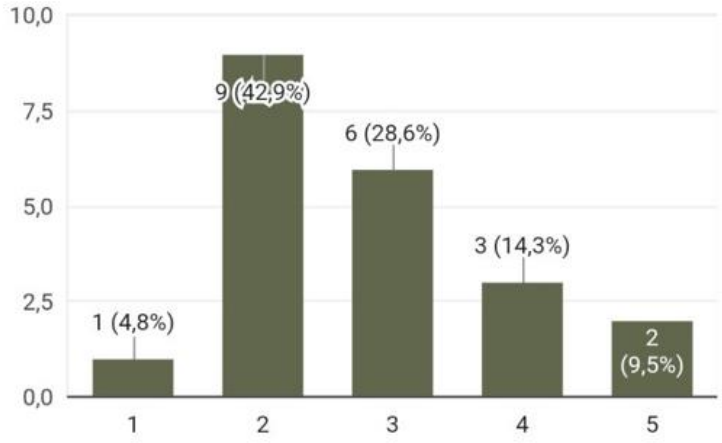
To the question, **"Are responsibilities clearly specified in municipality?"** out of 21 respondents, 8 rated with a score of 3, which represents 38,1% of the total sample, 7 responders gave a score 2 (33,3%), while 3 responders rated with scores 4 (14,3%) and 5 (14,3%) that responsibilities are clearly specified.



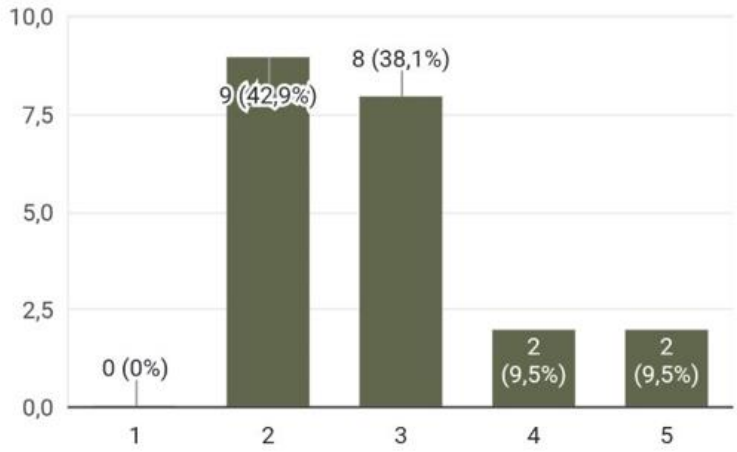
To the question, **"Is responsibility for climate change management established?"** out of 21 respondents, 8 rated with a score of 2, which represents 38,1% of the total sample, 5 responders gave a score 3 (23,80%), 4 responders gave a score 4 (19,0%), 3 responders gave a score of 1, accounting for 14,3% of the total sample. Only one respondent rated the *establishment of responsibility for climate change management* with a score of 5 (4,8%).



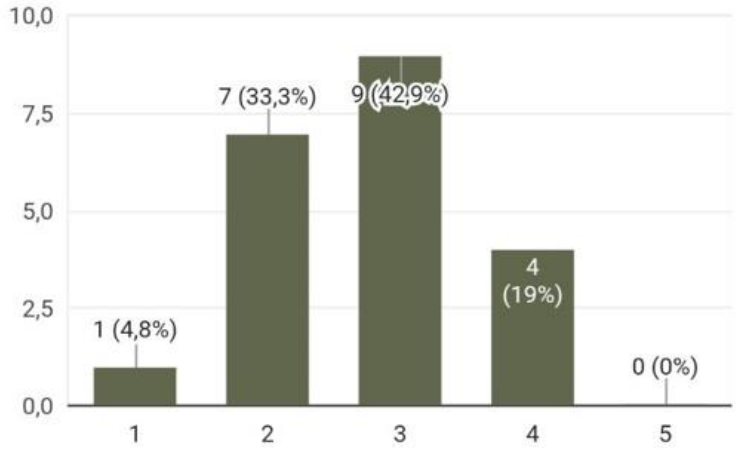
To the question, **"At what level is the responsibility for disaster risk management established?"** out of 21 respondents, 9 rated with a score of 2, which represents 42,9% of the total sample, 6 responders gave a score 3 (28,60%), 3 responders gave a score 4 (14,3%), while 2 participants gave a score of 2, accounting for 9,5% of the total sample. Only one respondent rated the *establishment of responsibility for disaster risk management* with a score of 1 (4,8%/).



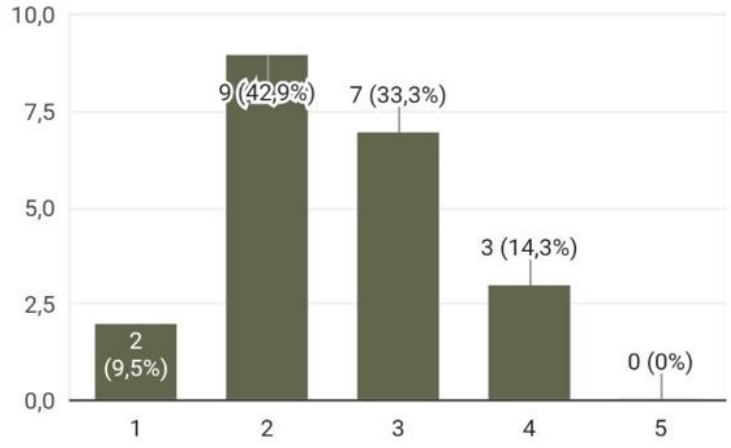
To the question, **"At what level is the existence, capacity, and effectiveness of a city's emergency and disaster response plan?"** out of 21 respondents, 9 rated with a score of 2, which represents 42,91% of the total sample, 8 responders gave a score 3 (38,10%), while 2 responders rated with scores 4 (9,5%) and 5 (9,53%).



To the question, **"How is the response system set up in terms of comprehensive and equipment for all specified natural hazards?"** out of 21 respondents, 9 rated with a score of 3, which represents 42,9% of the total sample, 7 responders gave a score 3 (33,30%), 4 responders gave a score 4 (19,0%), while 1 responder gave a score of 1, accounting for 4,8% of the total sample.



To the question**, "At what level is the update of the disaster response system set in municipality?"** out of 21 respondents, 9 rated with a score of 2, which represents 42,9% of the total sample, 7 responders gave a score 3 (33,3%), 3 responders gave a score 4 (14,3%), while 2 participants gave a score of 1, accounting for 9,5% of the total sample.



Part B_ Rate the responsibilities for disaster risk management and climate change management at the level of the city of Niš:

In relation to each of the questions asked, 60-85% of respondents gave a score of 2 (very low level) and 3 (average level)

4. Conclusions

The **UHI Risk and Vulnerability Assessment** for a city of Niš and selected pilot zone in the City of Niš/City Municipality Medijana was conducted to test the methodology and tools. After completing Activity 1: '**UHI Methodology Workshop for Local Application and Testing**' in November 2024, and midway through Activity 2: '**Methodology and Tools Testing – Conducting Vulnerability and UHI Risk Assessments**' (January 2025), we can conclude the following:

1. **Urban Climate**

   Available point-based and coarse-resolution spatial climate data do not allow for a detailed analysis of the urban climate. The World Bank's City Resilience Program (CRP) website (https://wbcrp.shinyapps.io/crc_workshop_western_balkans/) provides insights into UHI hotspots, but the data can only be viewed, not downloaded. A more comprehensive hazard (and exposure) analysis would benefit from access to surface temperature data from the WB website. Additionally, 22 available data layers contain spatial information about the city, supporting assessments using Tools 1 and 3.

2. **Tool 1 – Exposure of Buildings and Surroundings**

   The proposed methodology for assessing Tool 1 is applicable at the city and city municipality level, as data are available for most indicators. However, data related to greenery, especially trees, are lacking, which is one of the key indicators for assessing UHI risk. On the other hand, the existing data are often viewed partially, so it is necessary to establish a planning framework and mechanisms for implementing multi-criteria analysis of UHI assessment that would be applicable in practice.

   For the purposes of this project, a preliminary comparative analysis of key urban indicators at the city level was carried out - land use, population density and occupancy index. It indicates that possible areas that would be exposed to negative impacts of UHI are the following: central city core (especially the parts that are south of the Nišava River and the fortress park, such as the area around the Kalča shopping and business center, the central pedestrian street and the part of the main square), the North industrial zone (potentially North-2), the industrial and warehouse zone towards Niška Banja, the railway junction, etc. Due to the increasing densification of inherited multi-family residential areas and the loss of greenery, the occurrence of UHI can be expected in these areas as well as in newly built residential areas (Somborska) due to the negligible share (or even absence) of green spaces. However, to assessment UHI risk and vulnerability in those areas, a more detailed analysis is needed.

   At the pilot zone level, the possibility of applying the methodology on a smaller spatial scale was examined. The assessment faced difficulties due to the lack of detailed georeferenced data on small spatial scale. The use of national (GeoSrbija) and local (GIS Niš) spatial data bases required additional calculations and observations, making the process inefficient for urban planning.

3. **Tool 2 – Sensitivity of Equipment and Materials**

   The proposed methodology for assessing Tool 2 is generally appropriate at the city and city municipality levels, as key indicators of thermal characteristics of materials, such as thermal conductivity and thermal capacity, are defined at the national level through the "Regulation on the Energy Efficiency of Buildings." However, there are gaps in the data needed for spatial assessment and mapping of green cover, as well as materials used for streets, sidewalks, and building roofs. Currently, such data is unavailable through formal georeferencing systems and can only be gathered through direct observation, as the City/City Municipality lacks a usable georeference suitable for GIS analysis. Additionally, thermal imaging with a thermal camera is essential to gather data on the surface temperatures of materials at the city level.

4. **Tool 3 – Vulnerable Groups**

   The analysis was limited due to the absence of detailed population-related data. All indicators are either directly (Socioeconomic and Health Conditions groups) or indirectly (Infrastructure group) based on the assessed population density. As a result, the vulnerability assessment relies heavily on population density, which may oversimplify social and health-related risks.

5. **Tool 4 – Preparedness and Adaptive Capacity of Cities and Municipalities**

   Regarding the Institutional Factors and Technological Factors & Scientific Knowledge criteria, responsibilities for various aspects of climate change adaptation have been delegated to relevant city and municipal institutions (e.g., secretariats, municipal committees). Climate change issues are addressed in strategic and planning documents. At both the state and city levels, disaster risk data is available. The analysis of computer literacy indicates that representatives of city institutions, as well as citizens, are generally computer literate and capable of using available data and information. Additionally, numerous scientific and other organizations participate in projects aimed at increasing climate resilience. Overall, there is existing capacity to respond to climate change. When these insights are combined with findings from other criteria (e.g., budget allocations for climate adaptation and mitigation actions), a clearer picture will emerge.

   However, the results of the survey conducted for assessment of adaptive capacity within Tool 4 indicate that the adaptive capacity of the local office structure in the city of Niš and the responsibilities for disaster risk management and climate change management are assessed as being at a very low or average level.

6. **Assessment Activities**

   Workshops and participatory events provided valuable insights into data availability, usability, and stakeholder perceptions. A targeted survey should be conducted in the study area to refine the weighting of vulnerability indicators.

The testing process revealed significant gaps in the availability and consistency of data for UHI risk assessment. Existing data sources are too coarse (limited to country/city/municipality level) to support analyses at the neighbourhood- or building-level, highlighting the need for improved data collection and integration.

General conclusions for addressing climate change, UHI risk and adaptive capacity in the city of Niš can be the following:

- Climate change adaptation should not be considered an additional challenge to existing local policies and planning routines, but an opportunity for the city and city municipalities to set relevant future priorities, where systemic activities aimed at UHI would be one of the key ones.
- Policies and investments in the city and city municipalities should be based on improved information and data (local measurements), including quantitative data and an understanding of community actions and adaptive capacities. The lack of data and an appropriate information base is one of the key problems for identifying UHI and for taking systemic planning actions.
- Given limited resources, the initial focus should be on addressing existing shortfalls in infrastructure investment and basic services (e.g. in urban greening, replacing of impervious pavement, etc.) through small scale pilot and demonstration projects, as well as programs based on the dispersed application of smaller-scale measures (e.g. green waals, green roofs, urban pockets, etc.).
- Enhanced collaboration with the administrations of city and city municipalities, as well as with the academic institutions and local communities is crucial to the success of long-term planning.
- Capacity building should be emphasized at every level. The capacity-building and community-led actions must be even.

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Annexes

Annex A

Local participative event "Local Methodological Workshop - Urban Heat Islands"

Date: 29.10. 2024.

Place: Niš, SKIP center

1. Brief description of the Local participative event activities and outcomes

The City of Niš organized a one-day workshop entitled "Local Methodological Workshop - Urban Heat Islands", whichwas held at the SKIP Center (Trg Kralja Milana 8, Niš), starting at 10:30 am.

This workshop is the first in a series of activities implemented within the “Be Ready” project which is supported by the INTERREG Danube Region Programme, and co-financed by the European Union. The project deals with the assessment of the risk of urban heat islands, which arise due to the high

construction of cities, sidewalks, roads and buildings that retain heat and thus affect the increase in air temperature in the cities.

At the workshop, which was attended by representatives of the public, civil and business sectors and the academic community, participants were informed about the project objectives - the project will develop a methodology, prepare a report on the level of vulnerability and risk of heat islands, and present one of the potential innovative measures for reducing urban heat island effects. In cooperation with partners from 12 European countries and the Science and Technology Park Niš, capacities for climate change mitigation and management will be developed, thus creating the foundations for future development and investments in green infrastructure and adaptation to European Union policies in the field of environmental protection.

The main goal of the workshop was to initiate the development of a model for a comprehensive analysis of patterns and effects of urban heat islands and to identify relevant vulnerability indicators, as well as to familiarize with the methodology that will be applied in subsequent project activities. In addition to getting acquainted with the topic and activities of the project, the participants of the workshop discussed the expected results, and through an active discussion, past experiences and available data in the field of combating climate change were exchanged.

As external engaged team, experts from the Faculty of Civil Engineering and Architecture University of Niš (GAF) participated in the implementation of the workshop. GAF team members prepared and delivered two lectures on climate change and its mitigation in the context of Niš, as well as on the review of UHI assessment data and indicators and the assessment of local stakeholder participation:

1. ''The Niš context on climate change and climate change mitigation: Challenges and responses related to urban heat islands'', Dr. Borislava Blagojević, Assoc. Prof.
2. ''Data review and participation assessment: Organized data collection processes; what stakeholders can contribute to data collection by reviewing urban heat island assessment indicators'', Nikola Đokić, M.Sc.Civil Eng.

The lectures were sent to the Client in electronic version before the workshop and are available to all interested stakeholders.

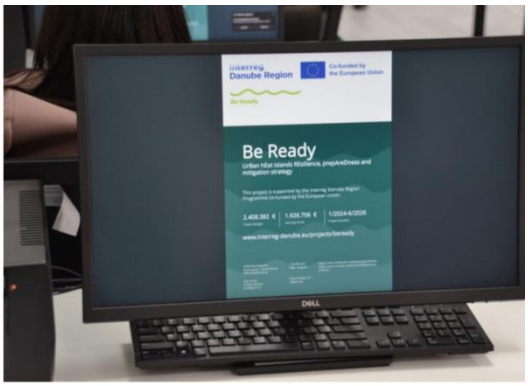
Using tools for visualizing data on climate change vulnerability, the lecturers pointed out to the workshop participants the importance that data visualization itself can have in the process of adapting to climate change.

Also, the lectures presented predictive scenarios and simulations of the impact of climate change and UTO effects on economic development, the environment and quality of life, thereby informing the workshop participants about the importance of using data and data visualization in the decision-making process and development policies related to reducing the negative effects of UTO. Additionally, the lecture presented a preliminary overview of available databases and performed a rapid analysis for vulnerability assessment.

The workshop was attended by a large number of stakeholders from the business, public, scientific and research sectors and the civil society. At the end of the workshop, they were invited to sign the Local Coalition Pact, the text of which was prepared by the Contracting Authority (OLED).

NOTE: Example of an Evaluation survey, Agenda and contact list are a part of Contracting Authority - OLED Niš Participative Event Report.

2. Photos



Annex B

Local participative event "Urban heat islands - resilience, preparedness and maintenance strategy - Be Ready"

Date: 05.12.2024.

Place: Niš, Niš City Hall and Faculty of Civil Engineering and Architecture University of Niš

1. Brief description of the Local participative event activities and outcomes

On December 5, 2024, a Local Participatory Event was held, consisting of two parts. The first part took place in the Hall of the City Hall, while the continuation was held at the Faculty of Civil Engineering and Architecture, with active participation from the academic community of the City of Niš. The Local Participatory Event was organized in accordance with the project task table of the "Urban Heat Islands – Resilience, Readiness, and Maintenance Strategies – Be Ready" project, Activity A1.3 "Implementation of UHI Risk Assessment", and as part of the contractual obligation of external collaborators from the Faculty of Civil Engineering and Architecture of the University of Niš, as part of Activity 2 "Testing Methodology and Tools: Implementing Vulnerability and Urban Heat Island Risk Assessments."

At the event in the Hall of the City Hall, which started at 12:00 PM, representatives from the academic community, civil and business sectors, as well as representatives from institutions and media, attended. Public sector representatives included the Regional Development Agency "JUG", the Regional Chamber of Commerce of the Niš, Pirot, and Toplica Administrative Districts, the Public Utility Company "City Heating Plant", the Urban Planning Institute of the City of Niš, and the Public Utility Company "Mediana" Niš. The academic community was represented by the Faculty of Civil Engineering and Architecture, the Faculty of Mechanical Engineering in Niš, and the Academy of Technical and Vocational Studies.

Representatives from the civil sector included organizations such as Deli, the Local Foundation Niš, PROTECTA, Eneca, and Green Key, while the business sector was represented by the NiCAT cluster, the dairy "Milk House", Jugo-Impex d.o.o., and Banker radio. All attendees were also signatories of the Local Participatory Agreement. The Local Coalition Agreement was signed by 19 institutions in the city, including public (7), civil (5), business (4), and academic (3) sectors. The goal of this agreement is to establish strong and strategic cooperation in efforts to mitigate the effects of urban heat islands. Project partners, representatives of the Niš Science and Technology Park, the Chief City Urban Planner Lidija Stefanović Nikolić, and Deputy Mayor Luka Gašević were also present at the event.

Deputy Mayor Luka Gašević opened the event with introductory remarks, emphasizing the importance of this initiative for improving the quality of life for citizens by reducing the effects of urban heat islands caused by climate change and expressing gratitude to all signatories of the agreement. Following him, Ivana Knežević Spasović from the Office for Local Economic Development of the City of Niš presented the Be Ready project, while Ivana Miljanović, also from the Office for Local Economic Development, introduced the Local Coalition Agreement and the survey intended for participants.

The participatory aspect of the event was reflected in the implementation of a survey, which is part of tool 3 of the project – vulnerable groups and vulnerability index, thus collecting additional data for the

City of Niš's Report on Urban Heat Island Risk Assessment through the "Be Ready" project. After completing the survey and the subsequent discussion, the Deputy Mayor formally presented the Local Coalition Agreement, one of the first results of this European initiative. On this occasion, he once again highlighted the importance of the issue of climate change and the mitigation of urban heat island effects for the well-being of citizens and thanked all attendees for their support. Local media and the city PR team attended the event, ensuring broader visibility of this important event. A statement for the media was given by Ivana Knežević Spasović from the Office for Local Economic Development of the City of Niš, representing the "Be Ready" project. Over 10 publications about the event were published by 6 local media outlets and the city PR team.

The second part of the Local Participatory Event was held at the Faculty of Civil Engineering and Architecture and lasted two hours. The event was attended by 16 undergraduate and master's students from the architecture department, along with three professors and two assistants form an expert team engaged by the City of Niš, which expertise covers topics related to climate change projects: dr Miomir Vasov, Full Professor, dr Borislava Blagojević, Asssitant Professor, Dr Jelena Đekić, Teaching Professor, Dr Danijela Milanović, Teaching Assistant with PhD, and MSc Nikola Đokić, Teaching Assistant.

The opening speech was given by Ivana Miljanović from the Office for Local Economic Development (OLED) and Milan Krstev from the Niš Science and Technology Park. They introduced the participants to the main goals and significance of the project, while Milan Krstev further presented the methodology applied during the workshop (developed through the "Be Ready" project and authored by the team) and explained in detail all four tools used in the project: buildings and surroundings, equipment and materials, vulnerable groups and vulnerability index, and adaptive capacities. Dr Ljiljana Vasilevska, Full Professor and Dr Danijela Milanović, Teaching Assistant with PhD, had prepared work materials in advance, including graphical templates adapted to the project, clearly highlighting the project and INTERREG Danube Region logos, the City of Niš logo, and a statement about the financing and support of the project by the European Union. The students were divided into four working groups, each supported by one moderator.

During the group work, participants analysed a specific location identified as an possible urban heat island and which could become the subject of analysis and a pilot initiative of the "Be Ready" project for the city of Niš through green intervention. Professors and assistants form engaged expert team provided expert support and coordinated activities aimed at finding solutions to improve these spaces.

The students focused on proposals for white, blue, and green interventions and on all four tools of the methodology, which were specially considered during the workshop for the specific location. After completing the group work, each group presented its results to the attendees.

The students' proposals included specific guidelines for improving public spaces, focusing on sustainability and reducing the heat island effect in urban environments. The presentations were constructive and enriched with innovative ideas, further strengthening the participatory component of the event. At the end of the session, the students filled out a survey and evaluation survey, collecting additional data for evaluating the event itself and the further development of the project for tool 3 of the methodology.

This workshop represented an important step in integrating the academic community into the process of solving urban challenges through the practical application of scientific and research methods. Along with the event that included all signatories of the Local Coalition Agreement, city authorities, and the media, the participation of all key actors (quadruple helix) for the activities following the project was ensured.

2. Target group attendees

Target group		I part - Participants	II part - Participants
Local authority		14	1
Regional authority		2	-
National authority		1	1
Interest groups and NGOs		5	-
Business support organizations		4	-
Cross-border legal body		-	-
General public		-	-
Higher education and research organization		3	7
Media		12	-
Student population		-	16
Summary		41	25
Gender	Woman	17	22
	Man	24	3

3. Local participatory event results

The Local Participatory Event was highly evaluated. We received 19 evaluation forms from students of Faculty of Civil Engineering and Architecture.

To the question, "How would you rate the organization and preparation of the event?" out of 19 respondents, 16 rated the event with the highest score of 5, which represents 84.21% of the total sample, while three participants gave a score of 4, accounting for 15.79% of the total sample.

To the question, "Were the topics covered during the event relevant and interesting to the community?" all 19 participants rated the topics with the highest score, indicating that all topics were highly relevant to them.

To the question, "How would you rate the interaction and engagement of participants during the event?" all 19 participants gave the highest score, confirming that everyone was actively engaged.

To the question, "Were the goals of the event achieved?" all 19 participants responded with the highest score, indicating that all goals were fully achieved.

The final question of the evaluation form was open-ended and invited suggestions for improving future events. Out of 19 participants, six provided responses. All who responded praised the organization and expressed a desire for these events to be held more frequently.

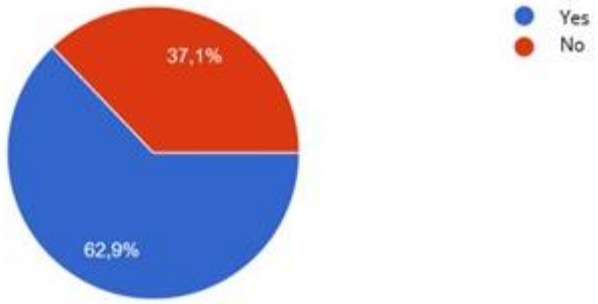
NOTE: Example of an Evaluation survey, Agenda and contact list are a part of Contracting Authority - OLED Niš Participative Event Report.

1. In which part of the city do you live?

35 answers

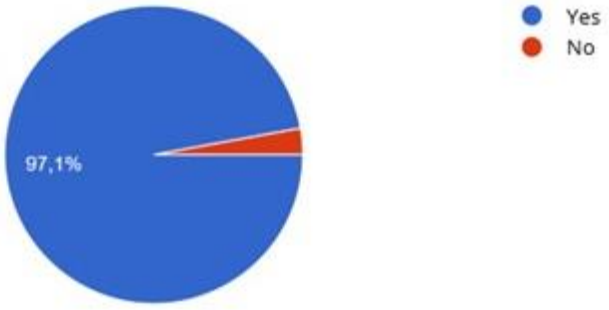
2. Do you find yourself particularly sensitive to heat?

35 answers



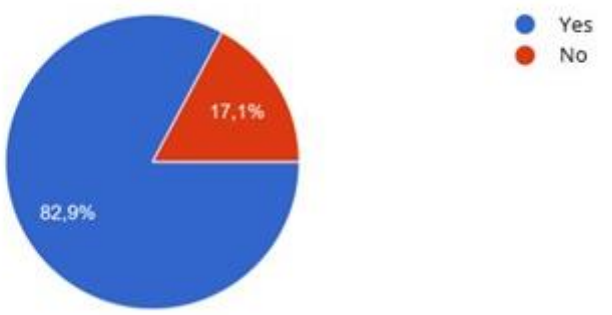
3. Are you familiar with the concept of “urban heat islands”?

35 answers



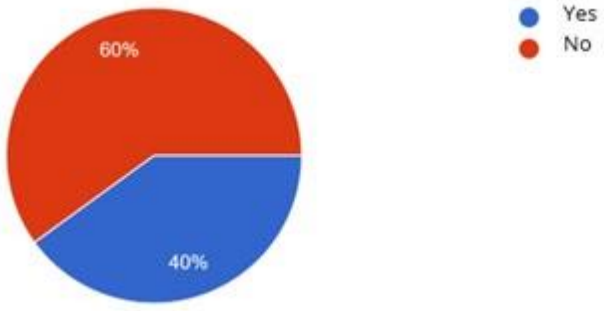
4. Have you ever experienced the effects of “urban heat islands”?

35 answers



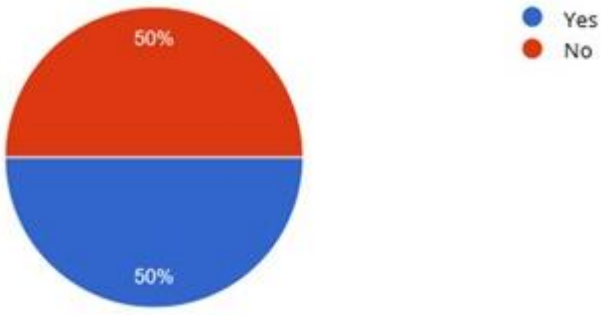
5. If yes, have you experienced heat-related illnesses such heat exhaustion or heat cramps?

35 answers



6. If so, were you able to access health services?

20 answers

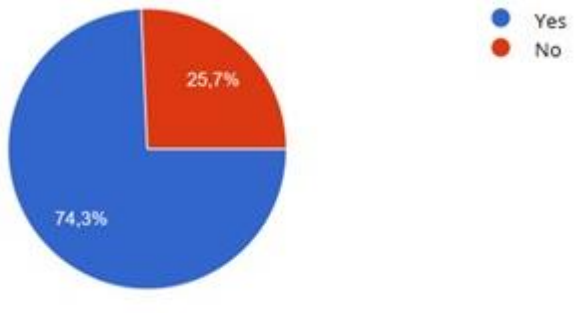


7. How do you deal with high temperatures during summer?

Positive	Negative	Neutral
Lowering the wind, air conditioning	Bad	I dont stay outside for long time
Excellent	Bad, I don't go outside in extreme heat	I don't leave the house unless absolutely necessary
I cool myself	Very difficult	I don't leave the house during the day
When I go out when the sun is strongest, I use the air conditioning and sit in air-conditioned rooms	Extremely difficult	Reduced movement and spending time outdoors
Good	Difficult	I use shading elements
GOOD	Very difficult	Air-conditioned spaces
Staying in air-conditioned spaces, going to the pool...	Very bad	I don't go outside, I drink a lot of fluids
I TAKE NORMAL PREVENTIVE MEASURES	They have a very negative effect on my mood and energy.	I SPEND THE DAY IN AN AIR-CONDITIONED SPACE
	Very difficult	Air conditioning, cold drinks
		By cooling down, regular refreshments and a moderate diet
		I drink plenty of water, cool down, avoid high temperatures during the day

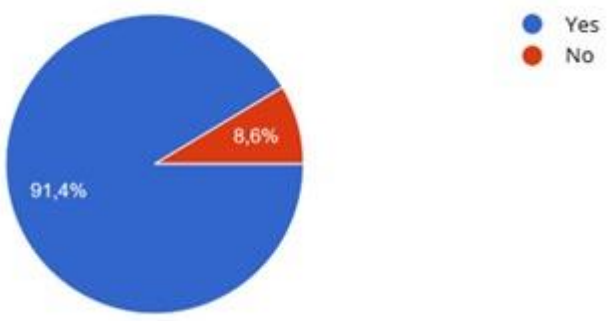
8. Is your home equipped with air conditioning?

35 answers



9. Do you have friend or family you can rely on during extreme heat?

35 answers



10. What are the biggest challenges you face during heat waves?

Problem with health	General	Location problem
Fatigue	HIGH HUMIDITY IN THE AIR	Overheating of residential spaces
HEALTH DISORDERS	Leaving the apartment at noon	Drinking water, watering water
Inability to move in nature	Regular functioning is difficult on a daily basis	Stuffiness of the air
Maintaining energy for work and functioning.	Sudden change in temperature from indoor to outdoor space	Lack of greenery
Health, and those related to mobility, food preparation...	How to prevent overheating of a space	Lack of places (in the city) for shelter and protection from the sun.
Private - health problems	NIGHT	
Problems with sleeping at night, exhaustion, nervousness, dizziness	Business - milk purchase and product cooling	
Performing daily activities	Night temperature	
Performing daily duties, hydration, rest	Lack of air	
Fatigue, poor sleep, dizziness	Inability to go outside during the day.	
Problem with exhaustion	Constantly staying indoors and in an air-conditioned space	
	High temperatures during the night	
	How to complete daily duties	

	Heat shock when moving from the apartment to the outside
	Staying outdoors
	Performing daily activities

11. How do your living conditions (e.g. type of housing, availability of air conditioning) affect your ability to cope with heat waves?	
positive	**negative**
rollers, as well as awnings	Negative, they create an unpleasant stay in the space
No problem, good insulation, heat pump	THEY MAKE IT EASIER BUT NOT ENOUGH
THE APARTMENT IS ORIENTED TO THE NORTH AND DOES NOT HAVE LONG SUN DURING THE DAY	They help to a certain extent, but not enough
favorable	They improve life a bit, but it's still unbearable
They contribute and help to make it easier to bear	Negative (lack of air conditioning and greenery)
Air conditioners have a favorable effect	Difficult
Rollers prevent direct sunlight	Unfavorable
Pretty good	Unfavorable
They allow me to use the air conditioners when necessary.	
GREAT, MY APARTMENT IS OCCUPATIONAL. NORTH	
FOR NOW I'M "COPYING" - THE BUILDINGS ARE NOT ADAPTED TO US	
They help a lot	
I LIVE IN A HOUSE - I CAN TAKE A COOLER PART	
Good insulation of the building provides a comfortable environment to stay in.	
Extremely important - existential	
A well-insulated building, air conditioning has a positive effect	
I don't have an air conditioning but the side of the building is surrounded/protected by other higher buildings	
The air conditioning has a great impact in this "fight"	

The air conditioning helps a lot
Influences
Influences
The air conditioning is the greatest help, without it the temperature is unbearable
The building is surrounded by greenery, but all apartments have air conditioning

12. How does the environment in the neighborhood (e.g. presence of green areas, tree cover) affect your experience of heat waves?	
positive	**negative**
High greenery has an effect on preventing direct sunlight	No trees
Large green areas (urban fields) significantly reduce temperatures and the impact of heat waves	HIGH CONCRETE TEMPERATURES IN SUMMER GIVE A LOT OF HEAT
Tall greenery creates natural shade and prevents direct solar radiation	There are minimal green areas in the immediate environment, so it has an adverse effect.
It eases the heating situation, mitigates heat	Not enough contribution in this sense
Pleasant feeling in the space	They have a positive effect but not enough because green areas are very few
THERE IS GREEN, FORTUNATELY	IT IS MUCH MORE PLEASANT BECAUSE THERE IS GREENERY
Green areas have a great influence and help.	GREEN HELPS, THERE IS LESS AND LESS
They mitigate and help	It does not have a big effect because it does not prevent the effect of heat islands.
TREES AND A WALL OVERGROWN WITH GREENERY ARE PLEASANT TO ME	There is none
It has very little effect, it is better than in the strict city center	Unfavorable
Green areas near the home significantly reduce the effect of heat waves.	Green spaces are minimal, lots of concrete surfaces that cause heat waves
Great impact of green spaces on microclimate	No impact
Positive	
The area I live in is not urban, so the UTO is not pronounced	
Green spaces around the building have a positive impact on reducing heat waves	
Favourable, they create shade, primarily	

It has a great impact because it provides me with a sense of comfort, as well as the possibility of a pleasant walk around the area...
Green spaces are very helpful
The orientation of the space you are in is also important

	13. If you could send a message to local leaders or policymakers about the impact of heat waves, what would you suggest?
1	More greenery
2	More green space and less pavement
3	More green space!
4	LEAVE MORE GREEN SPACE - NTP 2
5	I would recommend that as many concrete surfaces as possible be greened
6	More concrete actions, less talk.
7	Introducing green spaces, designing energy-efficient buildings
8	To introduce a greater number of green spaces, fountains, seating areas in natural shade or summer houses
9	Greening parts of the city that are not green
10	Increasing green spaces, turning to nature
11	TO FORGET ABOUT TIME AS MUCH AS POSSIBLE
12	To approach their work responsibly and with the idea that public open green spaces are necessary in general for the normal functioning of people and that they need to be foreseen to a much greater extent
13	More green spaces and less concrete.
14	FIGHT AGAINST THE IMPACT OF TUESDAY WITH CREATIVE SOLUTIONS FROM GAFA
15	STRATEGIC DOCUMENTS, ACTION PLANS, IMPLEMENTATION AND MONITORING IN PRACTICES
16	FOLLOW THE KNOWN RULES FOR LOW-RISE BUILDING BUILDING AND GOOD (LARGE) REPRESENTATION OF GREEN AREAS. DO SOMETHING IN NEW SETTLEMENTS, FOR EXAMPLE, SOMBOR BOULEVARD!
17	We need to invest more in solving modern environmental problems because this is the main problem of the future and something that directly affects the health of the population

18	Increasing the percentage of green areas.
19	Less violent urbanization
20	When arranging public open areas, do not apply economically viable solutions to them, but strive for what will be environmentally sustainable and oriented towards natural elements such as green and water areas.
21	Less paved areas, use of bioretention systems
22	Reduce the number of buildings without planned green areas
23	Combine paving with greenery, introduce plants, etc.
24	Identify UTO and implement measures to mitigate them
25	More greenery and water surfaces in urban centers would help reduce the impact of heat.
26	Increase green areas, introduce bioretention, water surfaces...
27	Introduce green areas in central city areas...
28	Awareness of these problems should be raised and worked on.
29	Respect for the Paris Agreement

4. Photos