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Urban heat islands vulnerability and risk assessment

City of Varaždin

Specific objective 1	Provide evaluation tools for cities to better understand the causes and effects of the UHI
Activity 1.3:	Testing the methodology and tools in the partner cities: conducting UHI vulnerability risk assessments
Result 1.3.1	City UHI risk assessment reports
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List of abbreviations

BCF - Building coverage factor

BCR - Building coverage ratio

DGU - State Geodetic Directorate

DHMZ - Meteorological and Hydrologycal Service (of Croatia)

DZS - Croatian Bureau of Statistics

EC - European Commission

ESA - European Space Agency

EU - European Union

FAR - Floor area ratio

GIS - Geographical Information System

GUP - General Urban Plan of the City of Varaždin

HEP DOS - Croatian electricity company - Operator distribucijskog sustava d.o.o.

HV - Hrvatske vode (Legal entity for water management)

LST - Landsat 8

NDVI - Normalized Difference Vegetation Index

OSM - Open Street Map

PPUG - Spatial Development Plan of the City of Varaždin

REA - Regional Energy Agency North

UHI - Urban Heat Island

USGS - United States Geological Survey

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1. Introduction

ABOUT THE PROJECT

Nineteen partners from twelve countries, including nine associate partners, are working together to tackle the challenge of urban heat islands (UHIs). The goal is to enhance urban resilience and strengthen society's capacity to adapt to climate change. The project enables the implementation of targeted, small-scale, and context-specific measures in critical urban areas. Pilot projects will test solutions across three key approaches: 'green acupuncture' (vegetation-based interventions), **'white acupuncture' (innovative surfaces and materials)**, and 'blue acupuncture' (new uses of water resources). By developing, testing, and evaluating these solutions, the project fosters knowledge exchange and strengthens the capacity of local and regional institutions to design effective policies and practical measures for addressing the UHI effect.

ABOUT THE REPORT

This report aims to test the assessment methodology, which includes 4 elements of vulnerability (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)

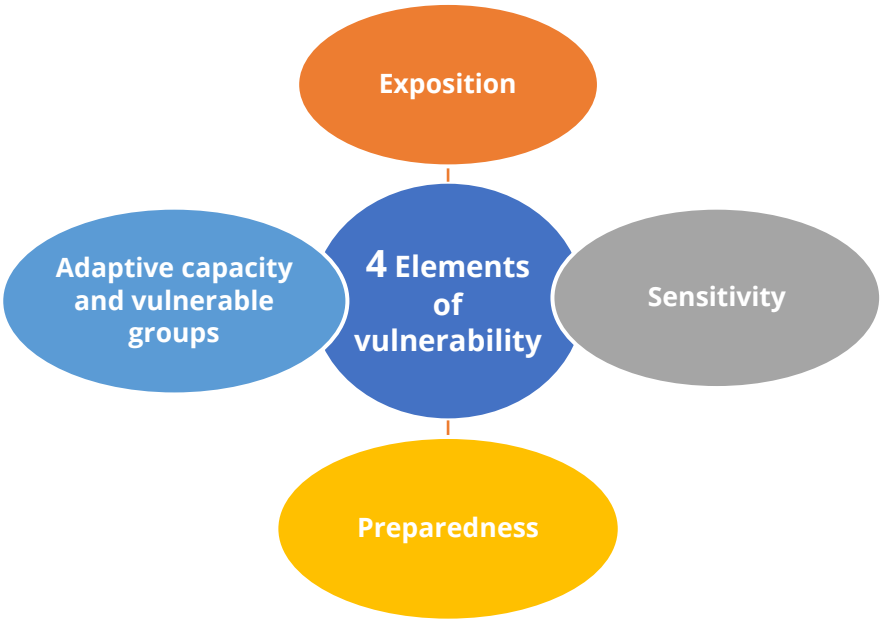

Figure 1 - Four Elements of Vulnerability to UHI

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AREAS OF ASSESSMENT AND INTERVENTION

Territorial context

Republic of Croatia

County of Varaždin

City of Varaždin

Statistics [1]

Area: 59,45 sq. km

Population: 43 782 inhabitants according to the 2011 census

Density: 731 in/sq.km

GDP per capita (€): 6 300 per capita (the 3rd city in terms of GDP in Croatia)

Minimum wage (€/2024): 840,00 (bruto salary for workers in Croatia)

About the City of Varaždin [1]

The city of Varaždin is located at 16°20'33" east longitude and 46°18'29" north latitude. It is located in northwestern Croatia along the Drava River, in a fertile alluvial plain that descends toward the Drava in a southwest-northeast direction. Towards the south, the plain gently rises to Haloze and Varaždinsko - Toplka Gora. The altitude of the area varies between 169 and 173 m.

An excellent traffic location is a great advantage of Varaždin and it is 80 km from Croatian capital city Zagreb, 140 km from Graz (Austria), 180 km from Ljubljana (Slovenia), 250 km from the main Croatian seaport Rijeka, 280 km from Budapest (Hungary) and Trieste (main Italian seaports), and 330 km from Vienna (Austria).

The city of Varaždin is the center of Varaždin County, and the city includes 10 settlements (Črnec Biškupečki, Gornji Kućan, Donji Kućan, Gojanec, Hrašćica, Jalkovec, Kućan Marof, Poljana Biškupečka, Zbelava and Varaždin) with a total area of 5 945 ha (59,45 km2). According to the 2011 census, there are 43 782 inhabitants in the city, of which 47,2% are men and 52,8% are women with an average age of 42,5 years.

The location of the Republic of Croatia in Europe and positon of the City of Varaždin is graphically presented below (Figure 2) .

[1] Source: Official city web page, https://varazdin.hr/zemljopisni-polozaj-varazdina/

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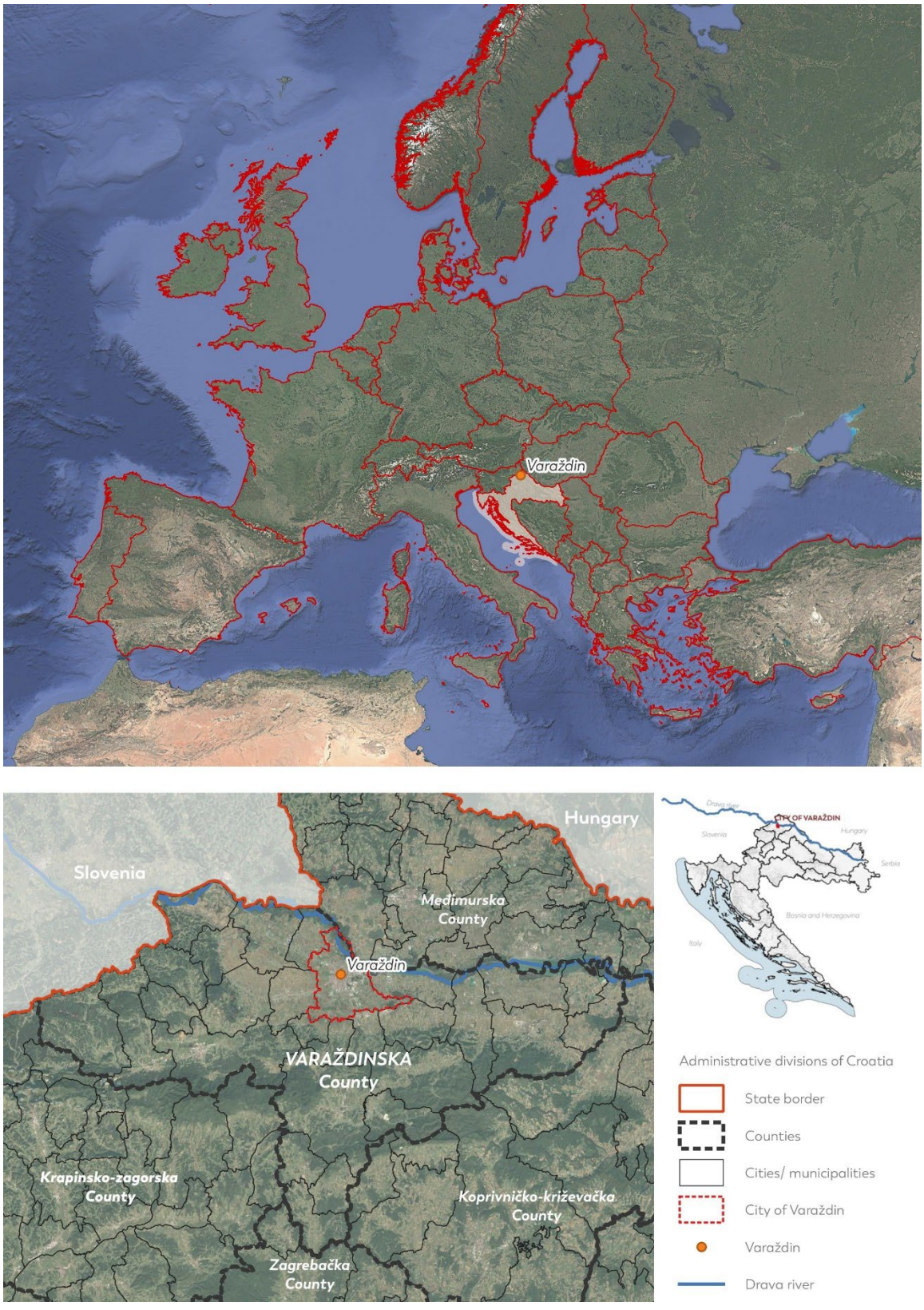

Figure 2 - Location of the Republic of Croatia in Europe and position of the City of Varaždin in Varaždin county (Map base: Google XYZ Satellite Imagery, Map content: GUP and OSM); author: 3 E PROJEKTI d.o.o.)

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2. Methodology of the process

SUMMARY OF THE UHI VULNERABILITY ASSESSMENT PROCESS

The urban heat island (UHI) vulnerability assessment process for the City of Varaždin follows a structured methodology aimed at understanding the causes, effects, and possible mitigation strategies for addressing urban heat accumulation. As part of the BeReady project, which officially started on January 1, 2024, the assessment involves Development Agency North (DAN) as a project partner, with the City of Varaždin serving as an associated partner and supporter. The process began with the establishment of a methodological framework to ensure a systematic approach to identifying UHI hotspots and assessing their impact. A combination of field measurements, climate data analysis, stakeholder engagement, and geospatial mapping was used to evaluate key risk factors. Special attention was given to defining and analyzing spatial characteristics, including urban morphology, vegetation coverage, land use, and socio-economic vulnerabilities. To ensure an inclusive and evidence-based assessment, local institutions and experts were consulted, and a dedicated workshop was held to gather insights from key stakeholders. The final stage of the assessment involved processing all collected data, applying GIS mapping techniques, and compiling the results into a comprehensive risk assessment report. This integrated approach guarantees that the findings provide a strong foundation for future urban planning and policy development aimed at mitigating the UHI effect in Varaždin.

PREPARATORY PHASE

The preparatory phase of the UHI vulnerability assessment was crucial in defining the methodology, securing relevant data sources, and ensuring stakeholder engagement. The project officially commenced on January 1, 2024, with Development Agency North (DAN) as an active partner and the City of Varaždin providing support. The first major milestone was the kick-off meeting in February 2024, where European project partners gathered to discuss the project's objectives, expected outcomes, and methodological approach. This meeting set the foundation for how the risk assessment would be conducted. In July 2024, a second project meeting was held in Vienna, where partners refined the methodology and outlined the structure of the first workshops, as well as the expected framework for the UHI risk assessment. By August 1, 2024, the first field measurements of urban temperature were carried out at multiple locations throughout Varaždin to identify heat hotspots and determine potential pilot areas for mitigation measures. Following this, an extensive data collection effort began, involving collaboration with various local and national agencies specializing in climate monitoring, meteorology, urban planning, and demography. This phase also included gathering satellite imagery, statistical data, and environmental reports to ensure a comprehensive analysis. In October 2024, the first and only workshop held so far in the project brought together local stakeholders from different sectors to

discuss potential mitigation measures and evaluate the available data. From this point forward, the risk assessment process intensified, with data processing becoming a priority. All available information was analyzed, mapped using GIS, and integrated into a structured risk assessment model, meeting the requirements set by the project's scientific partners. The preparatory phase played a fundamental role in ensuring that the assessment would be data-driven, methodologically sound, and relevant for urban resilience planning.

ACTIVITIES

The UHI vulnerability assessment in Varaždin was carried out through a sequence of well-defined activities aimed at ensuring a thorough and precise evaluation of urban heat effects. The process started with the project's launch in early 2024, followed by extensive stakeholder engagement to establish a shared understanding of project goals and methodologies. The first step involved coordinating with project partners and defining the structure of the risk assessment. By mid-2024, methodological refinements were made during a technical meeting in Vienna, clarifying how the workshops and risk assessment framework should be structured. The next key activity took place on August 1, 2024, when field teams conducted the first temperature measurements at multiple locations throughout Varaždin. These measurements helped identify heat hotspots and assisted in selecting a suitable pilot area for testing mitigation strategies. In the following months, research efforts intensified, focusing on acquiring data from meteorological institutions, environmental monitoring agencies, and urban planning authorities. This information was crucial for establishing a clear picture of the city's exposure to urban heat effects. The process also included a stakeholder workshop in October 2024, where experts from various fields provided valuable input on mitigation measures and potential adaptation strategies. Following this workshop, data analysis and GIS mapping became the primary focus, with experts working to visualize and interpret the information in a way that would support future planning efforts. The final stage of the process involved compiling all findings into a structured report that could serve as a reference for decision-makers in the City of Varaždin and beyond. By combining scientific analysis with practical, field-based research and stakeholder collaboration, the assessment was able to provide a robust and actionable framework for UHI mitigation.

TIMELINE OF THE PROCESS

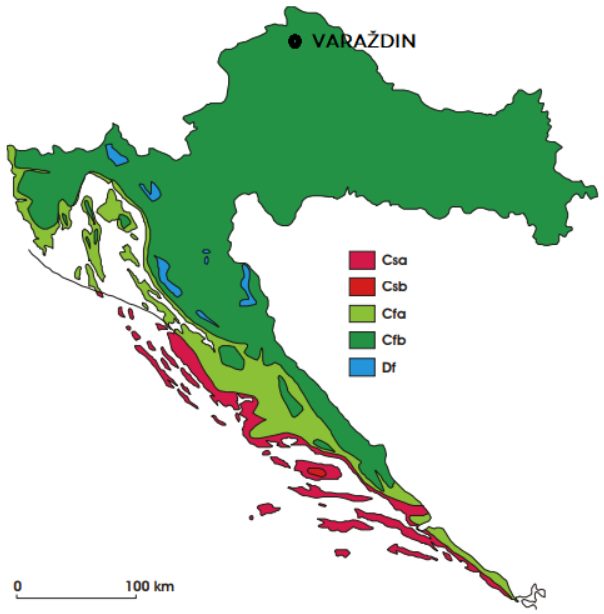
The UHI vulnerability assessment in Varaždin followed a structured timeline that ensured a systematic and comprehensive approach to data collection, analysis, and intervention planning. The project officially started on January 1, 2024, with Development Agency North (DAN) as a partner and the City of Varaždin providing additional support. The first significant event was the kick-off meeting in February 2024, where project partners from across Europe gathered to align expectations, define methodologies, and establish initial guidelines for the assessment. The next major milestone occurred in July 2024, when a second meeting in Vienna helped refine the project's methodological framework and clarified the structure of upcoming workshops and data collection efforts. On August 1, 2024, the first field measurements were conducted at multiple locations across the city to identify heat hotspots and evaluate potential pilot areas for mitigation measures. In the weeks following this, data collection was intensified, with local and national agencies providing critical climate, demographic, and spatial information. By October 2024, the first project workshop was held in Varaždin, bringing together experts and stakeholders to discuss key challenges and potential adaptation strategies. This marked a turning point in the assessment

process, as efforts were increasingly focused on processing, analyzing, and mapping the collected data. From October 2024 onwards, the project entered its most intensive phase, with all available data being integrated into GIS models and spatial analyses to provide a clearer understanding of UHI effects in the city. The final stage of the assessment, currently ongoing in 2025, involves compiling the results into a structured report and developing policy recommendations for future urban resilience strategies. This timeline ensured that each phase of the project was conducted in a systematic and methodical manner, leading to actionable insights that will guide the City of Varaždin in addressing the challenges of urban heat islands.

3. Urban climate

GENERAL INFORMATION AND URBAN CLIMATE TRENDS

According to the geographical distribution of climate types by W. Köppen in Croatia, during the standard period 1961-1990, the area of Varaždin belongs to the climatic zone - Cfb, temperate humid climate with warm summer.



Cfa, temperate humid climate with hot summer

Cfb, temperate humid climate with warm summer

Csa, Mediterranean climate with hot summe

Csb, Mediterranean climate with warm summer

Df, humid boreal climate

Figure 3 - The geographical distribution of Köppen's types of climates in Croatia in the standard period 1961-1990 (Filipčić, 1998)

Climatic parameters for the Varaždin area are presented for the ten-year period from 2013 to 2023 for:

- Air Temperature
- Precipitation
- Humidity
- Wind Speed and Direction

The data was provided by the Meteorological and Hydrologycal Service of Croatia (DHMZ)

Mean monthly values and extremes for air temperature, duration of sunshine and amount of precipitation in the period from 1949 to 2023 are also shown.

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The Climate Atlas of Croatia for the standard period 1961–1990, and for the period 1971–2000 contains climate charts of basic climatic elements. For the area of the city of Varaždin, the data has been extracted and displayed on maps.

Air Temperature

The lowest mean annual temperature was recorded in 2013 and was 11,1 0C, while the highest mean annual temperature was 12,4 0C recorded in 2023. The average annual temperature in the ten-year period varied by 1,3 0C, and the total average temperature was 11,8 0C. The average monthly temperature of the coldest month was recorded in January 2017 and was -4,80C, while the highest was recorded in July 2015 and 2021 and was 23,0 0C.

Average monthly and average annual temperatures of the dry thermometer for the Varaždin area in the period from 2013 to 2023 are shown in detail in the table (Table 1).

Climate charts for mean annual air temperature - extracted part for the Varaždin area are shown below (Figure 4).

Table 1 - Average monthly dry bulb temperature for the Varaždin area (Source: DHMZ)

Average monthly dry bulb temperature (⁰C)													
Year	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Mean**
2013	0,8	0,9	3,5	12,2	15,7	19,4	22,4	21,1	15,1	13,1	6,9	2,6	**11,1**
2014	4,3	4,9	9,3	12,7	15,0	19,3	21,1	19,2	15,8	13,3	8,6	3,8	12,3
2015	3,2	1,7	6,7	11,4	16,4	19,8	23,0	21,9	16,4	10,2	7,3	2,2	11,7
2016	0,7	6,5	6,9	12,3	15,3	19,8	22,1	19,4	17,7	9,7	6,6	-0,5	11,4
2017	-4,8	4,4	9,2	11,2	16,6	21,7	22,7	22,1	14,4	11,3	6,6	3,5	11,6
2018	5,0	-1,1	4,1	15,1	18,2	20,2	21,5	21,9	16,5	12,4	7,2	2,4	12,0
2019	0,9	4,3	8,6	11,3	13,0	22,8	21,4	22,1	16,3	13,0	8,6	4,5	12,2
2020	0,9	7,1	7,0	11,8	14,8	19,2	20,8	21,8	16,7	12,2	5,3	2,8	11,7
2021	2,5	4,6	5,9	9,0	13,5	22,0	23,0	19,8	16,1	9,3	5,7	2,7	11,2
2022	1,4	5,0	4,9	10,0	17,7	22,1	22,3	21,9	15,7	13,0	6,9	3,4	12,0
2023	4,4	3,2	8,1	9,6	15,0	20,2	22,4	21,0	18,4	15,1	7,2	4,1	**12,4**
SUM	19,3	41,5	74,2	126,6	171,2	226,5	242,7	232,2	179,1	132,6	76,9	31,5	129,6
MEAN	1,8	3,8	6,7	11,5	15,6	20,6	22,1	21,1	16,3	12,0	7,0	2,9	11,8
STD	2,6	2,3	1,9	1,6	1,5	1,2	0,7	1,1	1,1	1,7	1,0	1,3	0,4
MAX	5,0	7,1	9,3	15,1	18,2	22,8	23,0	22,1	18,4	15,1	8,6	4,5	12,4
YEAR	2018	2020	2014	2018	2018	2019	2015!	2017!	2023	2023	2014!	2019	2023
MIN	-4,8	-1,1	3,5	9	13	19,2	20,8	19,2	14,4	9,3	5,3	-0,5	11,1
YEAR	2017	2018	2013	2021	2019	2020	2020	2014	2017	2021	2020	2016	2013
AMPL	9,8	8,2	5,8	6,1	5,2	3,6	2,2	2,9	4	5,8	3,3	5	1,3

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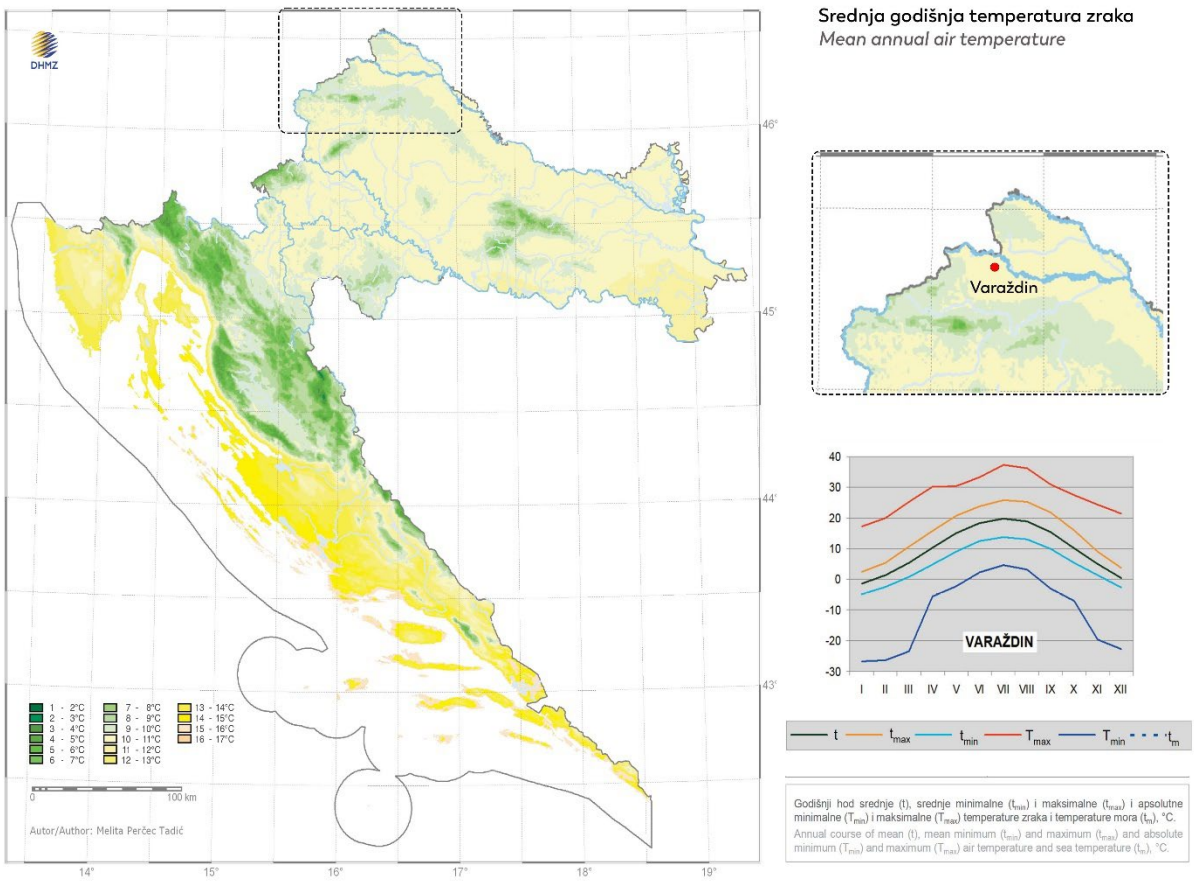

Figure 4 - Mean annual air temperature for the Varaždin area (Source: Climate Atlas of Croatia)

Precipitation

The average annual precipitation over a ten-year period ranged from 827,1 mm to 1312,2 mm. The lowest average amount of precipitation was recorded in December 2015 and was 1,2 mm, while the highest average amount of precipitation was recorded in September 2014.

Average monthly and average annual precipitation for the Varaždin area in the period from 2013 to 2023 are shown in detail in the table (Table 2).

Climate charts for mean annual precipitation - extracted part for the Varaždin area are shown below (Figure 5).

Table 2 - Monthly and annual amounts of precipitation for the Varaždin area (Source: DHMZ)

Monthly and annual amounts of precipitation (mm)													
Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Total**
2013	121,7	128,2	113,4	62,0	95,5	60,4	33,9	103,2	139,4	22,0	214,8	7,4	**1101,9**
2014	48,5	138,6	10,1	105,3	108,5	117,9	133,5	153,1	290,7	96,7	46,5	62,8	**1312,2**
2015	76,1	95,0	15,7	20,7	164,6	78,8	97,5	90,3	102,0	188,4	35,1	1,2	**965,4**
2016	58,2	125,3	68,3	46,1	101,3	106,9	48,9	94,6	34,3	88,0	105,6	8,5	**886,0**
2017	32,4	56,0	20,1	32,5	66,7	84,5	54,0	42,2	242,1	69,0	104,9	88,0	**892,4**
2018	44,1	119,9	92,6	72,6	91,2	85,5	83,2	93,7	105,0	32,4	68,9	9,7	**898,8**

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2019	31,6	26,8	43,1	70,8	209,1	104,4	142,5	93,2	71,6	32,7	144,4	120,0	**1090,2**
2020	29,0	25,9	41,9	23,2	49,9	175,5	205,2	125,0	117,5	154,3	39,7	100,7	**1087,8**
2021	39,9	23,0	23,9	57,9	165,5	18,9	82,4	130,2	59,2	84,5	76,8	72,3	**834,5**
2022	15,0	22,3	6,2	109,3	49,9	77,3	51,1	87,3	211,9	17,3	80,4	99,1	**827,1**
2023	175,0	30,2	76,5	90,4	127,0	125,5	153,4	72,7	48,7	47,8	110,2	78,3	**1135,7**
SUM	671,5	791,2	511,8	690,8	1229,2	1035,6	1085,6	1085,5	1422,4	833,1	1027,3	648,0	**11032,0**
MEAN	61,0	71,9	46,5	62,8	111,7	94,1	98,7	98,7	129,3	75,7	93,4	58,9	**1002,9**
STD	45,4	47,0	34,5	29,3	48,5	38,0	51,3	28,3	80,3	52,6	49,9	42,1	**146,3**
MAX	175,0	138,6	113,4	109,3	209,1	175,5	205,2	153,1	290,7	188,4	214,8	120,0	**1312,2**
YEAR	2023	2014	2013	2022	2019	2020	2020	2014	2014	2015	2013	2019	**2014**
MIN	15	22,3	6,2	20,7	49,9	18,9	33,9	42,2	34,3	17,3	35,1	1,2	**827,1**
YEAR	2022	2022	2022	2015	2020!	2021	2013	2017	2016	2022	2015	2015	**2022**
AMPL	160	116,3	107,2	88,6	159,2	156,6	171,3	110,9	256,4	171,1	179,7	118,8	**485,1**

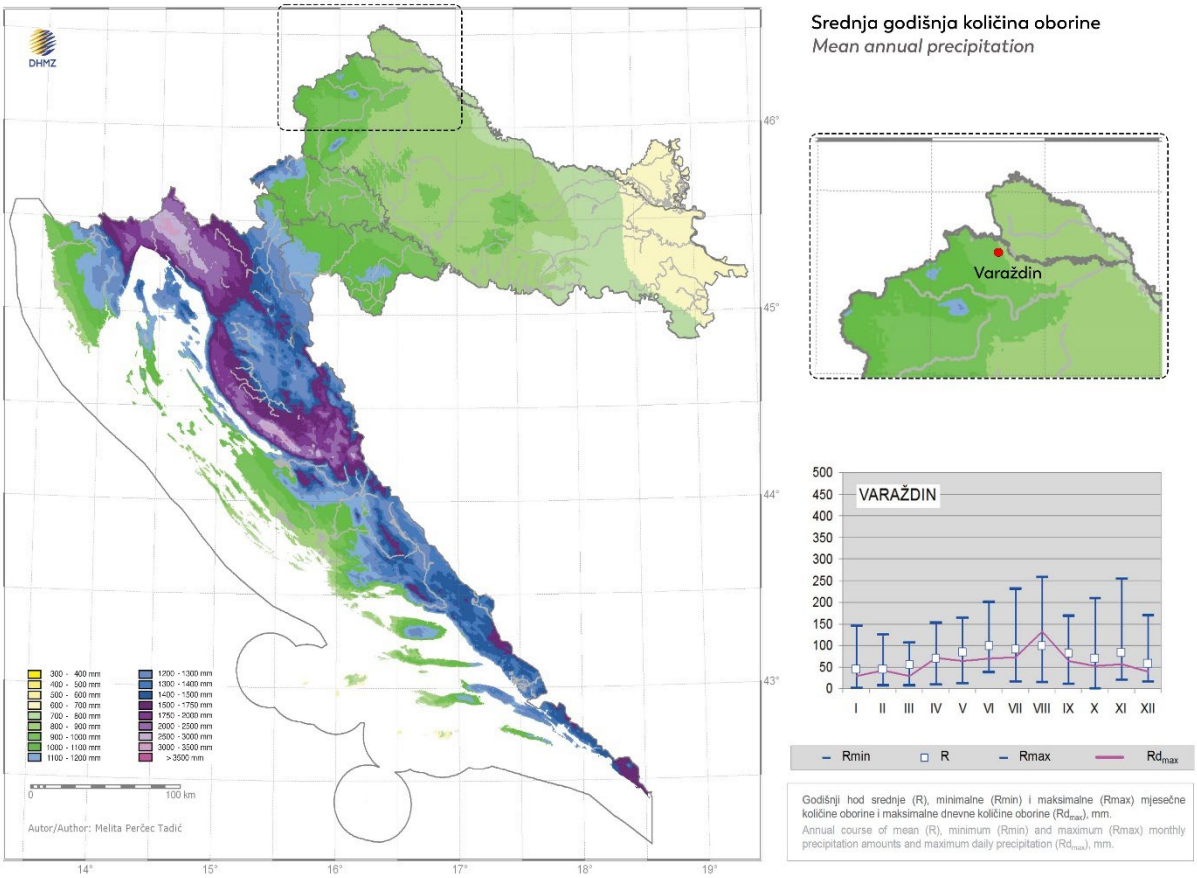

Figure 5 - Mean annual precipitation (Source: Climate Atlas of Croatia)

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Humidity

The average annual relative humidity in the observed ten-year period for the Varaždin area was 75,7%. The highest mean relative humidity recorded in December 2020 was 92%, while the lowest was recorded in June 2021 and was 62%.

The average monthly and annual amount of relative humidity for the Varaždin area in the period from 2013 to 2023 is shown in detail in the table (Table 3). [%]

Climate charts for air humidity - extracted part for the Varaždin area are shown below (Figure 6).

Table 3 - Mean monthly and annual relative humidity for the Varaždin area (Source: DHMZ)

Mean monthly and annual relative humidity [%]													
Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Mean**
2013	86	83	78	68	70	69	63	68	80	77	85	84	**76**
2014	85	84	68	73	69	68	74	77	85	81	86	80	**78**
2015	79	81	66	58	70	67	70	73	72	86	76	90	**74**
2016	80	76	73	63	74	74	70	74	73	81	78	83	**75**
2017	80	76	64	63	66	62	60	66	80	76	77	78	**71**
2018	80	84	79	68	75	72	72	74	78	79	88	82	**78**
2019	78	73	66	71	77	69	75	75	78	79	90	82	**76**
2020	86	68	69	59	66	72	73	76	78	82	89	92	**76**
2021	83	78	67	69	75	62	66	76	77	83	89	86	**76**
2022	80	71	60	69	71	68	63	68	81	86	91	90	**75**
2023	85	77	70	72	78	72	73	79	79	78	82	85	**78**
SUM	902	851	760	733	791	755	759	806	861	888	931	932	**833**
MEAN	82	77,4	69,1	66,6	71,9	68,6	69	73,3	78,3	80,7	84,6	84,7	**75,7**
STD	2,9	5,1	5,5	4,9	4	3,7	4,9	4	3,4	3,2	5,3	4,2	**2**
MAX	86	84	79	73	78	74	75	79	85	86	91	92	**78**
YEAR	2013!	2014!	2018	2014	2023	2016	2019	2023	2014	2015!	2022	2020	**2014!**
MIN	78	68	60	58	66	62	60	66	72	76	76	78	**71**
YEAR	2019	2020	2022	2015	2017!	2017!	2017	2017	2015	2017	2015	2017	**2017**
AMPL	8	16	19	15	12	12	15	13	13	10	15	14	**7**

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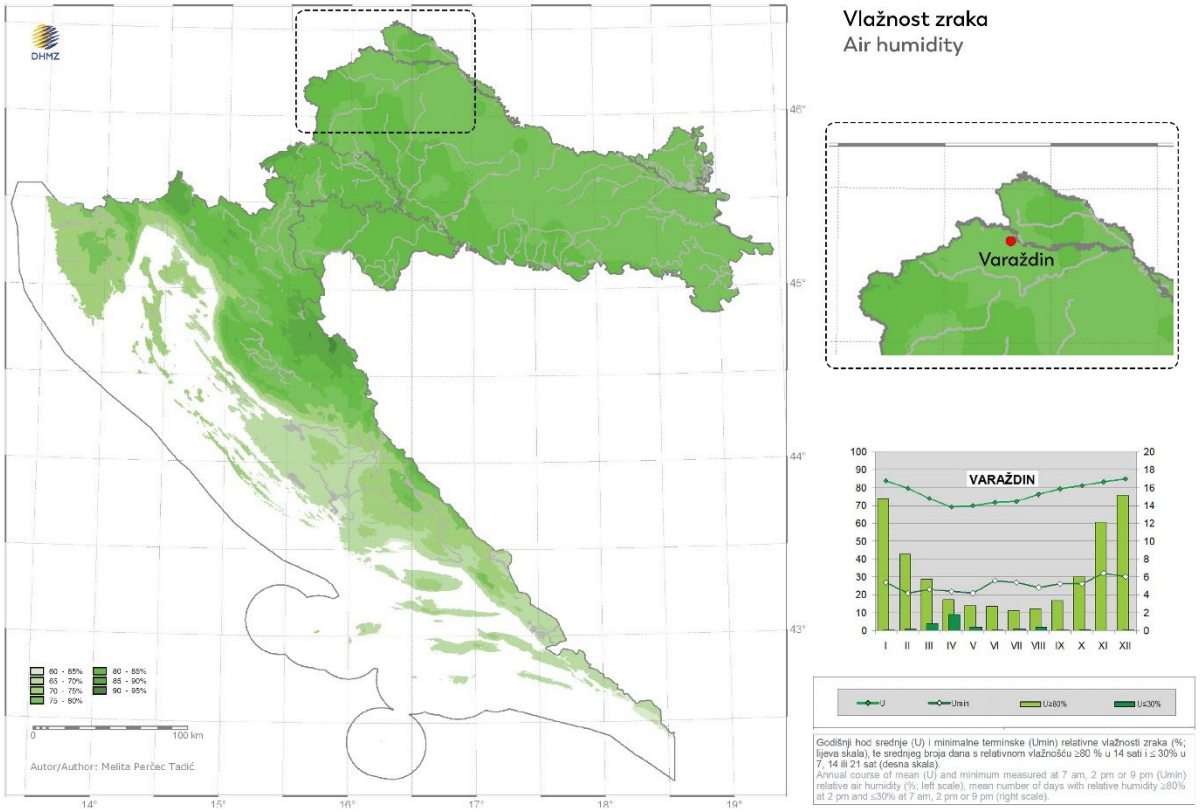

Figure 6 - Air humidity (Source: Climate Atlas of Croatia)

Wind Speed and Direction

The mean monthly and mean annual wind strength in the observed ten-year period for the Varaždin area was 2,1 bof. The highest mean monthly wind strength recorded in February 2020 was 3,4 bof, while the lowest was recorded in December 2015 and was 1,4 bof.

The mean monthly wind strength (bof) for the Varaždin area in the period from 2013 to 2023 is shown in detail in the table (Table 4).

Climate charts for annual distribution of mean hourly wind speed (%) for the period 1981-1990 - extracted part for the city of Varaždin are shown below (Figure 7).

Table 4 - Mean monthly and annual wind strength (bof) for the Varaždin area (Source: DHMZ)

Mean monthly wind strength (bof)													
Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Mean**
2013	1,8	1,9	2,0	2,1	2,2	1,8	1,8	1,7	1,6	1,9	2,3	1,7	**1,9**
2014	1,9	2,0	2,1	2,0	2,7	1,9	1,9	1,7	1,7	2,0	2,1	2,2	**2,0**
2015	2,4	1,9	2,5	2,6	2,2	1,9	1,5	1,6	2,2	1,7	1,8	1,4	**2,0**
2016	1,9	2,3	2,5	2,6	2,2	1,9	1,8	1,6	1,7	1,7	2,2	1,6	**2,0**
2017	1,8	2,2	2,1	2,2	2,0	2,2	1,9	2,0	2,0	2,3	2,6	2,5	**2,2**
2018	2,8	2,8	2,6	2,6	2,2	2,7	2,5	1,9	2,1	2,1	2,3	2,4	**2,4**
2019	2,6	2,6	3,0	2,5	3,0	2,5	2,3	1,9	2,2	2,6	2,2	2,6	**2,5**
2020	2,1	3,4	2,8	2,5	2,7	2,4	2,1	2,1	2,0	2,6	1,6	1,9	**2,4**

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2021	2,2	2,3	2,5	2,5	2,4	1,9	2,1	1,8	1,7	2,1	1,6	1,7	**2,1**
2022	1,8	2,4	1,8	2,1	1,7	2,0	1,9	1,8	2,0	1,5	1,8	1,7	**1,9**
2023	2,3	1,9	2,1	2,2	1,8	1,7	1,8	1,6	1,6	1,9	1,8	1,7	**1,9**
SUM	23,6	25,7	26,0	25,9	25,1	22,9	21,6	19,7	20,8	22,4	22,3	21,4	**23,3**
MEAN	2,1	2,3	2,4	2,4	2,3	2,1	2,0	1,8	1,9	2,0	2,0	1,9	**2,1**
STD	0,3	0,4	0,4	0,2	0,4	0,3	0,3	0,2	0,2	0,3	0,3	0,4	**0,2**
MAX	2,8	3,4	3,0	2,6	3,0	2,7	2,5	2,1	2,2	2,6	2,6	2,6	**2,5**
YEAR	2018	2020	2019	2015!	2019	2018	2018	2020	2015!	2019!	2017	2019	**2019**
MIN	1,8	1,9	1,8	2	1,7	1,7	1,5	1,6	1,6	1,5	1,6	1,4	**1,9**
YEAR	2013!	2013!	2022	2014	2022	2023	2015	2015!	2013!	2022	2020!	2015	**2013!**
AMPL	1	1,5	1,2	0,6	1,3	1	1	0,5	0,6	1,1	1	1,2	**0,6**

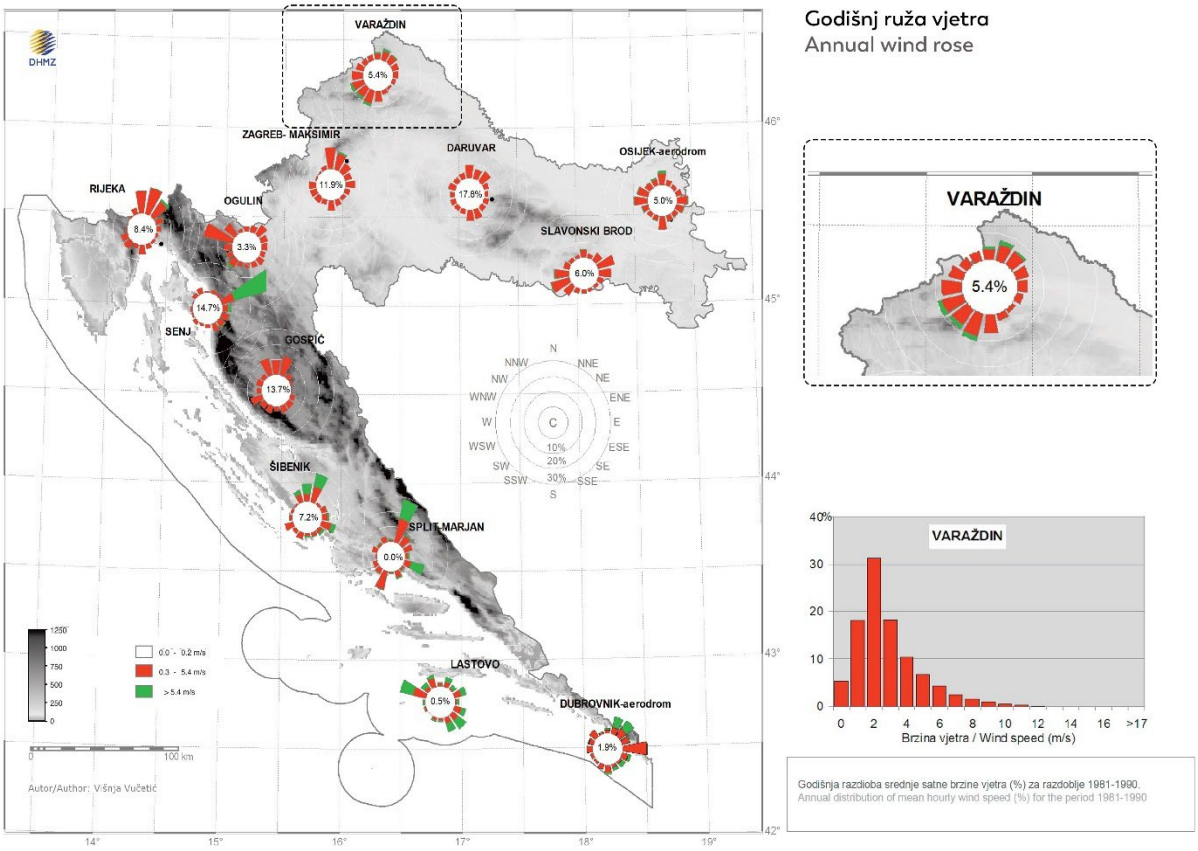

Figure 7 - Annual wind rose (Source: Climate Atlas of Croatia)

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Monthly values and extremes for air temperature, insolation and precipitation

The data in the table show mean monthly value and extremes for air temperature, duration of sunshine and amount of precipitation for the Varaždin area in the period 1949.-2023. year.

Values for Varaždin area in **1949.-2023. period** (Source: DHMZ, https://meteo.hr/klima_e.php?section=klima_podaci&param=k1&Grad=varazdin)

Table 5 - Extremes for air temperature, insolation and precipitation for the Varaždin area (Source: DHMZ)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AIR TEMPERATURE												
Mean [°C]	-0.3	1.7	5.8	10.8	15.5	19.1	20.6	19.8	15.6	10.6	5.6	1.3
Abs. maximum [°C]	19.1	22.5	25.3	30.4	33.2	36.0	39.3	39.4	32.9	28.1	24.3	21.4
Date (day/year)	29 /2002	28 /2019	31 /1989	29 /2012	27 /2008	23 /2003	5 /1950	8 /2013	11 /2011	8 /2023	16 /1963	17 /1989
Abs. minimum [°C]	-26.8	-28.0	-23.4	-6.4	-2.3	2.2	4.7	3.2	-3.1	-7.5	-19.6	-22.7
Date (day/year)	16 /1963	16 /1956	1 /1963	2 /2020	12 /1978	5 /1962	6 /1962	25 /1980	29 /1977	30 /1997	24 /1988	22 /1969
INSOLATION												
Duration [h]	76.1	103.7	150.6	188.4	238.5	256.2	285.0	261.3	191.5	146.2	82.2	63.7
PRECIPITATION												
Total Prec. [mm]	44.8	45.1	49.0	65.1	83.6	94.1	95.5	91.2	92.1	74.3	81.3	59.8
Max. Snow Cower [cm]	52	57	76	10	4	-	-	-	-	3	60	52
Date (day/year)	1 /1970	5 /1963	8 /1955	3 /1970	6 /1957	- / -	- / -	- / -	- / -	28 /2012	30 /1993	1 /1993
NUMBER OF DAYS WITH												
Clear Sky	3	4	5	4	4	4	7	8	7	5	2	2
Fog	8	5	3	1	1	1	1	2	5	9	7	8
Rain	6	6	9	12	14	13	12	11	10	10	11	9
Frost	10	10	10	3	0	0	0	0	0	5	9	12
Snow	6	5	4	1	0	0	0	0	0	0	2	5
Min. Temp ≤ -10°C	4	3	1	0	0	0	0	0	0	0	0	2
Max. Temp < 0°C	8	4	1	0	0	0	0	0	0	0	1	5
Min. Temp < 0°C	24	19	12	3	0	0	0	0	0	3	10	21
Max. Temp ≥ 25°C	0	0	0	1	6	15	21	19	8	1	0	0
Max. Temp ≥ 30°C	0	0	0	0	0	3	6	6	1	0	0	0

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4. Assessing the city against 4 elements of vulnerability: exposure, sensitivity, preparedness and adaptability

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Research area

The boundary of the analysis of urban heat islands is determined for the urban area of the Varaždin settlement, i.e. for the scope of the **General Urban Plan (GUP)** which has established the basic organization of space, the protection of natural, cultural and historical values, the use and purpose of areas with the proposed conditions and measures for their arrangement.

The area under analysis is 2444,63 ha (24,45 km^2), or 35% of the total administrative area of the City of Varaždin.

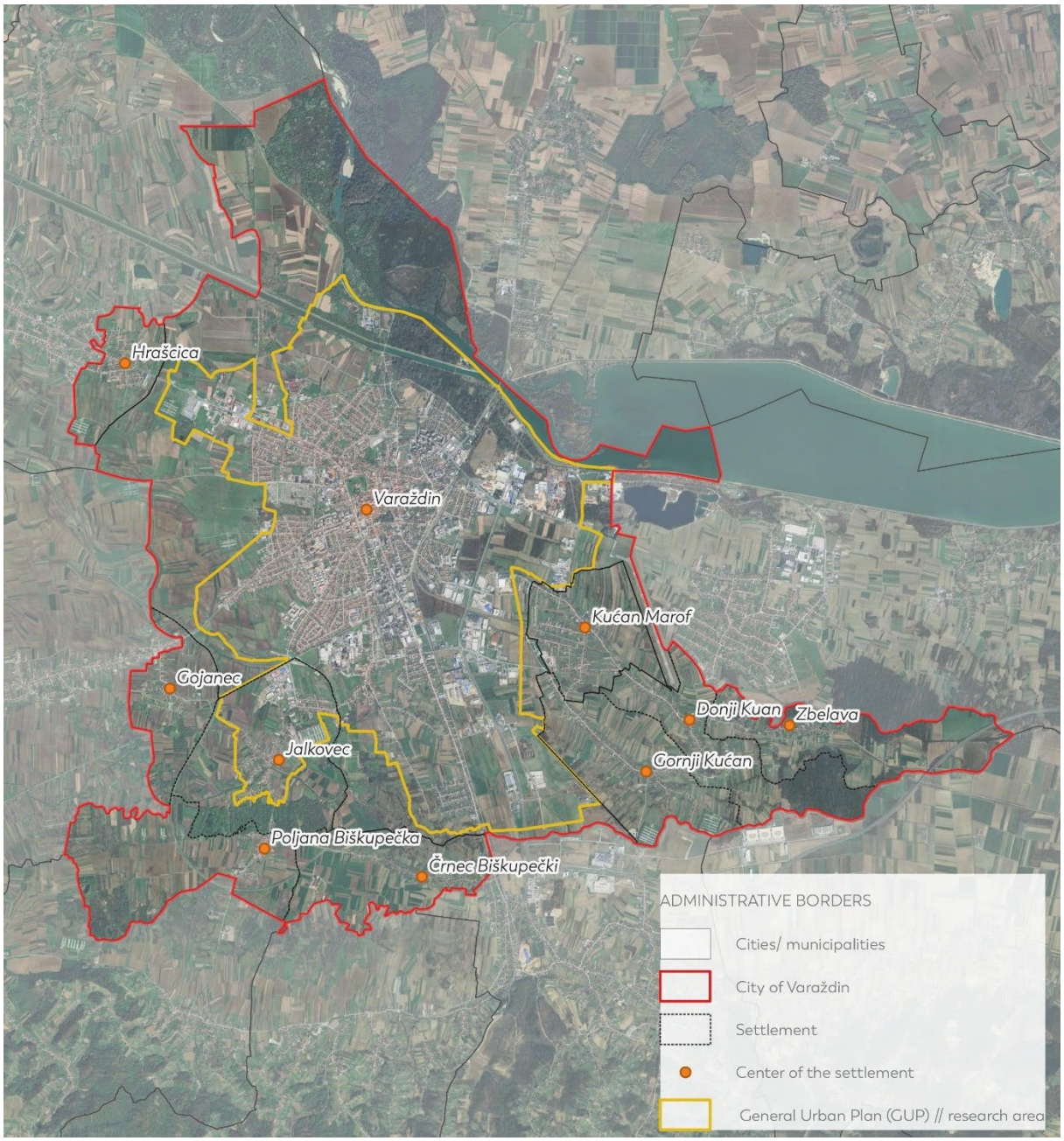

Figure 8 - Administrative division of City of Varaždin (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: PPUG, GUP and OSM, author: 3 E PROJEKTI d.o.o.)

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Trial zone/area for the planned mitigation measure

The trial zone/area for the planned mitigation measure is located north of the city center (main square). The location is surrounded by a local road, parking lots, family houses, and multi-residential buildings. It is graphically presented below (Figure 10).

The area itself is used as an open air market – **a flea market (SAJMIŠTE)** – operating on Thursdays and Saturdays, while on other days, it serves as a passage between two parts of the city.

Figure 9 - Flea market (SAJMIŠTE) on 1.08.2024. (author: 3 E PROJEKTI d.o.o.)

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Figure 10 - Trial zone/area for the planned mitigation measure in research area of GUP (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: PPUG, GUP and OSM, author: 3 E PROJEKTI d.o.o.

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4.1. EXPOSURE OF BUILDINGS AND SURROUNDINGS

4.1.1. Urban morphology

A. Building coverage ratio (BCR)

Building coverage of a parcel refers to the proportion of the footprint area of all buildings on the parcel in relation to the total area of the parcel. This ratio is expressed as a percentage and shows what port of the total area of the parcel is occupied by buildings.

The analysis is based on the cadastre, which was used to calculate the area of parcels and buildings.

The most represented category is < 0.5, covering 37,36% of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 6 - Building coverage ratio (BCR) for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
< 0.5	37,36%
0.5 - 0.6	1,22%
0.6 - 0.7	0,57%
> 0.7	1,09%
Undeveloped area	59,77%

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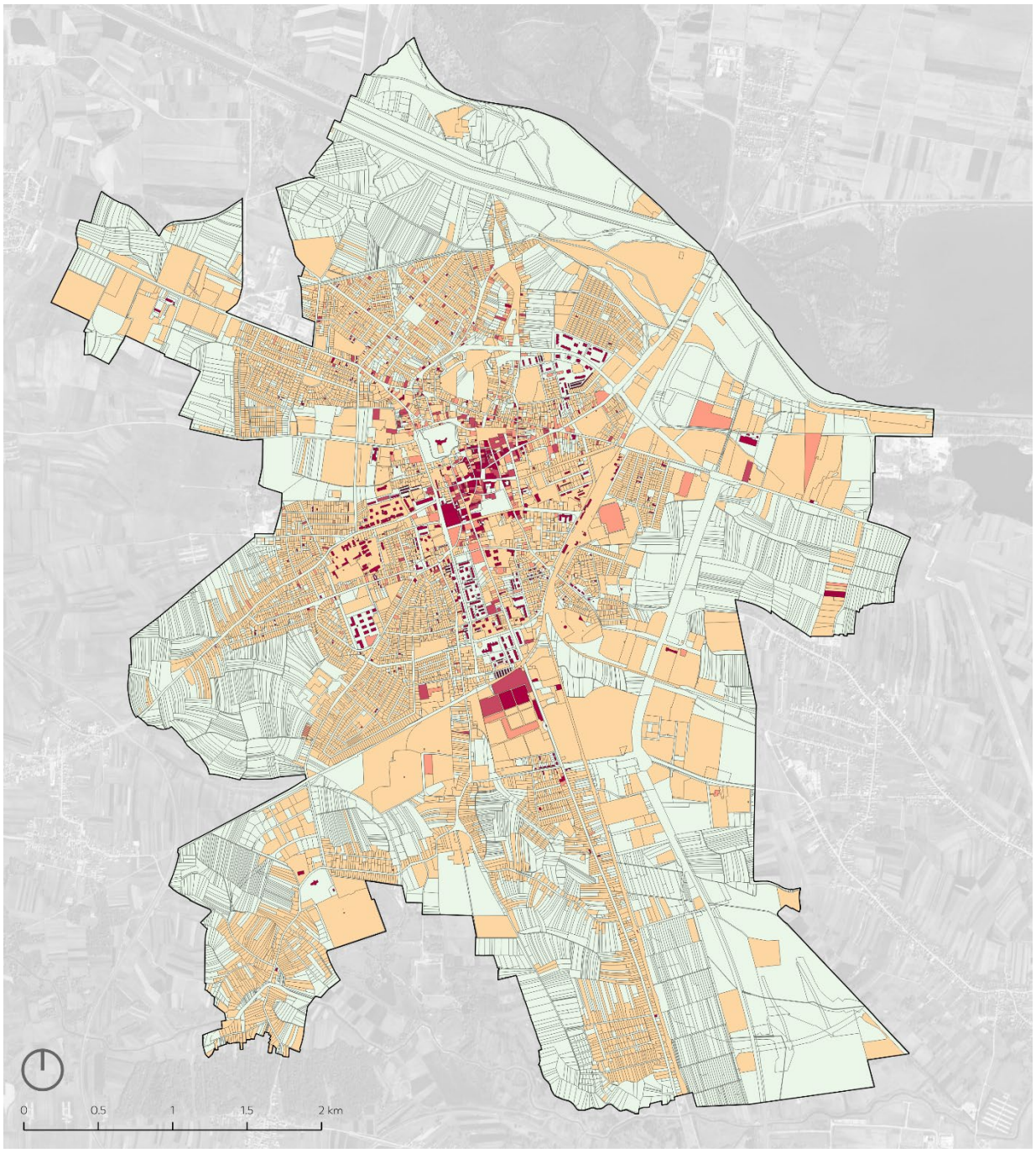

Figure 11 - Building coverage ratio - BCR (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: Display of building coverage ratio (BCR, proprietary data, based on digital cadastre plan, 2024); author: 3 E PROJEKTI d.o.o.)

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B. Floor area ratio (FAR)

Floor area ratio represents the ratio of the total gross building area of all buildings on a plot to the surface area of the plot itself. In other words, it measures how many square meters of space are built on a given land parcel.

For this analysis, gross building area includes only above-ground floors, with building height estimated based on values from the standardized digital surface model (DGU, 2024).

The most represented category is 0,5 -1 covering 12,66 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 7 -Floor area ratio – FAR for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
< 0.25	9,96 %
0.25 - 0.5	8,46 %
0.5 – 1	12,66 %
1 - 1.5	5,17 %
1.5 – 2	1,91 %
> 2	2,04 %
Undeveloped area	59, 77 %

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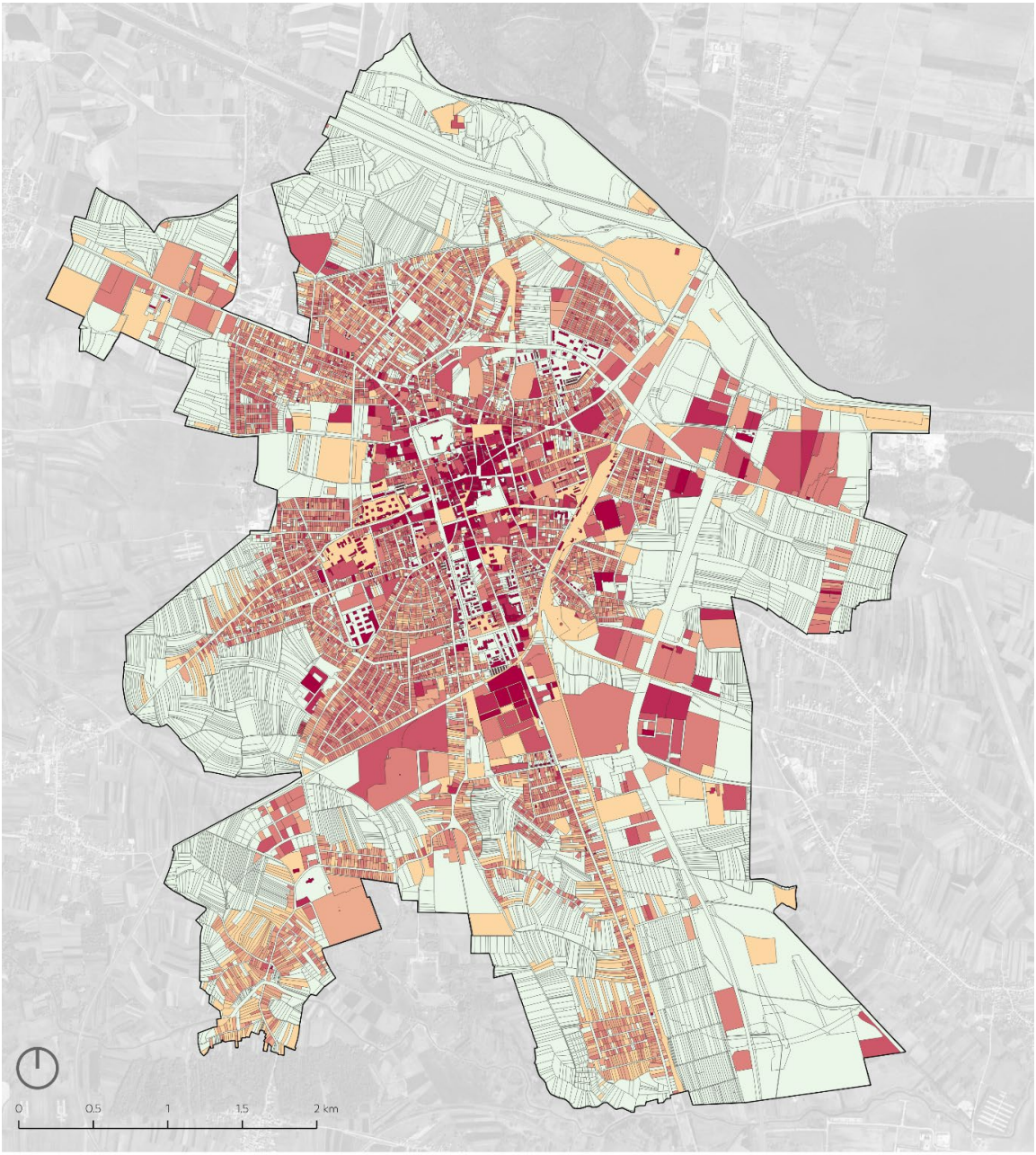

Figure 12 - Floor area ratio – FAR (Mop base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.) Map content: Floor area ratio - FAR (proprietary data, based on the digital cadastre map and digital surface map, 2024.); author: 3 E PROJEKTI d.o.o.)

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C. Street canyon ratio

A street canyon can be defined as a narrow street bordered by toll buildings. The degree to which a particular street can be considered a street canyon can be expressed through the ratio of the overage height of buildings along the street and its width.

The analysis included on assessment of street widths and building heights in the entire area of the GUP of the City of Varaždin, using points located on the rood axis at intervals of 5 m.

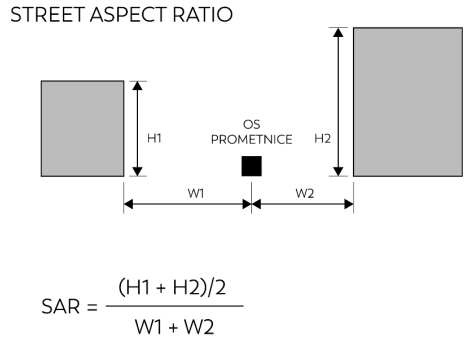

Figure 13 - Schematic representation of the ratio of dimensions of street canyons

For each point, the length of the perpendicular to the objects on their left and right sides was calculated, as well as the overage heights of these objects. Based on this analysis, street canyons were identified in the streets of Ivan Gundulić, Juraj Habdelić, Ivan Kukuljević, August Šenoa, Silvije Strahimir Kranjčevic and Janka Draškovic, and in Gajeva, Bakačeva, and Uršulinska Street.

The cartographic representation shows points classified into six categories according to the ratio of street canyon dimensions.

The most represented category is 0,05 – 0,25, covering 51,97 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 8 -The ratio of dimensions of street canyons for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
0,05 - 0,25	51,97 %
0,05 - 0,25	42,49 %
0,75 - 1,25	3,58 %
1,25 - 1,75	0,98 %
1,75 - 2,25	0,42 %
> 2,25	0,55 %

Points that are not bounded by buildings in a width of 30 m from the axis of the road (in both directions) are not included in the calculation.

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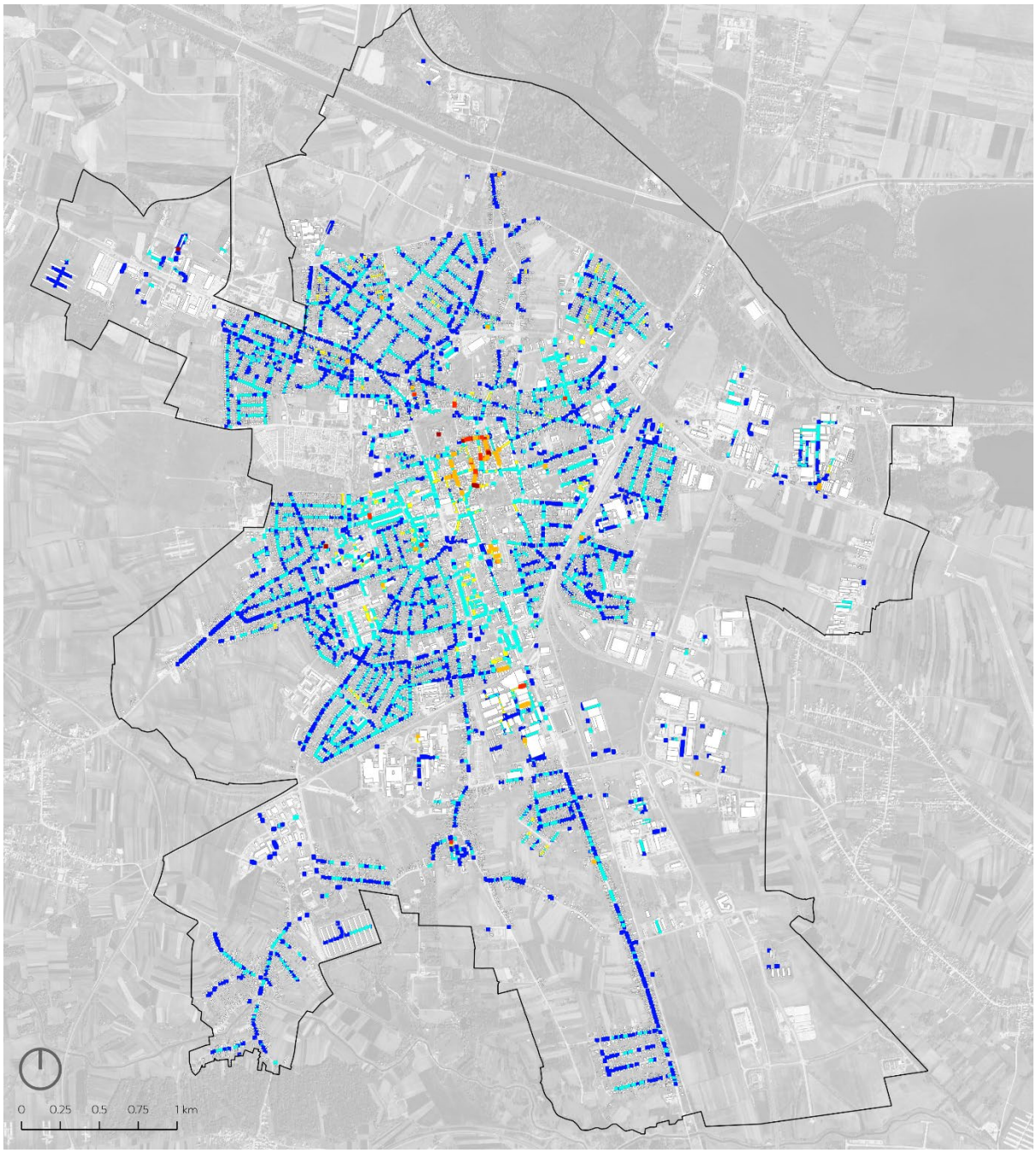

Figure 14 - Street aspect ratio - SAP (Map base: Buildings in the area of the city of Varaždin (proprietary data, based on DGU 2024.), Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: Street aspect ratio - SAP (proprietary data, based on DGU 2024.); author: 3 E PROJEKTI d.o.o.)

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D. Sky visibility factor

Street canyons can also be identified based on the sky view factor in the street space (SVF). The sky view factor represents the ratio between the visible sky and the hemisphere centered above the analyzed location (Oke 7981). This analysis provides insight into the extent to which the view towards the hemisphere is obstructed by surrounding buildings, vegetation, and other barriers (an unobstructed view hos an SVF value of 1).

The sky view factor is calculated using the SAGA GIS "Sky view factor" tool. Used observation points were placed on the oxes of roads at intervals of 5 m.

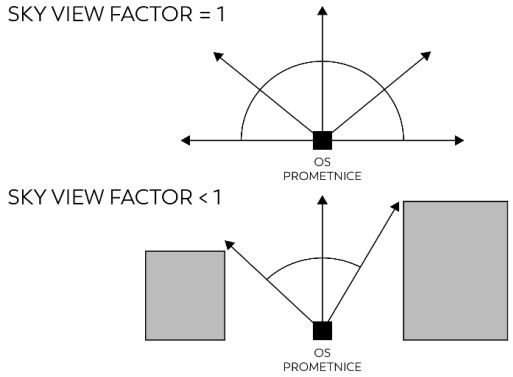

Figure 15 -Schematic representation of the sky visibility factor

The most represented category is 0,75-1,00, covering 92,88 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 9 - Sky view factor for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
0,05 - 0,25	0,24 %
0,25 - 0,50	0,73 %
0,50 - 0,75	6,16 %
0,75 - 1,00	92,88 %

Vegetation cover was not taken into account. Given the available data (nDSM provided by the State Geodetic Directorate - *DGU), this analysis con be carried out in the future taking into account the vegetation cover.*

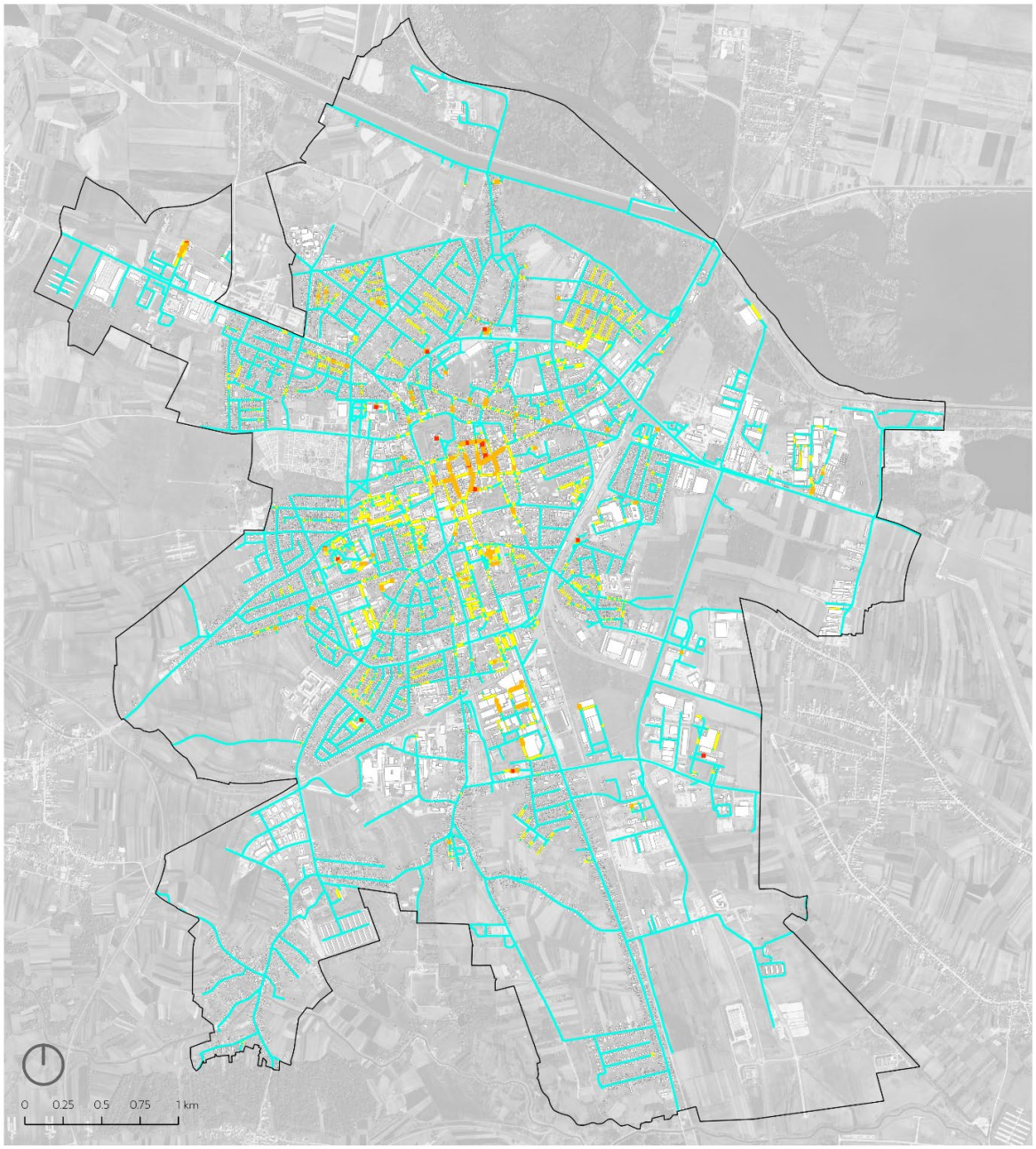

Figure 16 - Sky view factor - SVF (Map base: Buildings in the area of the city of Varaždin (proprietary data, based on DGU 2024.), Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: Sky view factor - SVF (proprietary data, based on DGU 2024.); author: 3 E PROJEKTI d.o.o.)

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4.1.2. Green urban areas and water bodies

A. Green coverage ratio

Vegetation cover analysis

For the assessment of vegetation cover in the GUP area of the City of Varaždin, images from the Sentinel-2 satellite (port of the Copernicus program of the European Space Agency - ESA) were used, with a 10 m resolution, captured on August 12, 2024.

The cover analysis included the calculation of the Normalized Difference Vegetation Index (NDVI), which represents the ratio of near-infrared (NIR) and visible red light reflected by plants. A higher NDVI value indicates greater vegetation density and vitality.

NDVI-o analysis was mode using QGIS tool 'Roster Calculator', with standard formula:

NDVI = (NIR - RED)/ (NIR + RED)

The most represented category is 0,20-0,40, covering 39,80 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 10 -Categories of Normalized vegetation difference index - NDVI for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
-0.14 - 0,00	1,29 %
0,00 - 0,20	29,06 %
0,20 - 0,40	39,80 %
0,40 - 0,60	29,03 %
> 0,60	0,81%

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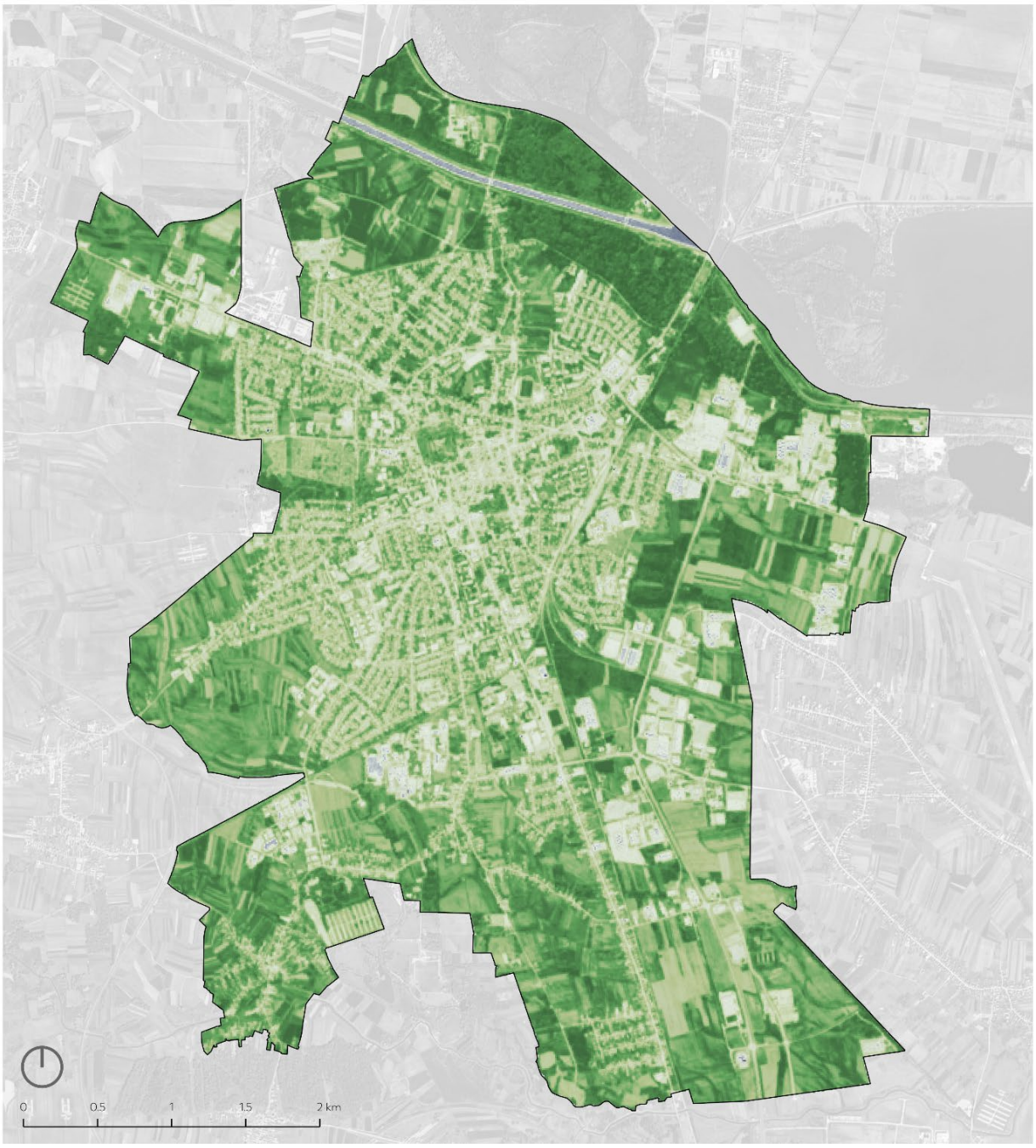

Figure 17 - Normalized vegetation difference index - NDVI (Map base: Sentinel-2 Satellite Imagery (European Space Agency, 2024), Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: Normalized Difference Vegetation Index on 12.08.2024. (proprietary data. based on ESA, 2024); author: 3 E PROJEKTI d.o.o.)

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Vegetation cover analysis - NDVI - high vegetation (summer 2024)

The NDVI calculation from the previous analysis was supplemented with elevation data from the Normalized Digital Surface Model (nDSM), with a 1 m resolution, provided by the State Geodetic Directorate (2024).

All areas higher than 3 m were overlaid with NDVI values greater than 0.2, and the obtained results were further refined using vector data containing the footprint projection of buildings within the GUP area. The final result represents on NDVI visualization for vegetation taller than 3 m.

The most represented category is 0,5 – 0,75, covering 63,44 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 11 -Categories of Normalized Difference Vegetation Index (NDVI) for vegetation toller than 3 m for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
0,25 - 0,50	34,78 %
0,50 - 0,75	63,44 %
0,75 - 1,00	1,77 %

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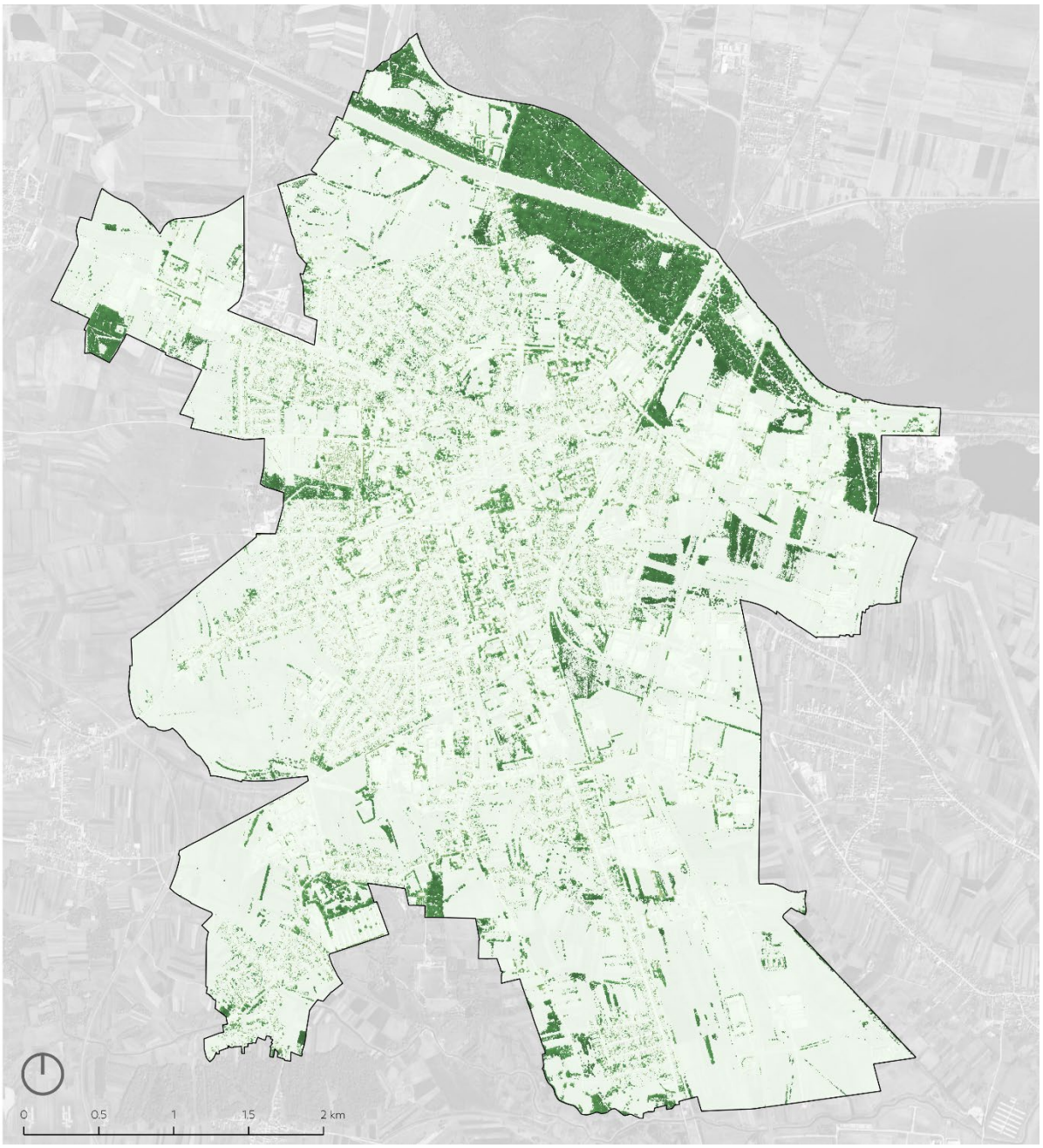

Figure 18 - Normalized Difference Vegetation Index for vegetation taller than 3m (NDVI) (Map base: Sentinel-2 Satellite Imagery (European Space Agency, 2024), Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: Normalized Difference Vegetation Index on 12.08.2024. (proprietary data. based on ESA, 2024); author: 3 E PROJEKTI d.o.o.)

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B. Tree canopy coverage

For the purposes of this analysis, the GUP area of the City of Varaždin was divided into 3,035 hexagonal polygons with a 100 m diameter, within which the presence of toll vegetation was calculated based on the available NDVI data.

The most represented category is 0 – 20 %, covering 78,19% of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 12 - Categories of Tree cover percentage for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
0 – 20 %	78,19 %
21 – 35 %	10,94 %
36 – 52 %	4,35 %
53 – 75 %	2,90 %
91 – 100 %	3,62 %

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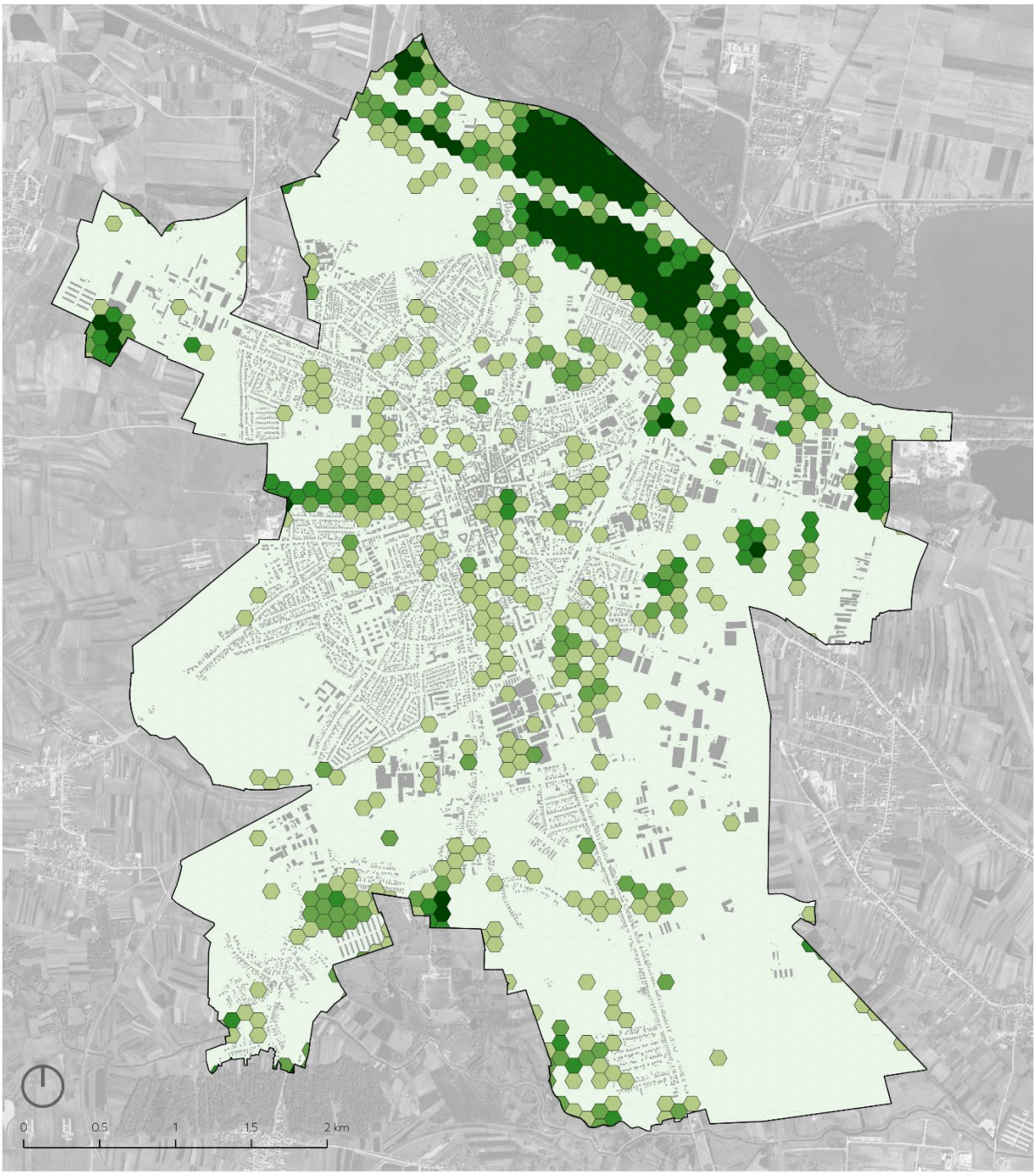

Tree canopy cover percantage

- 0% - 20% (78,19%)
- 21% - 35% (10,94%)
- 36% - 52% (4,35%)
- 53% - 75% (2,90%)
- 76% - 100% (3,62%)

Figure 19 - Tree canopy cover percentage (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: tree canopy cover percentage (proprietory data, based on ESA, 2024.), buildings in the City of Varaždin area (proprietary data, based on DGU, 2024.); author: 3 E PROJEKTI d.o.o.)

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C. Water coverage ratio

Display of water surfaces is based on data from Hrvatske vode d.o.o., the hydrological system within the areo of the General Urban Plan (GUP) of the City of Varaždin consists of the Drava River channel and Varaždin Lake in the north, and the Plitvica River with its smaller tributaries (intermittent streams/channels) in the south. In addition to these, within the scope of the study, there ore also two smaller reservoirs.

Water surfaces in research area (GUP) of the City of Varaždin:

Watercourses

- Plitvica - 0,6 km
- Drava - 4,3 km

Occasional watercourses - 3,1 km

Small lakes / reservoirs

- Ribnjak - 0,4 ha
- castle Jalkovec - 0,8 ha

Water surfaces occupy 1% of the GUP area.

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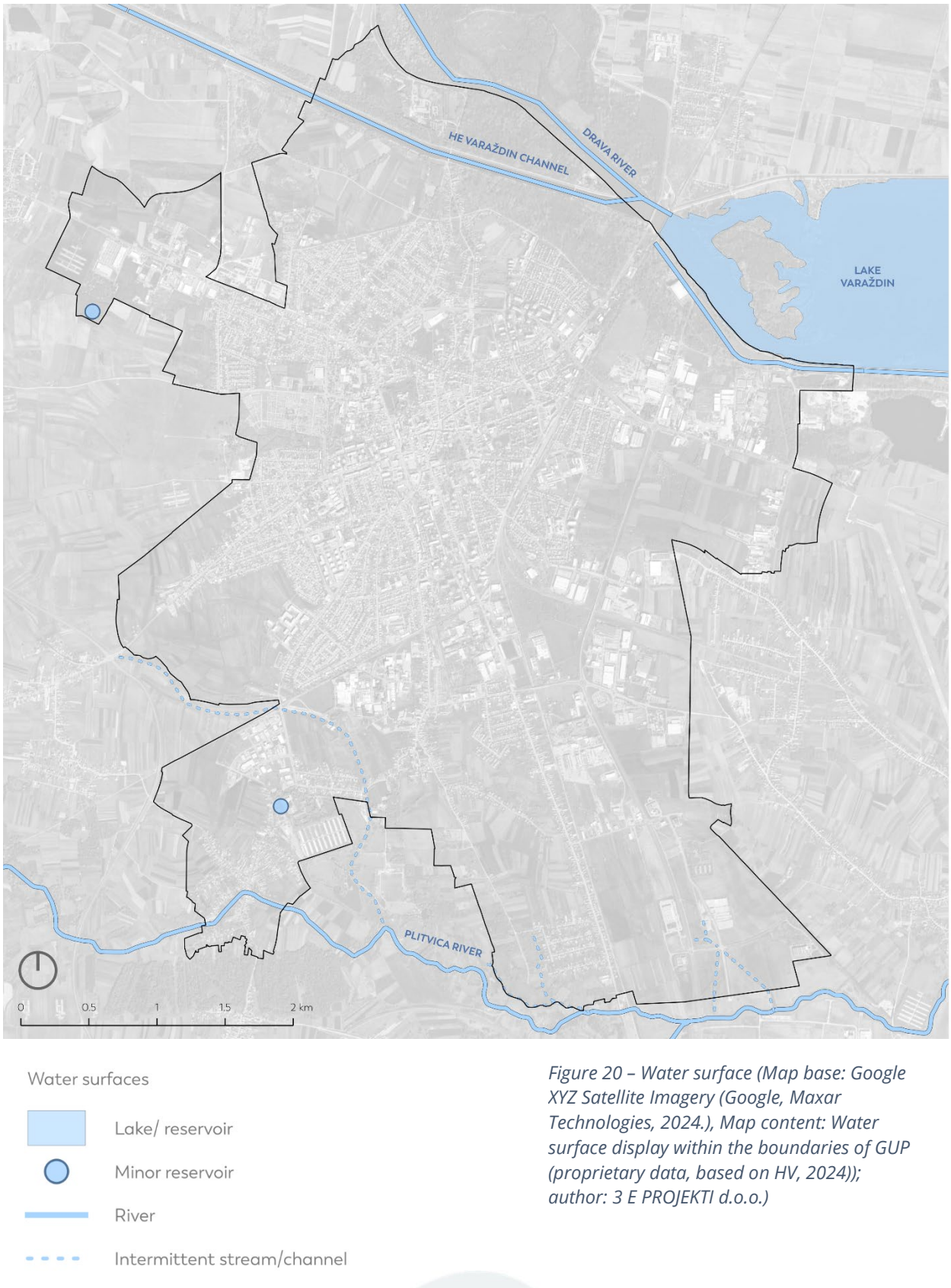

Figure 20 – Water surface (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: Water surface display within the boundaries of GUP (proprietary data, based on HV, 2024)); author: 3 E PROJEKTI d.o.o.)

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4.1.3. Permeability of surfaces

A. Share of permeable surfaces related to impermeable surfaces

For the analysis of the ratio of impermeable surfaces, modified data from the Basic Topographic Database (DGU, 2024) were used, which were classified according to water permeability:

- permeable surfaces (green areas, parks, sports fields (gross), agricultural areas, forests),
- partially permeable surfaces (cemeteries, railway corridor, sports fields (earth surface),
- impermeable surfaces (buildings, roods, parking lots, paved surfaces, sports fields (asphalt, concrete, acrylic).

According to the results, water-permeable surfaces occupy 70,29% of the total area within the GUP of the city of Varaždin, while impermeable surfaces occupy 27,25%.

The most represented category is Permeable surfaces, covering 70,29% of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 13 -Ratio of impermeable surfaces for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
Permeable surfaces	70,29 %
Partly permeable surfaces	1,24 %
Impermeable surfaces	27,25 %
Water surfaces	0,72 %

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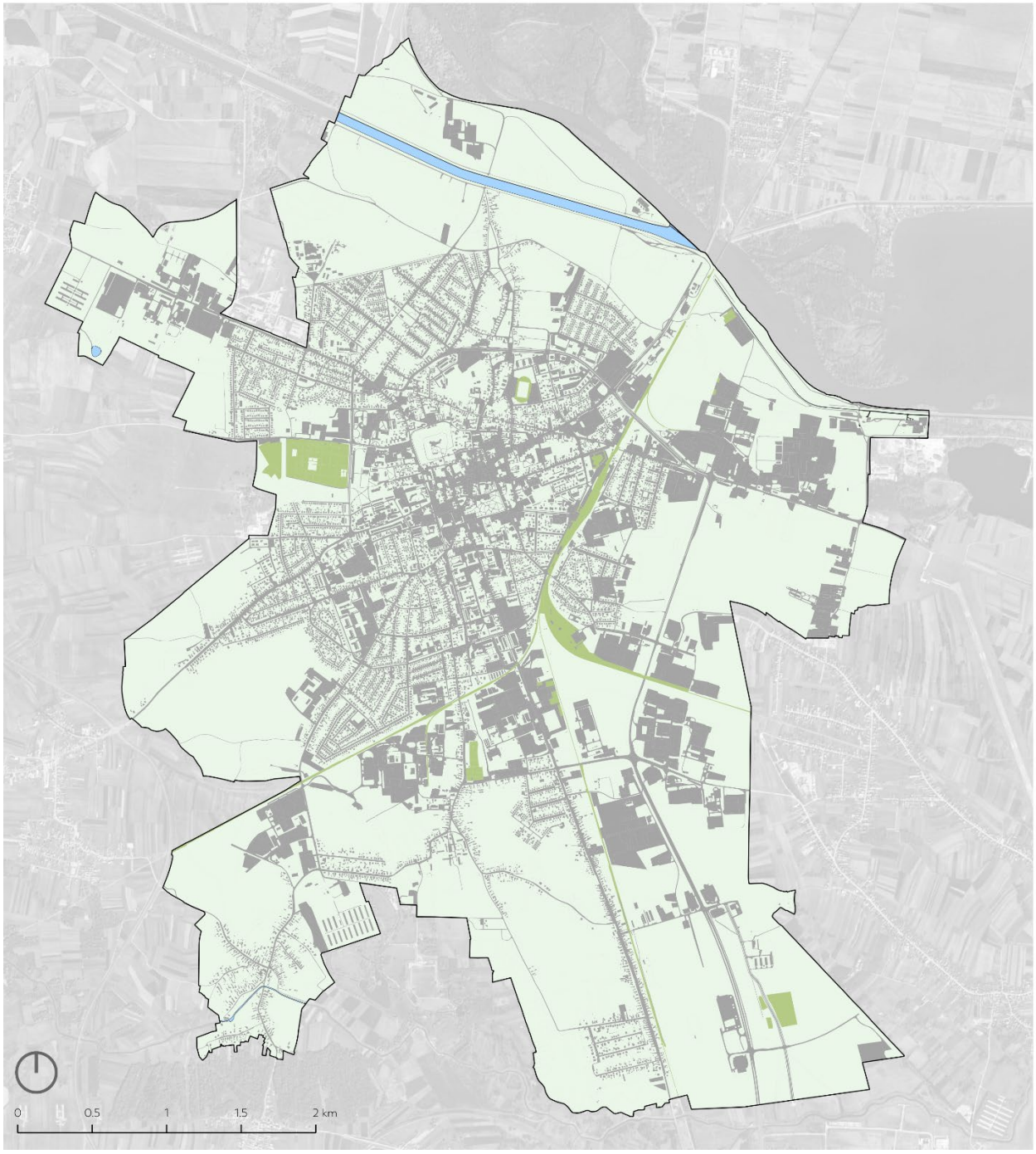

Figure 21 – Ratio of impermeable surfaces (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: ratio of impermeable surfaces (proprietary data, based on DGU, 2024.); author: 3 E PROJEKTI d.o.o.)

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4.1.4. Human activities

A. Population density

Census of population in 2021 by county, city and district level:

- Varaždin Country - 159 487 inhabitants
- City of Varaždin - 43 782 inhabitants
- Census district level (for research area - GUP) - 35 792 inhabitants

According to the data provided by the Croatian Bureau of Statistics (HZS), **in the research area (GUP), there are a total of 35 792 inhabitants**, of which 18 913 are women (52,88 %) and 16 855 are men (47,12 %). By groups 0-15 years 4 945 inhabitants, 16-74 years 27 075 inhabitants and 75 years and over 3 748 inhabitants. The population density is 1463,34 inhabitants per km^2.

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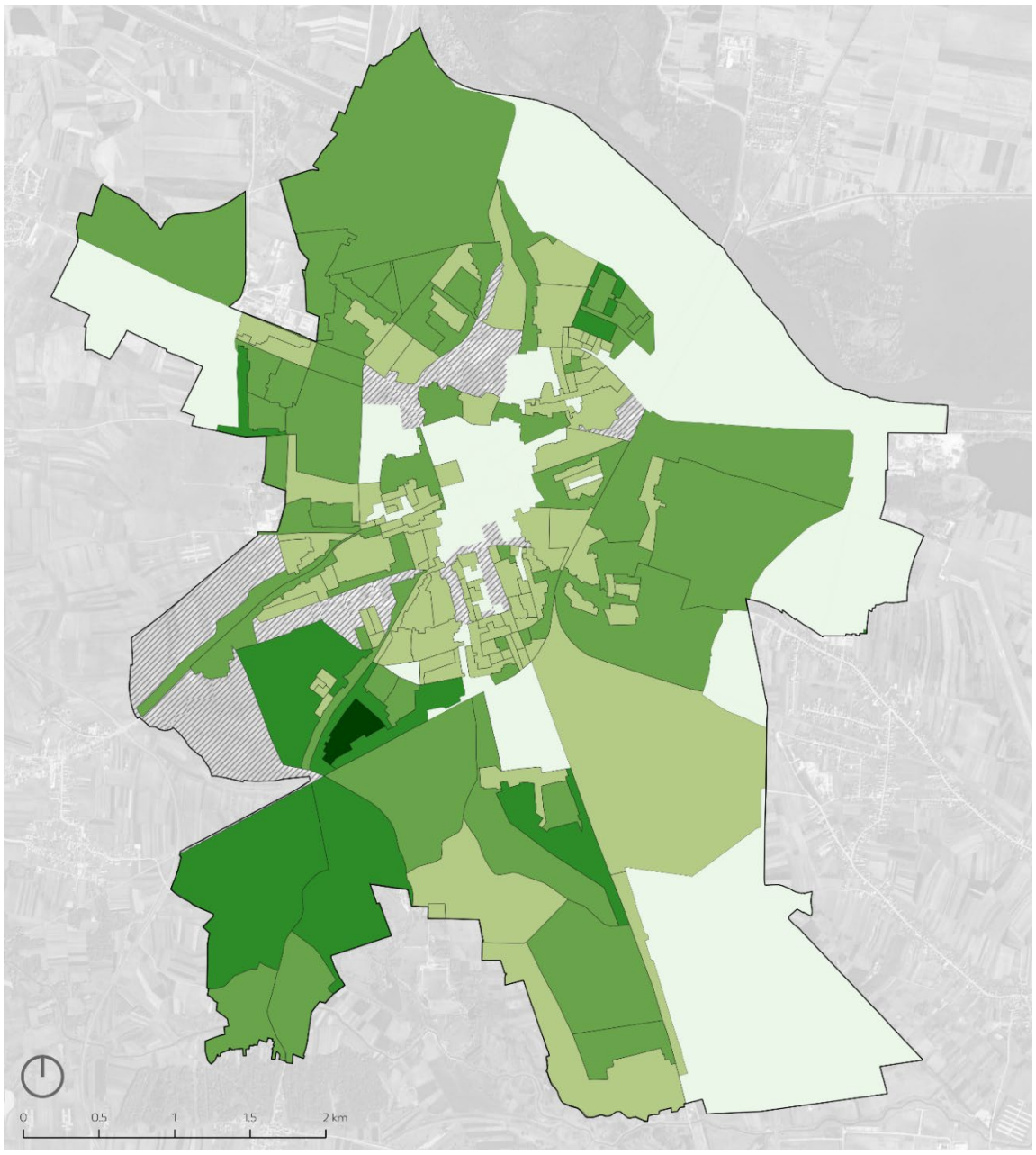

Figure 22 – Display of population by census districts (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: Display of population by census districts (proprietary data, based on DGU and DZS, 2024.); author: 3 E PROJEKTI d.o.o.)

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B. Land use

According to the current GUP, the largest area is occupied by agricultural use (27,38 %), followed by residential (15,63 %), commercial (14,14 %) and mixed use (10,14 %) areas. Additionally, transport and pedestrian areas also have a significant share (14,15 %).

The most represented category is Agricultural use, covering 27,38 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 14 - Purpose of surfaces for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
Industrial area	14.14%
Cemeteries	0.88%
Institutional	3.03%
Communal	0.38%
Mixed use	10.14%
Agricultural	27.38%
Commercial	1.57%
Sports	1.06%
Residential	15.63%
Forest	4,69%
Tourist purpose	0.03%
Water surface	0.77%
Brownfield	2.00%
Green spaces	3.77%
Traffic and pedestrian areas	14.52%

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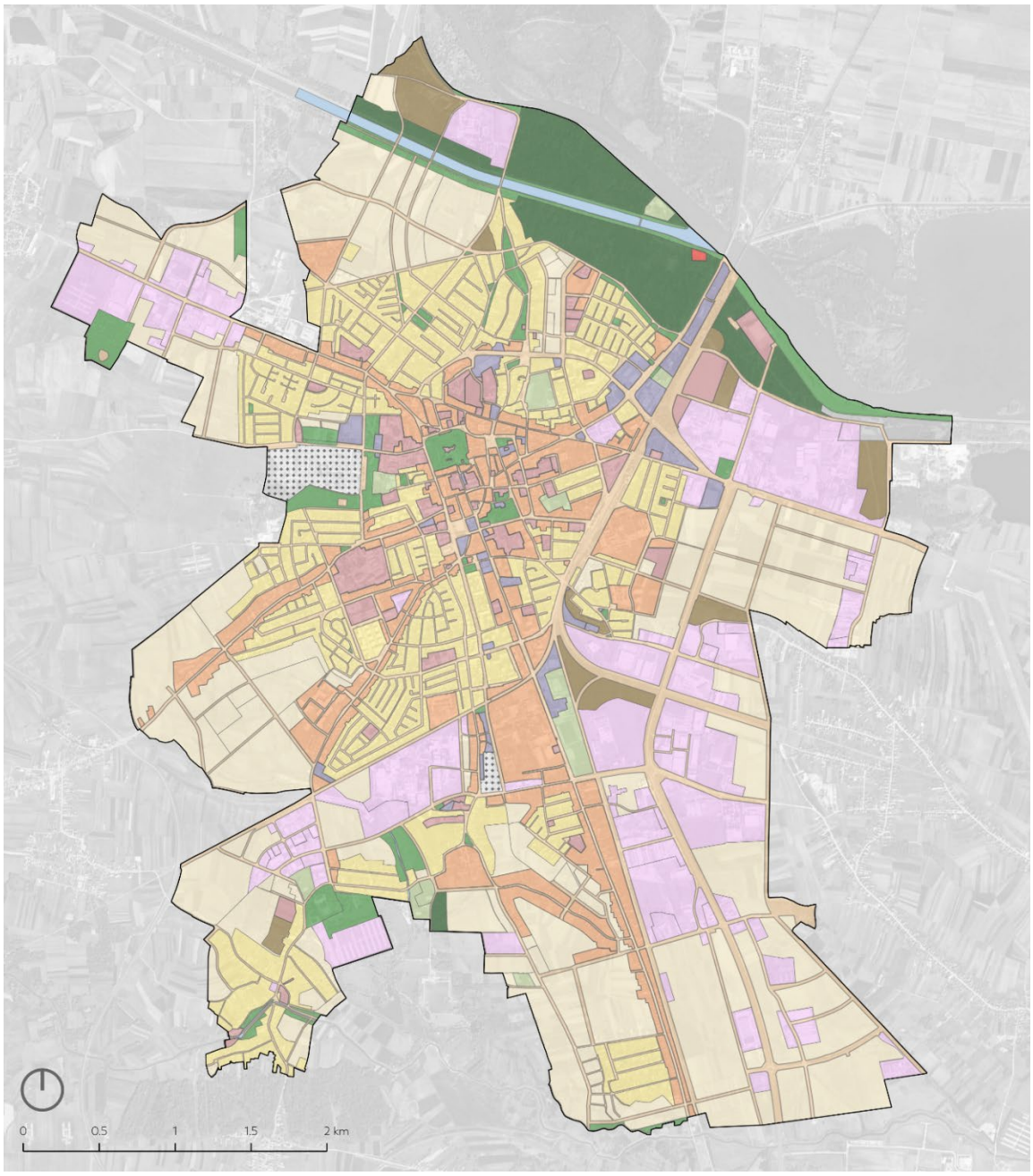

Figure 23 – Land use (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: land use display within GUP (proprietary data, based on GUP); author: 3 E PROJEKTI d.o.o.)

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C. Energy consumption of buildings

The display contains the spatial distribution and energy consumption of public buildings (primary energy consumption) according to data provided by the Regional Energy Agency North (REA) from 2023. According to the above data, the largest consumer of electricity among public buildings in the GUP of the **City of Varaždin is the Varaždin City Swimming Pools, followed by the Varaždin Technology Park, NK Varteks Stadium and VI. Varaždin Primary School**. Among the buildings in the immediate city center, the highest energy consumption is produced by the Croatian National Theatre in Varaždin, the City Administration building and the Herczer Palace.

Table 15 - Energy consumption in public buildings for the year 2023. (Source: REA)

Name of public buildings	Energy consumption [kWh]	Primary energy consumption [kWh]
1. Gradski bazeni Varaždin	737424	1190202.33
2. Tehnološki park Varaždin	192540	310759.56
3. Stadion NK Varteks	147384	237877.77
4. VI. OŠ Varaždin	125261	202171.26
5. Hrvatsko narodno kazalište u Varaždinu	114053	184081.55
6. IV. OŠ Varaždin	87046	140492.24
7. Sportska dvorana Graberje	82584	133290.56
8. I. OŠ Varaždin	77313	124783.19
9. III. OŠ Varaždin	74267	119866.94
10. Centar za odgoj i obrazovanje Tomislav Špoljar	67223	108497.91
11. II. OŠ Varaždin	65849	106280.28
12. Stadion "Sloboda"	51085	82451.20
13. Palača Herczer	50475	81466.65
14. Zgrada gradske uprave Varaždin	50106	80871.08
15. DV Dravska	43383	70020.16
16. VII. OŠ Varaždin	41719	67334.46
17. V. OŠ Varaždin	37210	60056.96
18. Javna vatrogasna postrojba Varaždin	37098	59876.17
19. Uredi Gradske uprave	33472	54023.81
20. Sportska dvorana "Srednjoškolac"	31052	50117.95
21. DV Aleja	28329	45723.01
22. Utvrda Stari grad	22379	36119.70
23. DV Koprivnička	20123	32478.51
24. Zgrada društvene namjene - udruge	19899	32116.97
25. DV Graberje	18961	30603.05
26. Gradska vijećnica Varaždin	18882	30475.55
27. Palača Sermage	18680	30149.52

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28. DV Kozarčeva	18400	29697.60
29. DV Gortanova	17175	27720.46
30. DV "Tratinčica" Varaždinske Toplice	16874	27234.64
31. DV Kućan	14643	23633.79
32. DV Biškupec	8293	13384.89
33. Zgrada gradske uprave Varaždinske Toplice	7057	11390.01
34. Kula stražarnica	6758	10907.41
35. Gradska knjižnica i čitaonica "Metel Ožegović" Varaždin	5641	9104.56
36. Pučko otvoreno učilište Varaždin	3786	6110.6
37. Zgrada knjižnice i čitaonice Varaždinske Toplice	1719	2774.46
38. Žitnica	22	35.51

The display also includes the headquarters of business entities in the area of GUP. As data on the energy consumption of the listed facilities were unavailable, the possible consumption was approximated based on the number of employees of each entity. The accuracy of the data is reduced by the fact that the centre of some business entities is dislocated in relation to the business and production facilities.

The electricity consumption in the area covered by GUP was obtained by the Croatian electricity company - Operator distribucijskog sustava d.o.o. (HEP DOS) for 2023 and amounted to 212.424.342 kWh. The most consumed energy was 18.852.616 kWh in January, and the least in 16.467.788 kWh. According to consumption categories, the following is distinguished: **public lighting** 3.257.481 kWh, **household** 44.603.465 kWh, **entrepreneurship low voltage** 61.919.284 kWh and **entrepreneurship medium voltage** 102.644.112 kWh.

Table 16 - Energy consumption in public buildings for the year 2023. (Source: HEP DOS)

Months	Energy consumption [kWh]
I	18.852.616
II	17.360.837
III	18.622.027
IV	16.467.788
V	17.057.432
VI	16.767.182
VII	18.655.282
VIII	17.932.767
IX	17.068.423
X	17.340.441
XI	17.705.626
XII	18.593.921
SUM	212.424.342

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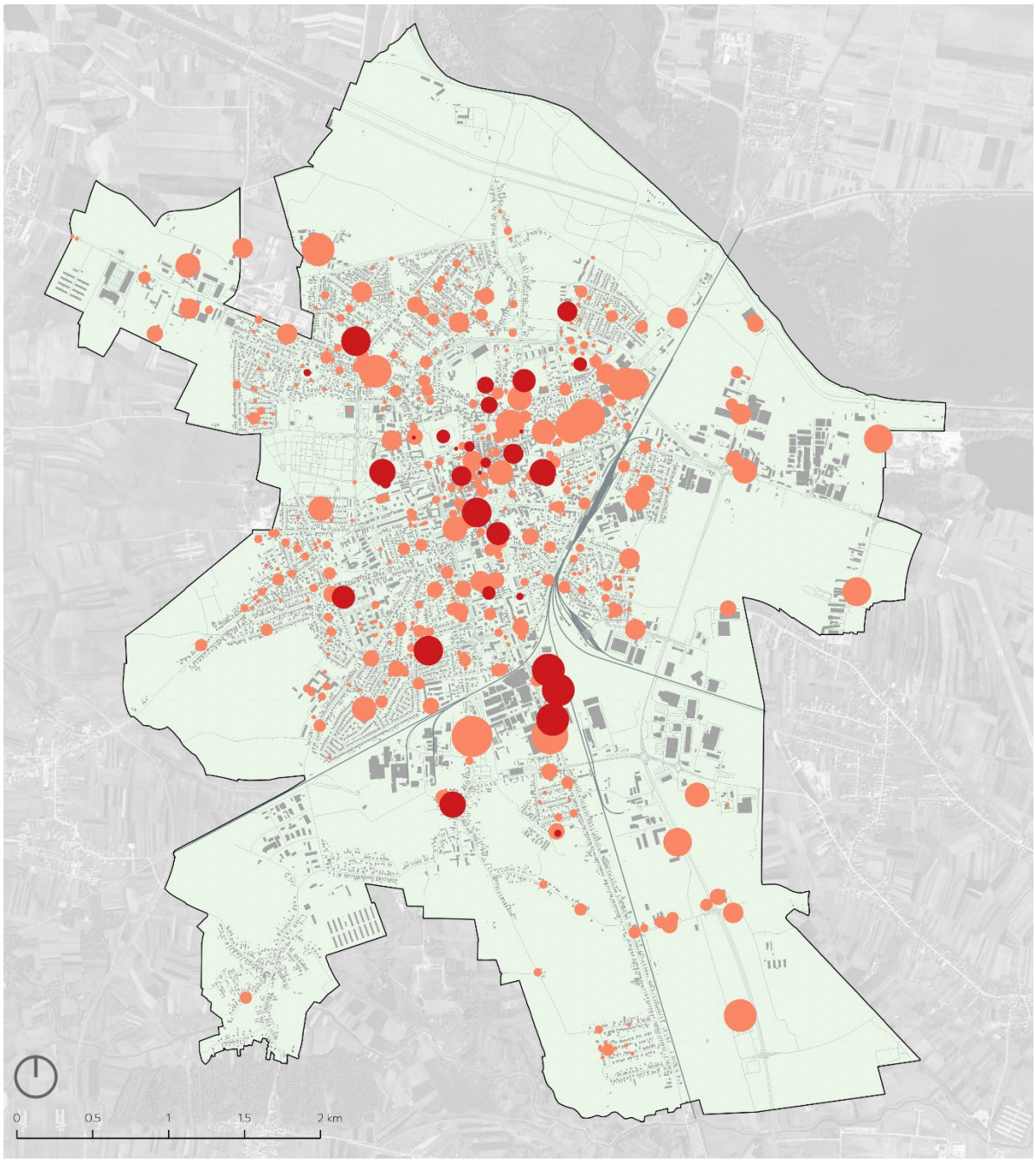

Figure 24 – Energy consumption public buildings and business entities (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: Energy consumption of public buildings and estimated consumption of business entities (proprietary data, based on REA, HEP DOS, 2024) author: 3 E PROJEKTI d.o.o.)

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D. Energy consumption of transportation

The display contains the distribution of the transport network in the areas of the GUP, which, given the frequency of use, can represent a significant source of energy consumption (operation of motor vehicles). Also, asphalt surfaces absorb solar energy and contribute to the urban heat island effect, which can lead to excessive heating of urban areas. **In the absence of data on the actual frequency of traffic, the traffic intensity was assumed based on the classification of an individual road.**

Table 17 -Traffic classification and length in the research area (GUP) (Author: 3 E PROJEKTI d.o.o.)

Category	Length (km)	%
Road network		
Major city streets	28,67 km	14,90 %
Collector streets	28,56 km	17,84 %
Other local streets	22,59 km	11,74 %
Other residential and service roods	112,63 km	58,52 %
Railroads		
Primary railway line	7,69 km	75,30 %
Secontdory railway line	2,52 km	24,70 %

Traffic Study – **Evaluation Plan of the Sustainable Urban Mobility Plan of the City** of Varaždin made by The Department of Logistics and Sustainable Mobility of the University North, provides a detailed overview of research on different types of transport. Research related to traffic vehicle counting (cars, trucks, motorcycles, etc.) at characteristic locations in the city, conducted at 12 sites, displayed in the table (Table 18) cartographic representation by numbers (id) (Figure 25) below.

Table 18 - Overview of road network load, based on the conducted traffic counting at selected locations in 2023. (Source: Evaluation Plan of the Sustainable Urban Mobility Plan of the City of Varaždin)

id	Street / sites	Number of vehicles
1	Koprivnička ulica	7 436
2	Međimurska ulica	12 210
3	Optujska ulica	14 337
4	Ul. braće Radić	9 328
5	Jalkovečka ulica	5 247
6	Zagrebačka ulica	14 850
7	Ulica A.Cesarca	11 594
8	Praradovićeva	1 991
9	Preradovićeva	5 390
10	Vrazova	12 936
11	Zrinskih i Frankopana	12 980
12	Gospodarska	14 135

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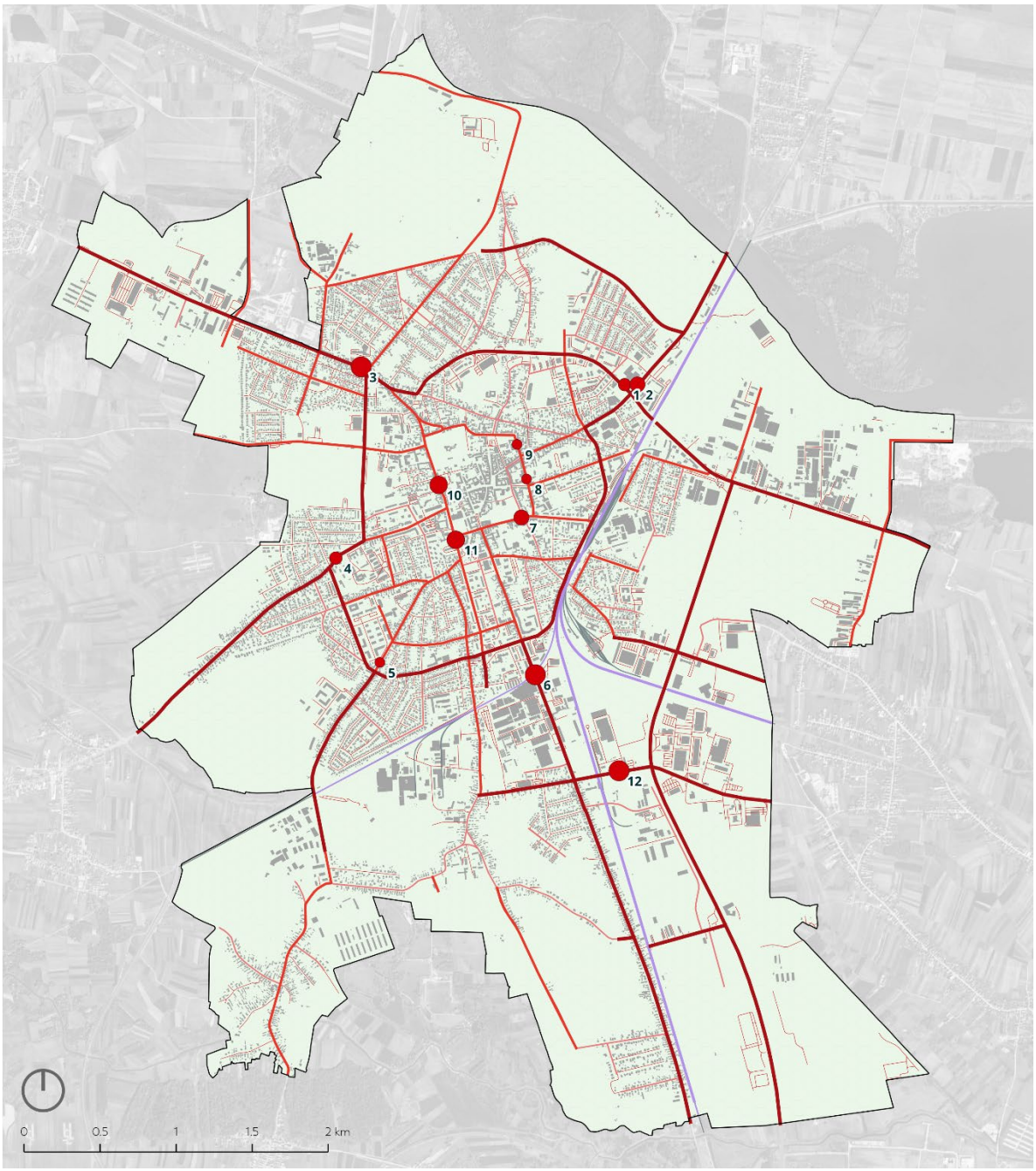

Figure 25 – Analysis of energy consumption road and rail transport (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: Traffic classification within the GUP, road traffic intensity (Traffic Study - Evaluation Plan of the Sustainable Urban Mobility Plan of the City of Varaždin); author: 3 E PROJEKTI d.o.o.)

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Composite map based on UHI vulnerability assessment – tool 1

Factors that contribute to UHI development

- Building coverage ratio(> 0.7)
- Floor area ratio (> 2)
- Street aspect ratio (> 7,25)
- Land use (Industrial, Commercial and Traffic area)
- Street aspect ratio (> 7,25)

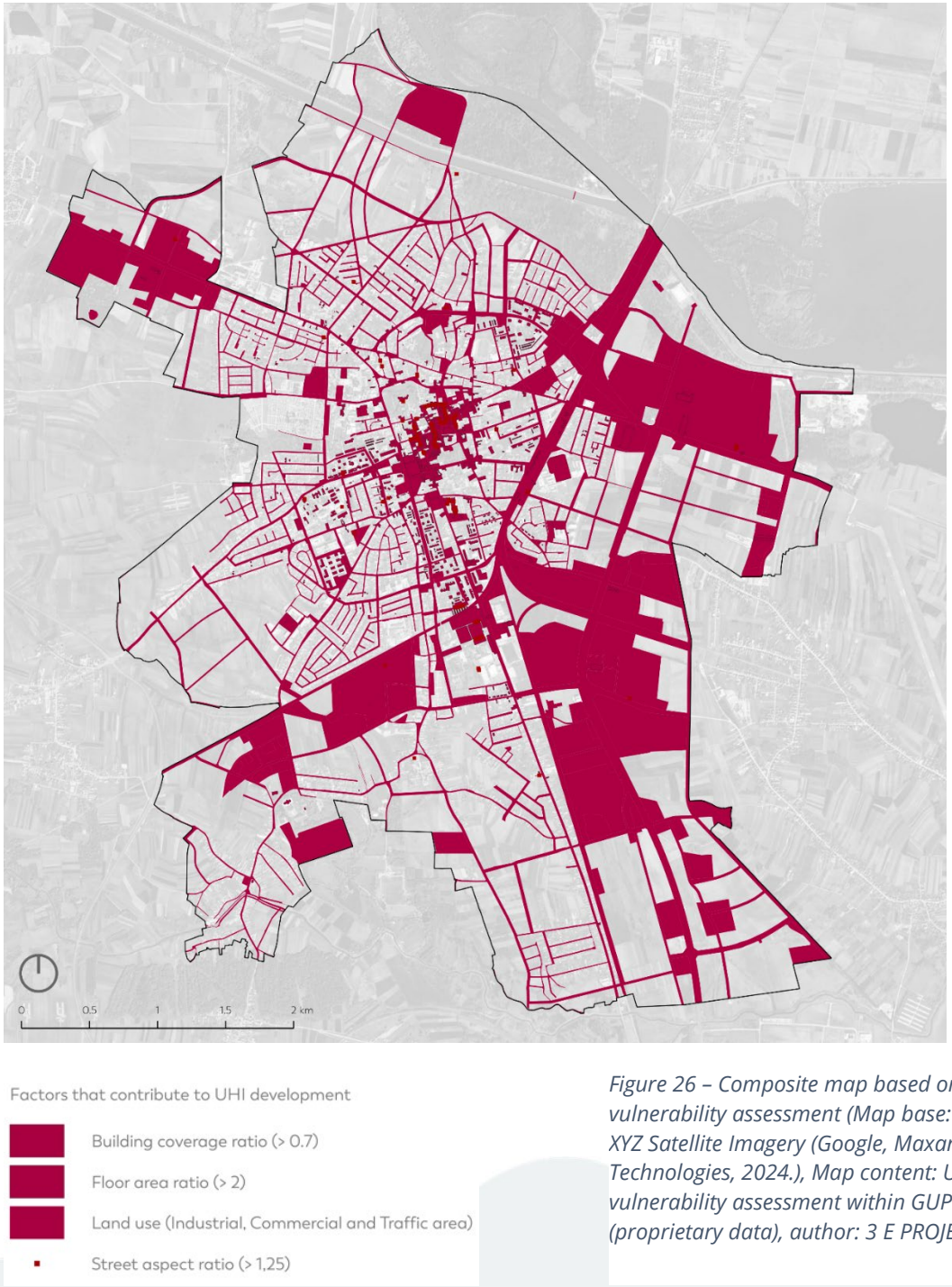

Figure 26 – Composite map based on UHI vulnerability assessment (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: UHI vulnerability assessment within GUP (proprietary data), author: 3 E PROJEKTI d.o.o.)

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4.2. SENSITIVITY OF EQUIPMENT AND MATERIALS

A. Albedo (Reflectivity) Coefficient

For the estimation of surface albedo in the research area (GUP), LANDSAT 8 satellite images (Landsat program of the US Geological Survey USGS) with a resolution of 30 m, token on August 12, 2024, were used.

The analysis included the estimation of albedo based on 5 spectral channels (BLUE, RED, IR, SWIR 1, SWIR 2).

The albedo calculation was mode using the QGIS "Roster Calculator" tool according to the formulas:

TOA=(MQ+A)/sin(S)

Albedo=((0,356*BLUE) + (0,130*RED) + (0,373*IR) + (0,085*SWIR1) + (0,072*SWIR2) -0,0018) /1,016

- M - Reflactance multiband value
- Q – Raster value
- A - Reflactance add band value
- S - Angle of inclination of the sun (expressed in radians)

The most represented category is 0,10-0,20, covering 79,88 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 19 -Representation of surface albedo categories in the research area (GUP) (Author: 3 E PROJEKTI d.o.o.)

Category	Percentage of surface
-0.05 - 0,10	0,55 %
0,10 - 0,20	79,88 %
0,20 - 0,30	19,23 %
0,30 - 0,40	0,31 %
0,40 - 0,50	0,03 %
0,50 - 0,60	0,01 %

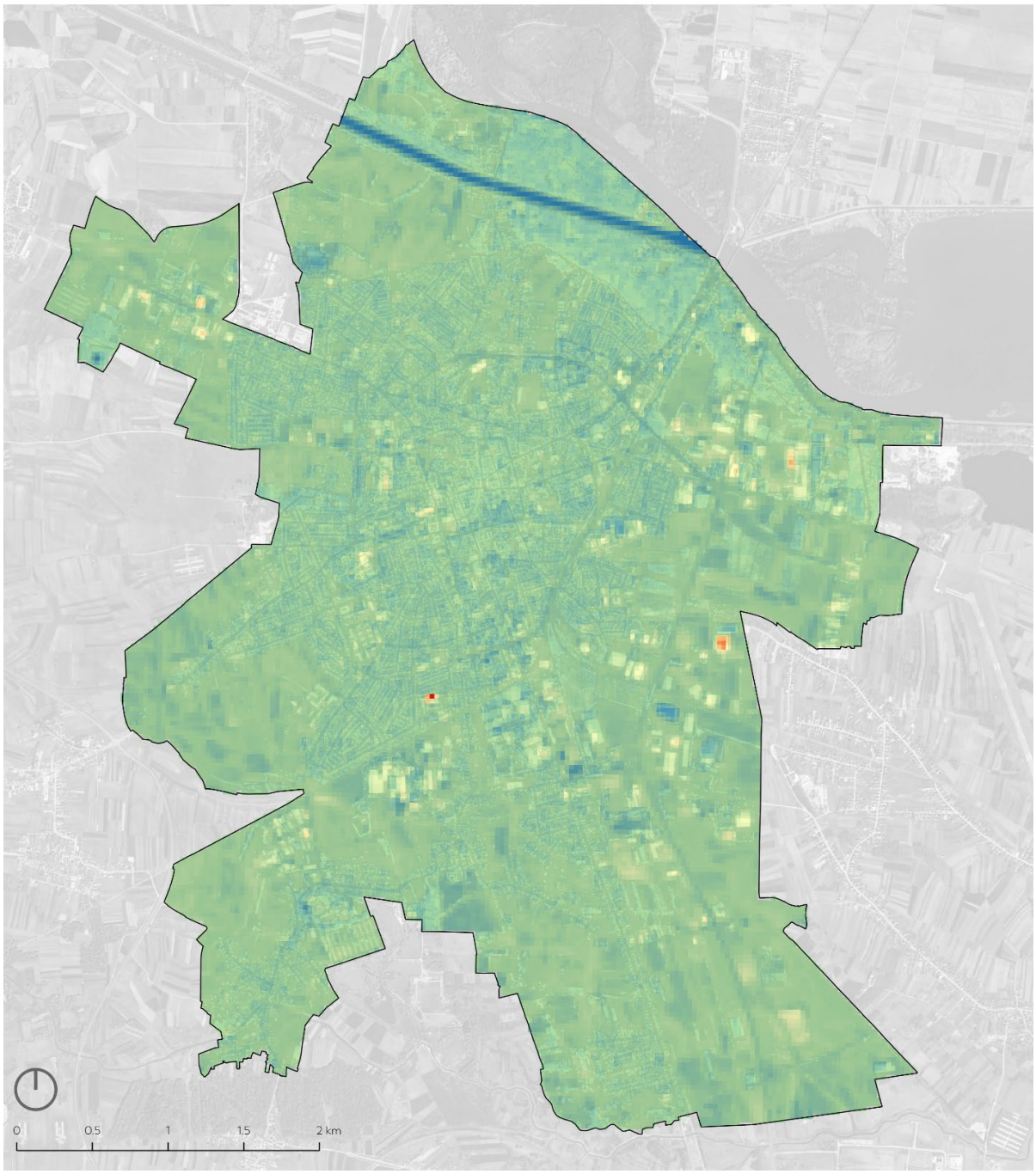

Figure 27 – Albedo (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), Map content: Estimation of surface albedo in the GUP (Land Surface Albedo Estimation, proprietary data, based on USGS, 2024.); author: 3 E PROJEKTI d.o.o.)

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B. Surface Temperature

For the estimation of land surface temperature in the research area (GUP), LANDSAT 8 satellite images (Landsat program of the US Geological Survey - USGS) with a resolution of 30 m, taken on **July 27, 2023,** and on **August 12, 2024,** were used in the analysis.

The analysis included the estimation of surface temperature based on three spectral channels (RED, IR, TIRS).

The LST calculation was made using the QGIS "Raster Calculator" tool, according to the formula:

LST=BT/(1+(λ*BT/c2)*ln(E))

- BT - Brightness temperature at the top of the atmosphere
- λ - Wavelength of emitted radiance
- E - Land surface emissivity
- c2 - Product of Planck's constant with the speed of light quotient and Boltzmann's constant

Average temperatures at the ground surface on **July 27, 2023** was 28,85 °C, and temperatures ranged from 20,24 °C (-8,6 compared to the average value) to 34,95 °C (+6,1 °C).

*Table 20 - Representation of land surface temperature categories (**July 27, 2023**) in the GUP area (Author: 3 E PROJEKTI d.o.o.)*

Category	Surface occupy
20 – 23 °C	2,01 %
23 – 25 °C	6,04 %
25 – 28 °C	21,81 %
28 – 31 °C	56,43 %
31 – 35 °C	13,71 %

The average value of the temperature at the ground surface during **August 12, 2024** was 30,9 °C, with other values ranging from 22,5 °C (-8,4 °C) to a maximum of 36,8 °C (+5,9 °C).

*Table 21 -Representation of land surface temperature categories (**August 12, 2024**) in the GUP area (Author: 3 E PROJEKTI d.o.o.)*

Category	Surface occupy
22 -25 °C	1,66 %
25 – 28 °C	8,38 %
28 – 31 °C	58,64 %
31 – 34 °C	29,50 %
34- 37 °C	1,81 %

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When we overlap the deviations from the average soil temperature with the land use in the GUP, we get the following values:

Table 22 - Average soil temperature with the land use in the GUP

Category	Average value LANDSAT 8 27.07.2023.	Average value LANDSAT 8 12.08.2024.
Industrial area	1.34	1.22
Cemeteries	0.69	0.41
Institutional	1.14	0.84
Communal	-0.11	-0.03
Mixed use	1.57	1.17
Agricultural	-0.56	-0.23
Commercial	1.53	1.00
Traffic and pedestrian areas	0.64	0.44
Sports	0.02	-0.14
Residential	1.14	0.83
Forest	-0.54	-4.42
Tourist purpose	-3.07	-1.27
Water surface	-2.14	-2.67
Brownfield	-0.49	-2.00
Green spaces	-4.59	-0.61

The values highlighted in the table indicate the increased temperature of built anthropogenic spaces compared to surfaces with a significant proportion of vegetation.

The highest recorded temperatures in the GUP area (+3 °C and more compared to the average) in both cases occur in the area of business and trade zones between Gospodarska and Kućanmarofska streets, production plants and shopping centres within the complex of the former Varteks factory, and within individual commercial facilities in the wider area of the GUP. Temperatures in the city centre and the wider built-up area on average range from +0-3 °C compared to the average value, with the exception of parks and larger green areas where ground temperatures range up to -2 °C compared to the immediate surroundings. The lowest temperatures in both analysed periods were recorded in the forest belt between the Drava River and the drainage channel (locality "City Park").

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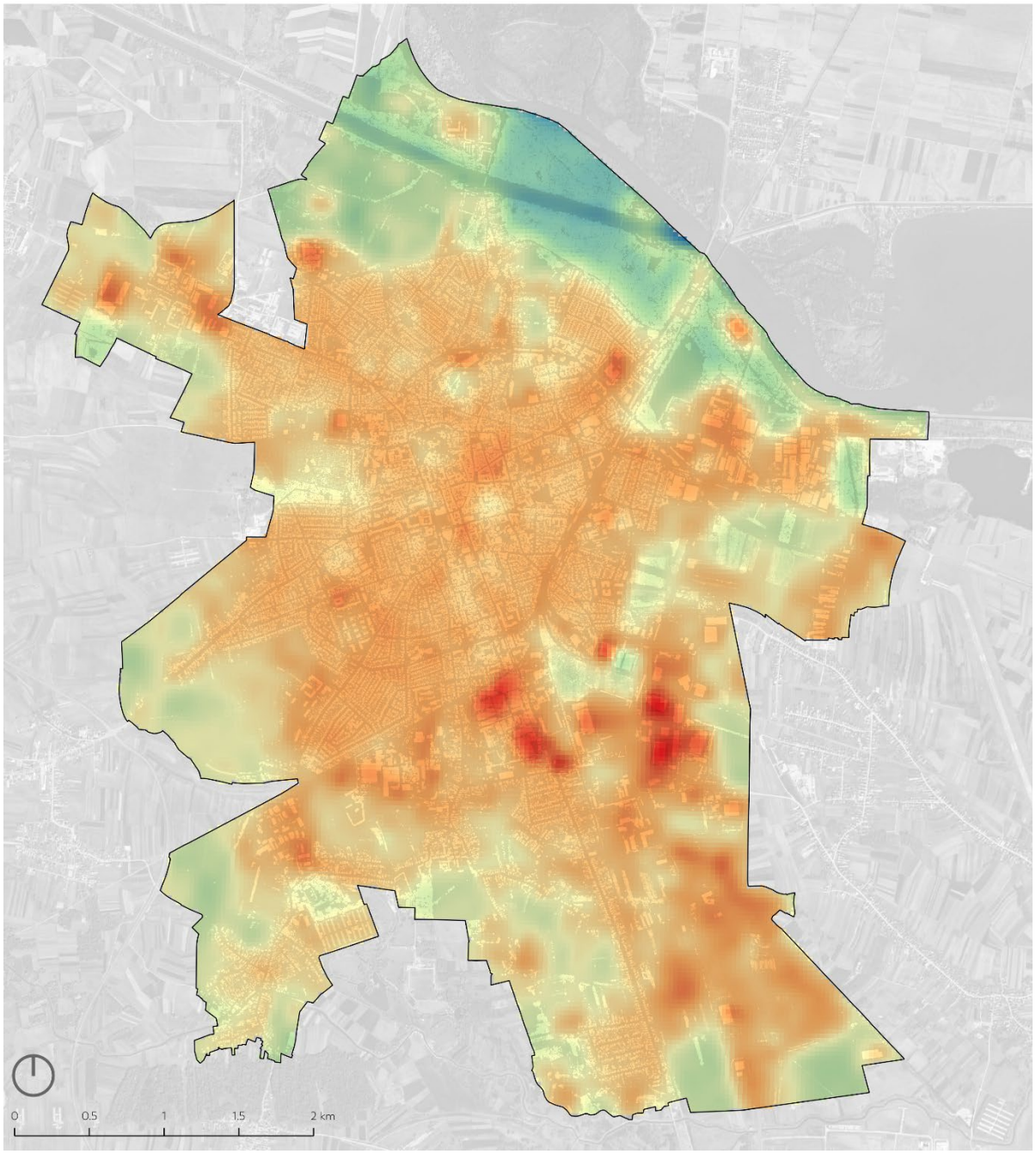

Figure 28 – Land Surface Temperature, July 27, 2023 (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), normalized digital surface model (DGU), Map content: Land Surface Temperature (proprietary data, based on USGS, 2023.); author: 3 E PROJEKTI d.o.o.)

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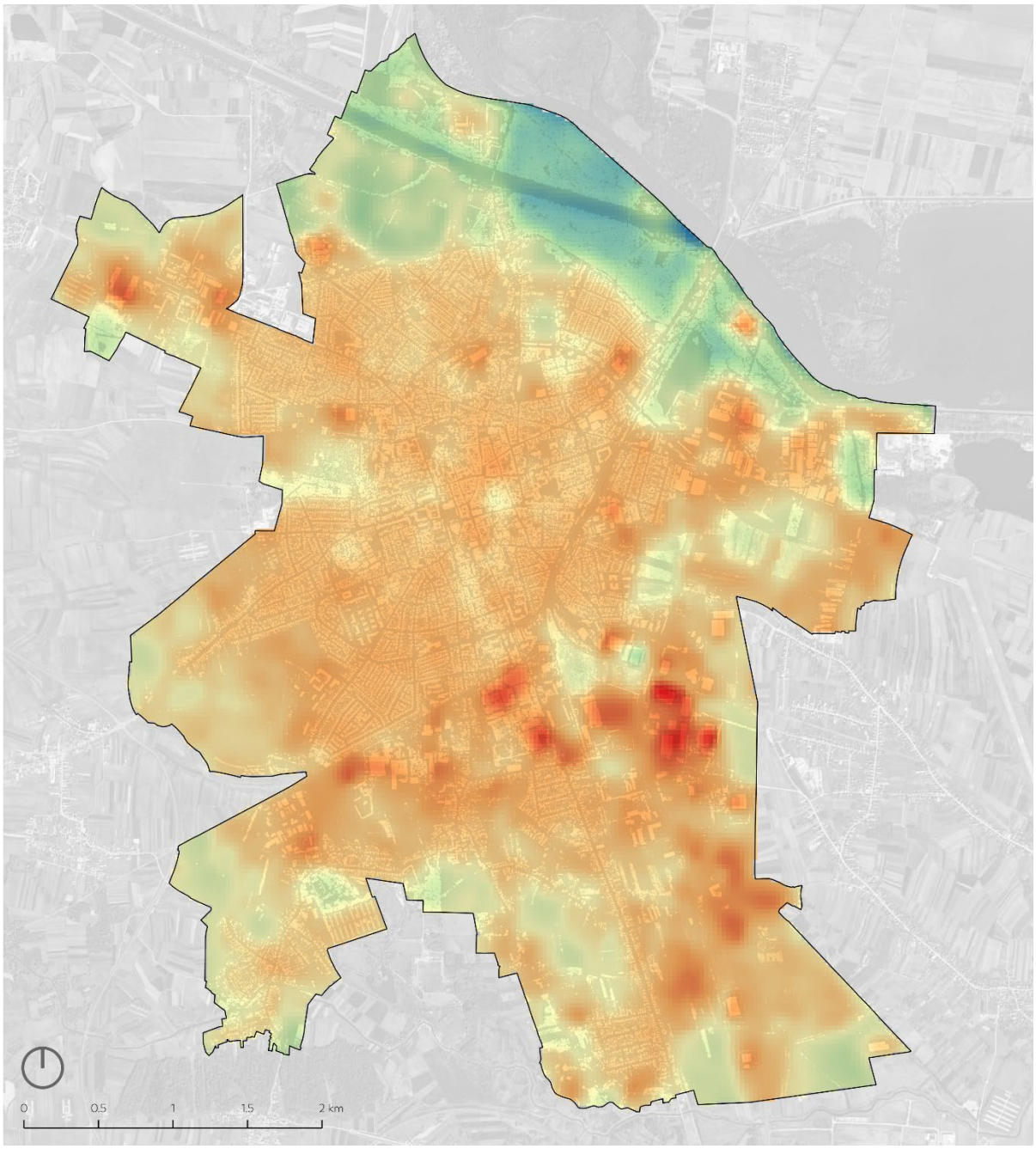

Figure 29 – Land Surface Temperature, August 12, 2024 (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), normalized digital surface model (DGU), Map content: Land Surface Temperature (proprietary data, based on USGS, 2024.); author: 3 E PROJEKTI d.o.o.)

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C. Emissivity

LANDSAT 8 satellite images (Landsat program of the American Geological Survey - USGS) with a resolution of 30 m, taken on August 12, 2024, were used to assess the emissivity of the surfaces in the GUP area.

The analysis included the assessment of emissivity based on two spectral channels (RED, IR).

The emissivity calculation was made using the QGIS tool 'Raster Calculator', according to the formula:

E=0.004 * PV * 0.986

- PV - proportion of vegetation
- 0.986 – correction value

The most represented category is 0.987 - 0.988, covering 49,03 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 23 - Representation of surface soil emissivity categories in the research area (GUP) (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
0.986 - 0.987	30,86 %
0.987 - 0.988	49,03 %
0.988 - 0.989	19,89 %
0.989 - 0.990	0,28 %

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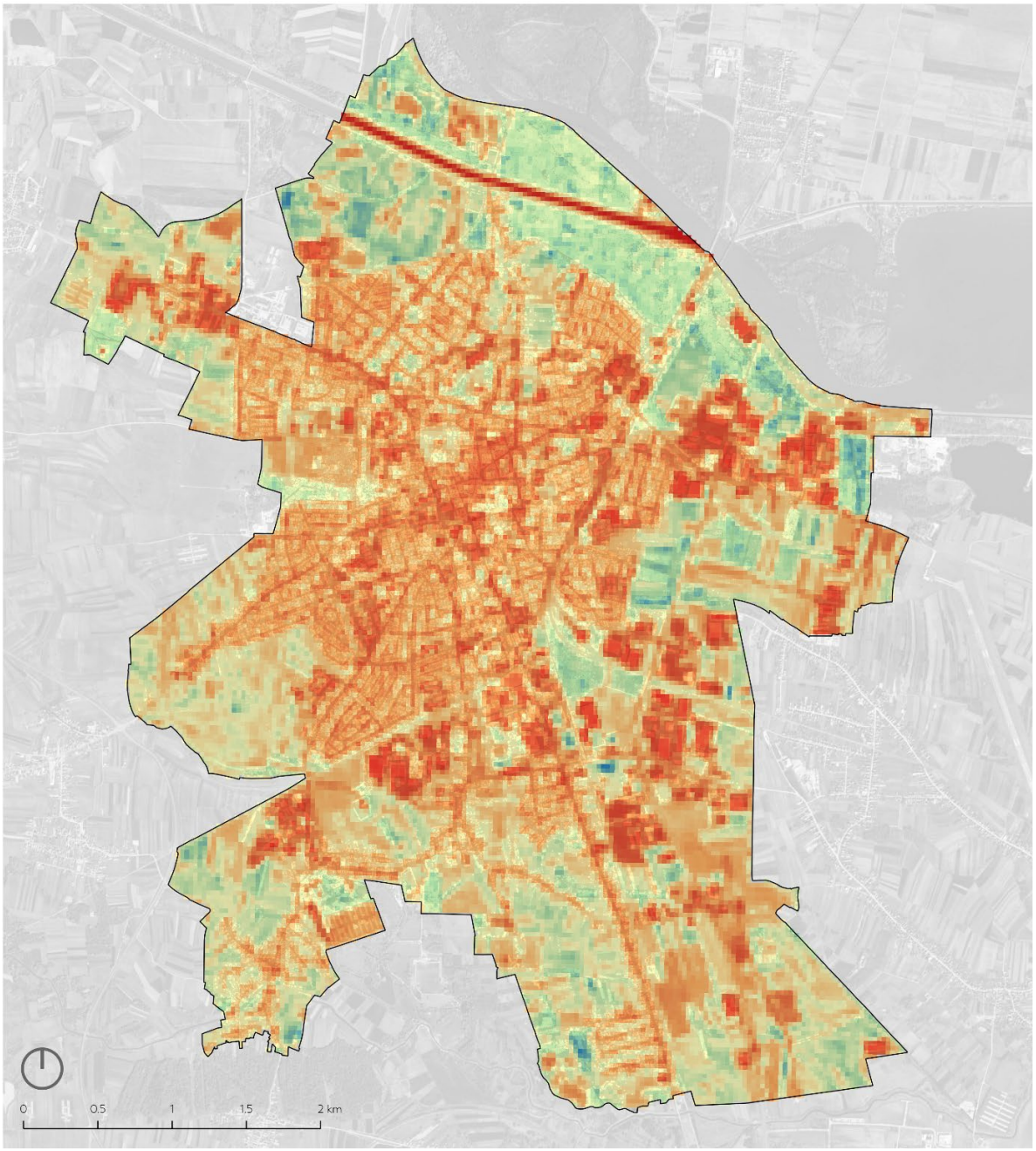

Figure 30 - Display of surface emissivity (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies, 2024.), normalized digital surface model (DGU), Map content: display of surface emissivity (proprietary data, based on USGS, 2024.); author: 3 E PROJEKTI d.o.o.)

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D. Vegetative Cover

The NDVI calculation from the previous analysis was supplemented with elevation data from the Normalized Digital Surface Model (nDSM), with a 1 m resolution, provided by the State Geodetic Directorate (2024).

All areas higher than 3 m were overlaid with NDVI values greater than 0.2, and the obtained results were further refined using vector data containing the footprint projection of buildings within the GUP area. The final result represents on NDVI visualization for vegetation taller than 3 m.

The most represented category is 0,5 – 0,75, covering 63,44 % of the surveyed area. A detailed overview of all categories is provided in the table and graphical representation below.

Table 24 -Categories of Normalized Difference Vegetation Index (NDVI) for vegetation toller than 3 m for research area (GUP) of the City of Varaždin (Author: 3 E PROJEKTI d.o.o.)

Category	Surface occupy
0,25 - 0,50	34,78 %
0,50 - 0,75	63,44 %
0,75 - 1,00	1,77 %

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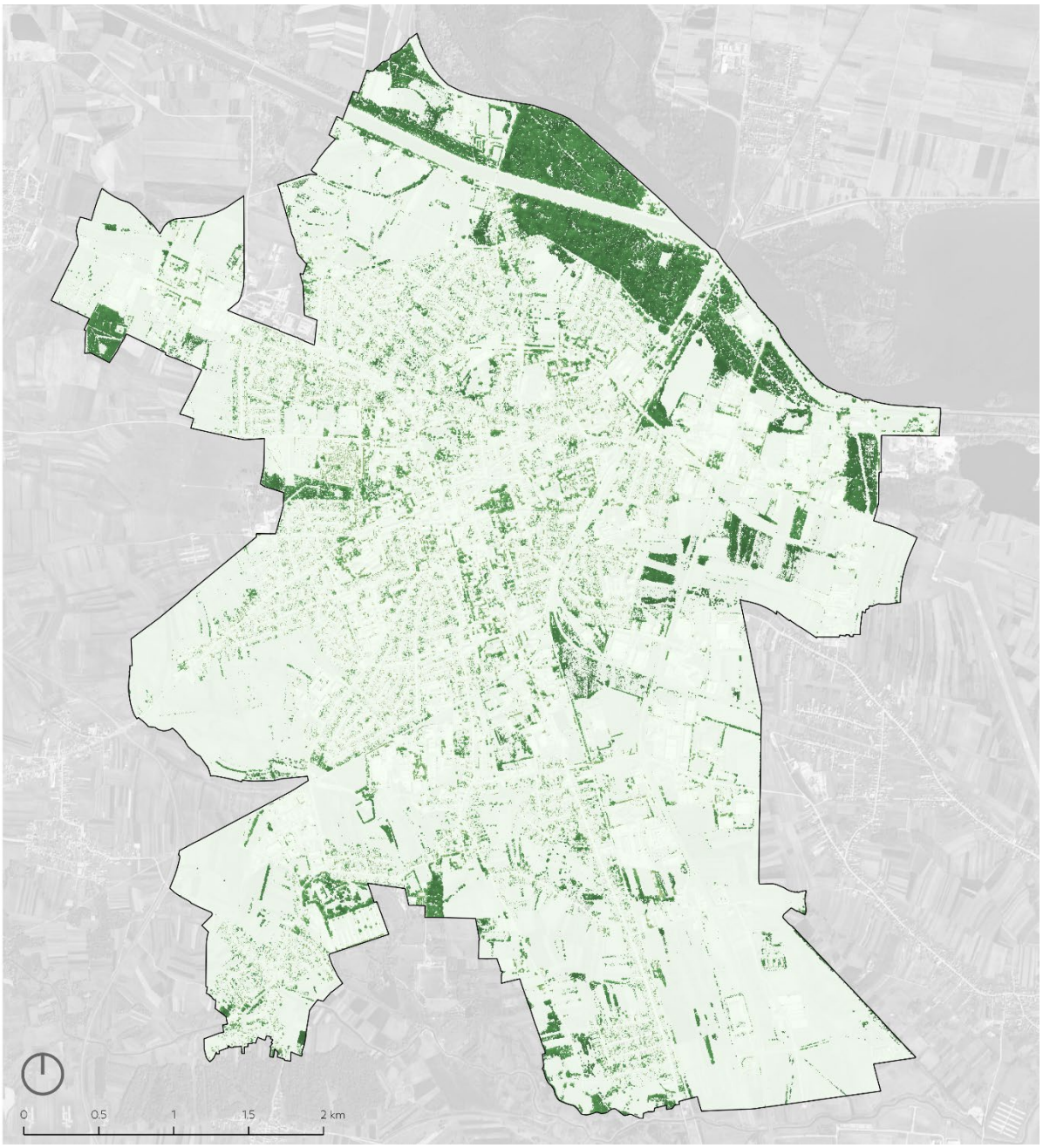

Figure 31 - Normalized Difference Vegetation Index for vegetation taller than 3m (NDVI) (Map base: Sentinel-2 Satellite Imagery (European Space Agency, 2024), Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: Normalized Difference Vegetation Index on 12.08.2024. (Proprietary data. based on ESA, 2024); author: 3 E PROJEKTI d.o.o.)

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Limitation:

Data on **thermal conductivity and heat capacity** for the City of Varaždin or the research area (General Urban Plan - GUP) are unavailable.

Data on **material conditions, surface coverage, or vegetation cover** for the research area (General Urban Plan - GUP) are unavailable. The analysis will be applied to the trial zone/area designated for the planned mitigation measure.

Trial zone/area for the planned mitigation measure

The trial zone/area for the planned mitigation measure is a **flea market (SAJMIŠTE)**, total 11071,3 m^2. The following analysis will examine subspace usage types, material types, material conditions, albedo, surface temperature, and other relevant factors.

Surface materials

In the flea market (SAJMIŠTE) zone, there are various subspaces used as the central market area, parking lots, roads, lawns with trees, and courtyard entrances. The most prevalent material by surface area is asphalt (53,76 m^2), which is of medium quality. Other values are shown in table (Table 25) below.

Table 25 - Land cover, surface material and material conditions in study area of flea market (SAJMIŠTE) (author: 3 E PROJEKTI d.o.o.)

Land cover	Square meters (m^2)	%	Surface material	Material conditions	
1 - Flea market space	1394,1	12,59	concrete pavers	poor	impermeable surfaces
2 - Parking	415,6	3,75	asphalt	fair	
3 - Road	4730,7	42,73	asphalt	fair	
4 - Parking	805,5	7,28	asphalt	fair	
5 - Lawn with trees	3059,4	27,63	grass	good	permeable surface
6 - Lawn with trees	326,3	2,95	grass	good	
7 - Concrete slab	55,5	0,50	concrete	poor	impermeable surfaces
8 - Substation	44,4	0,40	concrete	good	
9 - Entrance to the private yard	239,8	2,17	gravel	poor	

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Surface materials

- Asphalt
- Concrete
- Grass
- Gravel
- Permeable paving

Land cover/ surface material/
material condition within study area

1 - Flea market space / concrete pavers / poor
2 - Parking / asphalt / fair
3 - Road / asphalt / fair
4 - Parking / asphalt / fair
5 - Lawn with trees / grass / good
6 - Lawn with trees / grass / good
7 - Concrete slab / concrete / poor
8 - Substation / concrete / good
9 - Entrance to the private yard / gravel / poor

Figure 32 – Land cover, surface material and material conditions in study area of flea market (SAJMIŠTE) (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024); author: 3 E PROJEKTI d.o.o.)

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Figure 33 – Materials type (from left to right: grass, concrete pavers, asphalt and concrete) in study area of flea market (SAJMIŠTE) (author: 3 E PROJEKTI d.o.o.)

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Albedo, surface temperature, emissivity and vegetative cover

The market square (1) has the highest albedo value, the parking area (2) has the highest temperature value, and the concrete slab (7) has the highest emissivity.

A detailed overview of all indicators is provided in the table (Table 26) and graphical representation below.

Table 26 - Albedo, surface temperature, emissivity and vegetative cover in study area of flea market (SAJMIŠTE) (author: 3 E PROJEKTI d.o.o.)

Land cover	Material / conditions	Average value			
		Albedo	Surface temperature	Emissivity	Vegetative cover
1 - Flea market space	concrete pavers / poor	0,213	31,39	0,98669	0,080
2 - Parking	asphalt / fair	0,171	31,69	0,98725	0,230
3 - Road	asphalt / fair	0,179	31,53	0,98704	0,162
4 - Parking	asphalt / fair	0,198	31,36	0,98658	0,050
5 - Lawn with trees	grass / good	0,186	31,67	0,98723	0,343
6 - Lawn with trees	Grass / good	0,183	31,56	0,98689	0,236
7 - Concrete slab	Concrete / poor	0,173	31,67	0,98738	0,599
8 - Substation	Concrete / good	0,186	31,60	0,98696	0,363
9 - Entrance to the private yard	gravel / poor	0,205	31,60	0,98684	0,133

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Albedo value

0.295411

0.145566

	Average Albedo value per land cover type
1	0,213
2	0,171
3	0,179
4	0,198
5	0,186
6	0,183
7	0,173
8	0,186
9	0,205

Figure 34 – Albedo in study area of flea market (SAJMIŠTE (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), author: 3 E PROJEKTI d.o.o.)

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Land surface temperature value

33,13 °C

29,74 °C

Average Land surface temperature value per land cover type

1	31,39 °C
2	31,69 °C
3	31,53 °C
4	31,36 °C
5	31,67 °C
6	31,56 °C
7	31,67 °C
8	31,60 °C
9	31,60 °C

Figure 35 – Land surface temperature in study area of flea market (SAJMIŠTE) (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), author: 3 E PROJEKTI d.o.o.)

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Emissivity value

0.988331

0.986411

Average Emissivity value per land cover type

1	0,98669
2	0,98725
3	0,98704
4	0,98658
5	0,98723
6	0,98689
7	0,98738
8	0,98696
9	0,98684

Figure 36 – Emissivity in study area of flea market (SAJMIŠTE) (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), author: 3 E PROJEKTI d.o.o.)

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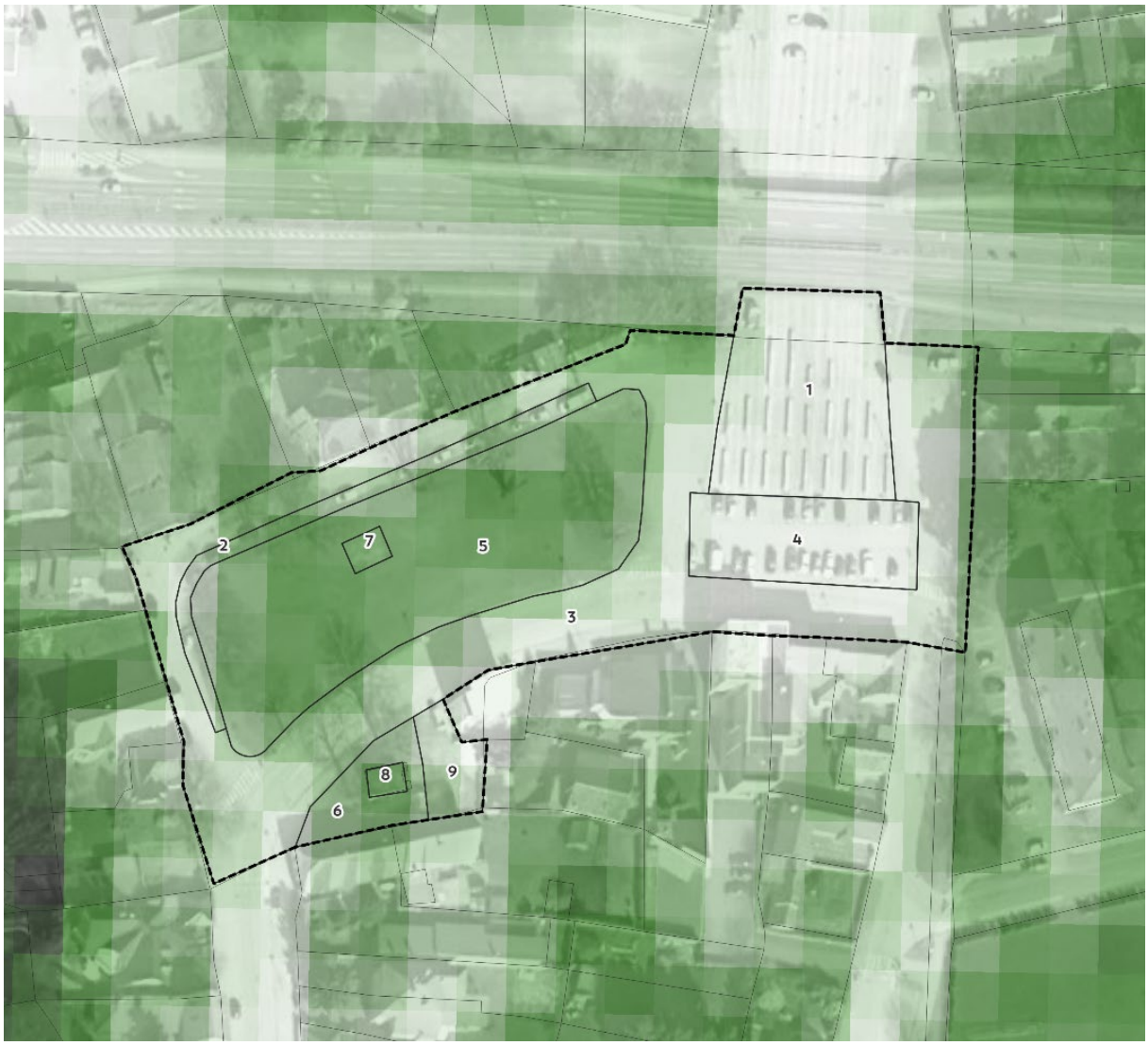


NDVI value

0.565244

0

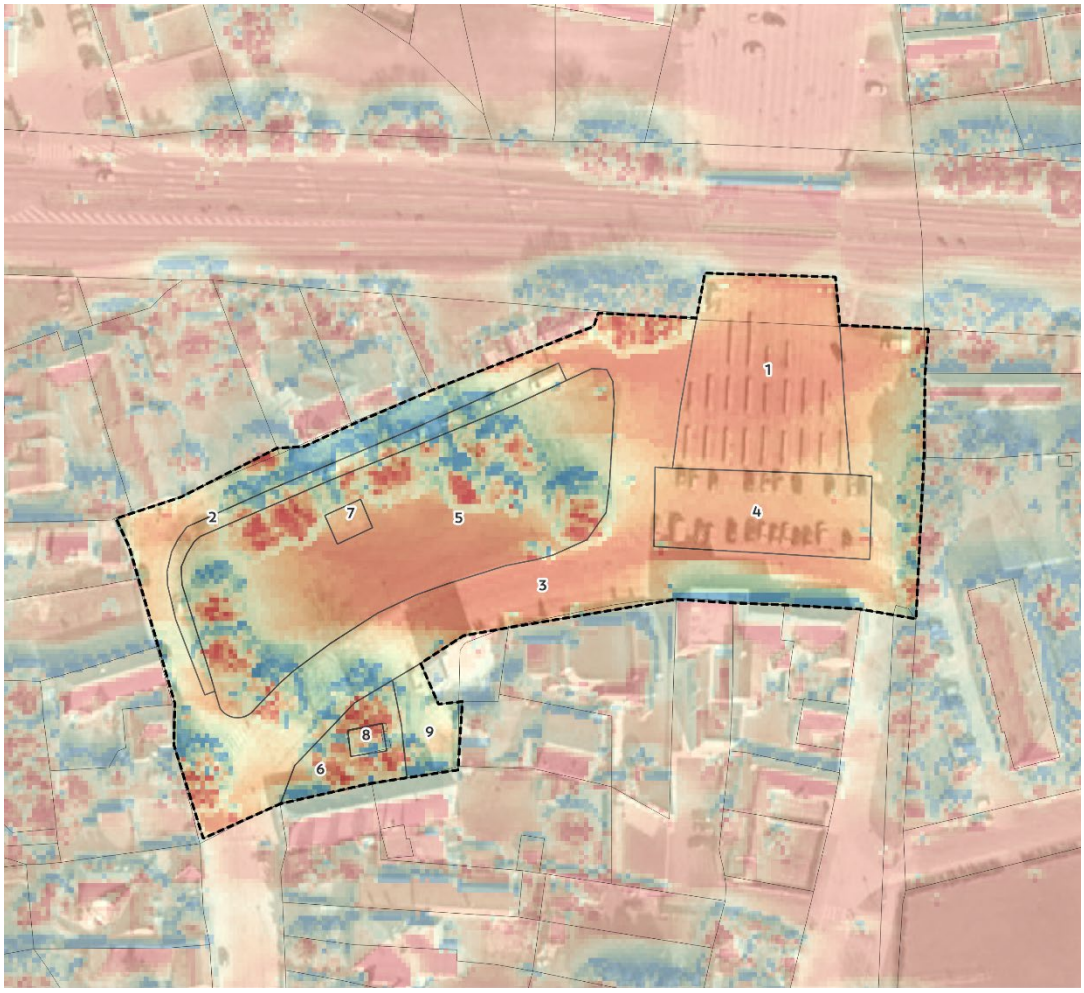
Average NDVI value per land cover

1	0,080
2	0,230
3	0,162
4	0,050
5	0,343
6	0,236
7	0,359
8	0,363
9	0,133

Figure 37 – Vegetative cover in study area of flea market (SAJMIŠTE) (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024); author: 3 E PROJEKTI d.o.o.)

Insolation analysis

The study area was analyzed in terms of exposure to direct solar radiation on August 12, 2024. The analysis was conducted based on a normalized digital surface model, which was used to create a simulation of the total solar energy level expressed in kWh/m² (Figure 38) and direct sun exposure over a 24-hour period (Figure 38). The results of the analysis confirm the exposure of the fairground area and highlight the need for implementing mitigating measures.



Total insolation [kWh/m]

7.112107

0.623703

Average Total insolation value per land cover type

1	5,94 kWh/m
2	3,29 kWh/m
3	4,47 kWh/m
4	5,68 kWh/m
5	4,57 kWh/m
6	4,37 kWh/m
7	5,46 kWh/m
8	4,26 kWh/m
9	3,02 kWh/m

Figure 38 – Total insolation (kWh/m²) in study area of flea market (SAJMIŠTE) (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024); author: 3 E PROJEKTI d.o.o.)

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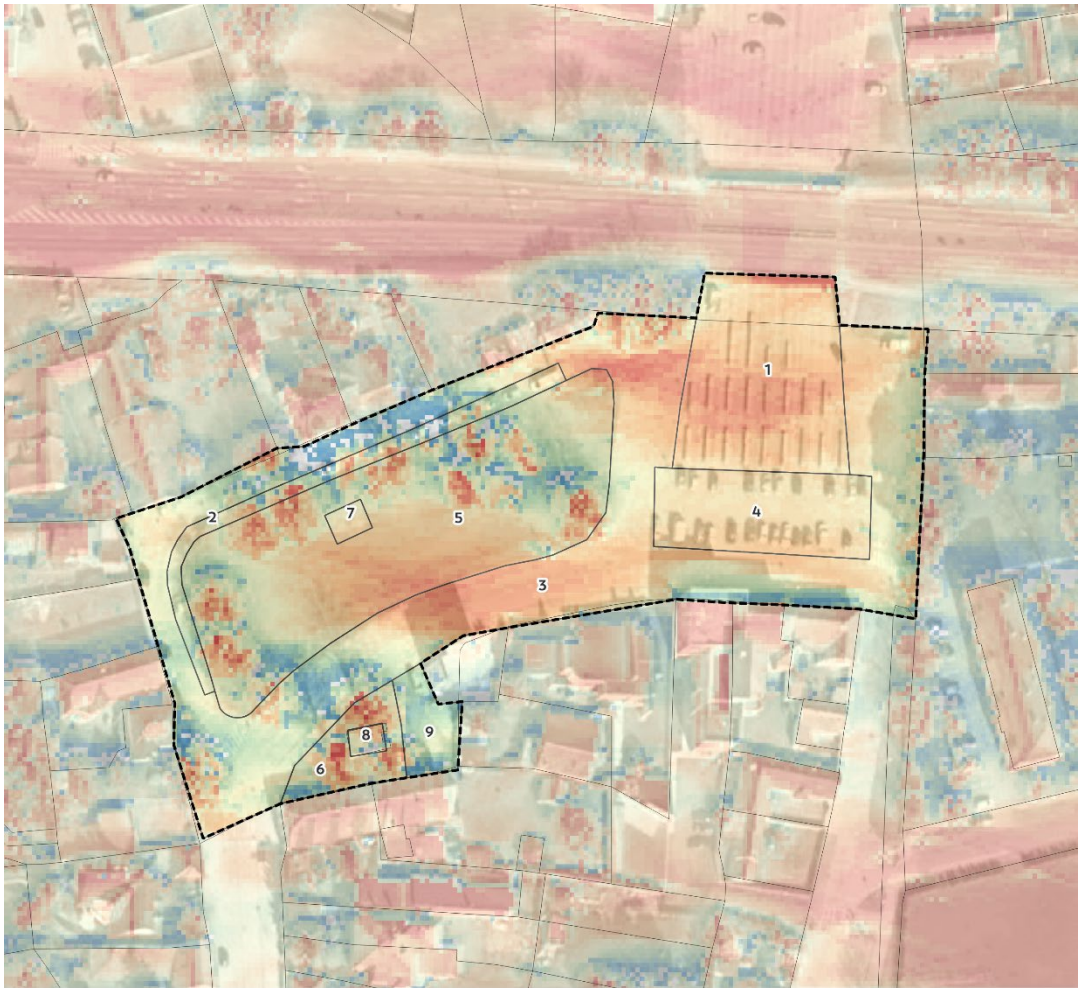

Average duration of direct insolation per land cover type

Duration of insolation [h]

14.5

0.5

1	11 h
2	7 h
3	8 h
4	9 h
5	8 h
6	8 h
7	9 h
8	8 h
9	4 h

Figure 39 – Duration of insolation (h) in study area of flea market (SAJMIŠTE) (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024); author: 3 E PROJEKTI d.o.o.)

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Field research - Measure surface temperatures using infrared thermometers.

Measurement with an infrared thermometer, to take the ground surface temperature, was conducted on August 1, 2023, between 11 AM and 1 PM at several locations in the city of Varaždin.

On the paved area of Sajmište (trial zone/area), a temperature of **50.3°C** was recorded, making it the highest measured temperature among the surveyed locations. On the Sajmište lawn, the temperature was already lower at **39.5°C**, highlighting the importance of plants and grass in urban areas.

*Figure 40 - Measure surface temperatures using infrared thermometers in trial zone/area for the planned mitigation measure - **a flea market (SAJMIŠTE)** (Author: 3 E PROJEKTI d.o.o.)*

asphalt: 50,3 °C

asphalt: 48,8 °C

paving surface under the bridge/passage: 25,7 °C

paved surface: 44,4 °C

under tree: 25,8 °C

lawn: 39,5 °C

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4.3. VULNERABLE GROUPS

The data presented in the tables below refers to the results of the analysis of vulnerable groups in the area of research (GUP - General Urban Plan of the City of Varaždin) ** through socioeconomic and health parameters and supporting infrastructure.

Due to the different level of data availability, starting from the level of the county (Varaždin County)*****, city (City of Varaždin)****, urban settlements***, up to census circles (area of research - GUP) ** and branches (Center for Social Welfare, etc.), there are different scopes and types of data, and they are indicated in the table below with the symbol * for easier connection. The data related to the research area (GUP) are shown cartographically below.

Socio-economic indicators

Table 27 - Socio-economic indicators (Author: 3 E PROJEKTI d.o.o.)

Socio-economic data	Result / Conclusion
Young people (%)	1 474 residents aged 0-4 *** **// 3,19%**
	4 945 residents aged 0-15 ** // 13,82 %
Elderly people (%)	8 945 residents aged 65 and over*** **// 23,76%**
	3 748 residents aged 74 and over // 10,47 %**
Poverty rate (%)	Data for the City of Varaždin is unavailable but: The Social Welfare Center - Varaždin branch states that as of December 31, 2022, there were **692 recipients of the guaranteed minimum allowance, representing 0.8% of the total population.**
Unemployment rate (%)	economically inactive or other inactive persons – 2 099 residents **** // **4,79 %**
Gender (%)	18 913 women **// 52,88 % **

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Immigrated people (%)	total population of City of Varaždin is 43 782, of which 342 are foreign nationals **** **// 0,78 %**
Low-skilled jobs (%)	No schooling – 123 residents // 0,34% Completed primary education – 4 400 residents // 12,29% Completed secondary education – 21 048 residents // 58,08% Total – 25 838 residents **** **// 72,18%**
Social housing (%)	Data unavailable; however, the City owns 2 buildings on A. Harambašić Street, providing a total of 46 apartments for social housing. Other city-owned apartments are located within multi-residential buildings and houses across the administrative area.
Density of population	35 792 residents / 24,45 km² research area = **1 466,34 residents per km² ** **
Retired people (%)	12 087 residents **** **// 27,60%**
Census data by age and gender for 2021 from the Croatian Bureau of Statistics (DZS) at **census district level (research area - GUP)** **	
Census data by age and gender for 2021 from the Croatian Bureau of Statistics (DZS) for **settlements in the City of Varaždin** ***	
Census data on households and housing for 2021 from the Croatian Bureau of Statistics (DZS) **for the City of Varaždin** ****	

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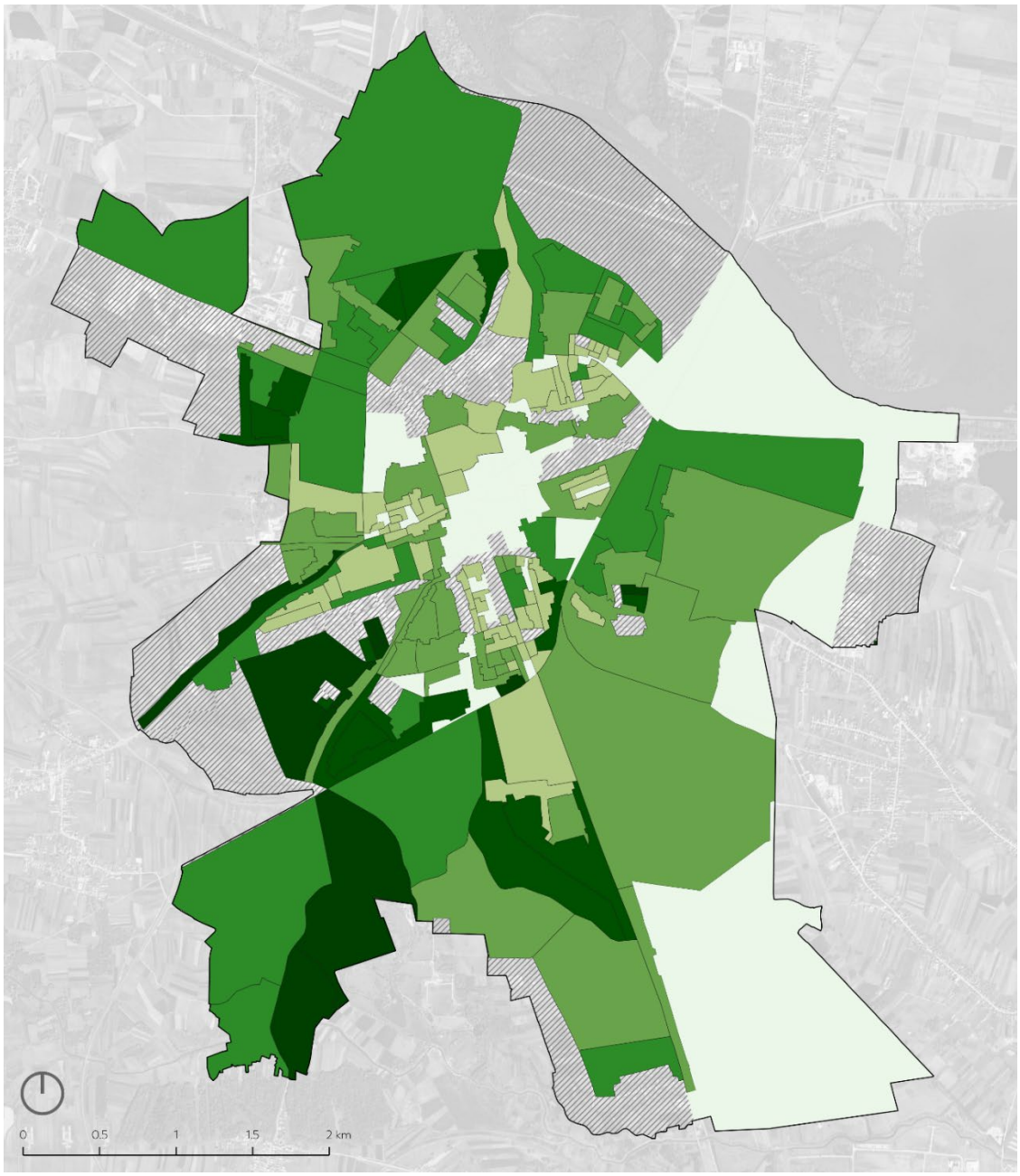

Figure 41 – Population under 16 years of age (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: Display of population by census districts (proprietary data, based on DGU and DZS, 2024.); author: 3 E PROJEKTI d.o.o.)

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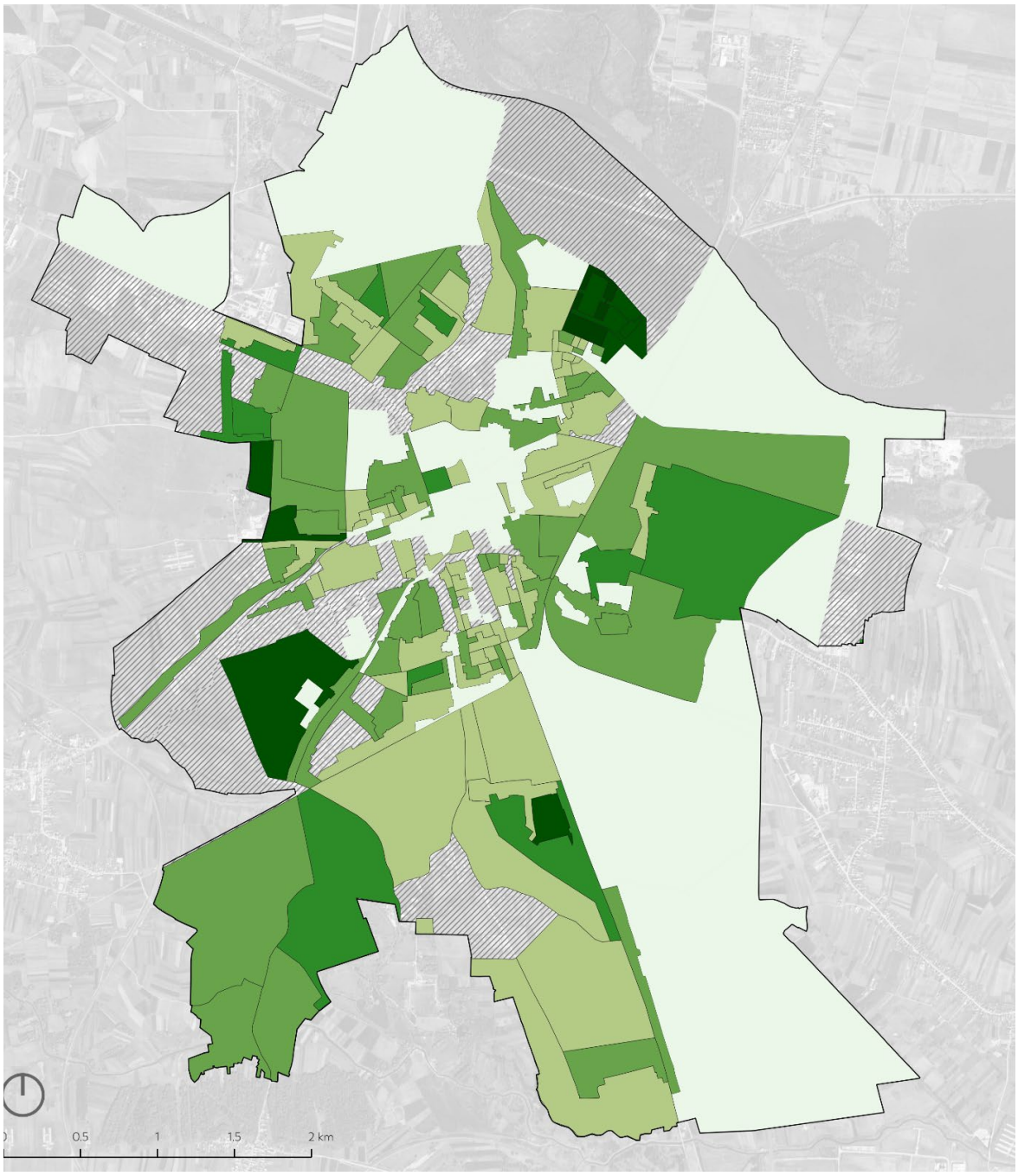

Figure 42 – Population over 75 years of age (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: Display of population by census districts (proprietary data, based on DGU and DZS, 2024.); author: 3 E PROJEKTI d.o.o.)

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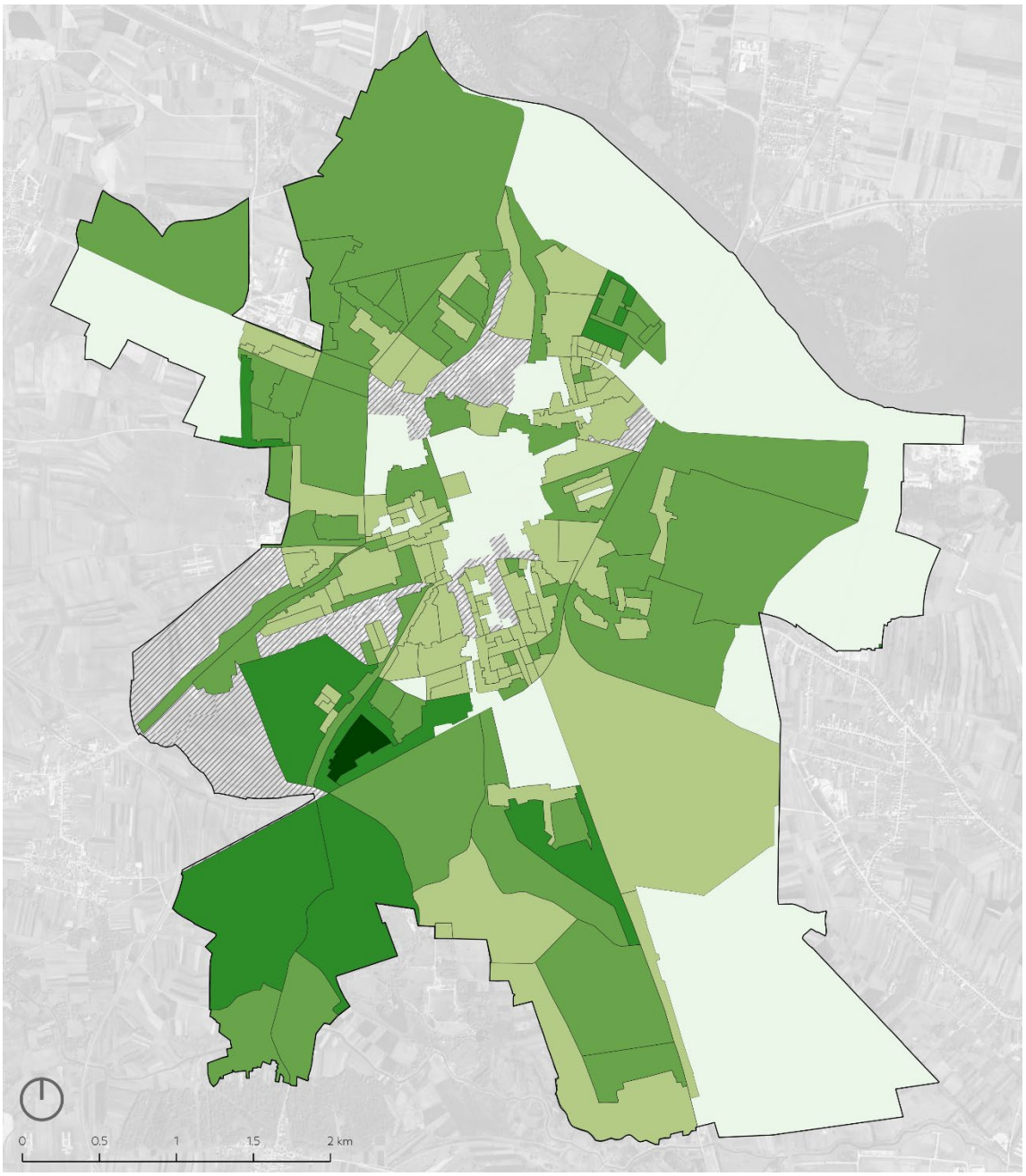

Figure 43 – Display of population by census districts (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: Mop content: Display of population by census districts (proprietary data, based on DGU and DZS, 2024.); author: 3 E PROJEKTI d.o.o.)

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Health condition indicators

Table 28 - Health condition data (Author: 3 E PROJEKTI d.o.o.)

Health condition data	**Result / Conclusion**
Share of ill people (asthma, diabetes, hypertension, and obesity) / **Ill people (%)**	Data for the City of Varaždin is unavailable. According to the Report on Persons with Disabilities in Croatia (2021), there were 4 213 individuals with **chronic illnesses** in Varaždin County. **** // **2,64%**
Disabled people (%)	6 296 residents, or **1.1%** of the total population of disabled persons ***
Share of mentally ill people / **Mentally ill people (%)**	Data for the City of Varaždin is unavailable. According to the Report on Persons with Disabilities in Croatia (2021), there were 4 341 individuals with mental illnesses in Varaždin County. **** **// 2,72%**
Mortality rate (%)	Data for the City of Varaždin (2023) ***: Number of deaths: 252 **// 0,57%** Number of births: 328 **// 0,74%** Natural population increase: 580 **// 1,32%**
**** Data for the City of Varaždin ***** Data for Varaždin County	

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Infrastructure indicators

Table 29 - Infrastructure data (Author: 3 E PROJEKTI d.o.o.)

Infrastructure data	Result / Conclusion
Hospitals capacity	935 beds available for hospital treatment** Possible 15% increase in case of emergencies** **0.94 beds per 1,000 residents**
Health centers	14 public and private clinics, polyclinics, medical offices, and hospitals ** **0.01 healthcare facilities per 1,000 residents**
Retirement houses	7 retirement homes **
Social housing	300 apartments The City owns 5 buildings, including: 3 buildings in Hrašćica with a total of 118 apartments *** 2 buildings on A. Harambašić Street with a total of 46 apartments** Other city-owned apartments are located in multi-residential buildings and houses.
*** Data for the City of Varaždin	

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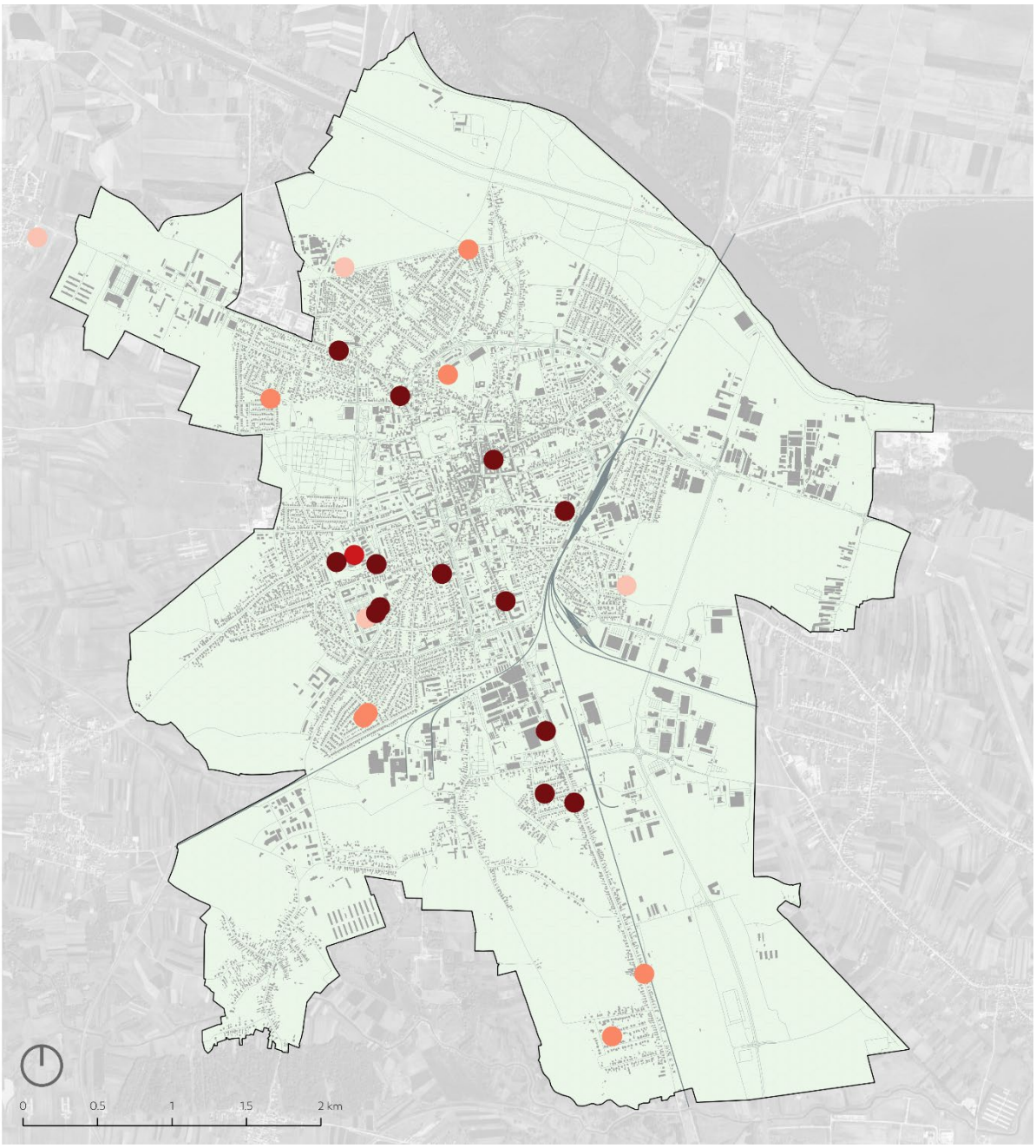

Figure 44 – Infrastructure (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: display of social infrastructure facilities (proprietary data, based on GUP); author: 3 E PROJEKTI d.o.o.)

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Vulnerability Index (VI)

We used official data provided by the state agency, the Croatian Bureau of Statistics, based on the 2021 census, in which the population is divided into age groups. Unfortunately, this data is limited to statistical regions within local **council area** (A - 1. mjesni odbor "Centar", Varaždin, B - 2. mjesni odbor Varaždin, C - 3. mjesni odbor Varaždin, D - 4. mjesni odbor Varaždin, E - 5. mjesni odbor Varaždin, F - 6. mjesni odbor "Bonfica" Varaždin, G - 7. mjesni odbor Varaždin "Biskupec",H - 8. mjesni odbor Varaždin i I - Mjesni odbor Jalkovec) boundaries, so we could not use it for our pilot area, which is smaller in size and falls between three distinct statistical regions. **Additionally, we lacked the resources or authority to acquire such data for the pilot area.**

In accordance with the prescribed methodology, the tables below analyze vulnerable groups: gender (women), young people (up to 15 years old), elderly people (over 75 years old), and infrastructure (hospitals, retirement houses, and social housing) in the local **council area** of research area (GUP).

The final vulnerability index indicates that the most vulnerable area is **E - 5. mjesni odbor Varaždin**, followed by C - 3. mjesni odbor Varaždin D - 4. mjesni odbor Varaždin and H - 8. mjesni odbor Varaždin. A detailed overview of all categories is provided in the table (Table 34) and graphical representation (Figure 43) below.

Table 30 -Calculation of the normalized value of the gender (female) people indicator and its corresponding weight (author: 3 E PROJEKTI d.o.o.)

Council area	Female	Fem (%)	normIndex (Fem)	wi (Fem)	VI (Fem)
A	1570	0,52	0,56	0,25	0,14
B	1162	0,53	0,63	0,25	0,16
C	3072	0,55	0,99	0,25	0,25
D	2467	0,55	1,00	0,25	0,25
E	2859	0,53	0,64	0,25	0,16
F	2632	0,53	0,67	0,25	0,17
G	1280	0,52	0,60	0,25	0,15
H	2741	0,52	0,53	0,25	0,13
I	615	0,49	0,00	0,25	0,00

Table 31 -Calculation of the normalized value of the young people (under 15) indicator and its corresponding weight (author: 3 E PROJEKTI d.o.o.)

Council area	Under 15	normIndex (>15)	wi (>15)	VI (>15)
A	340	0,23	0,25	0,06
B	379	0,29	0,25	0,07
C	701	0,76	0,25	0,19

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D	541	0,53	0,25	0,13
E	795	0,89	0,25	0,22
F	626	0,65	0,25	0,16
G	362	0,27	0,25	0,07
H	869	1,00	0,25	0,25
I	178	0,00	0,25	0,00

Table 32 - Calculation of the normalized value of the elderly people (over 75) indicator and its corresponding weight (author: 3 E PROJEKTI d.o.o.)

Council area	Over 75	normIndex (75+)	wi (75+)	VI (75+)
A	323	0,42	0,25	0,11
B	170	0,11	0,25	0,03
C	575	0,93	0,25	0,23
D	516	0,81	0,25	0,20
E	608	0,99	0,25	0,25
F	611	1,00	0,25	0,25
G	249	0,27	0,25	0,07
H	494	0,77	0,25	0,19
I	113	0,00	0,25	0,00

Table 33 - Calculation of the normalized value of the infrastructure and its corresponding weight (author: 3 E PROJEKTI d.o.o.)

Council area	Infrastructure	normIndex (Infr)	wi (Infr)	VI (Infr)
A	3	0,60	0,25	0,15
B	1	0,20	0,25	0,05
C	2	0,40	0,25	0,10
D	3	0,60	0,25	0,15
E	5	1,00	0,25	0,25
F	0	0,00	0,25	0,00
G	5	1,00	0,25	0,25
H	5	1,00	0,25	0,25
I	0	0,00	0,25	0,00

Table 34 - Vulnerability index for local council area (author: 3 E PROJEKTI d.o.o.)

Council area	Vi	Vi (1-5)	Council area	Vi	Vi (1-5)
A	0,45	3	F	0,58	3
B	0,31	2	G	0,54	3
C	0,77	4	H	0,82	4
D	0,73	4	I	0	1
E	0,88	5			

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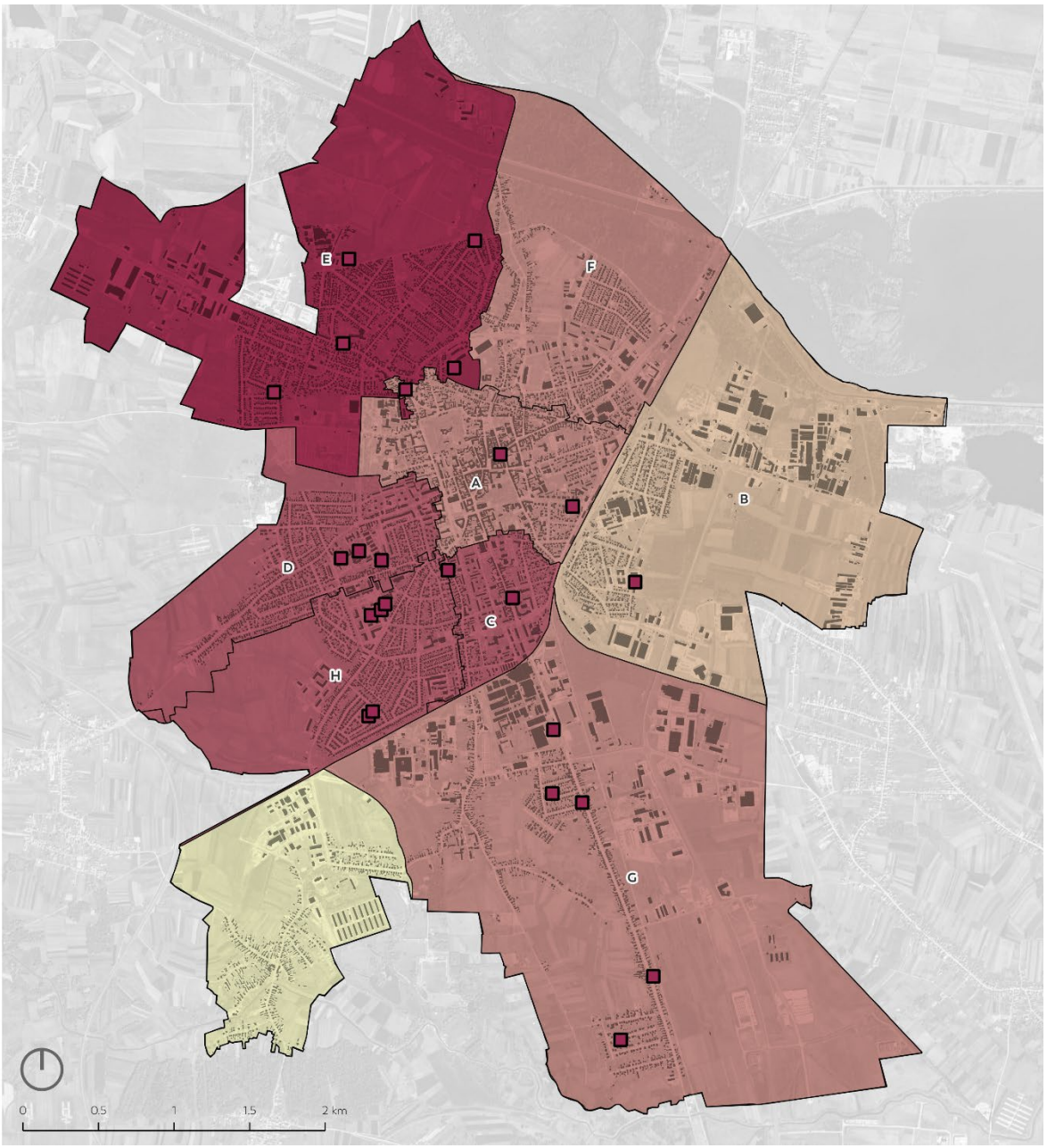

Vulnerability index | Local council area

1	A - 1. mjesni odbor "Centar" Varaždin B - 2. mjesni odbor Varaždin
2	C - 3. mjesni odbor Varaždin D - 4. mjesni odbor Varaždin
3	E - 5. mjesni odbor Varaždin F - 6. mjesni odbor "Banfica" Varaždin
4	G - 7. mjesni odbor Varaždin "Biškupec" H - 8. mjesni odbor Varaždin
5	I - Mjesni odbor Jalkovec

Local council area boundary within GUP

Buildings

Social infrastructure facilities (hospitals, health centers, retirement homes, social housing)

Figure 45 – Vulnerability index by local council area (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: Display of vulnerability index per Local council (proprietary data, based on DGU and DZS, 2024); author: 3 E PROJEKTI d.o.o.)

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4.4. READINESS AND ADAPTATION CAPACITY OF CITY

OVERVIEW OF THE LEGAL FRAMEWORK AND IMPLEMENTATION AT THE LEVEL OF THE CITY OF VAZAŽDIN

The legal framework and its implementation at the level of the City of Varaždin are graphically (Figure 46) presented and further elaborated in the following text.

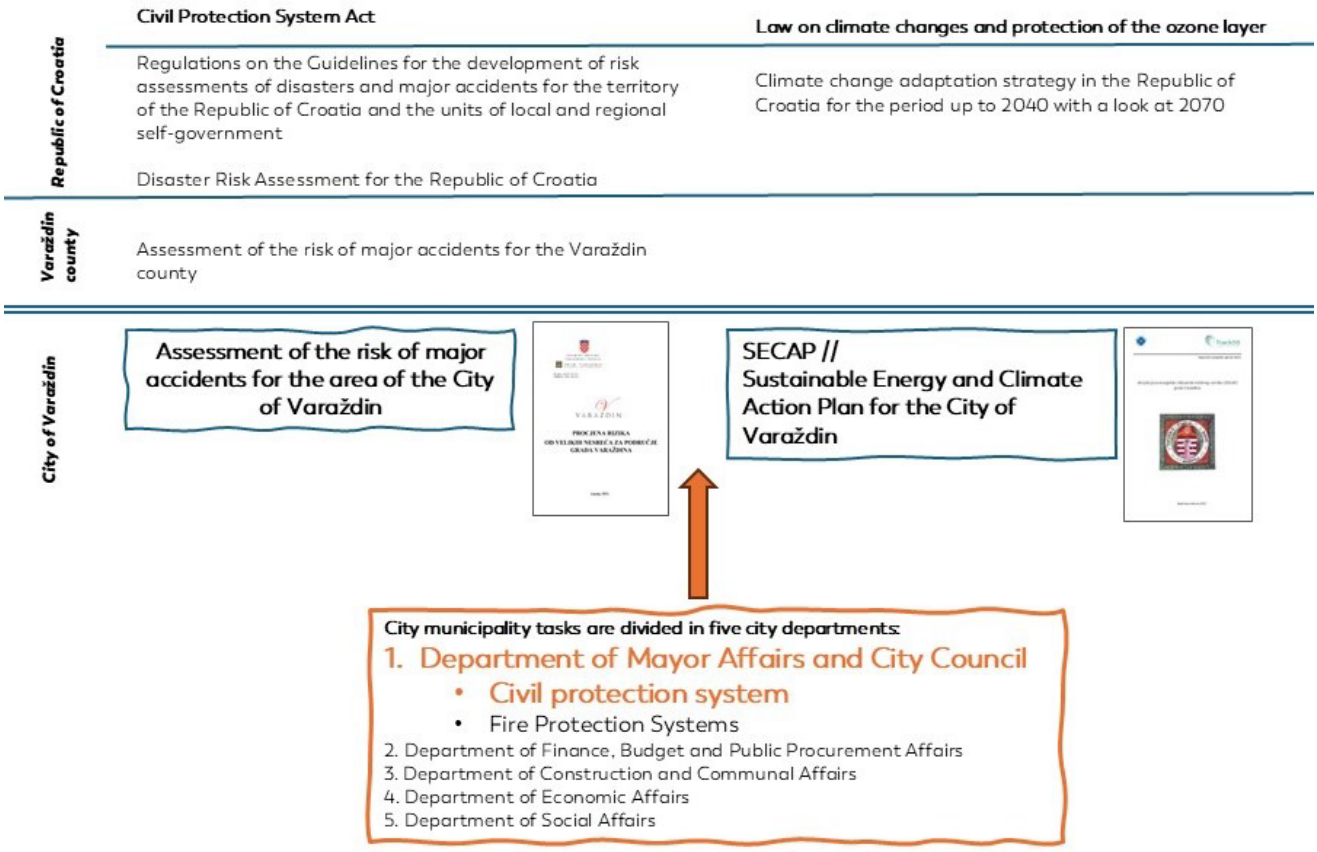

Figure 46 - The legal framework and implementation at the level of the City of Varaždin (author: 3 E PROJEKTI d.o.o.)

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LAW ON CLIMATE CHANGES AND PROTECTION OF THE OZONE LAYER (NN) 127/19)

(Source: https://narodne-novine.nn.hr/clanci/sluzbeni/2019_12_127_2554.html)

regulates the issue of adaptation to climate change. On the basis of Article 14, paragraph 3 of this law, the **Croatian Parliament** adopted at its session on April 7, 2020:

CLIMATE CHANGE ADAPTATION STRATEGY IN THE REPUBLIC OF CROATIA FOR THE PERIOD UP TO 2040 WITH A LOOK AT 2070

(Source: https://mingo.gov.hr/UserDocsImages/klimatske_aktivnosti/klima/prilagodba/strat_prilagodbe_rh_2020.pdf)

The main objectives of the Adaptation Strategy are: (a) to reduce the vulnerability of natural systems and society to the negative impacts of climate change, (b) to increase the ability to recover from the effects of climate change and (c) to take advantage of potential positive effects, which may also be a consequence of climate change. The adaptation strategy determines priority measures and coordinated action through short-term action plans and monitoring the implementation of measures.

The Adaptation Strategy recognizes the sectors that are expected to be most exposed to the impact of climate change: water resources, agriculture, forestry, fisheries and aquaculture, biodiversity, energy, tourism and health. Two cross-sectoral topics that are crucial for the implementation of a comprehensive and effective adaptation to climate change were also covered: spatial planning and development and disaster risk management.

Based on the list of identified climate change adaptation measures (85 measures, of which 83 are measures by sector, and two general measures, which were not taken into account because they are not part of any sector), sectoral measures were divided into five groups of measures based on the national priorities of the Adaptation Strategy. Adaptation measures to climate change are classified by type as regulatory and administrative measures (RE), implementation measures (PR), education and public awareness measures (ED) and research and development measures (IR). The measures are further classified according to the urgency and importance of implementation into three basic categories of importance: measures of very high importance of implementation, measures of high importance of implementation and measures of medium importance of implementation.

The adaptation strategy has an umbrella national character, but most of the adaptation measures are of a local or regional nature. Lack of awareness and knowledge on the subject of adaptation to climate change, with a few exceptions, was observed in all JLP(R)S. In this sense, strengthening the professional and implementation capacities of the JLP(R)S is of key importance for the successful implementation of the measures from the action plans.

For JLP(R)S to operate as effectively as possible in adapting to climate change, it is necessary to significantly strengthen their competencies and capacities. Both at the strategic level (creating regional development and spatial plans that will include a component of adaptation to climate change), and at the technical level by training officials and experts in certain areas of adaptation to climate change.

The engagement of JLP(R)S is contributed by the global initiative "Charter of Mayors on Climate and Energy", and the cities that join it demonstrate their commitment to work on mitigating and adapting to climate change.

By signing the Charter, the mayors undertake to implement the 20-20-20 measures program and apply specific energy efficiency measures developed in the Energy Sustainable Development Action Plans in order to reduce CO2 emissions in their area by at least 20% by 2020 and contribute to meeting the basic goals of the European Energy Policy.

The city of Varaždin is one of the Croatian cities that signed this Charter and undertook to take measures to adapt to climate change. As part of the above, Varaždin created a strategic document Action Plan for Energy and Climate Sustainable Development, abbreviated as SECAP (Sustainable Energy and Climate Action Plan).

ADMINISTRATIVE BODIES OF THE CITY OF VARAŽDIN

Administrative bodies of the City of Varaždin perform tasks in one or more administrative and/or professional areas, while respecting the organizational connection. In accordance with the above, one of the administrative bodies is the **Department of Mayor Affairs and City Council,** which performs activities in the field of civil protection, occupational safety, fire protection and protection from natural disasters.

(Source: https://varazdin.hr/sustav-civilne-zastite/)

The most important document of the City of Varaždin from the civil protection system is:

ASSESSMENT OF THE RISK OF MAJOR ACCIDENTS FOR THE AREA OF THE CITY OF VARAŽDIN (CLASS: 240-01/22-01/6, UR NO: 2186-1-02-22-1 from July 8, 2022) (hereinafter: Risk Assessment)

(Source: https://varazdin.hr/upload/2022/07/procjena_rizika_grada_varazdina-srpanj_2022-prihva_62d6be110a738.pdf)

The document defines the risks that represent a possible threat to the population, economy, social stability and politics of the City of Varaždin, namely**: 1. earthquake, 2. flood, 3. floods due to the breach of an embankment or dam of HPP Varaždin, 4. extreme temperatures, 5. epidemics and pandemics, 6. accidents at a waste dump, 7. industrial accidents, 8. accidents in the transport of dangerous substances**

Measures and activities in the civil protection system are carried out by the following operational forces of the civil protection system: **civil protection headquarters (Stožer CZ), operational firefighting forces (Vatoragstvo), operational forces of the Croatian Red Cross (GDCK), operational forces of the Croatian Mountain Rescue Service (HGSS), associations (Udruga), units and civil protection commissioners (povjerenici), on-site coordinators (kordinatori) of legal entities in the civil protection system (privatne osobe).**

Risk matrix

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The common matrix of all analyzed risks shows the relationship between the consequences **(1. insignificant, 2. small, 3. moderate, 4. significant and 5. catastrophic)** and probabilities **(1. extremely small, 2. small, 3. moderate, 4. large and 5. extremely large)** of all potential risks **(earthquake, flood, floods due to the breach of an embankment or dam of HPP Varaždin, extreme temperatures, epidemics and pandemics, accidents at the waste dump, industrial accidents and accidents in traffic with dangerous substances)** for the Varaždin area.

From the presented matrix, it is evident that in the order of high risk are primarily threats from technical and technological disasters, and in recent years, epidemics and pandemics due to the emergence of an epidemic caused by the COVID virus. The only significant consequences would be an earthquake and a flood due to the bursting of the dam or embankment of HPP Varaždin, but since the probability of the occurrence of these two disasters is extremely small, they belong to moderate risks. **Moderate risks also include the occurrence of extreme temperatures.** In the area of the City of Varaždin, there are no risks that would fall under very high risks.

A detailed presentation of the relationship between the consequence ratings and risk probability is shown in the graphic below (Table 35).

Table 35 - Common matrix of analysed risks for the Varaždin area (Source: Risk assessment; modified)

consequences	5- catastrophic					
	4 - significant	C				
	3 - moderate	A	G H	F		E
	2 - small			**D**		
	1 - insignificant			B		
		1. extremely small	2. small	3. moderate	4. large	5. extremely
		probabilities				

Potential risks: A. earthquake, B. flood, C. floods due to the breach of an embankment or dam of HPP Varaždin, **D. extreme temperatures**, E. epidemics and pandemics, F. accidents at the waste dump, G. industrial accidents and H. accidents in traffic with dangerous substances

	Very high risk
	High risk
	Moderate risk
	Low risk

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Readiness of operational capacities

The readiness of operational capacities, with regard to established criteria **(manpower, readiness of command staff, training of both manpower and command staff, training, provision of material resources and equipment, time of mobilization readiness/operational readiness and self-sufficiency and logistical resistance)**, was assessed as a high level of readiness.

A summary of the readiness of operational capacities according to the state of readiness of people and equipment is shown in detail in the table below (Table 36); briefly:

- civil protection headquarters (Stožer CZ) - *High readiness (2)*
- operational firefighting forces (Vatoragstvo) - *Very high readiness (1)*
- operational forces of the Croatian Red Cross (GDCK) - *Very high readiness (1)*
- operational forces of the Croatian Mountain Rescue Service (HGSS) - *Very high readiness (1)*
- associations (Udruga) - *High readiness (2)*
- units and civil protection commissioners (povjerenici) - *Low readiness (3)*
- on-site coordinators (kordinatori) - *Very high readiness (1)*
- legal entities in the civil protection system (privatne osobe) - *High readiness (2)*

Table 36 – Summary of readiness of operational forces according to the state of readiness of people and equipment (Source: Risk assessment; modified)

Operational capacities	civil protection headquarters (Stožer CZ)				operational firefighting forces (Vartogastvo)				operational forces of the Croatian Red Cross (GDCK)				perational forces of the Croatian Mountain Rescue Service (HGSS)				associations (Udruga)			
*Criteria	4	3	2	1	4	3	2	1	4	3	2	1	4	3	2	1	4	3	2	1
1.				X				X				X				X			X	
2.			X					X				X				X			X	
3.			X					X				X				X		X		
4.								X				X				X		X		
5.			X				X				X				X			X		
6.				X				X				X				X			X	
7.				X			X				X				X				X	
SUM			X					X				X				X			X	

Operational capacities	units and civil protection commissioners (Povjerenici)				on-site coordinators (Kordinatori)				civil protection system (Privane osobe)				**CONCLUSION**			
*Criteria	4	3	2	1	4	3	2	1	4	3	2	1	4	3	2	1
1.	X				X						X				X	
2.		X			X						X				X	
3.		X			X						X				X	
4.		X			X					X					X	
5.	X				X						X			X		
6.	X				X					X					X	
7.					X						X				X	
SUM		X			X						X				X	

* established criteria:
1. manpower
2. readiness of command staff
3. training of both manpower and command staff
4. training,
5. provision of material resources and equipment

4	Very low readiness
3	Low readiness
2	High readiness
1	Very high readiness

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The relationship of the civil protection system with threats/risks

Comparing the state of the civil protection system according to the identified and processed risks and threats, it is evident that the state of preparedness is high and that there are opportunities to achieve **a very high level of preparedness through certain measures and activities.**

The readiness of the responsible, management and operational capacities and the state of mobility of the operational capacities of the civil protection system and the state of communication capacities for the threat of extremely high temperatures is at the level of very high readiness.

The overall readiness of the civil protection system against the threat response area is shown in detail in the table below (Table 37).

Table 37 - Summary overview of the analysis of the civil protection system against the threat response area (Source: Risk assessment; modified)

Elements for the analysis of civil protection in the response area	Readiness of responsible and management capacities				Readiness of operational capacities				State of mobility of civil protection system operational capacities and state of communication capacities				**CONCLUSION**			
Threats:	4	3	2	1	4	3	2	1	4	3	2	1	**4**	**3**	**2**	**1**
A. earthquake			X				X				X				**X**	
B. flood				X			X					X				**X**
C. floods due to the breach of an embankment or dam of HPP Varaždin		X					X					X			**X**	
D. extreme temperatures				X			X					X				**X**
E. epidemics and pandemics			X				X					X			**X**	
F. accidents at the waste dump				X			X					X				**X**
G. industrial accidents			X			X						X			**X**	
H. accidents in traffic with dangerous substances			X			X						X			**X**	

4	Very low readiness
3	Low readiness
2	High readiness
1	Very high readiness

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Conclusions

This urban heat island (UHI) vulnerability and risk assessment for the City of Varaždin provides a comprehensive framework for understanding the causes, consequences, and potential mitigation strategies to address this growing urban challenge. As climate change intensifies, the phenomenon of UHIs becomes increasingly critical, affecting not only temperature regulation but also public health, energy consumption, and overall urban livability. The findings of this assessment underscore the need for evidence-based planning and proactive intervention to enhance the city's resilience to these challenges.

The analysis identifies several key factors contributing to the UHI effect in Varaždin, including high building density, limited green infrastructure in certain areas, the prevalence of impermeable surfaces, and the high energy demand of buildings and the transportation sector. These elements exacerbate local temperature variations, leading to increased cooling costs, greater thermal discomfort for residents, and elevated health risks, particularly for vulnerable populations such as the elderly, children, and individuals with pre-existing medical conditions.

Addressing urban heat islands is not just an environmental priority but a key component of sustainable urban development. By taking decisive action based on the insights of this report, the City of Varaždin can position itself as a leader in climate resilience within the Danube Region and beyond. This document serves as a foundation for informed policymaking, future investments, and long-term adaptation strategies, ensuring a more sustainable, livable, and climate-resilient urban environment for generations to come.

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Annex 1

SUMMARY OF PRELIMINARY FIELD RESEARCH

Measure surface temperatures using infrared thermometers

Measurement with an infrared thermometer, to take the ground surface temperature, was conducted on August 1, 2023, between 11 AM and 1 PM at several locations **(Kapucinski Square, Korzo, Mali Plac and Flea market (Sajmište))** in the city of Varaždin.

On the paved area of **(1) Sajmište (trial zone/area)**, a temperature of **50.3°C** was recorded, making it the highest measured temperature among the surveyed locations.

Other recorded temperatures:

- **(2) Kapucinski Square (paved area):** 42,6°C
- **(3) Mali Plac (in a planter):** 47,5°C
- **(4) Korzo (paved area):** 45,1°C

Figure 47 – Locations (Kapucinski Square, Korzo, Mali Plac and Flea market (Sajmište)) for research (Map base: Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024), Map content: proprietary data) author: 3 E PROJEKTI d.o.o.)

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(2) Kapucinski Square

paved surface: 42,6 °C

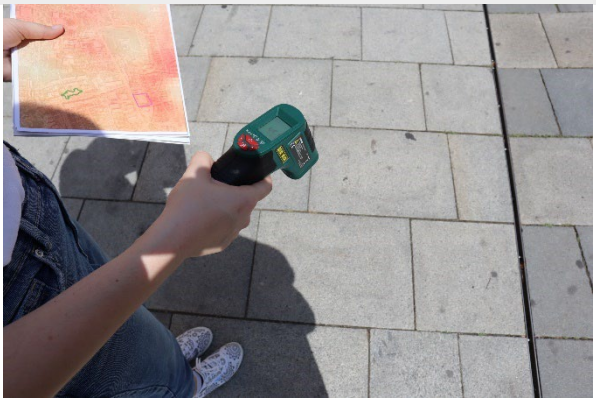
paved surface (shadow): 25,7 °C

(3) Mali Plac

grass/soil in a planter: 47,5°C

grass/soil (shadow): 24,1°

(4) Korzo



paved surface: 45,1 °C

paved surface (shadow): 27,7 °C

Figure 48 - Measure surface temperatures using infrared thermometer in city center (Author: 3 E PROJEKTI d.o.o.)

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Local methodology workshop

Organizer:¸Development agency North and City of Varaždin

City: Varaždin

Country: Croatia

Date: 01.10.2024.

The workshop on Urban Heat Islands (UHIs) brought together approximately 20 enthusiastic participants, including urban planners, environmental experts, and community stakeholders. The event aimed to foster collaborative solutions for mitigating urban heat and enhancing urban resilience.

Activities Included:

- Keynote Presentation: An expert overview of UHIs, their causes, and their impacts on urban ecosystems.
- Interactive Mapping Session: Participants identified local UHI hotspots and shared insights on high-risk zones.
- Group Brainstorming: Small groups collaborated on strategies for cooling urban environments, focusing on urban greening, innovative materials, and community engagement.
- Feedback and Q&A: Attendees shared reflections and questions, encouraging dynamic exchanges between experts and the audience.

Outcomes:

- A comprehensive understanding of the UHI phenomenon among participants.
- A preliminary map of UHI hotspots in the local area.
- Strengthened connections between stakeholders, laying the groundwork for future collaboration.

Recommendations for UHI vulnerability and risk assessment

- **Data Collection and Analysis:** Leverage remote sensing technology and GIS to map temperature variances and identify hotspots.
- **Community Engagement:** Incorporate local knowledge to ensure assessments reflect real-world challenges and priorities.
- **Green Infrastructure Assessment:** Evaluate current vegetation coverage and its cooling potential.
- **Socioeconomic Indicators:** Identify vulnerable populations (e.g., elderly or low-income groups) to prioritize interventions.
- **Policy Integration:** Ensure UHI assessments are embedded in broader urban development and climate resilience strategies.

Target group attendees

Target group		Number
Local authority		1
Regional authority		1
National authority		X
Interest groups and NGOs		4
Business support organizations		2
Cross-border legal body		X
General public		X
Higher education and research organization		2
Gender	Men	6
	Women	12
	Other	X

Workshop communication and dissemination

(Links to website announcement, Facebook event, information article on your institutional website, etc.)

The workshop was promoted through our facebook channels:
https://www.facebook.com/photo?fbid=983666583562567&set=a.502857928310104

Afterwards, the workshop was featured on following channels:

Hrvatska radiotelevizija (HRT) – Croatian national public TV broadcaster (screenshot in chapter 6)

Regionalni tjednik – regional newspapers (screenshot in chapter 6)

And through other various news portals:

https://varazdinske-vijesti.hr/nasim-krajem/na-sajmistu-bilo-cak-50-3-oc-sad-se-radi-toplinska-mapa-varazdina-86225

https://varazdin.hr/novosti/odrzana-strucna-radionica-o-toplinskim-otocima-sklopu-projekta-beready-11476/

https://evarazdin.hr/nasim-krajem/foto-strucnjaci-razmatrali-strategije-za-smanjenje-ucinaka-toplinskih-otoka-u-varazdinu-413101/

https://varazdinski.net.hr/vijesti/drustvo/13402932/odrzana-strucna-radionica-o-toplinskim-otocima-u-sklopu-projekta-beready/

Workshop evaluation results

Out of 10 evaluation forms the results (average grades) were as follows:

How would you rate the overall workshop program in terms of content and efficiency? **4.5**

How would you rate the Be Ready UHI risk assessment methodology and the tools in terms of content, clarity, and applicability? **4.6**

Which of the 4 thematic areas of the UHI risk assessment methodology and tools do you find most relevant to your city's current practices / strategies/ policies on climate change?

Exposure of buildings and surroundings **4.5**

Sensitivity of equipment and material **3.9**

Risk groups among city residents **4.0**

Preparedness and adaptive capacity of cities/municipalities **4.6**

How would you evaluate the opportunities for mutual learning and sharing of experience during the workshop? **4.4**

How do you assess your organization's contribution to the success of the workshop? **4.3**

1. Photos from the event

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NAJVEĆE STOPE OPORABE OTPADA NA SJEVERU

U Varaždinskoj i Međimurskoj županiji se odvaja najviše otpada

Str. 4.

URBANI TOPLINSKI OTOCI

Hoće li se neka od varaždinskih "vrućih točaka" hladiti podzemnim vodama?

Str. 6.

7 Plus Tjednik Regionalni

VARAŽDINSKA I MEĐIMURSKA ŽUPANIJA

Besplatan primjerak | Broj 1067 | 9. listopada 2024. | ISSN 1846-8969 | www.regionalni.com

KVALITETNIJA PRIPREMA ILI DODATNA OBVEZA DJECI?

Djeca će se za sakramente prve pričesti i svete potvrde pripremati dvije godine

Str. 2. i 3.

VARAŽDIN DOBIVA NOVI ZATVOR

U baroknom gradu bit će još 150 zatvorenika

Str. 3.

OTIŠLE CIJELE OBITELJI

S hrvatskog sjevera iselilo je 20.000 ljudi

Str. 5.

NASTAVAK UREĐENJA LUDBREŠKOG STAROG MLINA

Zgrada u kojoj se mijenjalo žito dobit će novu namjenu

Str. 11.

DINAMO MINIMALNO SVLADAO NOGOMETAŠE VARAŽDINA

Bjelica: Varaždinci imaju kvalitetu za četvrto, peto mjesto

Str. 18.

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Agenda

STRUČNA RADIONICA PROJEKTA „BeReady“

01.10.2024.

Palača Herzer
Franjevački trg 10, Varaždin
Dvorana u potkrovlju

Raspored radionice:

9:00 - 9:30	Registracija sudionika / Kava
9:30 - 10:15	Prezentacija projekta i do sad učinjenih istraživanja Govornici: Barbara Mušič (Urbanistički institut Republike Slovenije) Mateja Leljak (3 E Projekti, Zagreb) Filip Bišćević (Razvojna agencija Sjever)
10:15 -11:00	Radionica – World Caffe (1. dio)
11:00 - 11:30	Coffee Break
11:30 - 12:15	Radionica – World Caffe (2. dio)
12:15 – 12:30	Potpisivanje Koalicijskog pakta*
12:30 – 13:00	Predstavljanje projekta javnosti / Press

*Koalicijski pakt je neformalni dokument čijim potpisom podupirete projekt BeReady

References

Climate Atlas of Croatia https://klima.hr/razno/publikacije/klimatski_atlas_hrvatske.pdf

Monthly values and extremes
https://meteo.hr/klima_e.php?section=klima_podaci&param=k1&Grad=varazdin

Köppen's classification of climates and the problem of corresponding Croatian terminology
https://hrcak.srce.hr/clanak/14843

Official city web page, https://varazdin.hr/zemljopisni-polozaj-varazdina/

Traffic Study – Evaluation Plan of the Sustainable Urban Mobility Plan of the City of Varaždin, Department of Logistics and Sustainable Mobility of the University North

Sentinel-2 Satellite Imagery (European Space Agency, 2024)
https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-2

Google XYZ Satellite Imagery (Google, Maxar Technologies. 2024)

https://www.maxar.com/maxar-intelligence/products/satellite-imagery

Geoprtal https://ispu.mgipu.hr/#/

OpenStreetMap (OSM), https://www.openstreetmap.org/

LAW ON CLIMATE CHANGES AND PROTECTION OF THE OZONE LAYER (NN) 127/19),
https://narodne-novine.nn.hr/clanci/sluzbeni/2019_12_127_2554.html

CLIMATE CHANGE ADAPTATION STRATEGY IN THE REPUBLIC OF CROATIA FOR THE PERIOD UP TO 2040 WITH A LOOK AT 2070,
https://mingo.gov.hr/UserDocsImages/klimatske_aktivnosti/klima/prilagodba/strat_prilagodbe_rh_2020.pdf

ASSESSMENT OF THE RISK OF MAJOR ACCIDENTS FOR THE AREA OF THE CITY OF VARAŽDIN ,
https://varazdin.hr/upload/2022/07/procjena_rizika_grada_varazdina-srpanj_2022-prihva_62d6be110a738.pdf

Sustainable Energy and Climate Action Plan for teh City of Varaždin

Data provided by:

Varaždin City department - Department of Construction and Communal Affairs

DHMZ - Meteorological and Hydrologycal Service (of Croatia)

DGU - State Geodetic Directorate

HV - Hrvatske vode (Legal entity for water management)

REA - Regional Energy Agency North

HEP DOS - Croatian electricity company - Operator distribucijskog sustava d.o.o.