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Urban heat islands vulnerability and risk assessment

City of Kranj

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

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1. Introduction

ABOUT THE PROJECT

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

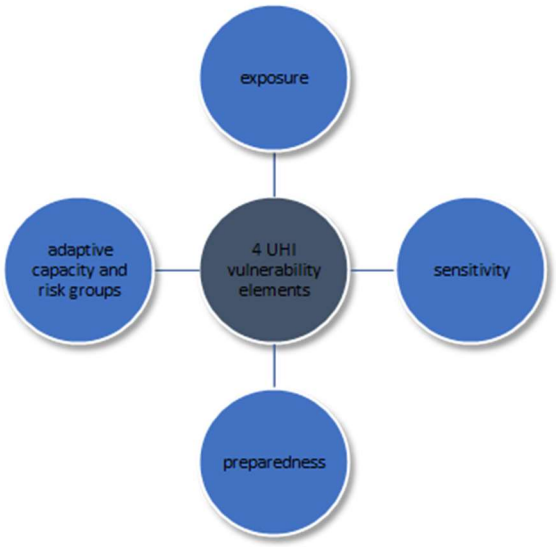

Figure 1: 4 UHI vulnerability elements

ABOUT THE REPORT

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

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Project partner cities will carry out UHI risk assessment for their cities as a preparatory activity for the implementation of the pilot actions as part of the Specific objective 2 Co-creating, testing, and validating jointly developed solutions to mitigate UHI effects in cities. The assessments will draw upon historical data and statistics, and other information and data from different sources. The risk assessment will be carried out with the support of the local coalitions (Activity 1.3), which will enable community engagement and raising awareness city-wide about the project objectives and expected results. The partner cities will choose which city zones to be included in the risk assessment, but to ensure comparability of the results and of the applicability and usability of the tools, we expect the UHI assessment to cover an area with high density of construction; an industrial zone; a densely populated area with mid- to low-income residents. Task leaders are the partner cities (conducting the risk assessment and drafting the resulting report; knowledge partners provide consultation and feedback.).

Each city will develop one city report supported by knowledge partners. The city report will include analysis of the usability of the tools and recommendations for adjustment of the methodology, where needed. The reports feed into the City Climate Sandbox concept and pilots.

AREA OF THE INTERVENTION

Territorial context

City	City of Kranj
Municipality	City Municipality of Kranj
Region	Gorenjska region
State	/
Country	Slovenia

Statistical data City Municipality of Kranj

Surface Area (km2)	150.9 km^2
Population	56.784
Density	379 residents per km^2
GDP per capita (€)	23.695 €
Minimum Wage (€/month)	1.277,72 €

ABOUT KRANJ

Municipality of Kranj is part of Gorenjska (Upper Carniola) statistical region, that comprises eighteen municipalities (Bled, Bohinj, Cerklje na Gorenjska, Gorenja village-Poljane, Gorje, Jesenice, Jezersko, Kranj, Kranjska Gora, Naklo, Preddvor, Radovljica, Šenčur, Škofja Loka, Tržič, Železniki, Žiri and Žirovnica). The municipality of Kranj has the largest number of inhabitants among the municipalities of the Gorenjska region. Gorenjska region had at the end of 2021 211,501 inhabitants, of which the Municipality of Kranj had 56,784 inhabitants, which is a good quarter of the total inhabitants of the region

(26.85%). According to the national level, city of Kranj is the third biggest city in the country and presents administrative, economic, commercial and educational center of Gorenjska region.

The size of the Kranj's municipal territory is 150.9 km2, of which 32.5 km2 are urban areas, that is 21,5 % of the municipal area. The city has a strategic traffic position; it lies at the crossroads of important transport routes leading from Northern Europe to the Adriatic and from Western Europe to the East. It is located approximately 20 km northwest of the capital city Ljubljana; it is close to highway A2 Ljubljana-Karavanke and international airport Ljubljana. The city developed on a conglomerate pier at the confluence of the 30-meter-deep incised riverbeds of the Kokra and Sava rivers, a river crossing at the intersection of the longitudinal route along the Sava and the transverse routes to Jezersko and Ljubelj and Škofja Loka.

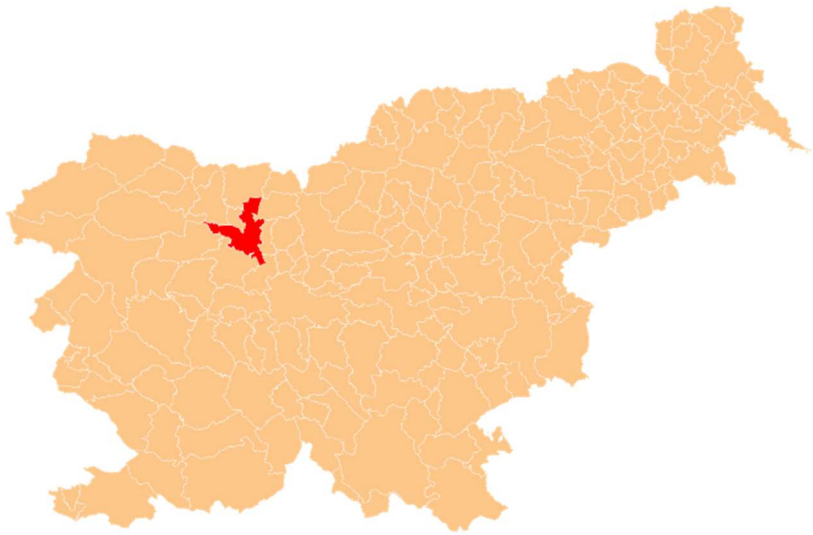

Figure 2: Location of the Municipality of Kranj in Slovenia, source: Wikipedia

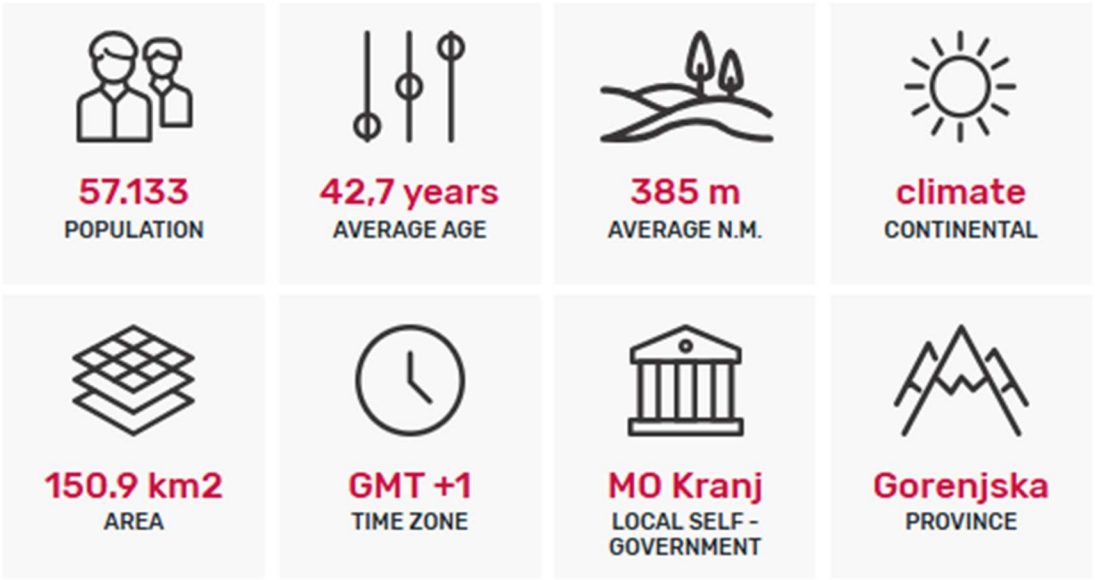

Figure 3: City of Kranj in numbers, source: https://www.kranj.si/en/kranj-in-numbers

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2. Methodology of the assessment

SUMMARY OF THE PROCESS

The analysis is prepared on the basis of a Methodology for UHI assessment, that was developed with the aim of guiding the cities participating in the project, to prepare an analysis based on four vulnerability elements: exposure, sensitivity, preparedness and adaptive capacity and risk groups. The final goal of cities, as well as the city of Kranj, is to identify UHI and develop solutions to mitigate the effects of UHI, with the help of stakeholders.

The process consisted of 4 phases: preparatory, starting, active and final phase. The preparatory phase consisted of a review of the Methodology and a preliminary assessment of the internal capabilities to perform the analysis. The starting phase consisted of conducting a workshop, collecting information and data and cooperation with other cities to exchange ideas, experiences and issues. Active phase consisted of processing the gathered information and data, cooperation with an external expert for the preparation of maps and preparation the data for urban climate part of the report and drafting the report. Finalising the report is the last phase of the process, were also a review by the scientific partner was included.

PROCESS DESCRIPTION

At the initial phase we have reviewed the document D.1.1.1 Methodology for UHI assessment and made initial analysis of the activities with which we could achieve the goals. We gathered and reviewed all available data and identified the one missing.

EVENTS/ ACTIVITIES

Several events/ activities were organised for the assessment, starting with the Local UHI Methodology Workshop Kranj, that took place on 02. of October 2024 in the premises of the Municipality. We hosted 22 stakeholders from different organisations, such as Ministry of Natural Resources and Spatial Planning, Urban Planning Institute of the Republic of Slovenia, Local energy agency of Gorenjska region, research organizations (ZaVita, Faculty of Arts, Faculty of architecture) and many more public & private interest groups. The exchange of opinions provided valuable insights from different angles of expertise. As the final evaluation made in Mentimeter programme showed, the participants value the most the workshop power of exchange of knowledge, professional skills and different opinions. The participants have additionally recommended the usage of:

- TOOL 3: Mobile data collections, story mapping, municipal demographic study,
- TOOL 2: usage of existing data from municipal platforms,

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- TOOL 4: qualitative tool with no possibility of graphic or numeric presentation. All needed data will be gathered from existing strategies, such as: Sustainable urban strategy, Municipal spatial plan, Operational environmental protection program,
- TOOL 1: Mobile data collections (transit of people);

The discussion was also about advanced data collections, which are suitable for advanced research.

We had a working meeting with the internal representative in charge of the municipality's GIS system, who is familiar with the scope of the data. We reviewed the data collection guidance for Tool 1 and obtained some useful information on the data and how to process it. This representative was available throughout the process to answer questions and provide guidance.

In addition, we had regular “3 cities” meetings, where we exchanged experience with the City of Varaždin and City of Zenica and tried to find solutions for current challenges, that we experienced during the preparation of different analysis.

General information and urban climate trends in Slovenia and Kranj were obtained using website of the Environmental Agency of Republic of Slovenia. Since we did not obtain climate information for the last ten years on the website, we ordered a report from Environmental agency of Slovenia.

The analysis for **Tool 1** was initially prepared with internal personnel resources. The work consisted of collecting data, consulting with various stakeholders, finding solutions, processing and displaying data in the Qgis program. Since we tried to prepare the analysis within the organization, the work was demanding and time-consuming, and we did not manage to solve certain problems. We contacted an external expert - Geodetic Institute of Slovenia, to continue the preparation of maps. The obtained and processed data was delivered to the external expert; few online meetings and other types of communication were carried out with the aim of clarify specific issues.

The analysis for **Tool 2** began with a review of available information online. Since the data was not satisfactory, we contacted the Faculty of Civil Engineering and Geodesy and connected with prof. dr. Boris Orel, a Slovenian physicist and chemist, who taught us about the albedo coefficient and the impact of building materials and the built environment on the city's microclimate. One on-site meeting and telephone calls were carried out with the aim of clarify specific issues. Since the topic goes beyond the project's tasks, we agreed to conduct a more detailed analysis of materials and the temperature they absorb when exposed to solar radiation and emit into the atmosphere in the project's pilot area if needed.

To obtain the data needed for analysis for **Tool 3** we reviewed in more detail the document Accessibility and sustainable planning of social infrastructure in the Municipality of Kranj (Urban Planning Institute of the Republic of Slovenia, August 2022), from which we extracted data on the population structure. We checked the data on the official website of the Statistical Office of the Republic of Slovenia (https://www.stat.si/statweb) and the SiStat (https://pxweb.stat.si/SiStat/sl) subpage.

For the analysis for **Tool 4** we used Tool application guide in the UHI Vulnerability and Risk Assessment methodology and proposed checklist to identify factors that influence a municipality’s preparedness and adaptive capacity. The method used was also confirmed at regular "3 cities" meetings with UIRS, City of Varaždin and City of Zenica. We have established a communication with Commander of Civil Protection of the Municipality of Kranj and representatives of the Department of General Affairs and Civil Protection and Rescue of the City Municipality of Kranj, which, among other tasks, is responsible for the coordination and organization of civil protection, fire safety and rescue in the event of natural and other

disasters, as well as all related tasks of cooperation and coordination with other competent persons and authorities in the aforementioned field of work.

TIMELINE OF THE PROCESS

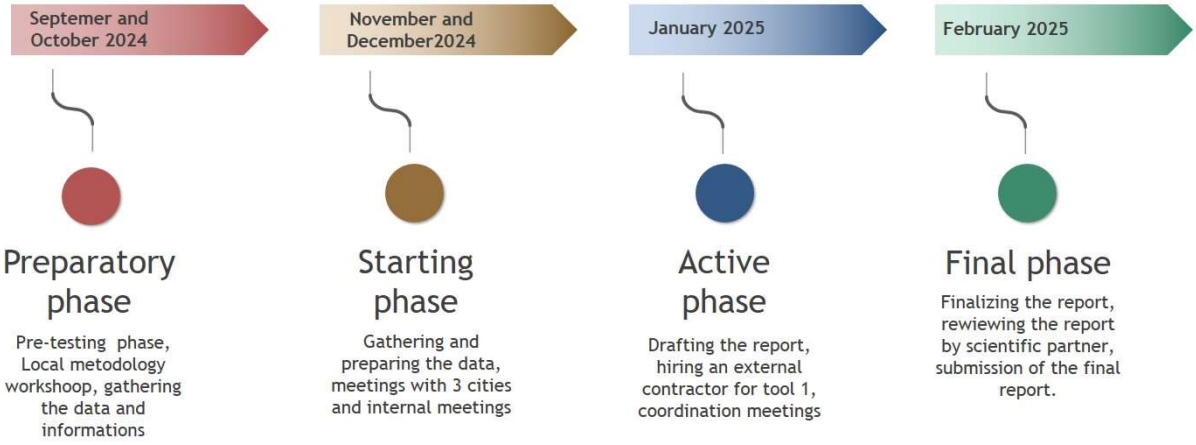

Figure 4: Timeline of the process, source: City of Kranj

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3. Urban climate

GENERAL INFORMATION ABOUT URBAN CLIMATE TRENDS

Data on the climate in Kranj has not been studied in detail to date, so the following presents data for Slovenia and cities closer to Kranj that are included in the national network of meteorological stations.

The chapter covers publicly available data from the Environmental Agency of the Republic of Slovenia from 1961 to 2011 with forecasts until the end of the 21st century.

Main characteristics of climate change in the period 1961–2011

We feel climate change in our everyday lives. In Slovenia, climate change over our regions is now described in detail. At the end of 2008, the Environmental Agency of the Republic of Slovenia launched a comprehensive project Climate Change in Slovenia and described the characteristics of the weather in the period 1961–2011.

Based on exceptional archival data, ARSO provided an assessment of the changes in our climate over the past fifty years:

- The average air temperature has risen by 1.7 °C.
- The trend of increasing air temperature is slightly greater in the eastern than in the western half of the country.
- Summers and springs have warmed the most, winters have warmed slightly less. Autumn has not warmed.
- The amount of precipitation has decreased by about 15% on an annual basis in the western half of the country, slightly less (10%) in the eastern half of the country, where the changes are not statistically significant.
- The amount of precipitation has decreased the most in spring (all over the country) and summer (in the southern half of the country).
- The total depth of snow cover has decreased by about 55%.
- The depth of newly fallen snow has decreased by 40%.
- On an annual basis, the duration of solar radiation has increased by 10% on average, mostly due to an increase in spring and summer. Per decade, the duration of solar radiation has thus increased by 30–40 hours.
- Evaporation has increased by around 20% since 1971, mostly due to an increase in spring and summer.

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● Air pressure has increased by 1.5 hPa on an annual basis on average.

● Air pressure has increased the most in winter, only slightly less in spring. The increase in air pressure is significantly smaller in summer, and the smallest in autumn. ● Water temperature has increased with a trend of 0.2 °C per decade for surface waters (period 1953–2015) and 0.3 °C per decade for groundwater (period 1969–2015).

Air Temperature

In the period 1961–2011, the most characteristic climate change in Slovenia is the increase in average air temperature, by about 0.36 °C per decade. The most obvious is the warming in spring and summer, in most parts of Slovenia by about 0.4 or 0.5 °C per decade. In contrast, the autumn temperature change is not statistically significant. The warming was mostly stronger in the eastern than in the western part of the country. The increase in daily maximum and minimum temperatures by season is similar to the increase in average temperature. Due to the general increase in air temperature, the frequency of the number of typical days has changed: the number of hot and warm days has increased, while the number of cold, frosty and icy days has decreased somewhat less significantly.

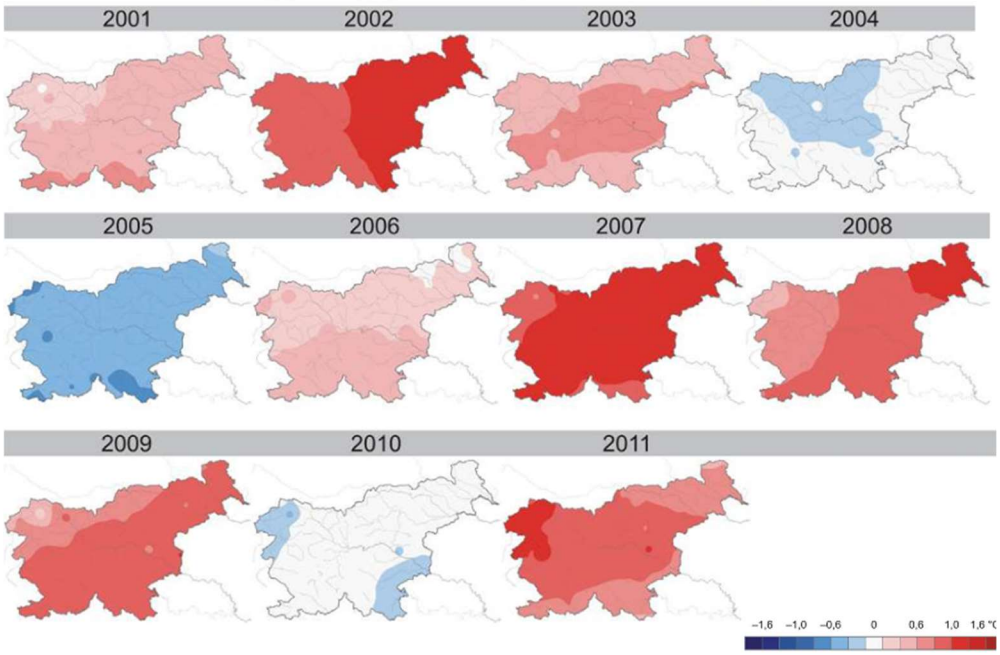

Figure 5: Deviation of the annual average air temperature from the average in the period 2001–2011, source: www.meteo.arso.gov.si/met/sl/climate/change/

Solar Radiation

In Slovenia, the duration of solar radiation is greatest in Goriška and the southern part of Primorska due to the relief and its influence on the weather (Figure 6).

In the period under consideration 1961–2011, the duration of solar radiation increased at the national level in spring and summer, with a trend of around 2–3%. The trend is also positive in winter, but it is not statistically significant in most of Slovenia. There were no noticeable changes in autumn. At the annual level, the trend is around 2% per decade, which means an increase in the number of sunshine

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hours of around 40 per decade. The spatial variability of the linear trend in the duration of solar radiation is significantly less diverse than the variability between seasons.

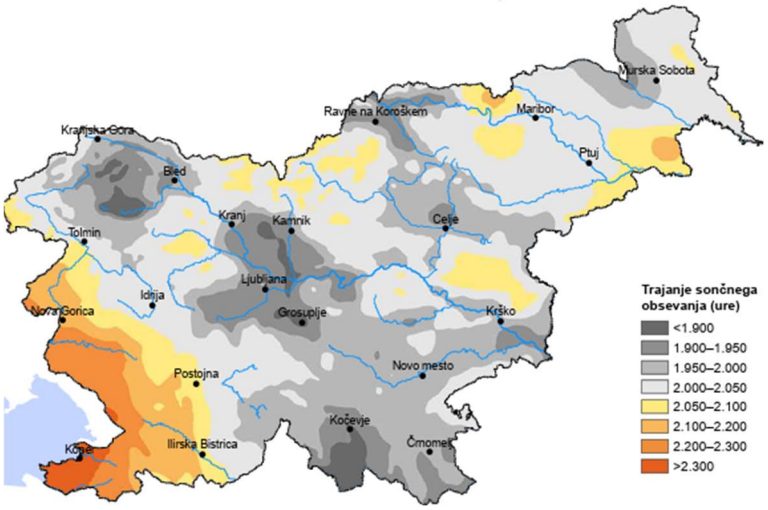

Figure 6: Annual average duration of solar radiation in the period 1981–2010. Source: www.meteo.arso.gov.si/met/sl/climate/change/

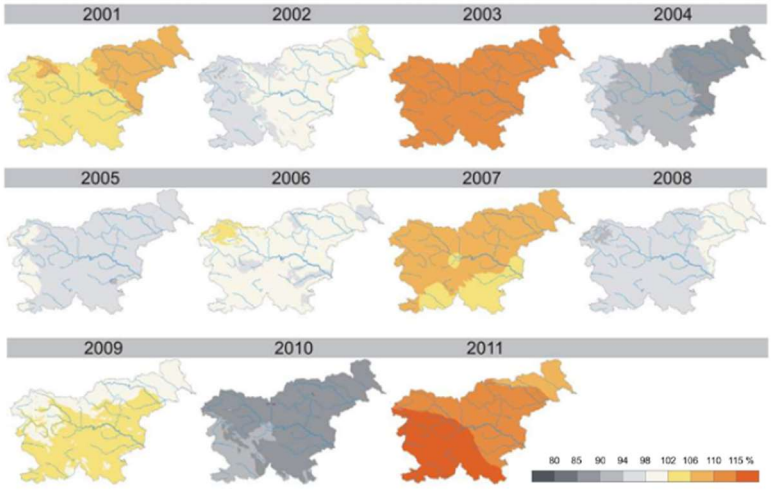

Figure 7: Annual indicator of the duration of solar radiation relative to the average in the period 2001–2010. Source: www.meteo.arso.gov.si/met/sl/climate/change/

Reference evapotranspiration

On average, reference evapotranspiration in Slovenia is highest in warm, windy and sunny areas, where it reaches around 1000 mm per year. In most of the interior, reference evapotranspiration is between 600 and 800 mm, and in mountainous areas, the values are even lower.

Due to the high dependence of evaporation on air temperature and solar radiation, reference evapotranspiration has a pronounced annual variation – in December and January it ranges from a few millimeters to around 30 mm, while in July it ranges between 100 and 170 mm in most of Slovenia.

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In all seasons, an increasing trend is recorded in the period 1971–2011 (Figure 8). Reference evapotranspiration increased the most in spring (5.0% per decade), the least in autumn (2.4% per decade). In summer and winter, the linear trend is 4.2% per decade, but the interannual variability in winter is much greater than in summer.

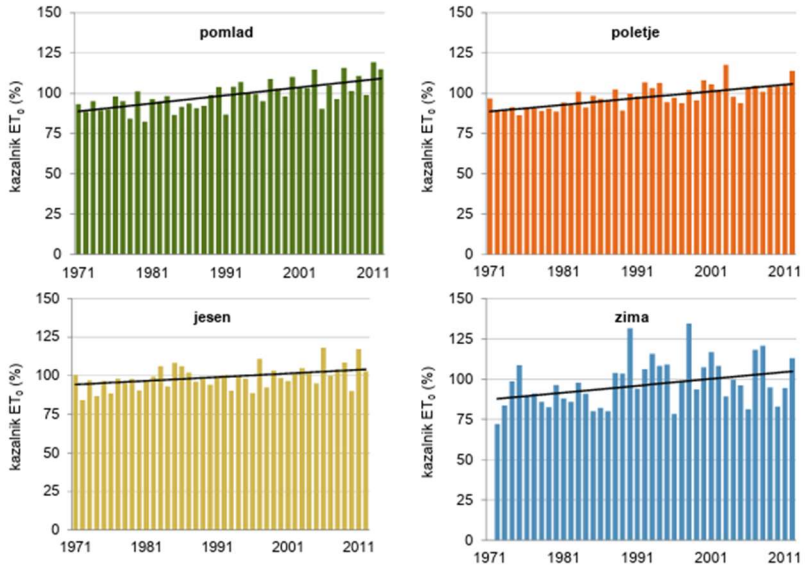

Figure 8: National reference evapotranspiration indicator for the period 1971–2012, for winter in the period 1971/72–2010/11. The indicator is calculated as the arithmetic mean of the indicator at the covered meteorological stations. The black line shows a linear trend that is statistically significant in all seasons. Source: www.meteo.arso.gov.si/met/sl/climate/change/

Precipitation

In Slovenia, several precipitation regimes are distinguished. Thus, peaks occur in different parts of the country at different times of the year. The wet parts of western Slovenia are characterized by an autumn peak, while towards the east the summer peak of precipitation is increasing, and the autumn peak changes into a gradual decrease in precipitation towards winter (Figure 9). Winter is the wettest season everywhere. Summer precipitation is often in the form of downpours, while in the cold part of the year orographic and cyclonic precipitation dominate.

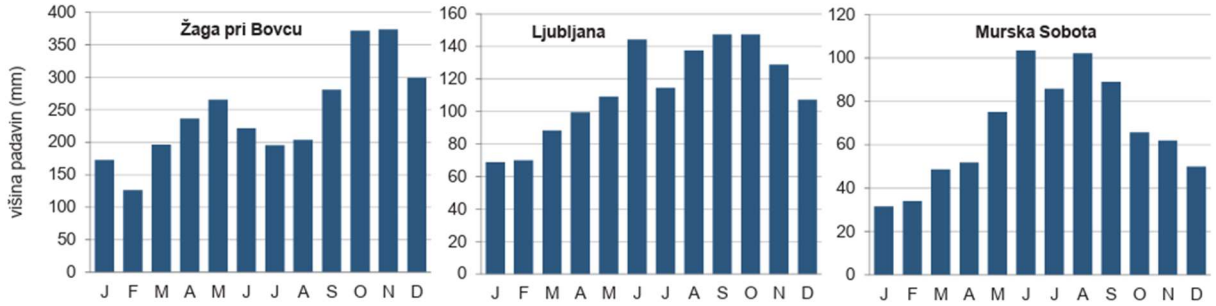

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Figure 9: Monthly average precipitation in the period 1981–2010 in the western (Žaga pri Bovcu), central (Ljubljana) and eastern (Murska Sobota) parts of Slovenia, source: www.meteo.arso.gov.si/met/sl/climate/change/

The amount of precipitation is very variable in space and time. In the period 1981–2011, the most variable is winter, where the precipitation indicator fluctuates between 29 and 214% of the long-term average, in spring and autumn the variability is smaller, and it is the smallest in summer, when the deviation from the average does not exceed 42%. Regional differences are noticeable in the time course of the annual amount of precipitation; The driest and wettest years can be completely different between individual locations (Figure 10).

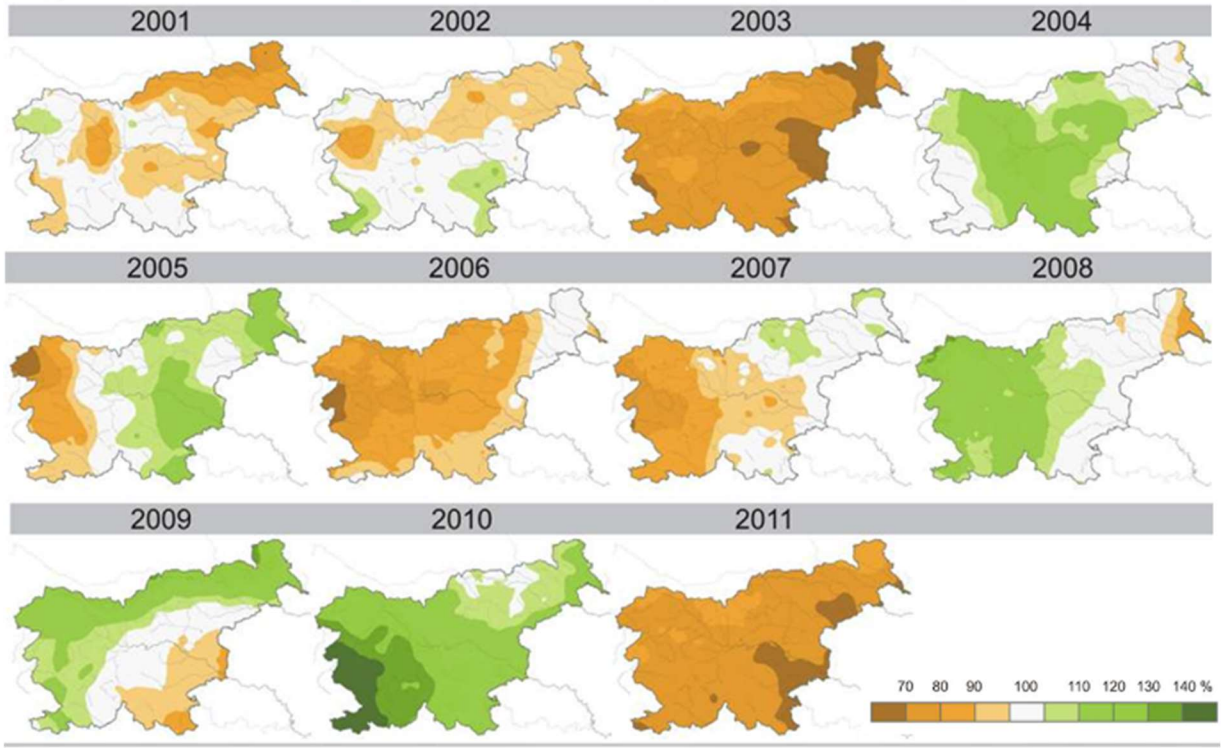

Figure 10: Deviation of annual precipitation from the average in the period 1981–2010. Source: www.meteo.arso.gov.si/met/sl/climate/change/

Height of new snow and height of snow cover

The highest average snowfall is in the highlands of the Julian Alps on Kredarica, the long-term average is just under 11 m of snow per year. In the Ljubljana, Novo Mesto and Celje basins, the annual average is approximately one meter, while in the lower parts of Goriška and on the Coast, snow is a rare occurrence, as many winters pass without snowfall and snow cover.

A decreasing trend is observed in the height of the snow cover and the amount of new snow in the period 1961–2011 in a significant part of Slovenia (Figure 11). The most noticeable changes are in the lower parts of the Alpine world, where the average estimate of the trend in the height of the snow cover reaches as much as -20% per decade, which means that the height of the snow cover has more than halved from the beginning to the end of the period. It should be emphasized that the magnitude of the trend is quite uncertain, as the interannual fluctuation in snow is very pronounced. At the national level,

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the median estimate for the magnitude of the trend in winter average snowpack depth is around –16% per decade.

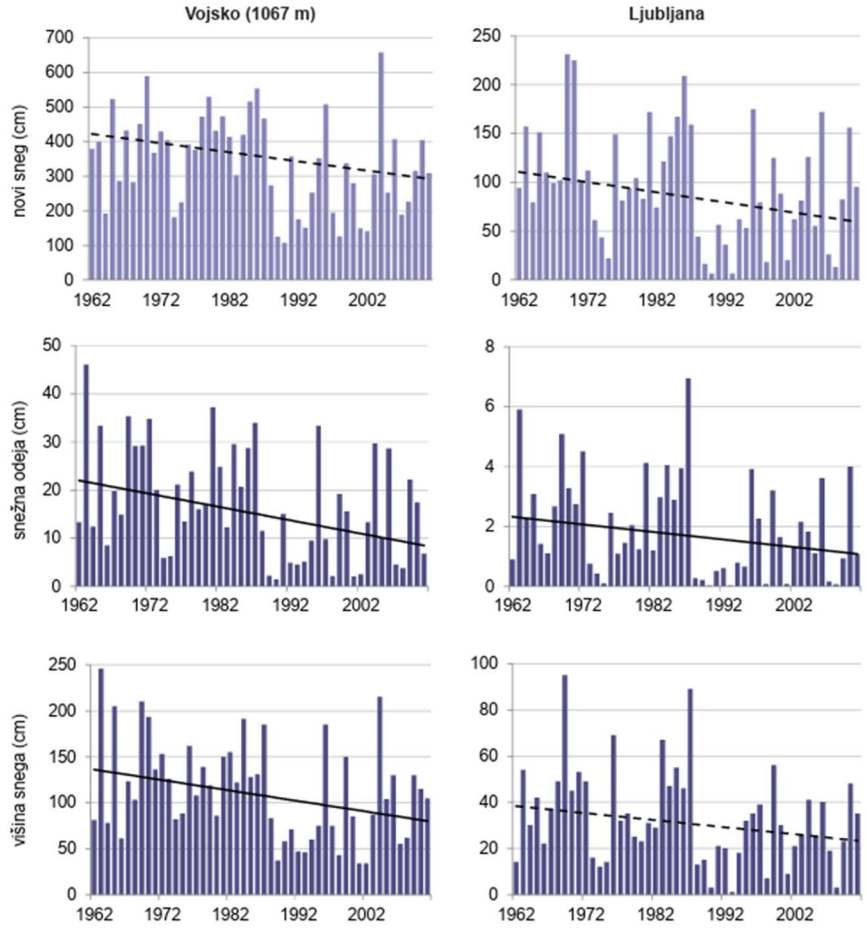

Figure 11: Time course of the total depth of new snow (top), the average depth of snow cover (middle) and the maximum depth of snow cover (bottom) by snow seasons in the period 1961/1962–2010/2011 for a station in the mountain (Vojsko) and lowland (Ljubljana) world. The black line shows a linear trend (a non-significant trend is indicated by a dashed line), which in all cases is either statistically significant or statistically significant. Source: www.meteo.arso.gov.si/met/sl/climate/change/

Assessment of climate change in Slovenia by the end of the 21st century

The impacts of climate change are felt across Europe, but vary between geographical regions, as it is a highly diverse region. South-eastern and southern Europe are among the most vulnerable, as the simultaneous increase in temperature and decrease in precipitation contribute to reduced water availability and an increased risk of droughts, biodiversity loss and forest fires. In mountainous areas, temperatures are rising more rapidly than the European average, leading to a rise in the limits of vegetation zones and a decrease in snow cover. In Central Europe, the main threats are heat waves in summer and river flooding in winter and spring. Slovenia lies at the junction of the Pannonian Plain, the

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Alps and the Mediterranean, which significantly affects the climatic diversity between its regions and the changes that individual regions will experience in different seasons.

The results of simulations for the future predict a significant increase in the annual average air temperature by the end of the 21st century across the entire territory of Slovenia in all seasons. The temperature will significantly increase the heat load in summer, and the growing season will be extended accordingly. By the end of the 21st century, a noticeable increase in precipitation in winter is predicted in Slovenia. Both the intensity and frequency of extreme precipitation events will increase. Annual groundwater recharge and large flows will increase, most significantly in the east of the country.

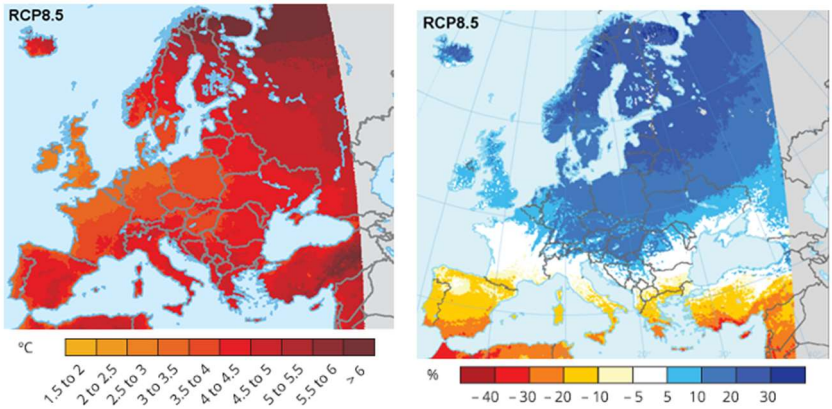

Figure 12: The maps show simulated changes in annual mean temperature (left) and precipitation (right) in Europe over the period 2071–2100 relative to the reference period 1971–2000 for the pessimistic greenhouse gas emissions scenario RCP8.5. They are intended to show the direction of the change signal across Europe (EEA, 2017). Source: Ocena podnebnih sprememb v Sloveniji do konca 21. Stoletja, ARSO, 2019

Greenhouse gas emission scenarios

The future course of climate change depends primarily on greenhouse gas emissions, which we attempt to capture using various scenarios of representative concentration pathways (RCPs). The scenarios are based on human activity and the associated emissions of CO2, CH4, N2O and other air pollutants. Each of the scenarios fundamentally depends on global socio-economic factors, such as population growth rates and gross domestic product, as well as technological developments in the 21st century, which directly affect the consumption of primary energy sources and oil, and land use change. The scenarios can be distinguished by the numerical designation of the total radiative contribution at the end of the century; the greater the radiative contribution, the greater the changes in the climate system can be expected.

The most optimistic scenario is **RCP2.6**, which assumes an active climate change mitigation policy and consequently low greenhouse gas emissions, the level of which is expected to peak at the beginning of the 21st century and then gradually begin to decline, with the radiative contribution expected to be 2.6 W m-2 at the end of the century. The stabilization scenario **RCP4.5**, which is considered moderately optimistic based on the current situation, assumes a gradual reduction in emissions and a stabilisation of the radiative contribution at 4.5 W m-2 by 2100. The most pessimistic scenario without the envisaged climate change mitigation is **RCP8.5**, which assumes high greenhouse gas emissions and a consequent

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increase in their content even after 2100, with the radiative contribution expected to be 8.5 W m-2 at the end of the century.

Temperature

Average air temperature at ground level

In line with the projected gradual warming of the air in Europe in the 21st century, the average air temperature in Slovenia will also increase, with a mean range of approximately 1 to approximately 4 °C, depending on the greenhouse gas emission scenario. All three emission scenarios in Slovenia predict an increase in air temperature by 2100, namely RCP2.6 by approximately 1.3 °C, RCP4.5 by approximately 2.0 °C and RCP8.5 by approximately 4.1 °C.

Slovenia will experience a significant change in temperature in all seasons, but especially in winter, warming at the end of the century is expected to be more pronounced than the average annual warming. Especially in the northern and eastern parts of Slovenia (highlands, northeastern region, central region), the temperature will increase faster than the annual average in winter. The temperature increase will be least pronounced in spring.

The predicted changes under the RCP4.5 scenario are reliable and largely match the predicted changes in most of Europe, where the greatest temperature increase is predicted in winter in the northern part of Europe and in summer in the southern part of Europe, while the mountain world will warm above average in both seasons. In the case of the RCP8.5 emissions scenario, the differences between the mountain world and the rest of Europe will be less pronounced, which is also reflected in the area of Slovenia.

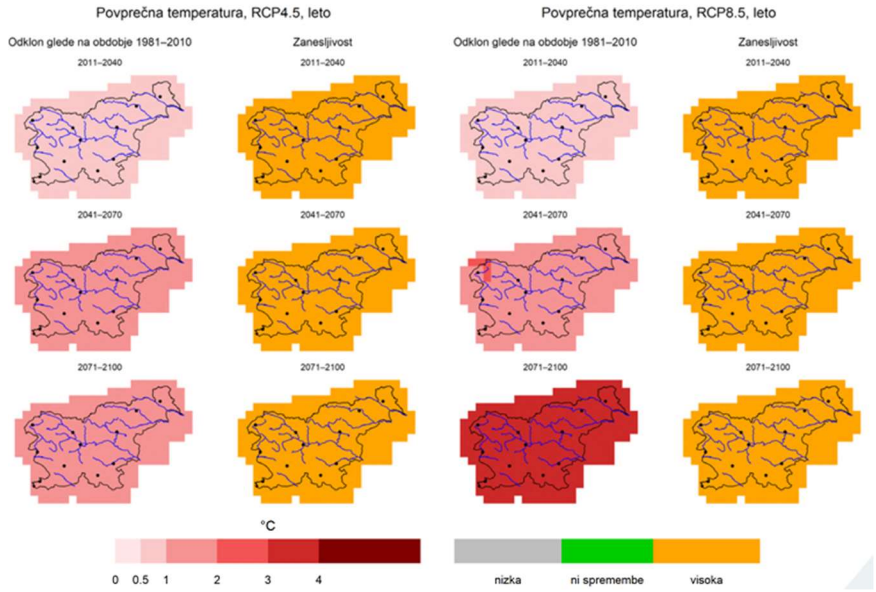

Figure 13: The deviation of the average temperature from the average in the comparative period 1981–2010 is shown. "High confidence" means that changes in a certain direction are highly likely to be expected. A confidence level of "no change" indicates small, statistically insignificant changes. "Low confidence" indicates significant differences in the results of climate models and means that significant changes in either a positive or negative direction can be expected. Source: Ocena podnebnih sprememb v Sloveniji do konca 21. Stoletja, ARSO, 2019.

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Weather data for Kranj for the period from 2014 to 2024 is available on the website https://meteo.arso.gov.si/met/sl/. The selected graphs below show the monthly average of the daily average, maximum and minimum air temperatures for 2014 and 2024.

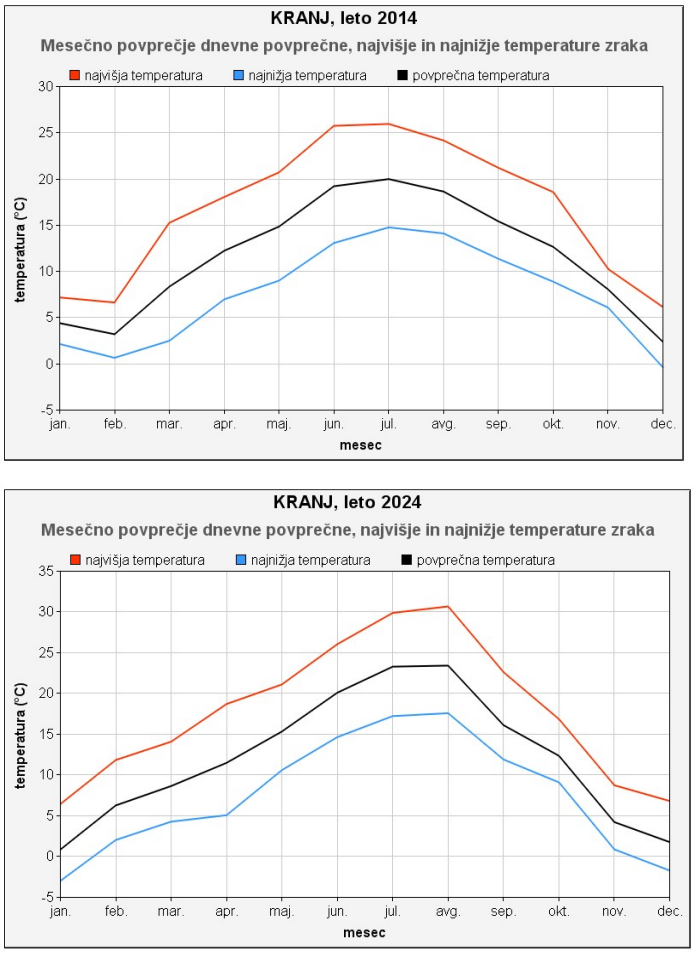

Figure 14: The deviation of max, min and average temperature from period 2014 and 2024 is shown. The graph from 2024 shows a steep increase in air temperature, the highest temperature in August 2024 is 5 Celsius higher than the highest temperature in July, which was the warmest month in 2014. Source: https://meteo.arso.gov.si/met/sl/climate/current/time-series-archive/

Extreme temperature conditions

Extreme temperature conditions are monitored with temperature indicators, for conditions when the air temperature becomes unfavorable for living beings.

Tropical nights, when the temperature does not drop below 20 °C even at night, indicate conditions when it does not cool down enough even at night for people and other living beings to be able to take a break from the heat load. Tropical nights are not recorded in areas of higher altitudes and, it seems, will not be recorded on average in the future either. The number is expected to increase by approximately 5 days elsewhere in the country (southwestern, northeastern and central regions) in the first period, and by up to 20 days in the second period, depending on the region. In the last period, the number of tropical nights will stabilize under the RCP4.5 emissions scenario, while in some areas, according to the RCP8.5

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emissions scenario, we will have up to 60 more tropical nights than in today's climate. When several such days follow each other in succession, living organisms can experience major problems due to increased heat stress.

In the most sensitive groups of people (chronic patients, infants and the elderly), heat stress occurs when the air temperature exceeds 25 °C. Days when the maximum temperature exceeds 25 °C are called warm days. There will be approximately 10 more warm days in the near future than in the comparison period, regardless of the emission scenario. The change for the second period already depends somewhat on the emission scenario. Under the moderately optimistic RCP4.5 emission scenario, we can expect slightly less than 20 more warm days, and under the pessimistic RCP8.5 emission scenario, up to 25 more warm days than in today's climate. At the end of the century, the change in the number of warm days will depend very much on the emission scenario. Under the RCP4.5 emissions scenario, there will be up to 25 more such days in most regions, while under the RCP8.5 emissions scenario, we can expect 55 to 60 more warm days compared to today's climate. When the air temperature exceeds 30 °C, temperature conditions become burdensome for the entire population, not only for the most vulnerable groups. The indicator of the number of hot days, when the maximum temperature exceeds 30 °C, also indicates a gradual increase in the number of such days. In the near future, there will be 5 to 10 more hot days in the lowland part of the country (central, north-eastern and south-western regions) than in the comparison period. A slightly higher estimate (up to 30 more days) applies to a larger part of the country in the second and, according to the RCP4.5 emissions scenario, also in the third period. By the end of the century, according to the most pessimistic scenario, we can expect up to 60 more hot days in the lowland part than in the comparison period.

Very low temperatures also pose a burden on living things, but this will decrease in the future. The number of cold and icy days depends strongly on the relief of the surface and the altitude. The number of cold days will gradually decrease in the future. In the first period, according to the RCP4.5 scenario, the number of cold days is expected to decrease by approximately 10 days, and in the second and last period by approximately 20 days per year. Both the changes, as well as the differences between the changes according to the altitude, are somewhat more pronounced in the RCP8.5 scenario. According to the pessimistic scenario, approximately 40 fewer cold days are expected in most parts of Slovenia by the end of the century, and in the highlands there will be up to 60 fewer such days than in the comparative period.

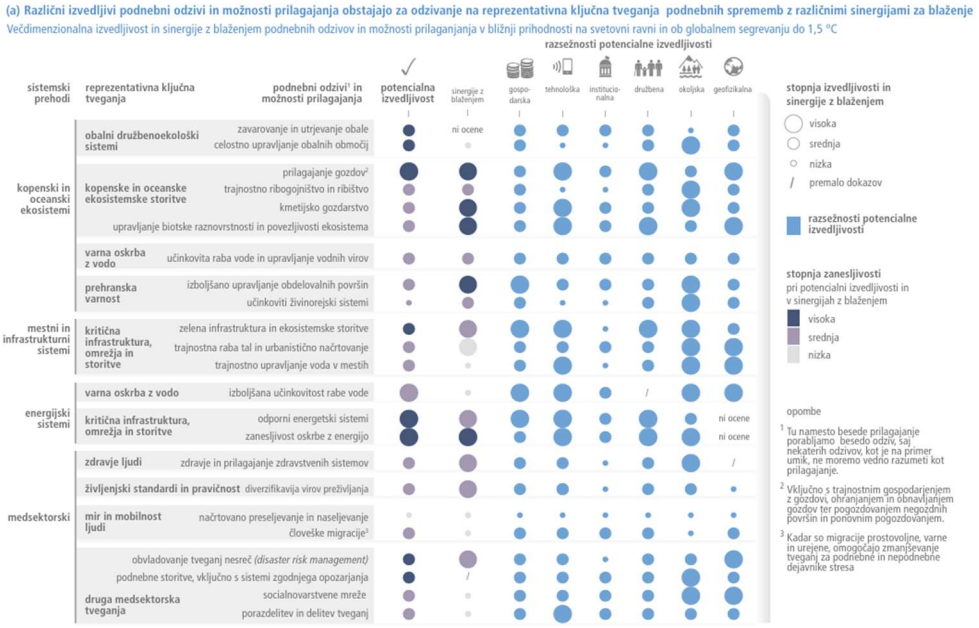

Figure 15: Relationships between vulnerable sectors and groups (based on observations) and sustainable development goals (important in the short term, at the global level and up to 1.5 °C of global warming) with climate responses and adaptation options. Source: Podnebne spremembe 2022, Vplivi, prilagajanje in ranljivost, Povzetek za odločevalce, ipcc, 2022

Precipitation

Average precipitation amount

In contrast to temperature, projections for precipitation changes are less reliable, as they are more variable in time and space. The projected changes in precipitation in Slovenia are not very pronounced, as it lies in an area of Europe where the precipitation change signal changes direction. In northern Europe, precipitation will increase on an annual basis, while in southern Europe it will decrease.

Extreme rainfall

The indicators used to measure extreme precipitation show that both the intensity and frequency of extreme precipitation will increase, with the increase being most pronounced in the case of the pessimistic RCP8.5 emissions scenario. Both indicators describing the characteristics of extreme precipitation (the highest monthly values of daily and five-day precipitation) show that extreme precipitation will intensify. In the future, one-day extreme precipitation will be more abundant in the entire area of Slovenia in spring and winter than in the comparative period 1981–2010. The signal of change is most uncertain for summer, where some simulations also show a decrease in one-day extreme precipitation.

20 mm of precipitation in one day is a large amount for most of Slovenia, which does not occur often. In the case of the RCP4.5 emissions scenario, the number of days with precipitation above 20 mm on an annual basis will increase already in the second period, and the increase will increase further by the end of the century. Even greater changes in the number of days with precipitation above 20 mm are predicted

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for the RCP8.5 emissions scenario. On an annual basis, the number of such days will reliably increase in the last two periods across the country, with the exception of the Alpine-Dinaric divide.

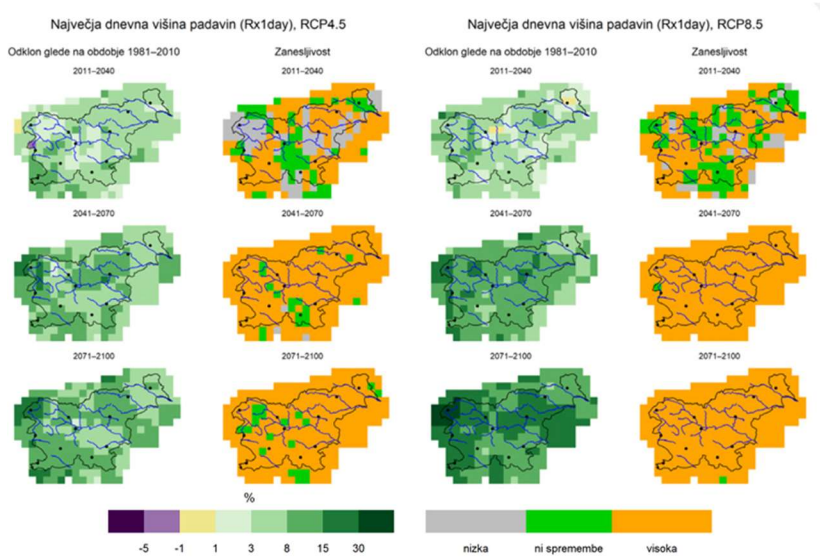

Figure 16: Change in the maximum daily precipitation amount in Slovenia in three projection periods and the confidence level of the change for the RCP4.5 (left) and RCP8.5 (right) emission scenarios. The relative deviation of the precipitation amount from the average in the comparison period 1981–2010 is shown. "High confidence" means that changes in a certain direction are expected with a high probability. The confidence level of "no change" refers to small, statistically insignificant changes that are comparable to or even smaller than natural variability. "Low confidence" suggests significant differences in the results of climate models and means that we can expect significant changes in either a positive or negative direction.

Weather data for Kranj for the period from 2014 to 2024 is available on the website. The selected graphs from https://meteo.arso.gov.si/met/sl/ show the monthly precipitation for 2014 and 2024. From the graphs we can see that precipitation is more evenly distributed throughout the year 2024. The peak is no longer in January, February and November (winter) in 2014, but in September and October (autumn).

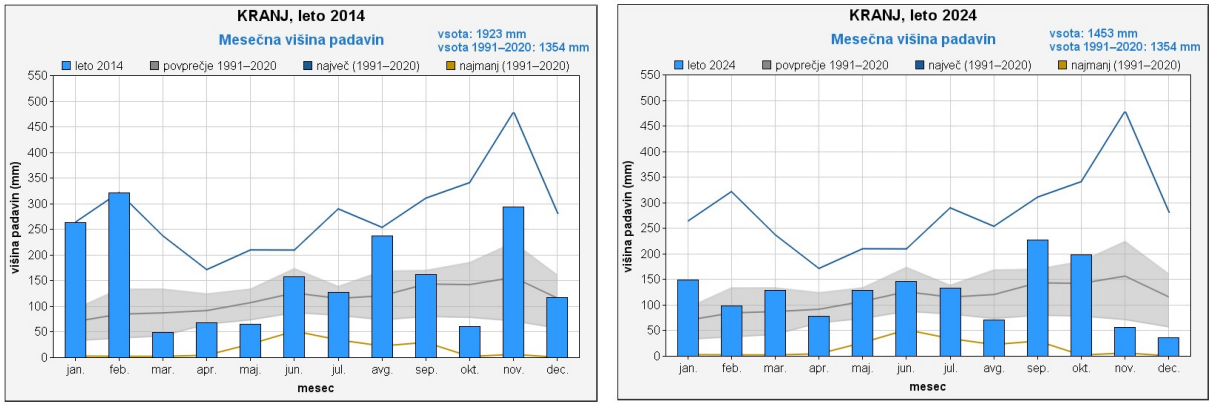

Figure 17: The deviation of precipitation from period 2014 and 2024 is shown. Source: https://meteo.arso.gov.si/met/sl/climate/current/time-series-archive/

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The dependence on **Greenhouse gas emission scenarios** can also be discussed when predicting changes in the **water balance**, more specifically in the reference evapotranspiration and groundwater recharge. An increase or decrease can be expected for both indicators.

The same applies to **hydrological variables** - large flows or average annual peaks will increase across the country in all emission scenarios compared to the period 1981–2010, on average by 20 to 30%, most in the northeast. For annual high water peak flows with a 100-year return period in the comparative period, an increase of 100-year levels is expected in all emission scenarios for all periods in the future compared to the period 1981–2010, mostly across the country.

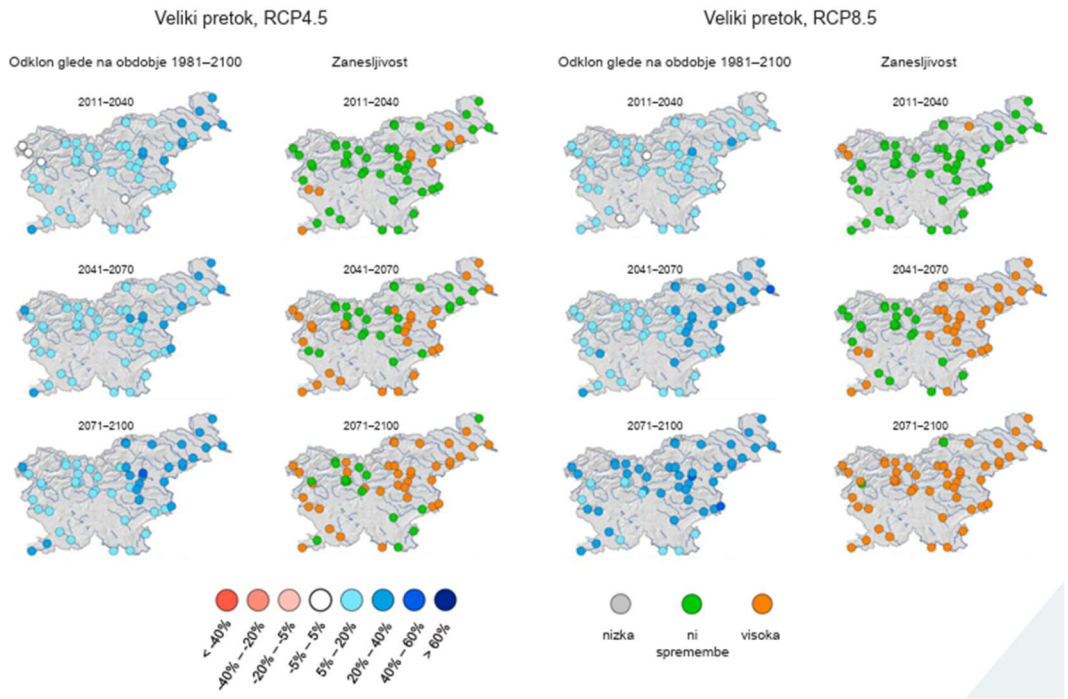

Figure 18: The relative deviation of large flows from the average over the comparison period 1981–2010 is shown. "High confidence" means that changes in a certain direction are highly likely to be expected. "No change" refers to small, statistically insignificant changes that are comparable to or even smaller than natural variability. "Low confidence" suggests significant differences in climate models and means that significant changes in either a positive or negative direction can be expected. Source: https://meteo.arso.gov.si/met/sl/climate/current/time-series-archive/

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Solar Radiation

Since Kranj has no national meteorological station, solar radiation dataj for the period from 2014 to 2024 is taken from nearby station at Ljubljana Jože Pučnik Airport.

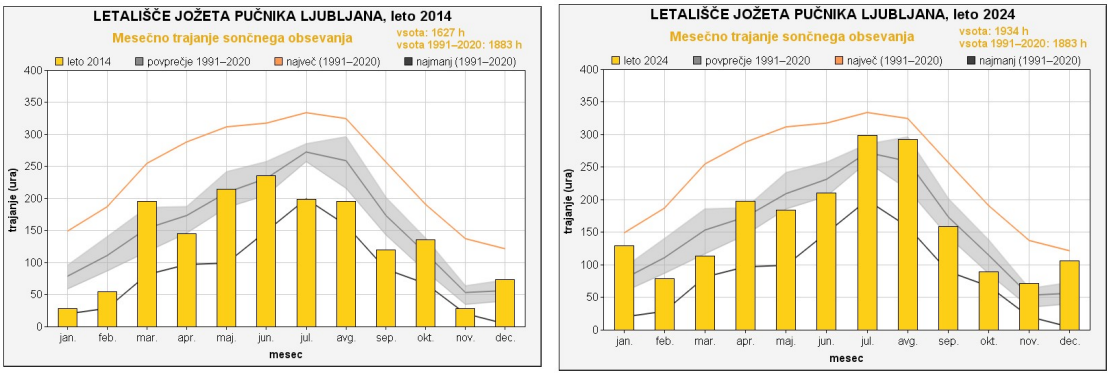

Figure 19: The Solar radiation from 2014 and 2024 shows a significant increase in solar radiation throughout the year, with the highest number of sunny days and solar radiation in the summer months, with 300 hours of sunshine recorded in July and August. Source: https://meteo.arso.gov.si/met/sl/climate/current/time-series-archive

SUMMARY

The climate in Slovenia has changed significantly over the past sixty years. The average air temperature has increased by 2 °C, in the west of the country we have less precipitation, there is less snow. We are increasingly encountering both hydrological extremes, droughts and floods. Projections show that the climate will continue to change over the course of the century, also due to our activities. We will increasingly face longer and stronger heat waves and droughts. Extremely heavy precipitation will be more frequent, and we will have less and less snow cover in winter. How large these changes will be at the end of the century also depends on our decisions. The following pages show climate changes over the course of the century in the event that we fail to significantly limit greenhouse gas emissions. The picture is therefore the blackest - the pessimistic scenario. We are running out of time to act. We must start acting immediately at all levels. We can do a lot ourselves, our personal decisions to make a difference count. The graph below shows how much an individual can contribute to reducing greenhouse gas emissions.

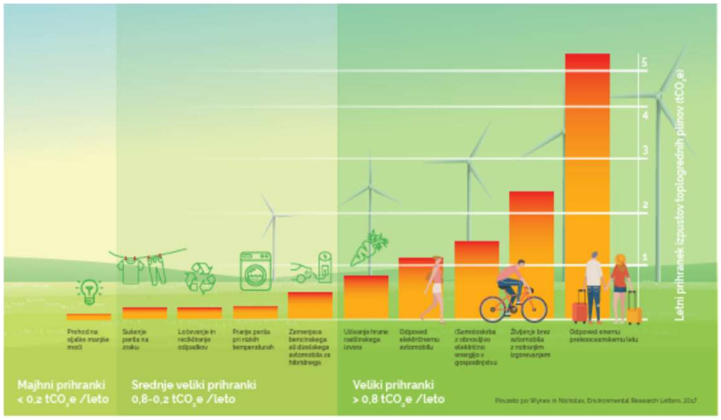

Figure 20: "It's time to take action!", Čas je, da ukrepamo!, Publication of ARSO, 2024

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

EXPOSURE OF BUILDINGS AND SURROUNDINGS

The analysis was prepared for the area of the Kranj settlement, as derived from the register of spatial units of Slovenia (RPE). The settlement of Kranj includes the districts of Čirče, Drulovka, Orehek, Kranj - Sever, Jedro, Labore, Planina, Huje, Primskovo, Rupa, Sava, Stražišče, Struževo, Šmarjetna gora and Zlato Polje. The area of the Kranj settlement is 26, 26 km2.

An all displays the color orthophoto was changed to a grayscale image and brightened for display purposes. All thematic contents are shown only for the area of the Kranj settlement, although the map also shows the areas of neighbouring settlements.

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Urban morphology/urban form

Building coverage ratio (BCR)

Building coverage ratio (BCR) reflects the relationship between the ratio of the site occupied by the building and the site area (plot/parcel or larger area). BCR is urban planning code which is defined in the Implementation part of the Municipal Spatial Development Plan.

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• data on built-up surfaces

• date: 2014

• source: City of Kranj

• data on settlement boundaries from the Register of Spatial Units (RPE)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

Process:

For the preparation of the map, we used the graphical data on the intended use from the current spatial planning act, which contained information on the FZ for most of the spatial planning units. Where this information was missing or textual, we have assigned the FZ to each spatial planning unit according to the knowledge of the area.

The data are prepared based on built-up areas of the spatial layer of the intended use of the space. This spatial layer also includes areas that are not yet built-up in nature, but in the client's layer a built-up factor has already been determined for them. Identification was required for such surfaces based on the DOF analyse. Identified surfaces assigned them a built-up factor = 0 and are not shown on the map. Only larger areas on the outskirts of the building were inspected. They are marked in the picture below.

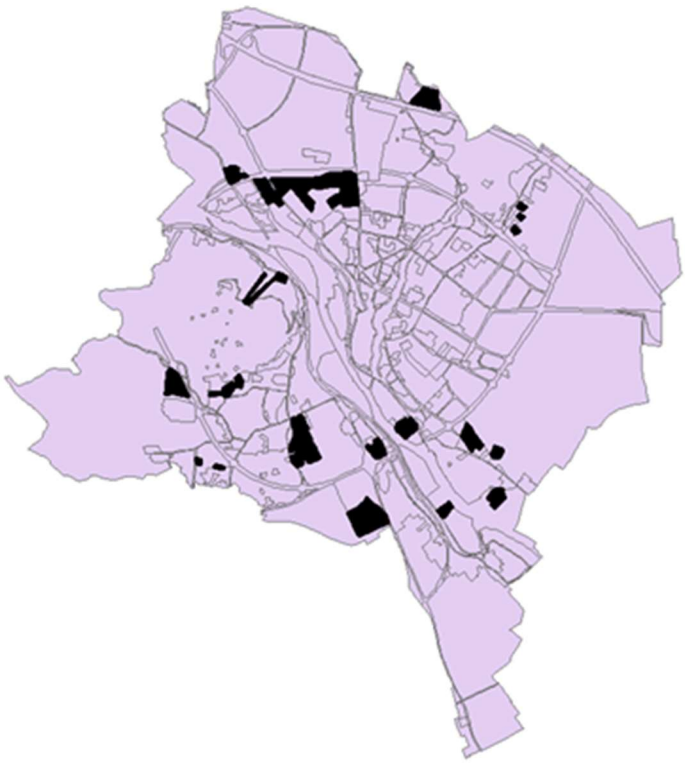

Figure 21: Not build up areas based on the DOF analyse, source: City of Kranj, Geodetic institute of Slovenia, 2025

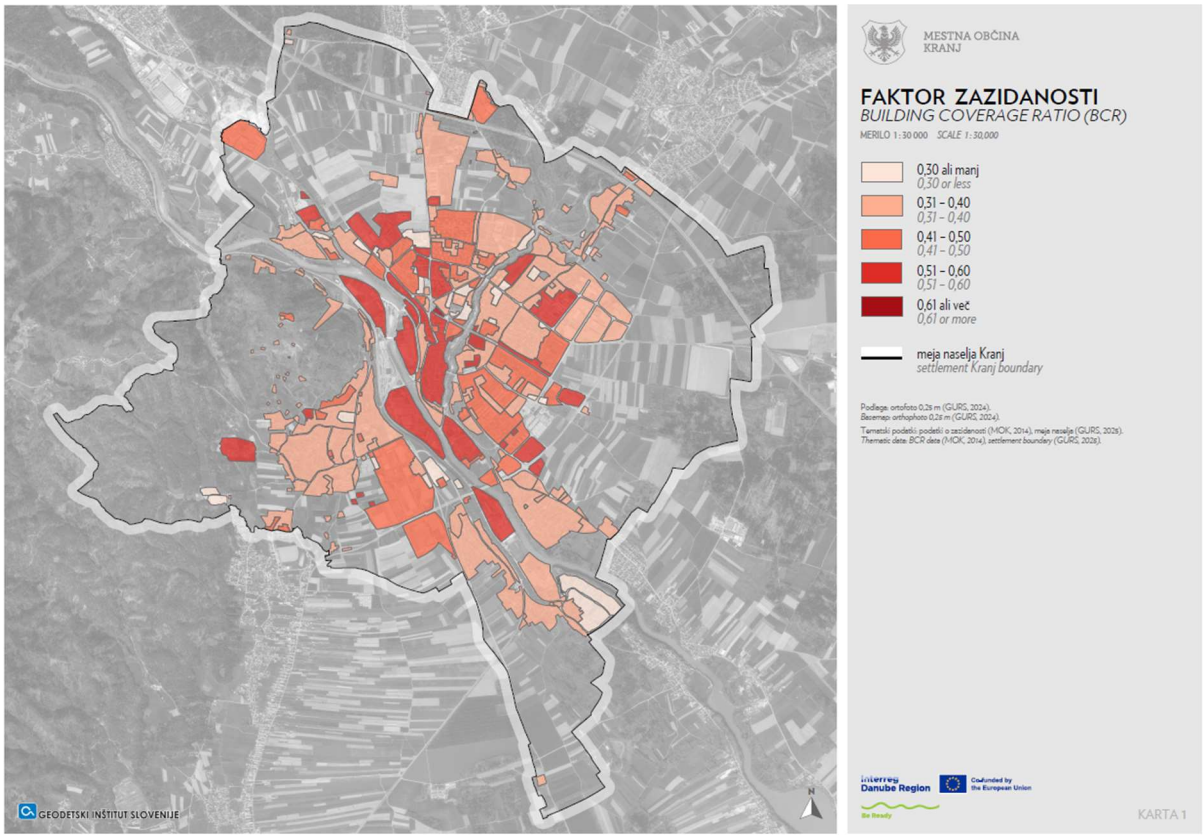

Figure 22: Building coverage ratio (BCR), source: CIty of Kranj, Geodetic institute of Slovenia, 2025

The greatest density of buildings represents areas of industrial, craft, business, commercial and similar use. Among other uses also the old city center presents a denser area.

Floor area ratio (FAR)

Floor area ratio (FAR) is a measure describing how much land is covered by a building. It is a relationship between the total floor area of land covered by buildings and the whole area where the building stands. FAR is urban planning code which is also defined in the Implementation part of the Municipal Spatial Development Plan.

Since the FAR is given only for a very small proportion of spatial units in the existing spatial act, the analysis is due to non-existent data, not given.

Street canyon aspect ratio

This analyse shows the road sections where the street canyon appears in the settlement of Kranj.

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• data on floor plans of buildings from the Real Estate Cadastre (KN)

• date: acquired in January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/parcele-in-stavbe/kataster-nepremicnin/

• data on settlement boundaries from the Register of Spatial Units (RPE)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

• data on national and municipal roads from the Collective Cadastre of Economic Public Infrastructure (ZK GJI)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/gospodarska-javna-infrastruktura/zbirni-kataster-gji/

• Road data bank (BCP)

• date: 2022

• source: Infrastructure Development Company

Process:

The following methodology for identifying road sections (state or municipal) where street canyons appear, was determined:

• data on state and municipal roads from ZK GJI is used for road geometry,

• the data from the BCP is used for the road width,

• for the geometry and height of the buildings, the building data from the KN is used,

• where relevant data (width, height) are missing in the specified sources or deviations (height) are detected, the data is supplemented by interpretation from the DOF,

• a street canyon appears on a road section if the buildings on both sides of the road are closer to the edge of the road than half the width of the road. Example: if the road is 5 m wide, then a 2.5 m distance from the edge of the road is taken into account.

For the purposes of determining the sections where the street canyon appears, the linear geometry of the roads from ZK GJI was divided into 25 m long sections. Using spatial analysis, the selection of sections that meet the above criteria was done. For each selected section, the calculation of the average height of the buildings in that section and calculation of the ratio of the street canyon was done. We generally checked the selected sections visually and eliminated sections that were not relevant due to discrepancies in the data sources (e.g. the axis of the road intersects the building polygon - the automated method marks the section as a street canyon, even though there are no buildings on the other side of the road).

The classes in the legend are adjusted to the values in the calculated layer.

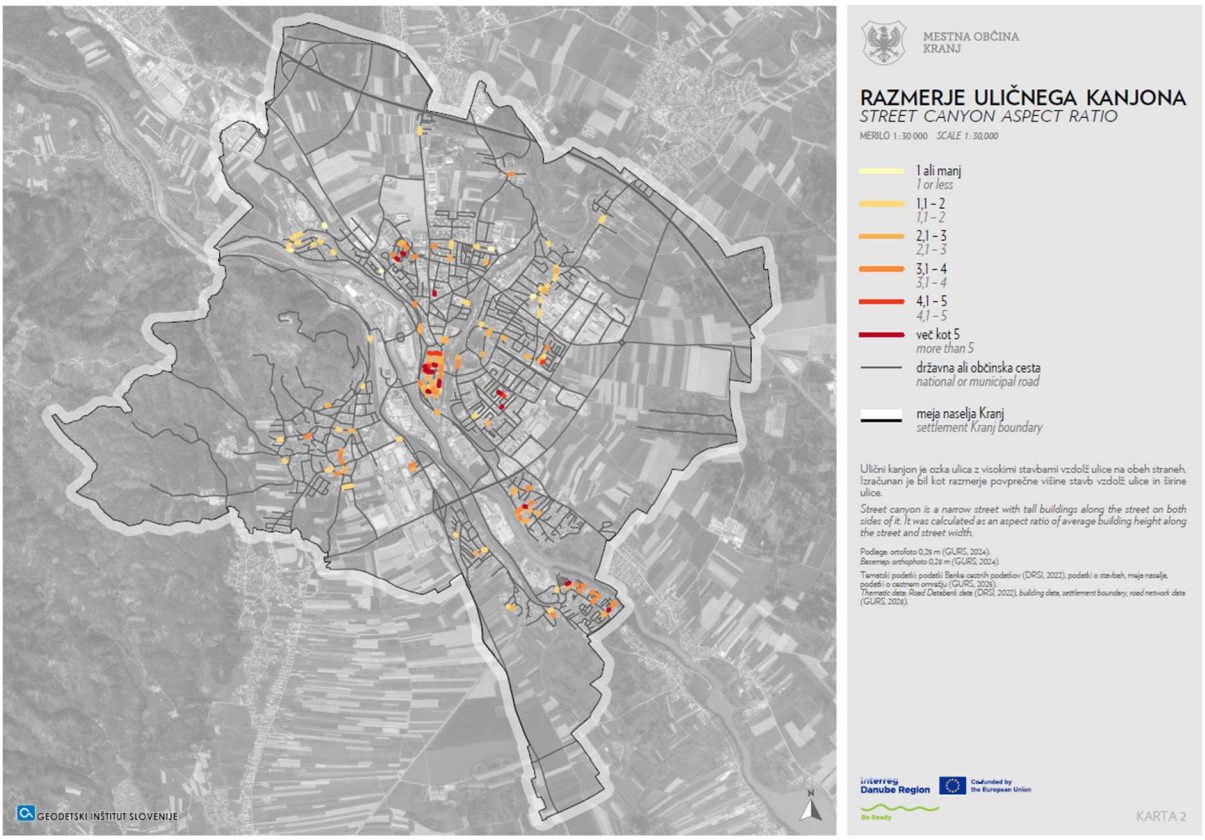

Figure 23: Street canyon aspect ratio, source: CIty of Kranj, Geodetic institute of Slovenia, 2025

The results show that the street canyon aspect ratio stands out the most in the old city centre, which is to be expected, since there are the narrowest streets, due to the typical historical designs of old city centres in Slovenija.

Green urban areas and water bodies

Green coverage ratio

There was not enough data to prepare the green coverage ratio map. The cadastre of public green areas, managed by the Municipality of Kranj, covers only part of the green areas in the city, i.e. those areas that are owned and managed by the city's green area management service. Data on green areas that are privately owned unfortunately do not exist. The city of Kranj at this moment does not yet have a green system analysis prepared. Since we are aware of this shortcoming, the preparation of the analysis of the green system is one of the analyses, which the city will try to prepare as soon as possible.

Figure 24: Extract from the city cadastre of green areas, source: GIS City of Kranj, 2025

We managed to prepare an analysis of the actual land use, which is presented below and from which the actual use of agricultural and forest land, as well as unbuilt building land, which often represents green areas, can be seen.

Tree canopy coverage

Tree canopy coverage is a ratio of tree canopy coverage at city level compared to a city unit (neighborhood, district, city level). In our case the city unit is settlement Kranj.

In the city cadastre the trees are recorded as point data, but it does not contain data on the width of the tree canopy. Due to the aforementioned shortcoming, we used data from the Copernicus online platform to display the tree canopies.

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• tree cover data

• date: 2018, acquired February 2025

• source: Tree Cover Density 2018 (raster 10 m) - Copernicus Land Monitoring Service

https://land.copernicus.eu/en/products/high-resolution-layer-tree-cover-density/tree-cover-density-2018

• data on settlement boundaries from the Register of Spatial Units (RPE)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

Process:

The tree cover data in the source shows the proportion of tree canopy cover at a resolution of 10 x 10 m. The coverage ratio is given in the range from 0% to 100%, divided in 5 classes.

The spatial unit chosen for the display is a hexagon in size, which in nature covers an area of one hectare. The size was chosen according to the scale of the map. For each hexagon, the average value of the proportion of tree cover from the source was calculated. The display thus gives the proportion of tree coverage per hectare. The classes in the legend were summarized according to the guidelines (Urban Heat Islands Vulnerability and Risk Assessment, Methodology with guide for application and tools, June 2024).

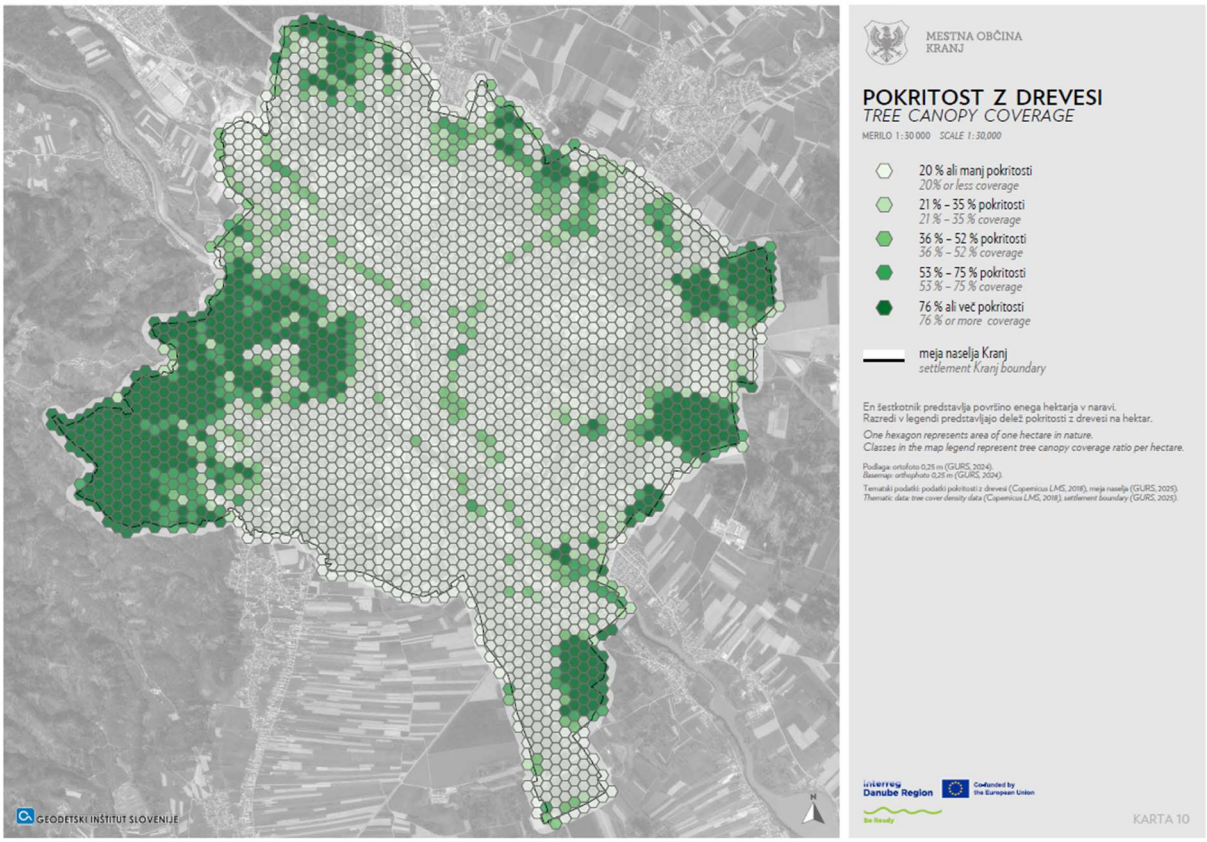

Figure 25: Tree canopy coverage, source: City of Kranj, Geodetic institute of Slovenia, 2025

The map shows a greater coverage of trees in the western part of the settlement of Kranj. individual areas of tree coverage are located along the border of the settlement from north to east and south, while coverage is poor in the central part of the settlement, with the exception of river corridors.

Water coverage ratio

Water coverage ratio is a relationship between the size of the city and water bodies within the city.

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• hydrography data from the Surface Water Database

• date: January 2025

• source: Directorate of the Republic of Slovenia for Water

http://www.evode.gov.si/index.php?id=108

• data on settlement boundaries from the Register of Spatial Units (RPE)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

Process:

The original hydrography data in the source also contain object types that are not subject to display on this map. Line and surface water layers were used. The following types of facilities were excluded from the display: roadside ditch, traffic infrastructure collector, industrial and recreational pool. Sections of liquid water that flow below the surface (are covered) are not shown. They are also not taken into account in the calculation of the proportion of water coverage. The display includes the names of the largest watercourses in the area of the settlement.

For the purposes of calculating the share of water coverage, we converted the flowing waters, which in the records are only covered by an axis (up to 2 m wide), into plots with a uniform width of 2 m. The plots obtained in this way were taken into account together with the other objects covered by the plot in the calculation of the share that the water plots represent in the total area of the Kranj settlement.

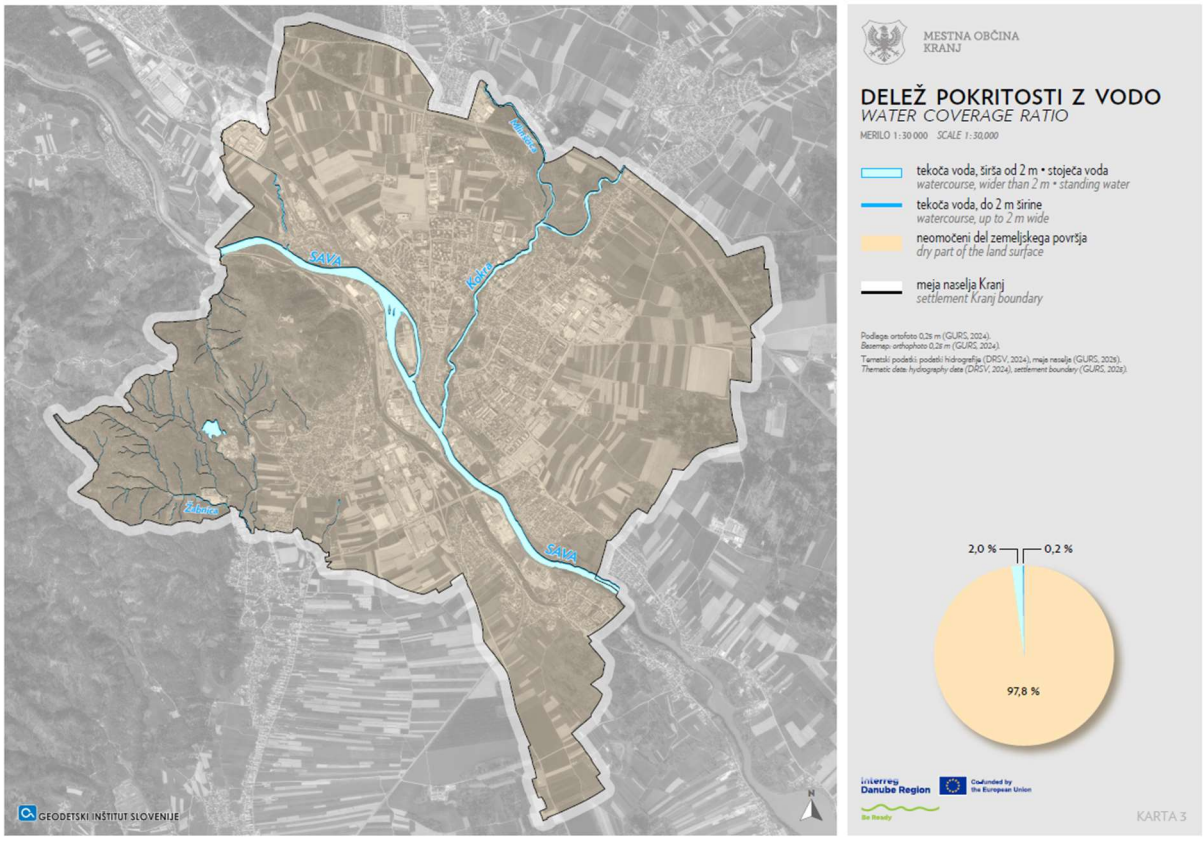

Figure 26: Water coverage ratio, source: City of Kranj, Geodetic institute of Slovenia, 2025

Two rivers flow through the city of Kranj, the Sava and the Kokra river, which merge into the Sava in the city centre. There are no other water bodies in the narrower part of the city. The water coverage ratio is low, it presents only 2,2 % of analysed area.

Permeability of surfaces

Share of permeable surfaces related to impermeable surfaces

The map shows permeable and impermeable surfaces in the settlement of Kranj.

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• layer 10 types of actual use, made for map Actual use of space

• data from the Cadastre of Public Green Areas (KJZP)
• date: 2024
• source: City of Kranj

• data on floor plans of buildings from the Real Estate Cadastre (KN)
• date: acquired in January 2025
• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/parcele-in-stavbe/kataster-nepremicnin/

• data on settlement boundaries from the Register of Spatial Units (RPE)
• date: January 2025
• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

Process:

The following methodology for showing the permeability of surfaces was determined:

• The layer of 10 types of actual use, was recategorized into two categories - permeable or impervious surfaces. On the basis of supplementary sources, permeability was determined for the entire type of actual use or part of it.

• One of the supplementary sources was KJZP, where using a manual inspection based on DOF, the asphalt and concrete playgrounds was separated as impervious surfaces. As part of the manual inspection, also grassy areas or greened sports fields was excluded and other larger grassy areas within the sports and recreation areas in the PZ layer. We also included playgrounds with artificial grass.

• The layer of 10 types of actual use, was combined with the refined data of KJZP and greened sports fields within the sports and recreation areas in the PZ layer, and the overlapping areas were determined as permeable surfaces.

• We also interpreted the permeability of residential areas and areas for agricultural activities from PZ in a similar way. For this purpose, we used data on floor plans of buildings from the Real Estate Cadastre (KN), which we previously limited to residential areas and agricultural activities. We combined the latter with data on building floor plans and defined overlapping areas as impervious.

Finally, even within other built-up lands, we determined the areas from the RABA layer with type of use 5000 as permeable, and the rest as impermeable.

The table below gives the rules for placement in permeable and impermeable surfaces:

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ACTUAL USE	PERMEABILITY
water land	permeable
forest land	permeable
agricultural land	permeable
Built-up land - Residential area	permeable except • where the polygon of the building is (KN)
Built-up land - Area for central activities	impervious except • grassed sports fields and other large grassy areas in PZ 3171 • where the KJZP polygon is
Built-up land - Area for production activities	impervious except • for PZ 3121, 3122, 3123, where there is no polygon of the building (KN) • where the KJZP polygon is
Built-up land - Area of traffic areas	impervious except • where the KJZP polygon is
Built-up land - Area for the needs of defense and protection	impervious except • where the KJZP polygon is
Built-up land – Other built-up land	impervious except • PZ 3181 and 3183 • USE 5000 • where the KJZP polygon is
Built-up land - Unbuilt building land	permeable

Table 1: The rules for placement in permeable and impermeable surfaces, source: City of Kranj, Geodetic Institute of Slovenia, 2025

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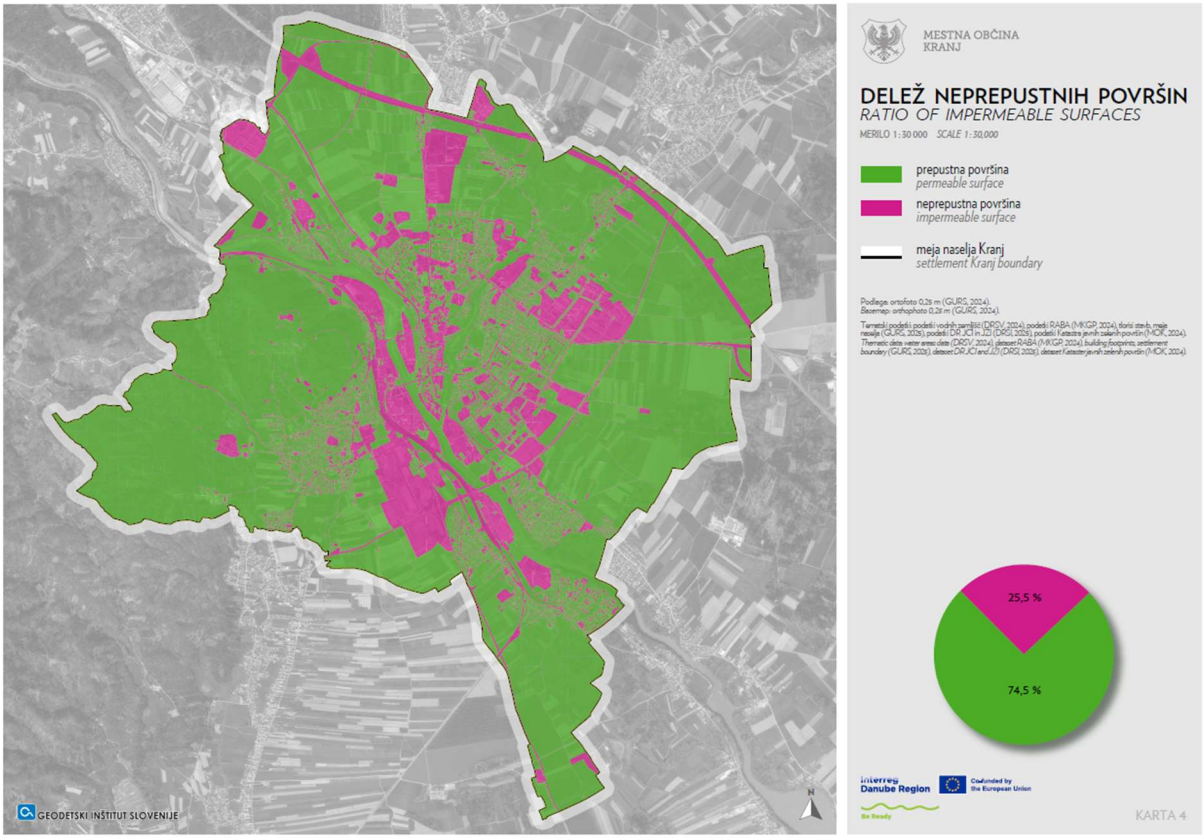

Figure 27: Ratio of impermeable surfaces, source: City of Kranj, Geodetic institute of Slovenia, 2025

The share of impermeable ratio within the boundaries of the settlement Kranj is 25,5 %. Industrial and business areas add the most to this share, as well as traffic surfaces and roofs of buildings.

Human activities

Population density

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• data on the number of inhabitants

• date: 2023, acquired January 2025

• source: STAGE, Statistical Office of the Republic of Slovenia

https://gis.stat.si/

• data on settlement boundaries from the Register of Spatial Units (RPE)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

Process:

The map shows the population density per selected spatial unit in the settlement of Kranj.

Data on the number of inhabitants show the total number of inhabitants who have registered permanent and/or temporary residence in Slovenia. More information on the age and gender composition of the population is published in the SiStat database, Population - Number of inhabitants.

A spatial unit of 100 x 100 m in nature was chosen for display, which is the most suitable according to the scale of the map. The display thus gives the number of inhabitants per hectare. The classes in the legend were summarized after the legend in STAGE II. STAGE II is an interactive cartographic application for displaying statistical data about Slovenia.

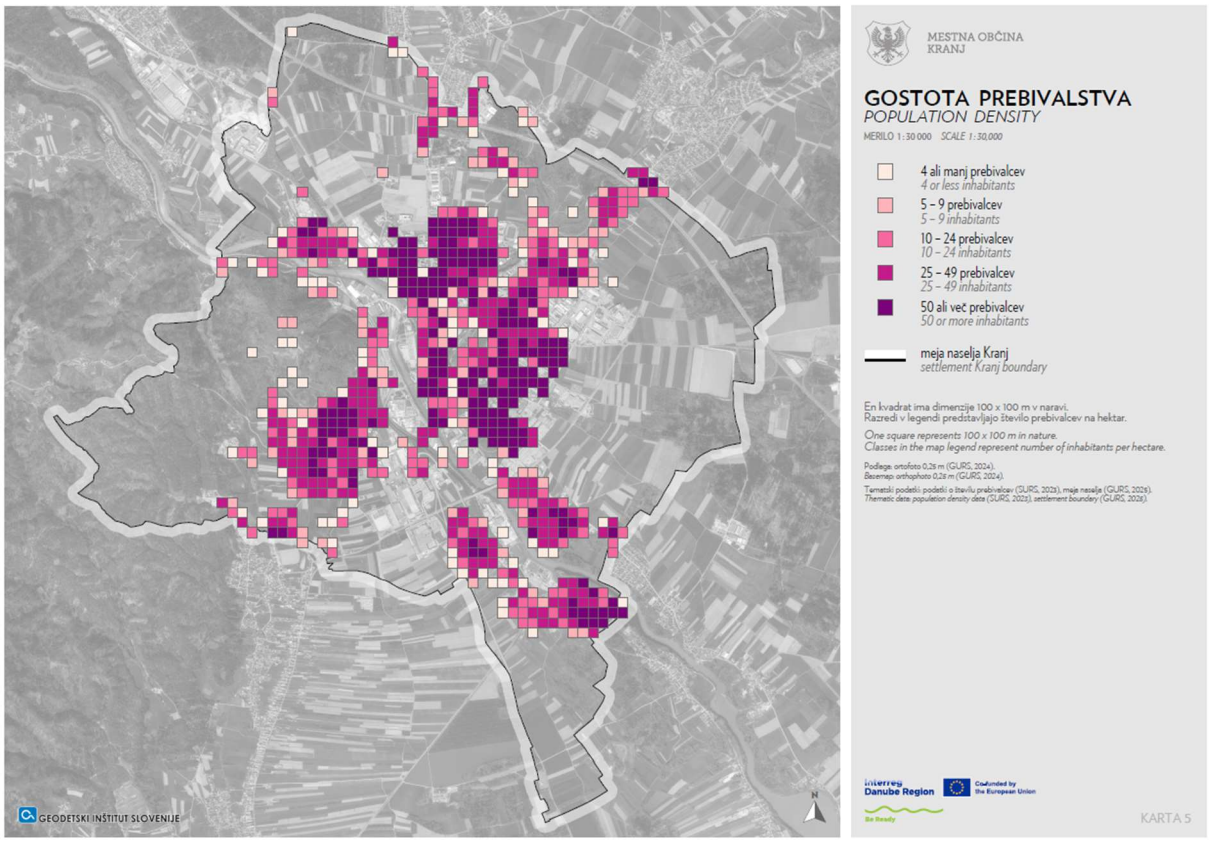

Figure 28: Population density, source: City of Kranj, Geodetic institute of Slovenia, 2025

Densely populated are areas where there are bigger residential neighbourhoods, such as Planina, Šorlijevo naselje, Zlato polje. The city centre and the Stražišče in the western part of the settlement also stand out.

Land use

The map shows the actual use of space in the settlement of Kranj.

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• data from the Register of Agricultural and Forest Lands (RABA)

• date: 2024

• source: Ministry of Agriculture, Forestry and Food

https://rkg.gov.si/vstop/

• hydrography data from the Surface Water Database (VZ)

• date: January 2025

• source: Directorate of the Republic of Slovenia for Water

http://www.evode.gov.si/index.php?id=108

• data on actual land use of public road and railway infrastructure (DR JCI and JŽI)

• date: January 2025

• source: Directorate of the Republic of Slovenia for Infrastructure

https://portal.drsc.si/draba

• data on inhabited land (PZ) and undeveloped building land (NPZ) from the Building Land Register (ESZ)

• date: 2021

• source: Ministry of Natural Resources and Space

https://pis.eprostor.gov.si/sl/pis/evidenca-stavbnih-zemljisc

• data on settlement boundaries from the Register of Spatial Units (RPE)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

Process:

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The following methodology for showing the actual use of the space was used:

• in the first step, the data of the RABA layer were combined with the PZ data and only the PZ data were taken into consideration in the areas of overlap,

• in the second step, we combined the result of the first step with the NSZ data and only the NSZ data were taken into consideration in the areas of overlap,

• in the third step, the result of the second step was combined with the VZ data and only the VZ data were taken into consideration in the areas of overlap,

• finally, we combined the result of the third step with the DR JCI and JŽI data and adopted them in overlapping areas.

We have categorized the values of individual types of actual use of space into 10 categories, which are given in the table below.

ACTUAL USE	SOURCE AND STYPE OF LAND IN THE SOURCE
water land	VZ, RABA 7000
forest land	RABA 2000
agricultural land	RABA 1100, 1180, 1190, 1211, 1221, 1222, 1300, 1410, 1500, 1600, 1800
Built-up land - Residential area	PZ 3111, 3112
Built-up land - Area for central activities	PZ 3131, 3132, 3133, 3134, 3135, 3136, 3141, 3142, 3151 in 3171
Built-up land - Area for production activities	PZ 3121, 3122, 3123, 3161, 3162
Built-up land - Area of traffic areas	DR JCI, JŽI
Built-up land - Area for the needs of defense and protection	PZ 3191, 3192
Built-up land – Other built-up land	RABA 3000, 5000, PZ 3181, 3183, 3184, 3211, 3212, 3234, 3241, 3242, 3243, 3244, 3410, 9000
Built-up land - Unbuilt building land	NPZ

Table 2: Values of individual types of actual use, source: City of Kranj, Geodetic institute of Slovenia, 2025

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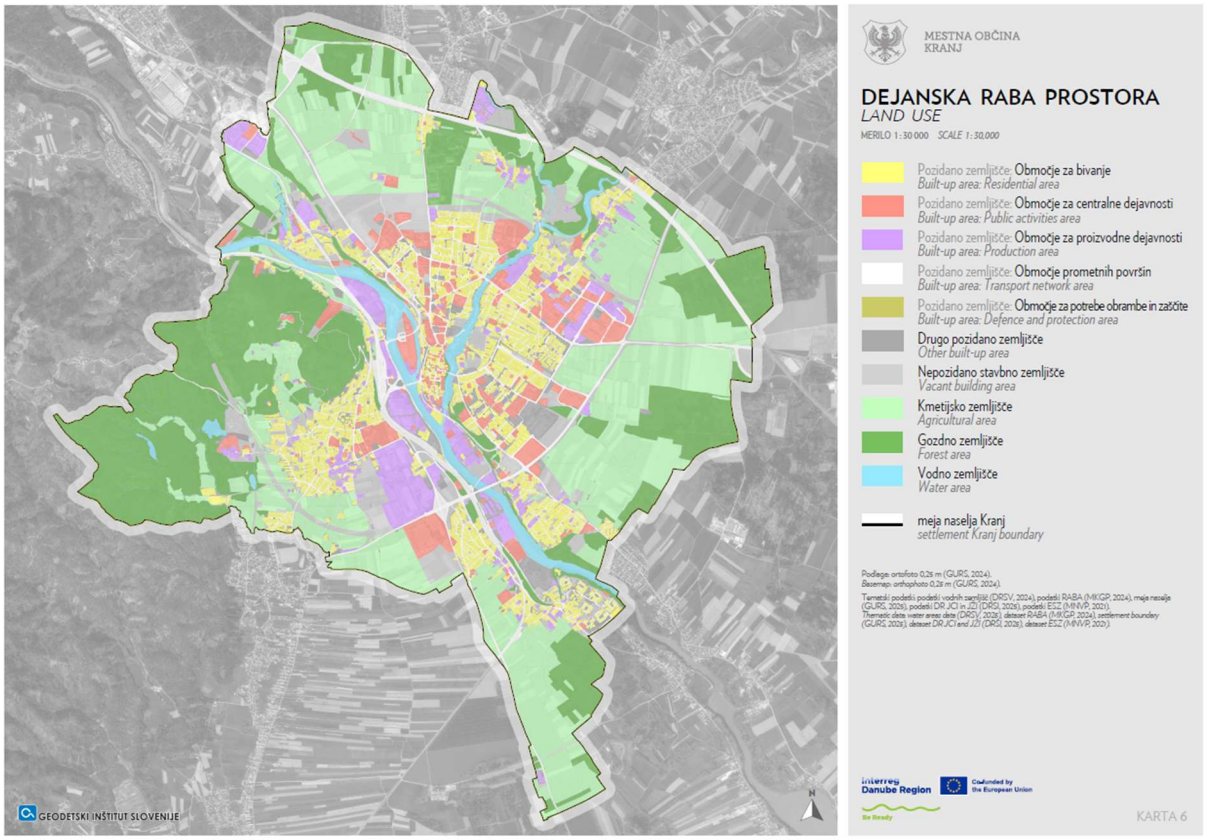

Figure 29: Actual land use, source: City of Kranj, Geodetic institute of Slovenia, 2025

Energy consumption of buildings

Data for this analysis were sparse. We firstly obtained information about business entities, such as industry, commercial buildings, etc., which are the biggest consumers of energy in Kranj, but without any data on how much energy they consume, so we decided not to use this source.

We searched for graphic data on energy certificates for buildings, but we manage to acquire only tabular data which is in the form of Register maintained at the national level by the Ministry of the Environment, Climate and Energy. The further process is described below.

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• Register of energy certificates

• date: December 2024

• source: Ministry of the Environment, Climate and Energy

https://www.energetika-portal.si/podrocja/energetika/energetske-izkaznice-stavb/register-energetskih-izkaznic/

• data on settlement boundaries from the Register of Spatial Units (RPE)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

• data on floor plans of buildings from the Real Estate Cadastre (KN)

• date: acquired in January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/parcele-in-stavbe/kataster-nepremicnin/

Process:

Data on the building's energy efficiency are taken from the building's energy certificate. Since the data was in a tabular form for the whole country, we had to extract the data for the Municipality of Kranj and then the data for the city of Kranj. We matched the data on the energy certificates with the floor plans of buildings from the KN via the unique identifier of the building. They are shown only for buildings where data on the energy certificate is available in the resource. In multi-apartment buildings, the energy certificate is kept for each apartment, so the display on the map does not necessarily show the energy status of all apartments in the building.

The centroids of buildings for which data were available were used for display. They are shown with circles. The classes in the legend have been summarized according to the Rulebook on the Methodology for the Production and Issuance of Energy Certificates for Buildings (ZURE, Uradni list RS, no. 4/2023) and are divided into 7 classes, from A-the less consuming, to G-the most consuming buildings. The display was structured in such a way that, in case of overlap, spheres with lower energy efficiency are displayed above spheres with higher energy efficiency.

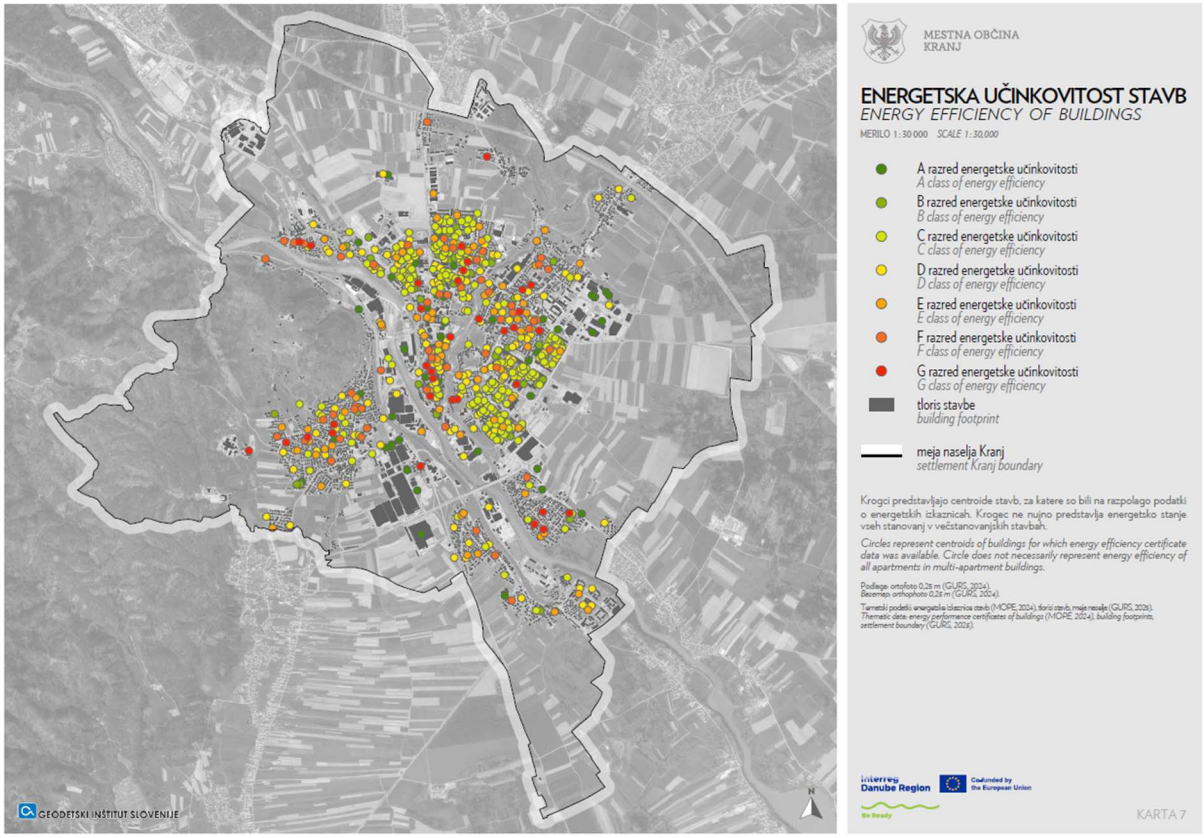

Figure 30: Energy efficiency of buildings, source: City of Kranj, Geodetic institute of Slovenia, 2025

Energy consumption of transportation

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

• data on areas of traffic jams and traffic junctions

• date: January 2025

• source: City of Kranj

• data on daily traffic counts

• date: December 2024

• source: Directorate of the Republic of Slovenia for Transport

• data on settlement boundaries from the Register of Spatial Units (RPE)

• date: January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/prostorske-enote-in-naslovi/register-prostorskih-enot/?acitem=1791-1798

• data on state and municipal roads from the Collective Cadastre of Public Infrastructure (ZK GJI)

• date: acquired in January 2025

• source: Geodetic Administration of the Republic of Slovenia

https://www.e-prostor.gov.si/podrocja/gospodarska-javna-infrastruktura/zbirni-kataster-gji/

Process:

The data for traffic jams and traffic junctions were not existing. The data had to be prepared. They were prepared on the basis of interviews with employees of the transport office and employees of the space office within the city administration. Informal interviews were held, where the points of traffic congestion and traffic jams were marked on the map of the city of Kranj and then transferred to the Qgis form. The data comprises of road sections where traffic jams most often occur, the location of two traffic hubs (bus and train stations) and the location of daily traffic counts with the average daily number of vehicles. The last data was obtained from the Directorate of the Republic of Slovenia for Transport, which has daily traffic counts installed in certain places in Kranj (on national roads).

In addition to the above-mentioned contents, the map also shows the values of the average daily number of vehicles for each counting place.

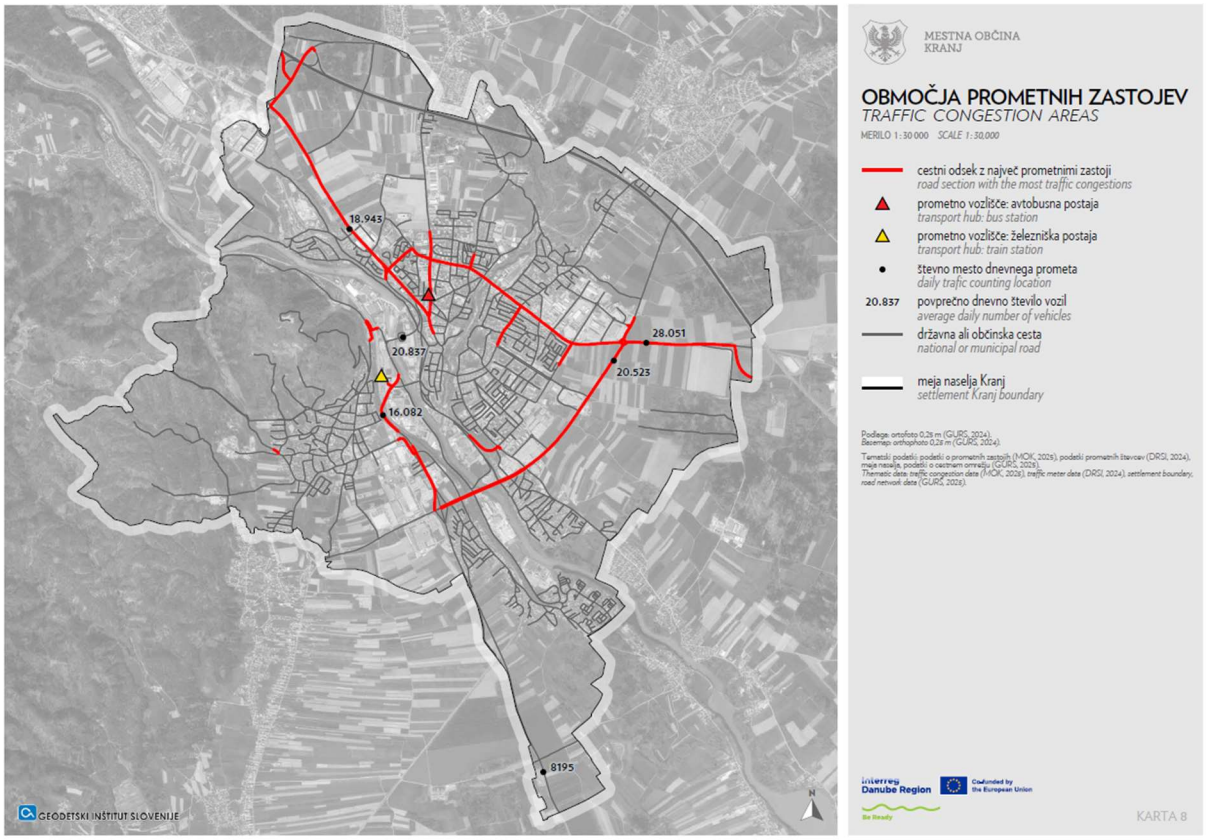

Figure 31: Traffic congestion areas, source: City of Kranj, Geodetic institute of Slovenia, 2025

SENSITIVITY OF EQUIPMENT AND MATERIALS

Albedo (Reflectivity) Coefficient

Albedo is closely connected to the Urban Heat Island (UHI) effect, which refers to the phenomenon where urban areas experience significantly higher temperatures than their surrounding rural or natural areas. The connection between albedo and the UHI effect lies in the ability of different surfaces within a city to reflect or absorb solar radiation.

In cities, a significant portion of the surfaces, such as roads, buildings, parking lots, and rooftops, tend to have low albedo, meaning they absorb a large amount of solar radiation. These surfaces, often dark-colored like asphalt or concrete, convert the absorbed sunlight into heat. This absorbed heat increases the temperature of the urban environment, both during the day and night, because the heat is stored and gradually released back into the atmosphere. This can lead to uncomfortable living conditions and increased energy demand for cooling, such as air conditioning, which can lead to higher electricity consumption and increased greenhouse gas emissions, further contributing to global warming.

SURFACE TYPES	ALBEDO
black asphalt	0,15
white painted asphalt	0,6
concrete	0,3
grey painted concrete	0,6
white painted concrete	0,24
brick	0,30
gravel	0,72
wood	0,40
galvanized sheet metal	0,35

Table 3: Albedo values for different surfaces, source: Oke, 1987

Used data:

a) Base

• color orthophoto with an image element of 0.25 m

• date: 2024

• source: Geodetic Administration of the Republic of Slovenia

b) Thematic data

- layer of permeable and impermeable surfaces, created for map 4 – Proportion of impermeable surfaces

- data from the Register of Agricultural and Forest Land (RABA)
- status: 2024
- source: Ministry of Agriculture, Forestry and Food

  https://rkg.gov.si/vstop/

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-
- data on the actual use of public road infrastructure land (DR JCI)
- status: obtained in January 2025
- source: Directorate of the Republic of Slovenia for Transport

  https://portal.drsc.si/draba

- data on building floor plans from the Real Estate Cadastre (KN)
- status: obtained in January 2025
- source: Geodetic Administration of the Republic of Slovenia

  https://www.e-prostor.gov.si/podrocja/parcele-in-stavbe/kataster-nepremicnin/

- hydrography data from the Surface Water Database
- status: obtained in January 2025
- source: Directorate of the Republic of Slovenia for Water

  http://www.evode.gov.si/index.php?id=108

Process:

The color orthophoto was changed to a grayscale image and brightened for display purposes. All thematic contents are shown only for the area of the Kranj settlement, although the map also shows the areas of neighbouring settlements.

The following methodology was defined for displaying the reflectance coefficient (albedo):

- The land use layer data was placed in the selected land cover types. They are given in the table below.
- Areas with land use type 7000 (water) were initially combined with hydrography data. In this process, a surface water area layer and a line layer was used, which was previously converted into a two-meter-wide area layer around the surface water axis. In the area where water data from two records overlapped, the DRSV hydrography data was adopted. The remaining independent polygons with land use type 7000 were manually inspected by DOF and classified into the appropriate type of selected land cover types.
- Built-up areas were upgraded using surface permeability data from Map 4. In areas where permeable surfaces overlap with built-up areas, the areas are classified as grass, vegetation.
- The remaining built-up areas are finally separated into asphalt and other built-up areas. In areas where built-up areas overlap with DR JCI polygons, the areas are classified as asphalt.

TYPE OF GROUND COVER	SOURCE AND TYPE OF LAND IN THE SOURCE	USED ALBEDO
Asphalt	LANDUSE 1190, 3000, where it is located in the DR JCI polygon area	0,08

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Bare ground	LANDUSE 1100, 1180	0,10
Trees	LANDUSE 1410, 1500, 2000, 4220, 5000	0,13
Grass, vegetation	LANDUSE 1211, 1221, 1222, 1300, 1600, 1800 LANDUSE 1190, 3000, where it overlaps with the permeable surface polygons from map 4	0,20
Other Built-up land – Areas (concrete, buildings)	LANDUSE 1190, 3000	0,28
Water	flowing and standing waters of the hydrographic layer DRSV RABA 7000	Low solar elevation 0,65 High solar elevation 0,07

Table 4: Type of ground cover, source and albedo, source: City of Kranj, Geodetic institute of Slovenia, 2025

Because the albedo for water varies greatly depending on the angle of sunlight (low, high), two versions of map were produced.

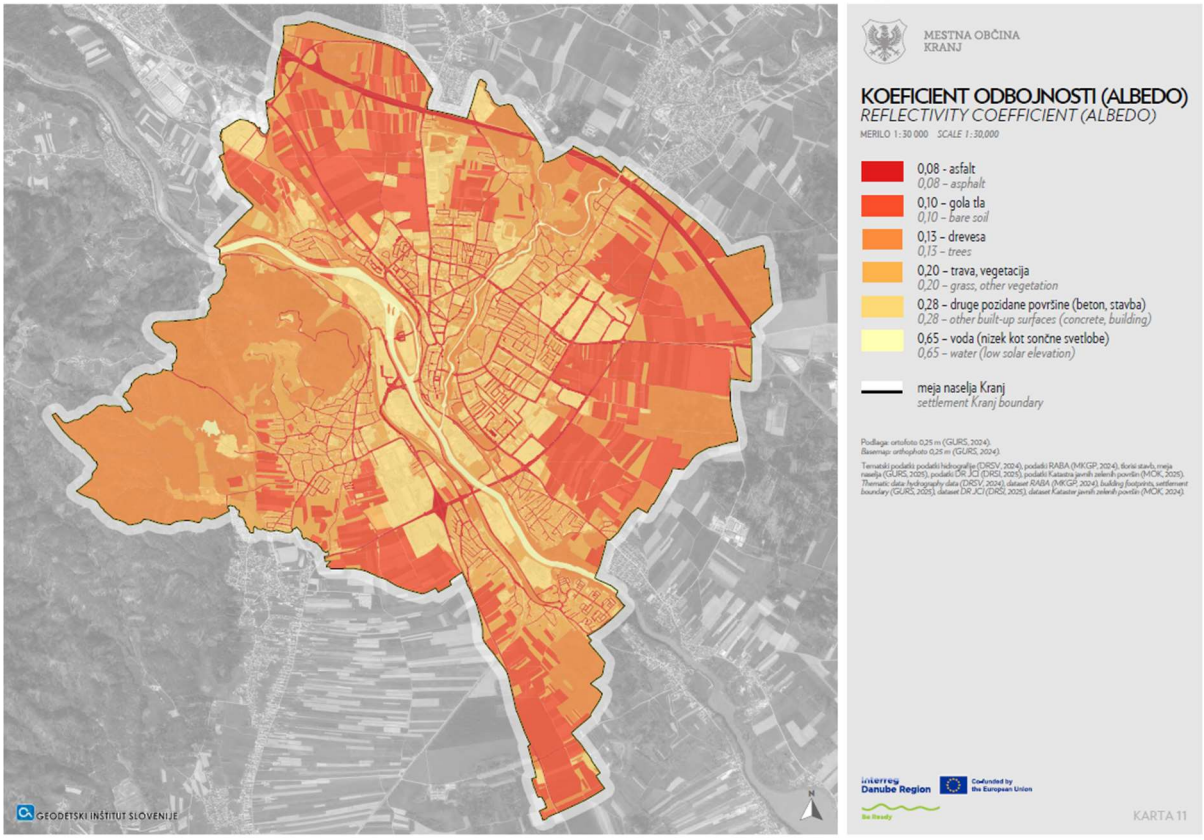

Figure 32: Reflectivity coefficient (albedo) on the low angle of sunlight, Source: City of Kranj, Geodetic institute of Slovenia, 2025

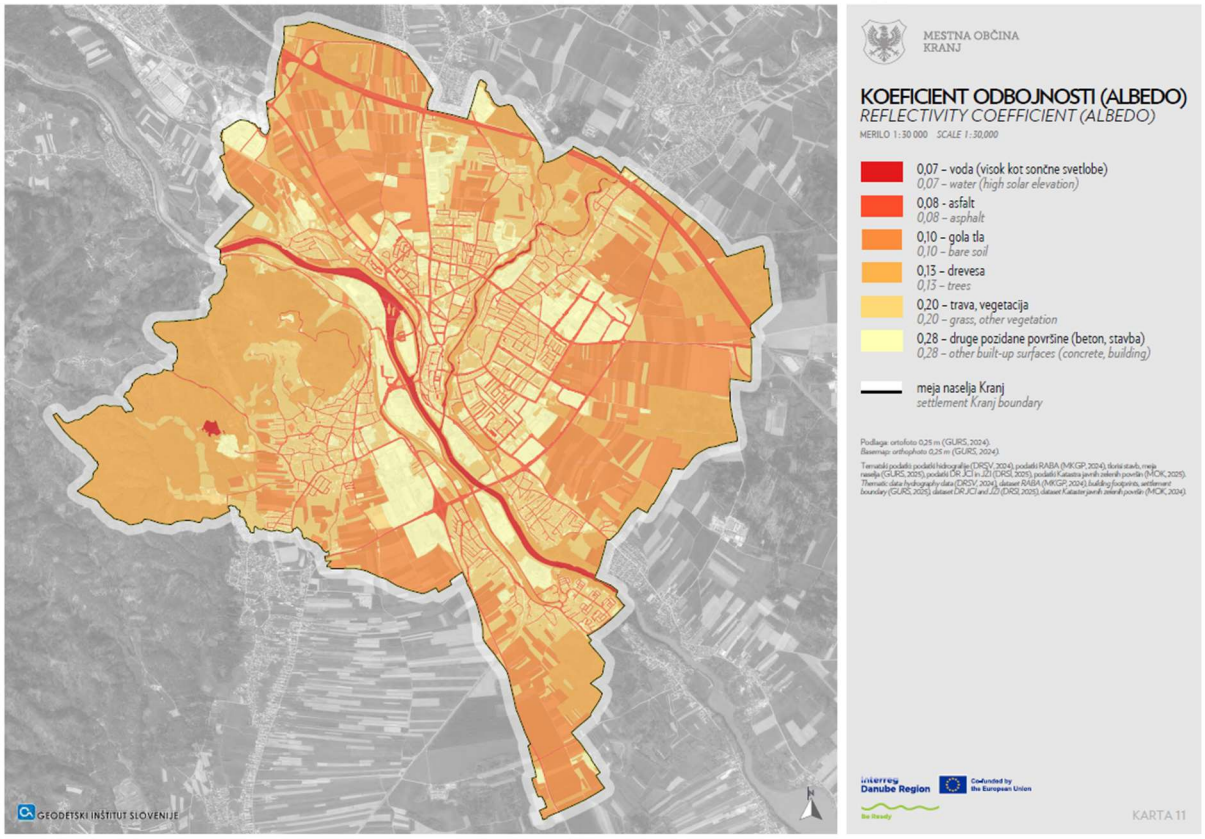

Figure 33: Reflectivity coefficient (albedo) on the high angle of sunlight, Source: City of Kranj, Geodetic institute of Slovenia, 2025

To mitigate the Urban Heat Island effect, one of the key strategies is to increase the albedo of urban surfaces. Here are some measures to do this:

Reflective or Cool Roofs:

- Cool roofing materials with high albedo (light colors or reflective coatings) can reduce the amount of heat absorbed by buildings. This helps lower both the air temperature and the cooling energy demand.
- Light-Colored Pavements and Roads:
- Replacing traditional dark asphalt with lighter-colored or reflective pavement materials can significantly reduce heat absorption. This also lowers the surface temperatures of streets and other paved areas.

Urban Greening and Vegetation:

- Planting trees, grass, and creating green spaces in cities can help improve the albedo because vegetation typically has a higher albedo compared to urban infrastructure. Additionally, plants cool the air through evapotranspiration, which further helps mitigate the UHI effect.

Green Roofs and Walls:

- Installing green roofs or living walls with vegetation can both increase the albedo of buildings and reduce the amount of heat they absorb. These green spaces also contribute to cooling the immediate surroundings.

Water Features:

- Introducing water bodies (ponds, fountains, lakes) or using cooling techniques such as misting can lower temperatures and increase local humidity, helping to reduce the heat island effect.

Albedo is directly linked to the Urban Heat Island effect because surfaces with low albedo in cities absorb more solar radiation and contribute to higher local temperatures. By increasing the albedo of urban surfaces through reflective materials, vegetation, and urban design strategies, cities can reduce the UHI effect, making urban areas cooler, more comfortable, and more sustainable for their inhabitants.

In conclusion, albedo plays a central role in shaping the microclimate by affecting temperature, humidity, and wind patterns. By manipulating albedo, cities and regions can manage their microclimates to reduce excessive heat and improve the comfort and sustainability of their environments.

Thermal Conductivity and Heat Capacity

Soil thermal conductivity (λ) is a property of soil that determines how well it conducts heat. It is expressed in watts per meter Kelvin (W/m·K) and is crucial in geotechnical and civil engineering analyses, especially in the design of foundations, geothermal systems, and underground structures.

Factors that affect soil thermal conductivity:

- Soil composition – Sand, clay, silt, and organic matter have different thermal conductivities.
- Water content – Moist soils have higher thermal conductivity than dry soils.
- Soil density – More compact soils have higher conductivity.
- Soil temperature – Increasing temperature can change the thermal properties of a material.
- Mineralogical composition – Minerals such as quartz have high thermal conductivity.

Typical values of soil thermal conductivity:

- Dry sandy soil: 0.15 – 0.25 W/m·K
- Moist sandy soil: 1.5 – 2.5 W/m·K
- Dry clay soil: 0.25 – 0.5 W/m·K
- Moist clay soil: 1.0 – 1.8 W/m·K
- Saturated soil: 2.0 – 3.5 W/m·K

Thermal conductivity of soil are among others usable in Environmental engineering when assessing the impact of groundwater on heat flows.

Limitation of the analysis

For accurate values of soil thermal conductivity in the Kranj area, local geotechnical investigations would be required, as soil properties may vary depending on the specific location. Although we do not have specific data for Kranj, we can give approximate values based on the general characteristics of soils in Slovenia:

Sandy soil: Thermal conductivity ranges between 0.15 and 2.5 W/m·K, depending on humidity and compaction.

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Clay soil: Values range between 0.25 and 1.8 W/m·K, also depending on water content and density.

Surface temperature and emissivity

Urbanization involves the concentration of population and the replacement of natural landscapes with built structures such as buildings, roads and parking lots. This change in land cover also influence on the properties of the earth's surface temperature - the energy balance, or the amount of radiation that the surface reflects and absorbs, and how heat is dissipated from the surface (Kalnay, Cai, 2003). The energy balance is also changed by humans, who, through their activities in the city (heating, industry and transport), release energy into the atmosphere. They also release substances into the atmosphere, mainly in the form of pollutants, water vapor and dust particles, which modify the energy balance, as they reduce the share of direct and increase the share of diffuse solar radiation (Žiberna, Ivajnšič, 2022). Changes in surface properties and the concentration of substances in the air can change local weather and climate (Kalnay, Cai, 2003). The most studied local climate change due to urbanization is the Urban Heat Island effect (Arnfield, 2003; Qian et al., 2022), i.e. the warming of urban areas compared to their surroundings or an equivalent non-urbanized area (Serco Italia SPA, 2018). Under conditions of global warming, these local effects of urban climate are even more potent (Žiberna, Ivajnšič, 2022).

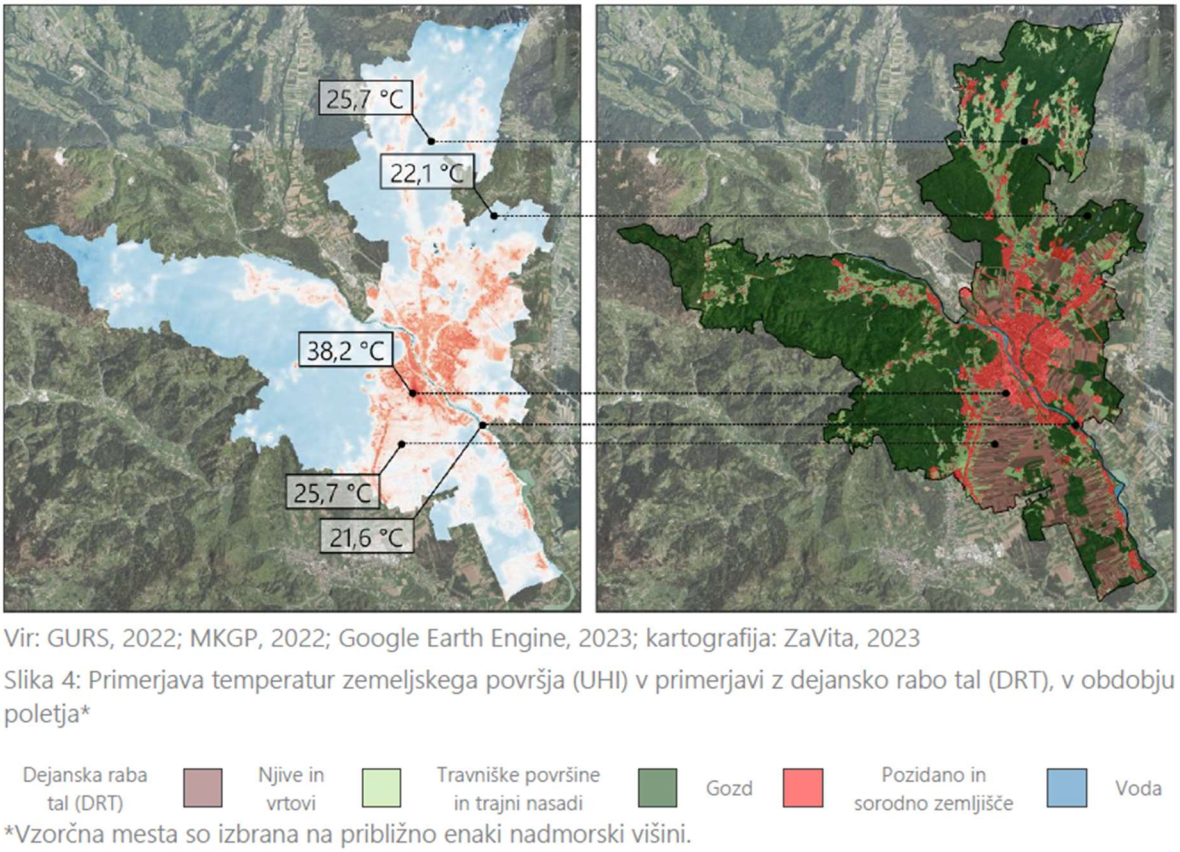

Figure 34: Comparison of land surface temperatures (UHI) compared to actual land use during the summer period (sample sites are selected at approximately the same altitude), Source: GURS, MKGP, 2022, Google Earth Engine 2023, Urbani toplotni otoki MOK, ZaVita, 2023;

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There are numerous measures to mitigate the effects of urban heat islands (UHI). In general, sustainable development in the city follows measures to mitigate urban heat islands (UHI). Most importantly, the phenomenon of urban heat islands (UHI) should be acknowledged and recognized as a potential threat to the quality of life in the city, which, especially in summer, can also pose a health threat to those who are unable to tolerate high heat loads. The issue of urban overheating should be included in documents on urban development, while simultaneously monitoring local weather and climate (Ogrin, 2022).

Urban heat islands (UHI) are one of the most pronounced impacts of human activity on local weather and climate and a problem that concerns everyone. Therefore, effective action to reduce the effects of urban heat islands (UHI) will require the approach of all users and decision-makers. In particular, raising awareness among the residents of the City Municipality of Kranj (MOK) and developing the skills of experts, planners, architects, urban planners and decision-makers will be essential for the successful planning and implementation of measures to reduce the impact of urban heat islands (UHI) in the City Municipality of Kranj (MOK).

Limitation of the analysis

Since emissivity data for the entire Kranj settlement area is not available, a more detailed analysis for surface temperature and emissivity will be performed in the pilot area, which will be selected by cross-referencing all maps and data that have/will be generated in this analysis.

Material Condition

City of Kranj's traffic network is 353.355 km long. The condition of categorized roads is seen on map "Assessment of road damage in the municipality of Kranj".

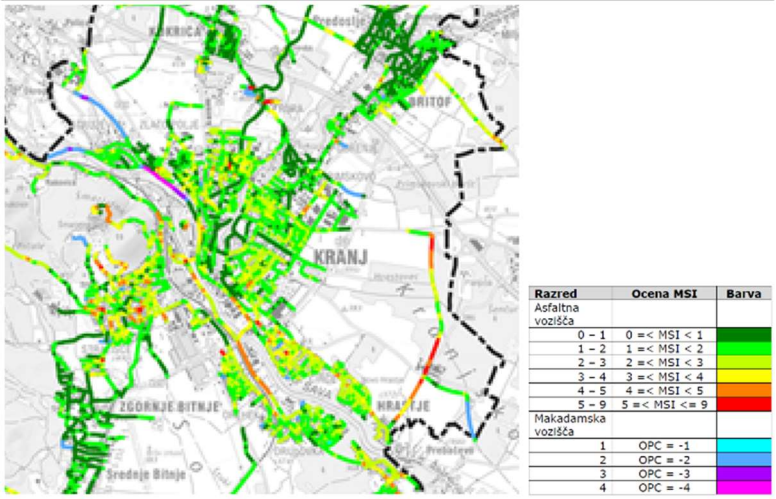

Figure 35: Assessment of road damage in the municipality of Kranj Source: ELENA MOBILITY Slovenia – sustainable mobility programme in Slovenia, 2022

We find this information important for planning the reconstruction of the transport network, which would require taking into account the albedo coefficient of the material used and seeking solutions to prevent or mitigate road overheating.

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Based on publicly available data from the Register of Energy Certificates, which is managed by the ministry responsible for energy pursuant to the Energy Efficiency Act (ZURE), 1.129 buildings or parts of buildings in Kranj have energy certificates. The list includes public buildings, individual buildings, single-family houses, and multi-family buildings. City of Kranj has, in a public-private partnership, renovated 21 municipal public buildings in recent years, and is continuing the renovation by preparing project documentation for another 19 buildings.

Limitation of the analysis

Material condition as qualitative assessment of the state of material for Kranj settlement area of 26.26 km^2 (City municipality has over 150 km^2) more time and sources are needed, because there is no official data on the condition of the material other than the condition of the roads shown above. A more detailed analysis for condition of the material will be performed in the smaller pilot area, which will be selected by cross-referencing all maps and data that have/will be generated in this analysis.

Coverage Area

To analyse the "coverage area" beside the Reflectivity coeficient (Albedo) map presented above a land use map and a soil permeability map form TOOL1 can be used, because they complement each other. The data from the expert basis Urban heat islands in the Municipality of Kranj, ZaVita, 2023, show the connection with albedo coeficient and remote sensing methodology, using the geoinformation tools Google Earth Engine and QGIS Desktop 3.22.11, according to authors Tirthankar Chakraborty (Tirthankar Chakraborty, 2023) and Igor Žiberna and Danijela Ivajnšič (Žiberna, Ivajnšič, 2022), which were adapted to the specifics of the area under consideration.

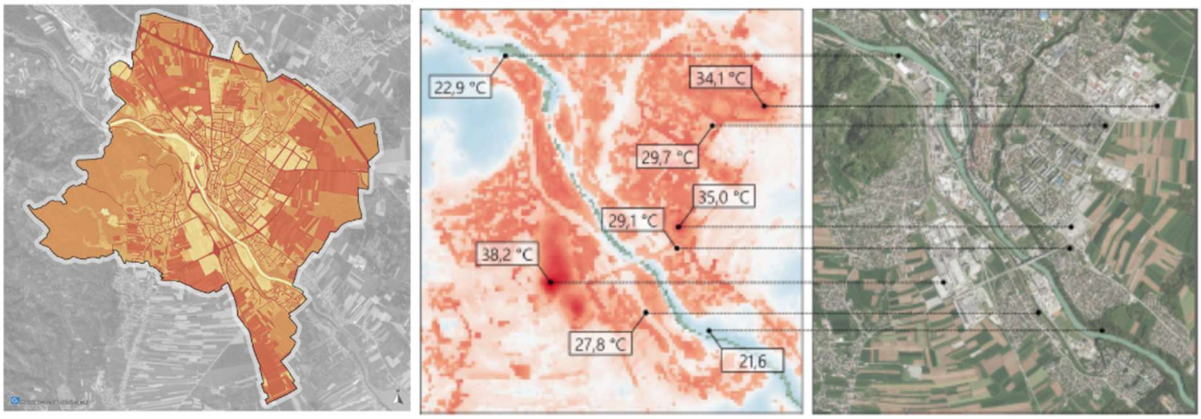

Figure 36: Comparison of different maps regarding reflectivity coeficient. Source: Source: GURS, MKGP, 2022, Google Earth Engine 2023, Urbani toplotni otoki MOK, ZaVita, 2023;

Vegetative Cover

To analyse the "coverage area" a land use map and a soil permeability map form TOOL1 can be used to analyse the impact of green system on the reflectivity coeficient of different materials.

Limitation of the analysis

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A more detailed analysis of impact of green system on UHI will be performed in the smaller pilot area, which will be selected by cross-referencing all maps and data that have/will be generated in this analysis.

VULNERABLE GROUPS

Socio-economic indicators

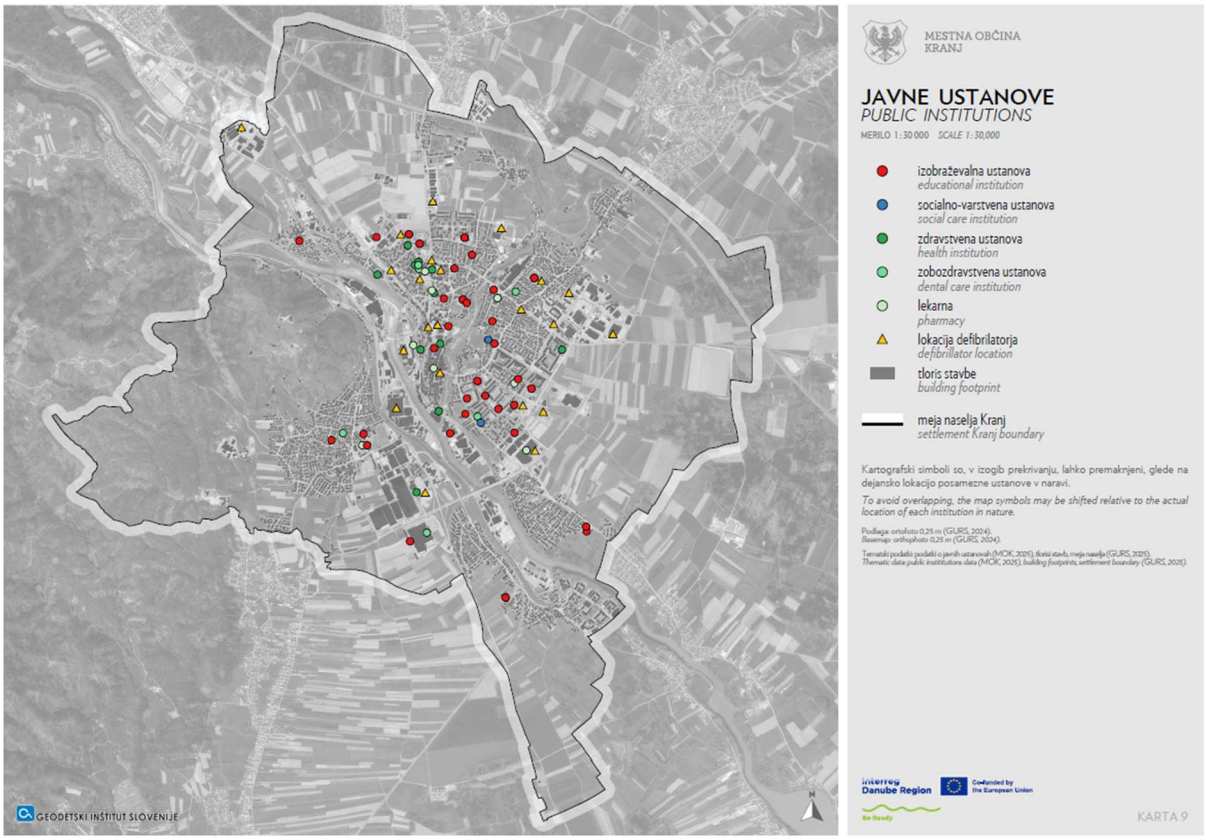

Figure 37: The network of public institutions in the settlement of Kranj is shown. The network of educational institutions is the most extensive, Kranj is the center of secondary education, and in recent years colleges and universities have also appeared in the municipality. Schools are followed by health institutions, Kranj has a maternity hospital and a health center. Source: City of Kranj, Geodetic Institute of Slovenia, 2025

Young people

Due to their higher body surface area to volume ratio, children and infants are more vulnerable to heat waves than healthy adults. Children are also more physically active and are less able to take care of themselves, so parents need to take care of their protection (e.g., adequate fluid intake, appropriate clothing, etc.). Children are less able to adapt to heat effectively than adults due to their ongoing development.

City of Kranj's population under 14 years is 8.864 and is distributed as follows (SURS, CRP, 2024)

- 1 – 5 years: 3.091
- 6 – 14 years: 5.773

Prebivalstvo po starosti, občine, Slovenija, polletno

		2024H1	2024H2
	0 let	486	423
	1 leto	503	482
	2 leti	494	518
	3 leta	556	503
	4 leta	550	549
	5 let	567	560
	6 let	592	591
	7 let	583	570
	8 let	645	624
	9 let	619	635
	10 let	657	672
	11 let	627	616
	12 let	681	653
	13 let	703	712
Kranj	14 let	688	677

Table 5: Population by age, Slovenia, Kranj. Source: SURS, 2024

Elderly people

Among the inhabitants of this municipality, the number of the oldest was – as in most Slovenian municipalities – greater than the number of the youngest: for every 100 persons aged 0–14, there were 127 persons aged 65 or over. This ratio indicates that the value of the ageing index for this municipality was lower than the value of this index for the whole of Slovenia (which was 142). It also indicates that the average age of the inhabitants of this municipality is rising on average more slowly than in the whole of Slovenia. Data presented by gender show that the value of the ageing index for women in all Slovenian municipalities, except for four (Črna na Koroškem, Dobrovnik/Dobronak, Jezersko and Mislinja), was higher than the ageing index for men. In the municipality – as in most Slovenian municipalities – there were more women aged 65 or over than those aged less than 15; the picture was the same for men.

According to SURS data for 2024, the population of Kranj is 57.133. The median age of the population is 42.7 years. Among people aged 15–64 (i.e. working age population) about 72% were persons in employment (i.e. persons in paid employment or self–employed persons), which is more than the national average (69%).The number of people over 65 (not working-age population) is 11.865, of which 5.552 are over 75 years old.

Poverty rate

In Kranj, average monthly gross earnings per person employed by legal persons were about 1% lower than the annual average of monthly earnings for Slovenia; net earnings were about 1% lower.

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Stopnja tveganja revščine, statistične regije, Slovenija, letno

Stopnja tveganja revščine po: MERITVE, STATISTIČNA REGIJA , LETO

		2023
Stopnja tveganja revščine (% oseb)	Gorenjska	9,6
Število oseb pod pragom tveganja revščine	Gorenjska	23.000

Table 6: The AT-Risk of Poverty Rate for Gorenjska region. Source: SURS, 2024.

Warnings: THE AT-Risk of POVERTY RATE is the percentage of people living in households with an equivalent (net) disposable income below the at-risk-of-poverty threshold. The AT-Risk of POVERTY THRESHOLD is defined (calculated) as 60% of the median equivalent (net) disposable income of all households. The adapted OECD equivalence scale is used to calculate the EQUIVALENT INCOME (income per equivalent adult household member). The scale gives a weight of 1 to the first adult member, a weight of 0.3 to children under 14 years of age, and a weight of 0.5 to other members aged 14 or over.

Active working population

In 2020, there were 36,715 working-age people in the Municipality of Kranj (all persons aged 15 to 64). From SURS data, we can see that in 2020, 25,161 of these people were employed (by place of residence) or 22,843 people (by job). The employment rate is the percentage share of the active population in the working-age population. This has been growing in the municipality in recent years, which means that more people are employed. The labor migration index is an indicator that, for an individual territorial unit (municipality, administrative unit, statistical region), connects the number of jobs with the number of employed people (by place of residence). The index value fluctuates slightly above 100, which means that slightly more labor force comes to the municipality than lives in the municipality. The differences in the years shown are small, which means that the number of labor migrations is more or less constant.

	Stopnja delovne aktivnosti (%)	Indeks delovne migracije
2012	59,2	101,5
2013	58,6	101,3
2014	60,1	100,3
2015	61,1	100,6
2016	62,8	100,4
2017	65,6	100,4
2018	68,2	101,3
2019	69,2	101,1
2020	68,5	100,9

Table 7: Labor activity rate and labor migration index for the City Municipality of Kranj from 2012 to 2020. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022, SURS, 2022

There are around 10% of self-employed people in the Municipality of Kranj, and this percentage remains more or less constant throughout the entire period from 2012 to 2020.

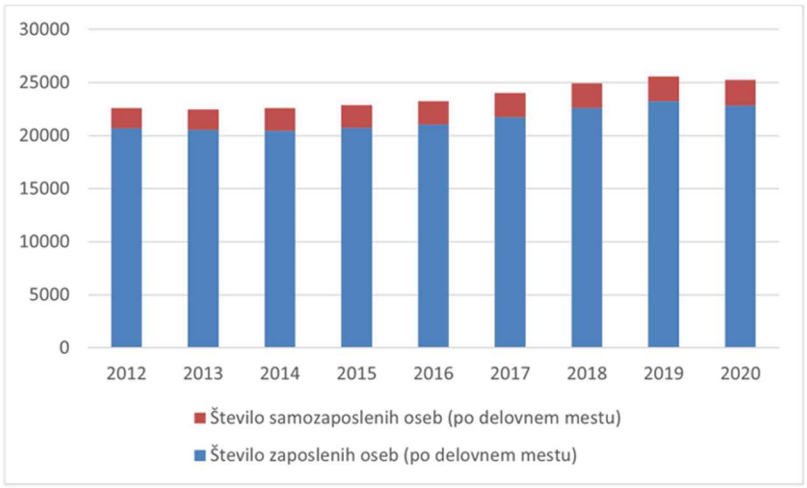

Table 8: Number of employed and self-employed persons by job position in the Municipality of Kranj from 2012 to 2020. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022, SURS, 2022.

Gender

The femininity index, which describes the ratio between the number of women and the number of men and indicates how many women per 100 men live in a certain area, is decreasing in the City Municipality of Kranj. An overview of the number of men shows that their number increased significantly between 2018 and 2020 and decreased in 2021. The reasons can be found in the migration increase from abroad, which shows that many more men than women immigrated to the municipality. From this, we can conclude that this is mainly a foreign workforce. The decline in the years from 2020 to 2021 can probably be attributed to the pandemic, which forced many residents of the municipality to return home.

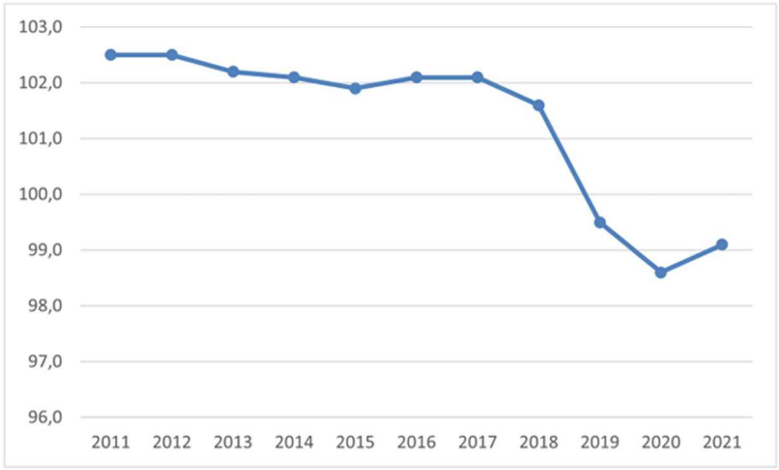

Table 9: Femininity Index for the City Municipality of Kranj for the period between 2011 and 2021. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022, SURS, 2022

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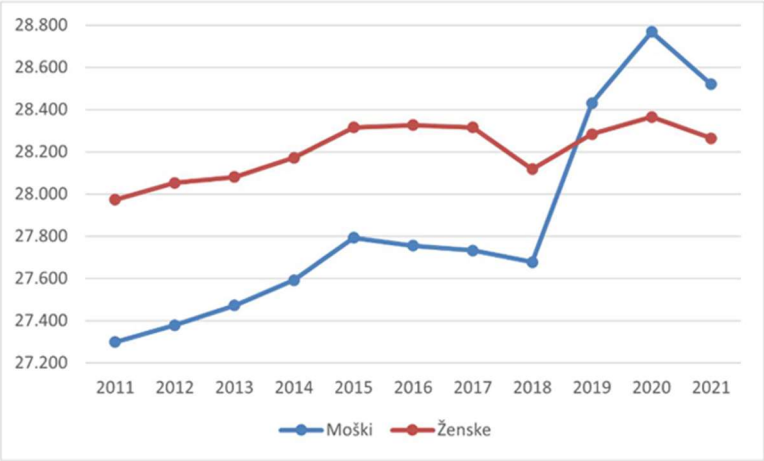

Table 10: Number of men and women in the Municipality of Kranj between 2011 and 2021. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022, SURS, 2022

Immigrated people

Migration trends between settlements in the City Municipality of Kranj show major changes in the settlement of Kranj, which recorded an increase in immigration in 2019 (SURS only has data up to 2019), and in previous years, an increase in emigration from the settlement. The settlement of Kranj also has the largest population (63% or 35,785) among the other settlements in the municipality. In 2013, 2016 and 2019, around 2,000 people immigrated and emigrated to the settlement of Kranj for each year shown, which is around 5.5% of the settlement's population. The migration increase in other settlements is very small and, in most cases, negligible.

	2013			2016			2019		
	Priseljeni	Odseljeni	Selitveni prirast	Priseljeni	Odseljeni	Selitveni prirast	Priseljeni	Odseljeni	Selitveni prirast
Kranj	1.940	2.031	-91	1.935	2.104	-169	2.248	1.859	389
Britof	75	113	-38	120	97	23	168	102	66
Srednje Bitnje	38	19	19	34	48	-14	101	49	52
Golnik	79	60	19	54	78	-24	79	48	31
Mlaka pri Kranju	75	86	-11	66	82	-16	88	61	27
Zgornje Bitnje	133	111	22	89	82	7	120	94	26
Breg ob Savi	11	28	-17	44	14	30	39	25	14
Kokrica	86	76	10	89	118	-29	107	93	14
Žabnica	17	17	0	9	19	-10	26	14	12
Jama	21	13	8	20	14	6	22	14	8
Predoslje	45	64	-19	52	57	-5	41	34	7
Srednja vas - Goriče	7	5	2	3	2	1	7	0	7
Meja	2	0	2	2	3	-1	6	1	5
Podreča	9	26	-17	41	38	3	34	29	5
Rakovica	8	3	5	12	13	-1	9	4	5
Zalog	11	14	-3	7	5	2	13	8	5
Letenice	8	4	4	2	4	-2	5	1	4
Čadovlje	14	6	8	3	7	-4	4	1	3

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Praše	9	4	5	5	7	-2	8	10	-2
Pševo	6	3	3	2	1	1	3	5	-2
Zgornja Besnica	13	23	-10	28	22	6	27	29	-2
Goriče	16	18	-2	8	14	-6	9	12	-3
Tenetiše	8	13	-5	11	29	-18	2	8	-6
Mavčiče	19	17	2	10	11	-1	11	20	-9
Spodnja Besnica	34	34	0	26	44	-18	41	50	-9
Javornik	1	1	0	0	1	-1	6	3	3
Spodnje Bitnje	33	33	0	28	15	13	27	24	3
Povlje	2	4	-2	6	0	6	3	1	2
Srakovlje	3	2	1	1	2	-1	5	3	2
Šutna	22	19	3	20	27	-7	26	24	2
Babni Vrt	1	5	-4	2	4	-2	1	0	1
Planica	0	0	0	1	1	0	2	1	1
Suha pri Predosljah	7	17	-10	11	18	-7	6	5	1
Trstenik	21	24	-3	42	19	23	20	19	1
Hrastje	35	44	-9	47	48	-1	65	64	1
Čepulje	1	1	0	2	0	2	0	0	0
Ilovka	1	4	-3	1	1	0	3	3	0
Jamnik	0	1	-1	1	5	-4	2	2	0
Nemilje	2	7	-5	4	0	4	2	2	0
Pangršica	3	1	2	5	3	2	1	1	0
Sveti Jošt nad Kranjem	0	0	0	0	0	0	0	0	0
Zabukovje	2	5	-3	0	4	-4	3	3	0
Žablje	1	4	-3	4	6	-2	0	0	0
Bobovek	7	2	5	9	10	-1	16	17	-1
Lavtarski Vrh	1	2	-1	1	1	0	0	1	-1
Njivica	1	0	1	0	0	0	0	1	-1
Orehovlje	12	12	0	7	3	4	12	13	-1
Podblica	3	2	1	6	3	3	2	3	-1
Tatinec	4	3	1	2	1	1	0	1	-1

Table 11: Migration movement for settlements of the City Municipality of Kranj for 2013, 2016 and 2019. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022, SURS, 2022

Since there are small differences in the data on migration movements by settlement, the table below is made for the City Municipality of Kranj for the years 2019 and 2020. The data below shows that residents migrate much more between municipalities than abroad or between settlements in the City Municipality of Kranj. The migration increase from abroad was greater in 2019 (796 residents) than in 2020 (524 residents). Migration movements between municipalities are negative for the City Municipality of Kranj for both years shown. In 2019, 138 more residents emigrated than immigrated, and in 2020, 431 more residents emigrated than immigrated to the municipality. The size of migrations ranged from around 1,600 to 2,600 residents. However, the total migration increase in 2020 is noticeably lower than in 2019 (SURS does not yet have data for 2021).

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	2019			2020		
Občina Kranj	Moški	Ženske	Skupaj	Moški	Ženske	Skupaj
Priseljeni iz tujine	925	310	1.235	690	361	1.051
Odseljeni v tujino	301	138	439	364	163	527
Selitveni prirast s tujino	624	172	796	326	198	524
Priseljeni iz drugih občin	893	709	1.602	1.261	993	2.254
Odseljeni v druge občine	935	805	1.740	1.455	1.230	2.685
Selitveni prirast med občinami	-42	-96	-138	-194	-237	-431
Skupni selitveni prirast	582	76	658	132	-39	93
Priseljeni iz tujine na 1000 prebivalcev	8	14	22	9	9	18
Priseljeni iz drugih občin na 1000 prebivalcev	31	-2	28	47	-8	40

Table 12: Migration movement for settlements of the City Municipality of Kranj for 2019 and 2020. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022, SURS, 2022

The migration increase with abroad (graph A-41) shows that the number of men fell in 2020 (Covid), while the number of women increased. This means that women and children are probably coming to Slovenia after men with a few years' delay. This may also mean that the number of women and children will also fall in the coming years and may only start to rise in a few years. The question is also what the emerging inflation will do. If these are mainly construction workers, there will not be much impact, because a lot of construction is still being done, but this may also stop in the coming years, because construction is becoming increasingly expensive. If we ignore Covid and inflationary pressures and their impact on the economy, we could say that the increase in women and children will increase annually - but at the time of preparing this report, it is difficult to predict anything with certainty due to the aforementioned circumstances.

Low-skilled jobs

As of January 2023, the Gorenjska region, which includes Kranj, reported a registered unemployment rate of 3.6%, one of the lowest in Slovenia. This low unemployment rate suggests a relatively stable job market in the area.

In Slovenia, approximately 16% of jobs that are hard to fill require low skills, a higher share than in other OECD countries. This indicates a demand for low-skilled workers in the country.

The sectors with the largest surpluses, indicating potential opportunities for low-skilled workers, are accommodation and food service activities, and construction. These industries may offer employment prospects for individuals seeking low-skilled positions.

Additionally, Slovenia has been experiencing a severe shortage of labor, leading to an increased reliance on foreign workers. As of January 2024, 15% of the workforce were foreigners, up from 14% in January 2023. Most work permits were granted for sectors such as construction, manufacturing, transport and warehousing, hospitality, and agriculture. This trend suggests that low-skilled job opportunities are available, particularly in these sectors.

While specific data for Kranj is limited, the overall trends in the Gorenjska region and Slovenia indicate a demand for low-skilled workers, especially in sectors like construction and hospitality.

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Social housing

According to SURS data, in 2021 there were 373 apartments per 1.000 inhabitants in the City municipality Kranj, which is equal to the housing census in 2018.

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Število stanovanj (na 1.000 prebivalcev)	Kranj	373	...	...	375	...	...	373	...	...	...

Table 13: Number of apartments per 1.000 inhabitants. Source: SURS

The structure of apartments according to the year of construction shows that as much as 60% of the housing stock is from the period 1960-1990, which indicates a great need for energy renovations. After 2006, 1,511 or 7% of all apartments were built. During the boom, several residential buildings were built in Kranj, in which apartments were mainly sold, according to real estate agencies. Due to the recession, there are still a few unfinished or unfinished residential buildings in the city. After 2008, the dynamics of construction in the MO decreased significantly, which is also shown by the number of building permits issued per 1.000 inhabitants and it is after 2020 increasing again. (Table XX).

		2008		2010		2015		2020		2023	
		Število stavb	Število stanovanj v stavbah	Število stavb	Število stanovanj v stavbah	Število stavb	Število stanovanj v stavbah	Število stavb	Število stanovanj v stavbah	Število stavb	Število stanovanj v stavbah
Kranj	Stanovanjske stavbe	75	451	39	108	32	35	54	58	47	62

Table 14: Number of building permits issued. Source: SURS

City municipality Kranj owns a total of 382 non-profit and 62 profit apartments. Since 2022, when the last public tender was held, 25 non-profit apartments have been allocated, and 239 applicants are still waiting for a non-profit apartment. The tender for the allocation of non-profit housing will be announced in 2025. In the meantime, new needs for non-profit apartments have arisen in the municipality. The city municipality co-finances market rents for the most vulnerable groups of the population but does not have its own financial resources for the construction of non-profit apartments. In such circumstances, young people and materially disadvantaged communities are particularly vulnerable compared to other social groups of the population. Despite numerous housing auctions, the market situation is not favorable to young people, as there are no regular jobs and, consequently, no loans, given the still too high starting prices of real estate.

The urban part of Kranj has several compact and densely populated multi-apartment neighborhoods, which are a result of the rapid industrial development of Kranj in the 1970s and 1980s. Today, the neighborhoods of Kranj (Planina, Zlato polje, Šorlijevo naselje, Drulovka, Vodovodni stolp, ...) are facing specific spatial and social problems. The Planina neighborhood with 12,500 inhabitants, 52 ha of open space and 140 multi-apartment buildings is one of the largest urban neighborhoods in Slovenian cities and is characteristically multicultural. With new living habits and generational changes, the neighborhood is facing various problems: lack of parking spaces, lack of playgrounds and areas for children and youth to play, reduction of green areas, social conflicts and youth delinquency, needs of older residents, unemployment and social hardship, energy waste of buildings, problems with

maintenance of the building stock and green areas, irregular ownership of outdoor areas. Because of all of the above, Planina neighborhood is classified as an area of functional and social degradation.

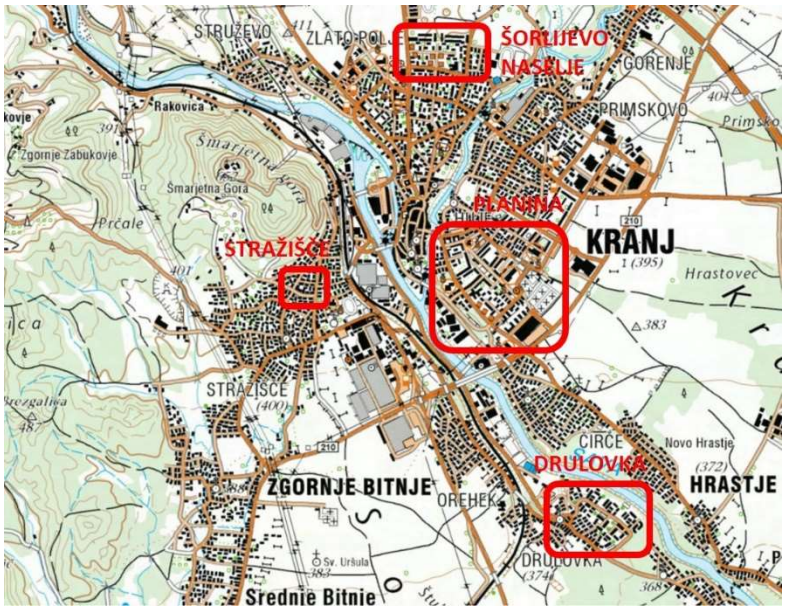

Figure 38: Position of the residential neighbourhoods in Kranj, source: Operational analyses of the City of Kranj, Interreg Danube AGORA, City of Kranj, 2021 Photo XX: Planina Kranj, Photo: MOK

Figure 39: Planina Kranj, Source: City of Kranj

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			Stražišče	Planina	Šorlijevo naselje	nova Drulovka
1. General Information	Location		western part of Kranj and south of Šmarjetna gora	southeastern part of Kranj, left bank of the Kokra river	northern part of Kranj	southern part of Kranj on the right bank of the Sava River
	Ownership		public and private	public and private	public and private	public and private
2. Physical characteristics	Surface Areas	Surface Area	15 970 m2	520 000 m2	84 800 m2	178 450 m2
		build land	no data	no data	no data	no data
		zoning	Residential neighbourhood Public ownership: 76% Private ownership: 24 %	Residential neighbourhood Public ownership 61% Private ownership 39%	Residential neighbourhood Public ownership 84% Private ownership 16 %	Residential neighbourhood Public ownership 72 % Private ownership 28%
	Buildings	Nr. of buildings	44 buildings, 166 residents	140 buildings, 12 500 residents	27 buildings, 1313 residents	212 buildings, 1000 residents
		Building Types	individual terraced houses	multi-apartment houses	multi-apartment houses	individual terraced houses and multi-apartment houses
		Time of the construction	1953-1960	1971-2006	1961-1972	1981-2004
		Year of the oldest premises	1953	1971	1961	1981
		Year of the most recent premises	1960	2006	1972	2004
	condition of the premises	Current state of the area	/	/	/	/
		cultural or any other heritage protection	/	/	/	/
3. Functional characteristics	former and current functions/use of the area and buildings		Residential/ residential	Residential/ residential	Residential/ residential	Residential/ residential
	function according to zoning		residential	residential	residential	residential
	informal use of the area		use of public areas for the purposes of gardening, parking, construction of auxiliary facilities		use of public areas for private use	use of public areas for the purposes of gardening, parking, construction of auxiliary facilities
	time of vacancy, date of the end of the activity		in use	in use	in use	in use
	degree of emptiness		/	/	/	/

4. Economic characteristics	Number of SME		11 companies according to the business register of Slovenia	670 companies according to the business register of Slovenia	66 companies according to the business register of Slovenia	113 companies according to the business register of Slovenia
5. Environmental characteristics	pollution		no information	no information	no information	no information
	Environmental protection in areas		/	/	/	area of natural value, national importance – Sava river; an archaeological site on Špik – part of the neighbourhood
	Environmental potentials		close to the hill Šmarjetna gora	close to the agricultural landscape on the east	close to the green hinterland	Sava river canyon, forest belt along the river
	Quality of green areas		improperly used and maintained	high quality of green areas	currently very high quality with a few minor illegal interventions	improperly used and maintained
	Microclimate state of the art		No information	No information	No information	No information
	Retention state of the art		No information	No information	No information	No information
6. Social characteristics	Users in the area /social groups		residents, visitors	residents, visitors	residents, visitors	Residents, visitors
	Number of different social groups		Children, youth, working group, elderly	Children, youth, working group, elderly	Children, youth, working group, elderly	Children, youth, working group, elderly
	Level bottom up initiatives		determination of functional areas to facilities and transfer to private ownership	determination of functional areas to facilities and transfer to private ownership		determination of functional areas to facilities and transfer to private ownership
8. Other	Documentation of the area			strategy of comprehensive renovation of the residential neighbourhood Planina Kranj		
	Initiatives for the redevelopment		- adequate use of public green areas; - regulated ownership structure; - maintenance of public areas; - uniform typology and design of auxiliary facilities;		- adequate use of public green areas; - regulated ownership structure; - maintenance of public areas;	- adequate use of public green areas; - regulated ownership structure; - maintenance of public areas; - reduction of vandalism; - uniform typology and

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						design of auxiliary facilities; - sufficient parking capacity; - regulated waste collection points.
	Goals and motivation of the owner and users			- getting quality public spaces with attractive programmes	- sufficient parking capacity;	- sufficient parking capacity;
	Photographs					

Table 15: Analysis of the residential neighbourhoods in Kranj, Source: Operational analyses of the City of Kranj, Interreg Danube AGORA, City of Kranj, 2021

We estimate that the biggest social vulnerability is in the largest neighbourhood in Kranj, that is Planina neighbourhood. Planina is home to a greater concentration of immigrants and workers from abroad, who often face problems integrating into society, finding well-paid jobs and obtaining adequate education. Problems such as crime, drug use and vandalism appear in the neighbourhood, which reduces the quality of life of the residents and contributes to the poor social condition of the area. Planina has large number of low-income residents, as this part of the city is home to a lot of social housing vulnerable groups such as the unemployed, pensioners with low pensions and low-wage workers.

Šorlijevo naselje is a smaller residential neighborhood that is more orderly and peaceful compared to Planina, but still belongs to the areas where residents with different economic situations live. Šorlijevo naselje has lower concentration of social problems and a greater sense of community.

Other neighbourhoods are located outside the settlement of Kranj and they do not represent the significant social vulnerability areas.

In recent decades, there has been a noticeable trend of the foreign community immigrating to the old town center of Kranj. This is the result of several factors, the most important of which are economic opportunities, real estate availability and existing social networks. Although the new community is well organized, there are still challenges to full integration, such as language barriers and social integration into the wider community. Due to the mentioned facts, we estimate that the old town centre of Kranj is also a place of social vulnerability.

Density of population

A review of publicly available data from SURS, CRP shows that the highest population density is in the settlements of Golnik, Mlaka pri Kranju and Kranj. However, if we also take into account the percentage of built-up area of the statistical settlement and the density (the number of all residents in the statistical

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settlement), the density is highest in the settlements of Orehovlje and Kokrica, followed by the settlements of Kranj and Britof.

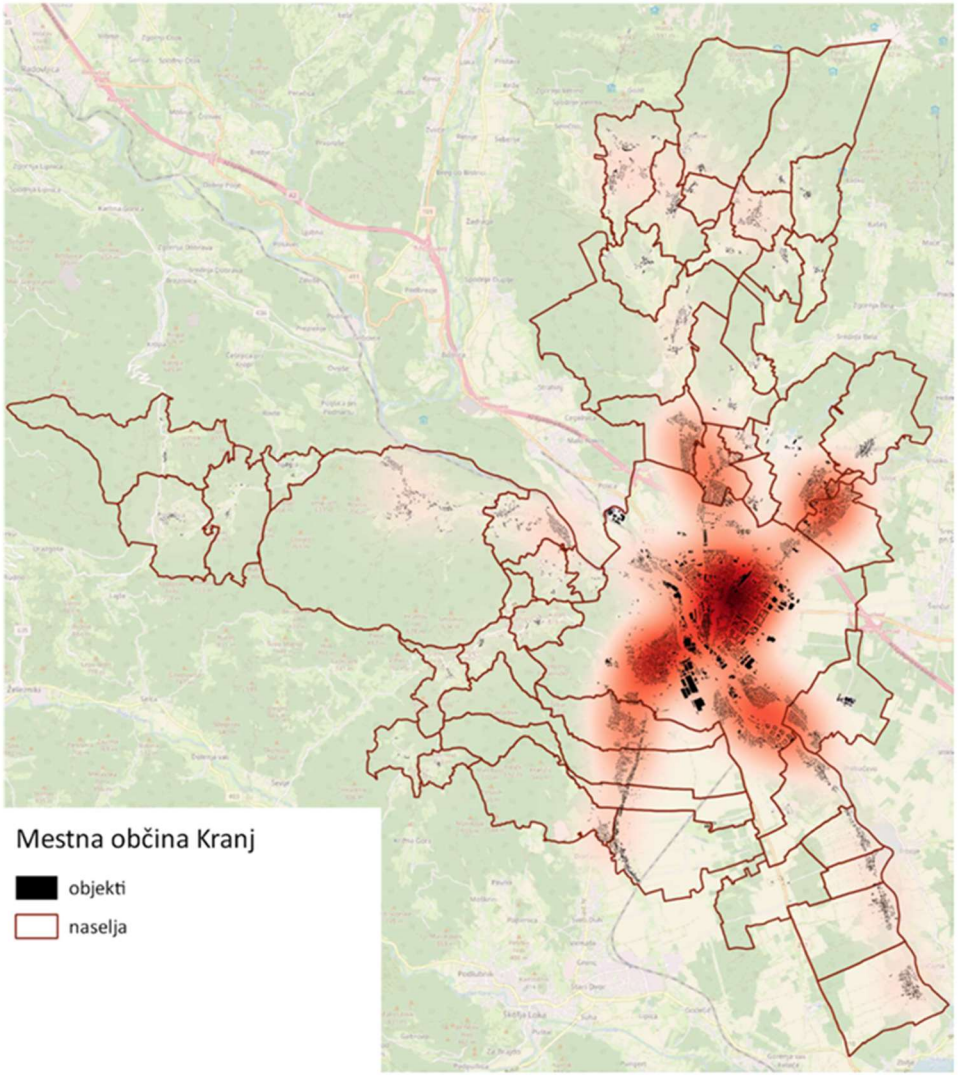

Figure 40: Population density in the form of so-called hot spots, calculated based on the number of residents within a 500m radius around the house number. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022

		2022	2023	2024
Površina (km2) - 1. januar	Kranj	151	151	151
Število prebivalcev - 1. januar	Kranj	56.639	57.171	57.138
Gostota naseljenosti - 1. januar	Kranj	375	379	379
Gostota naseljenosti - 1. julij	Kranj	377	378	...

Table 16: Population in 2022, 2023, 2024. Source: SURS, 2024

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Retired people

The aging index of the City of Kranj is similar to the index of the Gorenjska region and Slovenia and shows the aging of the population in the City of Kranj as well. The index began to increase in 2016 and has been increasing to this day.

		2024
Število prebivalcev - 1. januar	Kranj	57.138
Delež prebivalcev starih 65 let ali več - 1. januar	Kranj	20,7
Povprečna starost prebivalcev - 1. januar	Kranj	43,4
Indeks staranja - 1. januar	Kranj	132,3
Indeks staranja za moške - 1. januar	Kranj	106,6
Indeks staranja za ženske - 1. januar	Kranj	160,8

Table 17: Elderly people, average age of the population, aging index for men and women in 2024. Source: SURS, 2024

The old-age dependency ratio is the ratio between the number of older people (65 years or older) and the number of working-age residents, i.e. residents aged 15 to 64, multiplied by 100. The old-age dependency ratio shows how many older people are dependent on 100 working-age residents. In the City Municipality of Kranj, this indicator has been increasing since 2011 and reached a value of 31.2 inhabitants in 2021. This is still less than the value for the Gorenjska region, which is 32.6 inhabitants, and the value for Slovenia, which is 32.7 inhabitants per 100 working-age residents. For comparison, the Osrednjeslovenska region has the lowest coefficient with 29.3 inhabitants per 100 working-age residents, and the Pomurska (38.2) and Goriška regions have the highest (38.3). This means that there are fewer and fewer young working-age residents in the municipality, but more and more elderly people.

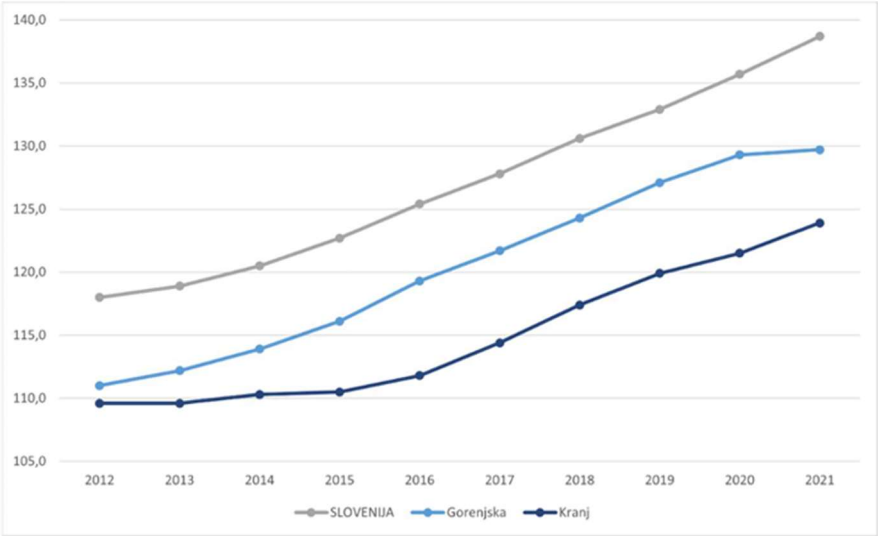

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Figure 41: Ageing index for the period from 2012 to 2021, comparison between Slovenia, the Gorenjska region and the City Municipality of Kranj. Source: SURS, 2024

Social protection and health

In City of Kranj in 2021 (data from June), there were 56,784 residents, of whom 10,664 were over 65, which means that 18.78% of the population is over 65. According to statistical estimates, the share of the elderly in the Kranj Municipality will continue to increase, and with it the need for care for the elderly. The network of public services for institutional care of nursing homes is provided by the state and is under the jurisdiction of the Ministry of Health, Welfare and Sport (Strategy for the Care of the Elderly in the Kranj Municipality for the Period 2020-2024). The Strategy for the Care of the Elderly in the Kranj Municipality for the Period 2020-2024 also states that institutional care of the elderly is provided by nursing homes. Nursing homes also perform tasks that include preparing the environment, family and individuals for old age. All nursing homes belonging to the regional unit of the ZZZS Kranj are fully occupied. The needs in the Gorenjska region as of March 23, 2022 amount to 5.682 people waiting for admission (registered active applications), of which 1.928 were current applications for immediate admission.

The Intergenerational Center is located at city center and is managed by the People's University of Kranj. The activities and programs offered by the Intergenerational Center significantly contribute to improving the quality of life of older people and at the same time enable the transfer of social and other skills between generations. Therefore, it is necessary to strengthen intergenerational centers as an important part of the social care network, especially by developing programs that are responsive to the generational needs of the rapidly changing socio-technological structure of modern society.

The Strategy for the Care of the Elderly in the Kranj Municipality for the period 2020-2024 states that the plan is to upgrade and expand the institutional care network (new nursing home, new day center, serviced apartments, residential communities and crisis accommodation for the elderly).

City of Kranj has a developed environment of social protection programs both within public service providers and social protection programs as well as non-governmental organizations. The table below presents the available social programs for individual target groups in the MOK. According to the providers, the social hardship of individuals and families has increased during the economic crisis and the COVID pandemic. At least half of those currently materially threatened are also facing other problems in addition to material vulnerability: housing problems, chronic diseases, long-term unemployment, problems with addiction, mental problems, problems in family relationships. The city is also experiencing a greater influx of people from other backgrounds, especially Albanian families, who need forms of social integration adapted to them.

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Ranljiva skupina	Socialna storitev	Izvajalec
Starejši	Pomoč in oskrba na domu: osebe, ki so socialno izključene ali potrebujejo podporo in pomoč v vsakodnevnem življenju	Dom upokojencev Kranj: v letu 2014 268 uporabnikov
	Individualno družabništvo Medgeneracijsko druženje in učenje	Medgeneracijsko središče, ki ga upravlja Ljudska univerza Kranj
	Skupina za samopomoč za starejše ljudi	
	Namestitvene zmogljivosti v domovih za starejše z dnevnim varstvom Varovana stanovanja	Dom upokojencev Kranj: kapaciteta 211 (čakalna doba 2 leti za dvoposteljne sobe in ljudi z demenco, za enoposteljne sobe je čakalna doba daljša od 2 leti), število mest dnevnega varstva: 20
Osebe s posebnimi potrebami	Delovna rehabilitacija	VDC KRANJ in koncesionarji CENTER KORAK, Kranj; VDC, SONČEK Kranj
Otroci in mladostniki	Programi za otroke in mladoletnike, prikrajšane za normalno družinsko življenje ter programi, namenjeni otrokom in mladostnikom s težavami v odraščanju	Dnevni center za otroke in mladostnike (mladinski center Škrlovec je leta 2014 beležil v poprečju 16 uporabnikov na dan) Specialistični terapevtski program za posameznike, pare in družine Kranj
Žrtve nasilja	Programi za preprečevanje nasilja, obravnavo žrtev nasilja in programi za delo s povzročitelji nasilja	Varna hiša Gorenjske
Brezdomci	Programi za brezdomce	Zavetišče za brezdomce Kranj (v letu 2014 beleži povprečno 23 uporabnikov na dan) Razdelilnica hrane v Kranju (v letu 2014 beleži povprečno 93 uporabnikov na dan)
Zasvojenost	Programi na področju preprečevanje zasvojenosti:	Center za pomoč, terapijo, socialno rehabilitacijo in reintegracijo svojcev Kranj (7 uporabnikov/mesec v 2014) Stanovanjska skupnost Katapult Kranj 5 klubov zdravljenih alkoholikov LAS na področju zasvojenosti
Osebe in družine v socialni stiski	Osebe in družine s socialnimi stiskami	Program Socialne vključenosti posebej ranljivih skupin Kranj,

Ranljiva skupina	Socialna storitev	Izvajalec
		Socialna samopostrežna za mlade
	Denarna pomoč	Leta 2014: 447 izdanih odločb, 336 odobrenih Leta 2013: 350 izdanih odločb, 256 odobrenih
Osebe s težavami v duševnem zdravju	Programi na področju duševnega zdravja:	ŠENT, slovensko združenje za duševno zdravje, dnevni centri Kranj, OZARA, nacionalno združenje Za kakovost življenja, Humana, združenje svojcev pri skrbi za mentalno zdravje, stanovanjska skupina Novi Paradoks
Invalidi	Programi za podporno bivanje invalidov in drugi specializirani programi za organizacijo in spodbujanje neodvisnega življenja invalidov:	Medobčinsko društvo AURIS (gluhi in naglušni), Medobčinsko društvo slepih in slabovidnih, programi za osebe po možganski poškodbi glave Kranj, Program zaposlitvene rehabilitacije CenterKontura d.o.o. Kranj

Table 18: Overview of accessibility of social protection programs by vulnerable target groups in the City of Kranj. Source: Sustainable urban strategy Kranj, 2015

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Accessible healthcare and infrastructure

As a regional centre, various health services are concentrated in Kranj, which is why access to health care measured in the number of doctors per 1000 inhabitants in the MOK is in most cases above the Slovenian average. Accessibility to health services in the MOK is ensured within the public health network and through concessionaires. At the primary level, health activities are carried out by the primary health care of Gorenjska within the Kranj Health Centre, which combines medical and dental services. Both the medical and pharmacy services do not have adequate premises to expand their activities. At the secondary and tertiary levels, Gynecology and Obstetrics Hospital Kranj and University Clinic for Pulmonary Diseases and Allergy Golnik operate, and two units of public health institutions are also present in Kranj (the Regional Unit of the National Institute of Public Health Kranj, NIJZ, and the Kranj NLZOH Location). Rather than the accessibility of services, health programme providers point out the poor responsiveness of urban residents to preventive programmes. In the coming years, there is a possibility that a Regional General Hospital will be built in Kranj.

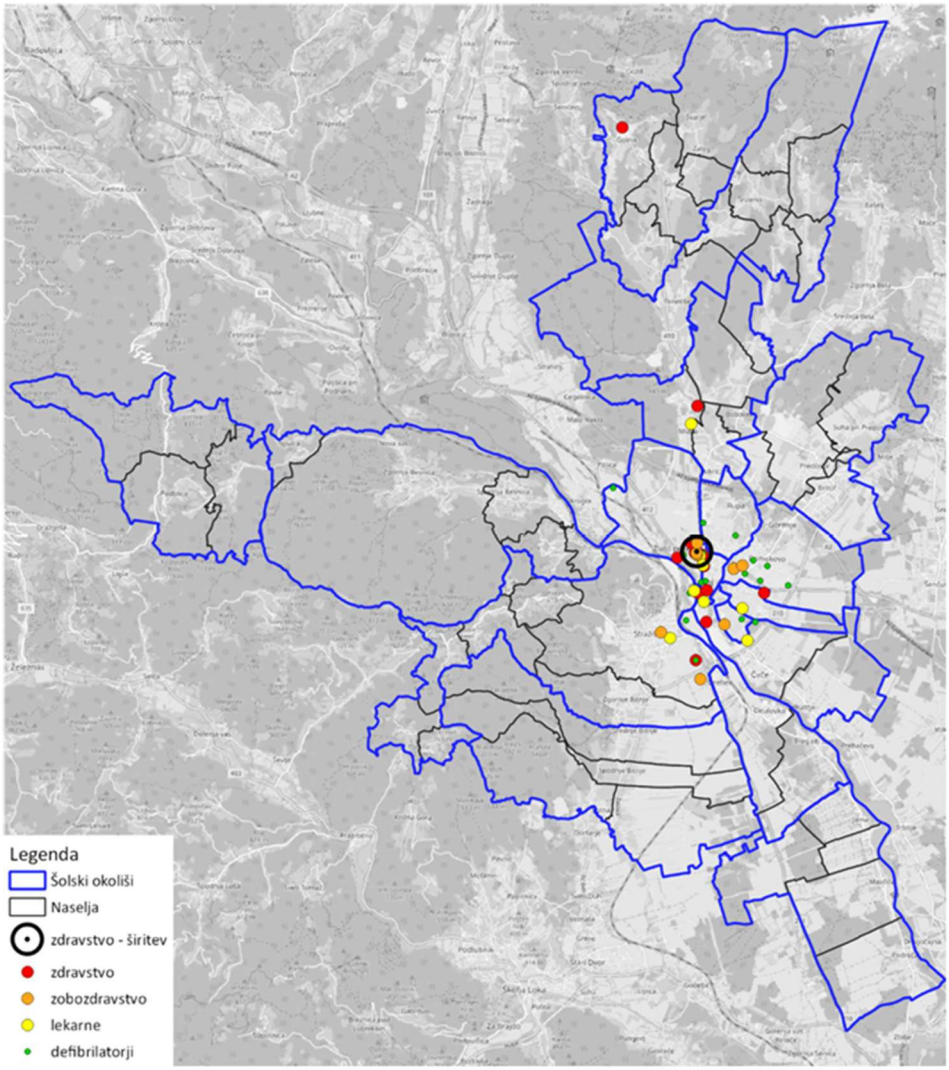

Figure 42: Spatial location of healthcare activities in the City Municipality of Kranj; for comparability with other graphical representations in this study, school district boundaries are also shown, although they do not play a

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role in terms of content. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022

According to data from the Kranj Municipal Council, it is estimated that at least 6,000 citizens are without a chosen doctor, and the problem will increase even more when older doctors who have high salaries retire (at the time of retirement, there are almost 2 clinics with insured persons). It is impossible to determine how many are from the Kranj Municipal Council alone (not from the Kranj Medical Center), as the identified patients also include people from Ljubljana and elsewhere. According to data from the Kranj Municipal Council, it is estimated that additional space is needed to expand healthcare and pharmacy activities.

Starostno obdobje	*Št. oseb*	*Oblika osnovne zdravstvene oskrbe (in normativ)*
0 let - 5 let	2.790	pediatrija
6 let - 14 let	5.960	šolski dispanzer
15+	48.034	ambulanta družinske medicine (1.895 = glavarinski količnik; min. št. potrebnih programov po normativu je 25,3)

Table 19: Needs for basic health care according to age groups in the Kranj Municipality, as defined by the demographic study; methodological note: such services in the Kranj Municipality are also used by residents outside the Kranj Municipality, which is why there is an overload. Source: Dostopnost in trajnostno načrtovanje družbene infrastrukture v Mestni občini Kranj, UIRS, 2022

Vulnerability Index

Vulnerability index is a measure of the exposure of a population to some hazard. Typically, the index is a composite of multiple quantitative indicators that via formula, delivers a single numerical result.

Limitation of the analysis

To calculate the vulnerability index, there is lack of data, quantitative indicators and appropriate formula.

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PREPAREDNESS AND ADAPTIVE CAPACITY OF CITIES AND MUNICIPALITIES

Institutional factors

The structure of the city administration

The City Administration performs administrative, professional, acceleration, development tasks, tasks related to the provision of public services and other tasks. The city administration performs its tasks in accordance with the laws, the Statute of the Municipality of Kranj and the decree.

In performing its tasks, the city administration cooperates with local communities, city and municipal administrations of other municipalities, public authority, state bodies, institutes, companies and other organizations by exchanging opinions, experiences, data and notifications, also through joint working bodies.

In accordance with the Statute of the Municipality of Kranj, the publicity of the work of the City Administration is ensured through official announcements and the provision of information to the media, press conferences, organization and participation in round tables and other forms of cooperation with media representatives.

The organization of the city administration ensures legal, professional and rational execution of tasks of the city administration. It also ensures legal, professional and timely realization of rights, interests and obligations of participants and other parties in proceedings. City administration ensures rational organization and management of work in the administration, coordinated implementation of tasks and project tasks, internal control over the performance of tasks, cooperation with other bodies, organizations and institutions.
The head of the city administration is the mayor, who supervises and directs the work of the city administration. The city administration is directly managed by the director of the city administration, who is responsible for his work and the work of the city administration to the mayor.

The tasks of city administrations are performed in the following internal organizational units:

- The mayor's office, within which the Department of Communication and Protocol and the Department of City Council and Local Communities operate,
- Office of social affairs,
- Office of economic affairs and transport, within which the Department of economic activities and Department of traffic operate,
- Office of development, smart community and projects, within which Department of development and smart community and Project department operate and
- Office of finance and general affairs, within which Finance department, Legal and human resources department, Department of general affairs and Civil protection and rescue, Joint procurement and Public procurement departments operate.
- Depending on the area they cover, internal organizational units also perform tasks from state competence, which the state transfers to the municipality.

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- The Inter-Municipal Office of the environment and spatial planning is a body of the joint municipal administration of the 3 founding municipalities: The Municipality of Kranj, Jezersko and Preddvor.

- The Inter-Municipal Inspectorate Kranj is a body of the joint municipal administration of the 6 founding municipalities: The Municipality of Kranj, Tržič, Cerklje na Gorenjskem, Šenčur, Preddvor and Jezersko.

- The Inter-Municipal Inspectorate of Kranj, performs administrative and misdemeanour tasks in the field of inspection and supervision in the area of the founding municipalities in accordance with the decree establishing the joint municipal administration body.

- The Joint Internal Audit Service Kranj, as a body of the joint municipal administration, performs the tasks of establishing and effectively performing the function of internal auditing of the founding municipalities and their direct and indirect budget users in accordance with the decree establishing the joint municipal administration body.

- The main office is an internal organizational unit of the city municipality that receives, opens, records, signs, classifies, dates and sorts received mail, prepares outgoing mail and takes care of the dispatch of documentary material.

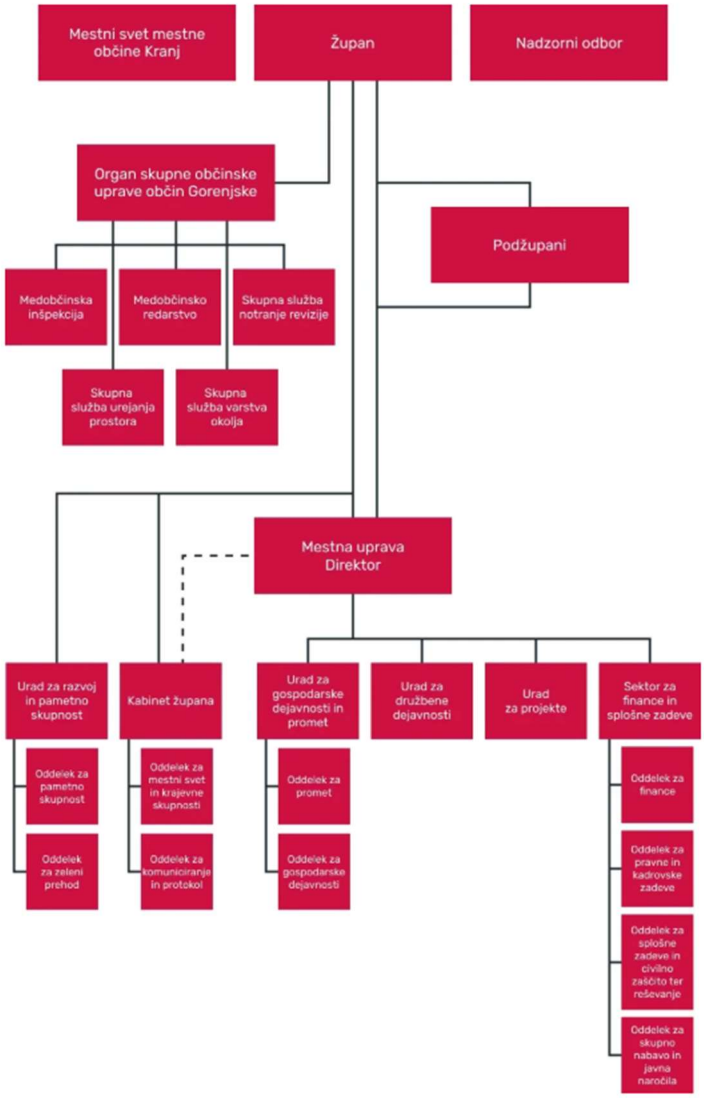

Figure 43: The organization of the Municipality of Kranj, source: https://www.kranj.si/mestna-obcina/mestna-uprava/organigram-mestne-obcine-kranj

Within the national administration for protection and rescue there is a Civil protection unit and service, are generally organized when the tasks of protection, rescue and assistance cannot be performed by professional or voluntary rescue services. Civil protection is the protection of people, the environment and property against all forms of natural and man-made disasters. Together with the use of forces and equipment in emergency situations, it also includes planning for action in the event of such events and preparing for them.

In the City of Kranj the Civil protection unit and service comprises of five parts:

- Protection and rescue units, such as e.g. various associations, the Federation of Scouts of Slovenia, the Red Cross of Slovenia, rescue dog handlers, etc.,
- Headquarters of civil protection
- Fire rescue service Kranj
- Firefighters Association of Municipality of Kranj

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- Different companies for technical support.

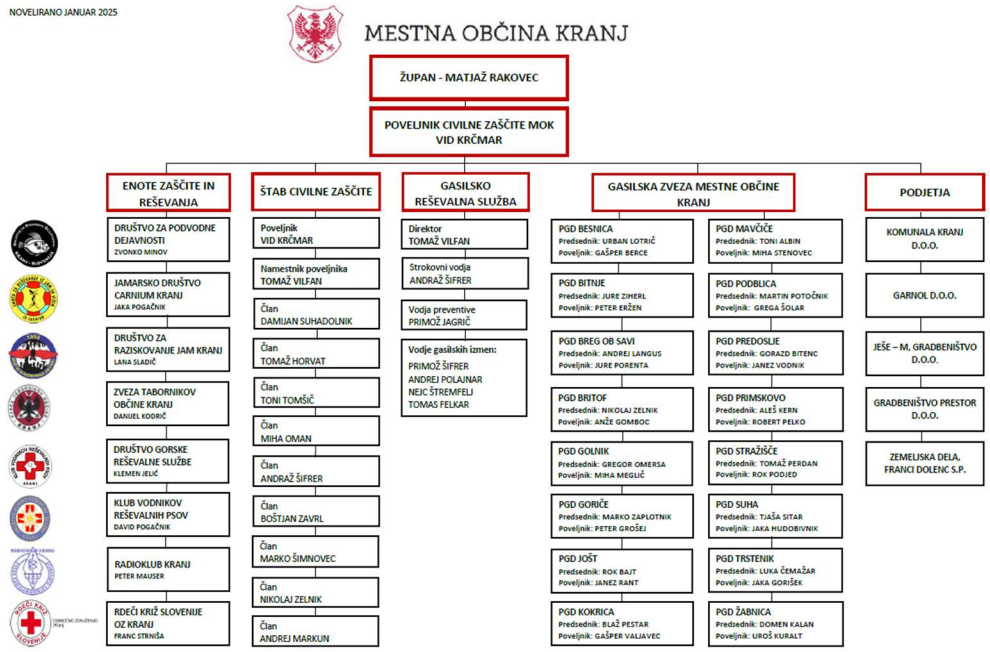

Figure 44: The organization of Civil protection unit and service, source: City of Kranj

Legislative and regulatory regimes on national level

The Spatial Development Strategy of Slovenia 2050 (SPRS) is a strategic spatial act, which prioritizes the quality of life for everyone. The strategy includes the goals of sustainable development agreed at the global level, and five strategic orientations and twelve interconnected development goals, thereby setting new ones the long-term development foundations of Slovenia. The act recognizes the challenges associated with climate change and heat islands. Among its goals, it addresses improving the resilience of the urban environment to climate change and emphasizes the importance of green infrastructure planning at the regional and local level. The strategy supports the realization of climate goals in accordance with the Paris Agreement on climate change (Paris Agreement, Paris 2015). Thus, its integral part is the direction of spatial development for optimal mitigation of climate change and adaptation to it.

For the period up to 2030, The climate strategy rests on the decisions already taken, defined in various sectoral documents, among which the Comprehensive National Energy Climate Plan (NEPN) plays an important role, which assumes the role of an action document. The climate strategy builds on the sectoral documents with the set vision and long-term goals until 2050 and the directions for their achievement. The climate strategy indicates a clear path for Slovenia's long-term development in the direction of net zero greenhouse gas emissions, accelerated transition to renewable energy sources, abandonment of the use of fossil fuels and reduction of final energy use. It indicates the opportunities with which we can have a beneficial impact on the environment, preserve biodiversity, reduce energy import dependence, enable new development opportunities in common energy markets, control costs and thus energy poverty, ensure green jobs, increase the competitiveness of companies and ensure coherent regional development .

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The comprehensive national energy and climate plan of the Republic of Slovenia (NEPN) is also a strategic document that sets goals, policies and measures for the five dimensions of the energy union: decarbonisation and renewable energy sources, energy efficiency, energy security, the internal energy market and research, innovation and competitiveness. With it, Slovenia defines energy and climate goals as well as policies and measures to achieve these goals by 2030, as well as projections for the next ten years.

The Climate Change Act provides a comprehensive framework for more effective implementation of climate policies and the fulfillment of the goal of climate neutrality by 2050 at the latest, and regulates both climate change mitigation and adaptation. In the area of adaptation to climate change, the Act prescribes a national strategy for adaptation to climate change and regional action plans, which will define the necessary measures at the local level to increase the resilience of our society, and at the same time establishes an adaptation mirror that reports on the implementation of policies and measures in this area.

At the national level, the Strategy for Adapting Slovenian Agriculture and Forestry to Climate Change has also been adopted. Measures to manage the risks brought about by climate change are aimed at:

- adaptation of agricultural production or production-technological and economic adaptation to changed conditions,
- mitigating or reducing greenhouse gas emissions and
- prevention and reduction of the consequences of natural disasters.

Other approaches

The Ministry of the Environment, Climate and Energy and the Community of Municipalities of Slovenia (SOS) established a climate office for municipalities and regions. The project is designed as a public-public partnership and will last from November 2024 to October 2026. The establishment of a climate office is an approach to solving the challenges of climate change, the consequences of which are felt especially at the local level, where municipalities bear a large part of the burden of eliminating the damage. The goal of the project is to strengthen the climate resilience of Slovenian municipalities and regions in the long term, to help them manage climate risks and integrate adaptation to climate change into municipal and regional plans and spatial acts.
Among the more important goals of the project is strengthening the capacity of municipal administrations, which, thanks to the climate office, will be better equipped to plan adaptation measures, such as directing settlement away from threatened areas and increasing the resistance of infrastructure to floods, heat waves and other weather extremes. The project will also enable municipalities to be actively informed about national and European measures to support adaptation, which will improve the municipalities' readiness to implement measures at the local level.

Policies and plans

The Sustainable urban strategy (SUS) of Municipality of Kranj 2030 was adopted in 2016. The strategy directs the development of the city in the direction of a sustainable, progressive and lively urban centre of Gorenjska region. The strategy includes adaptations to climate change and measures to reduce greenhouse gas emissions.

Figure 45: Main objectives in Sustainable urban strategy of Municipality of Kranj, source: Operational analyses of the City of Kranj, Interreg Danube AGORA, City of Kranj, 2021

A Sustainable Energy and Climate Change Action Plan (SECAP) was also prepared. It includes measures to increase energy efficiency, use renewable energy sources and adapt to climate change.

City of Kranj does not yet have a developed strategy for adapting to climate change. A climate change adaptation strategy for the Gorenjska region is being prepared, which will also be used by the municipalities of the Gorenjska region, once it is adopted by the regional council. The coordinator of the Climate Change Adaptation Mission for the Gorenjska Region is the Local Energy Agency of the Gorenjska Region.
With the accession to the mission, the Gorenjska region gained access and assistance to services:

- assistance in accessing knowledge and methods for climate risk assessments;
- access to examples of good practices from other regions and information on the results of the latest research;
- support in linking these examples and research results to local adaptation plans, roadmaps or adaptation pathways;
- access to tools, examples and good practices for interaction and cooperation with citizens;
- advising on possible public and private funding sources for adaptation.

City of Kranj as a part of 100 climate neutral and smart cities

The city of Kranj, selected in 2022 for the Mission of climate-neutral and smart European cities until 2030, which is one of the missions of the EU within the Horizon Europe program, was the first Slovenian city to officially submit a climate contract for review in Brussels on March 13, 2024. This is a complex document, which has three parts - an action plan of measures, an investment plan and the commitment of the partners in the project. After the submission, in October 2024, Kranj was recognized for its successfully prepared and above all realizable action and investment plan to become a climate-neutral and smart city by 2030. The action plan of Kranj envisages six main measures in five key areas: energy,

transport, waste and circular economy, green and blue infrastructure and buildings (built environment). In addition to Kranj, there are two more Slovenian cities part of a mission, namely the capital city of Ljubljana and the city of Velenje.

Figure 46: EU mission label for Kranj, source: City of Kranj

Institutions

At the national level, the Directorate for Climate Policies is established within the Ministry of the Environment, Climate and Energy, where they prepare and monitor strategic documents and policies in the field of climate change. In the Directorate, they lead the policies of the strategic directions of measures to reduce greenhouse gas emissions and adapt to climate change, we prepare proposals for national legislation, they take care of monitoring EU and international legislation, and coordination with it. They coordinate and participate in international climate negotiations. They lead and implement policies related to trading in emission coupons (ETS), exemptions from environmental duties, and monitor and implement tasks from the Climate Change Fund. Within the institution there is a Sector for climate policies and Sector for the implementation of climate policies.

Social factors

Social connections

The City of Kranj actively involves citizens and various organizations in the preparation and implementation of sustainable measures. In 2023, the municipality conducted a survey among residents to co-design sustainable, climate and environmental changes and received the support of almost 50 partners, including the Ministry of Health.

Community cohesion, Self-learning/self-organizing capacities of communities, Available skills and knowledge

Limitation of the analysis

No data available.

Economic factors

Public financial resources

The City of Kranj budget for 2025 foresees 94.94 million euros in revenue and debt in the amount of 15 million euros. Estimated expenses amount to 115.51 million euros.
The budget envisages quite a few significant investments. The largest investment projects are the installation of solar power plants and other measures for energy independence (EUR 7.5 million), the construction of infrastructure in the Hrastje business zone (EUR 4.6 million), the energy rehabilitation of municipal buildings (EUR 4.4 million), the comprehensive development of the Savska road (EUR 3.25 million), the communal infrastructure of Golnik - Mlaka (EUR 3.2 million), the development of the space between Kidričeva and Bleiweisova roads for the needs of the Northern Gate project (EUR 2.7 million), equipping the Kranj agglomeration (1.85 million), arrangement of the area on Planina 1 (1.1 million), reconstruction of the Kokrica branch school (1 million), introduction of digital solutions, renovation of the former trade school, extension of the Helene Puhar elementary school, road maintenance, investments in local communities, relocation of Pševska cesta, participatory budget, smart city, construction of Sonček kindergarten, maintenance and renovation of schools, investments in sustainable mobility and in the Sorško polje irrigation system. There are quite a few projects that will also receive funds for implementation in the following budgets or have already been used up in the current or previous years.

At the end of 2022, an analysis of the absorption of EU funds by municipalities was carried out. The municipality of Kranj was quite successful for Slovenian conditions, as it gained 47.976,244 € of funds (absolute). Only the capital city Ljubljana gained more.
In the 2025, the acquisition of 6 million EU funds is expected from structural funds for the period 2014 – 2020 and of the cohesion fund for the period 2014 – 2020.

Possible financial instruments dealing with climate change adaptation for City of Kranj are:

- Integrated territorial Instrument - a mechanism for the implementation of the European cohesion policy, through which projects of sustainable urban development of municipalities are supported in Slovenia. The fundamental characteristics of this instrument are a bottom-up approach, where sustainable urban strategies of municipalities are implemented, and multi-level management, where cities are responsible for the selection of projects through Association of City Municipalities of Slovenia.
- Regional development mechanism - implementation of regional policy, co-financing the implementation of regional development programs 2014-2020 in 12 development regions. With this mechanism, we support regional and national projects that activate the development capacities of the regions and eliminate the biggest development obstacles in them.
- Climate Change Fund - The Climate Fund is managed by the Ministry of the Environment, Climate and Energy (MOPE), is intended for priority measures for adaptation or mitigating the consequences of climate change, with the greatest emphasis on the decarbonization of the building and transport sectors for adapting to climate change.
- European Urban Initiative - support urban areas of all sizes with innovative actions, capacity and knowledge building, policy development and communication on sustainable urban development.
- Interreg, Life and European Territorial Cooperation programs - Interreg is a key European Union (EU) instrument that strengthens cooperation between regions and countries within the EU. As part of the EU's Cohesion Policy, Interreg plays a vital role in promoting regional development,

cohesion, and reducing economic disparities. For the 2021-2027 period, Interreg is focused on addressing current challenges like climate change, digital transformation, and social inclusion. The LIFE program is a financial instrument managed and financed by the European Commission. LIFE is the largest European financial mechanism dedicated exclusively to measures in the field of environmental protection, nature conservation and mitigating and adapting to climate change. European territorial cooperation (ETC) is the goal of cohesion policy that aims to solve problems across borders and to jointly develop the potential of diverse territories. Cooperation actions are supported by the European Regional Development Fund (ERDF) through three key components: cross-border cooperation, transnational cooperation and interregional cooperation.

- Norwegian financial mechanism - The Norwegian Financial Mechanism is fund established in 1994. It is headquartered in Brussels. It is intended for the co-financing of social programs of EU member states in South-Eastern Europe and Portugal.
- ERASMUS programme - Erasmus+ is an EU program that supports education, training, youth and sport in Europe. It supports the priorities and activities set out in the framework of the European Education Area, the Action Plan for Digital Education and the European Skills Programme.
- Municipal participatory budget - Participatory budgeting is a budget financing system that enables citizens to make direct decisions about the use of budget funds. The implementation of participatory budgeting has many positive social and developmental effects that benefit both citizens and the entire local community.

Household income

In Slovenia, the share of one-member households, which have higher expenses and also a greater impact on the environment, has been increasing rapidly in the last ten years. A third of households would not be able to cover unexpected expenses, and only a little under a fifth spend a month without financial problems. Despite this, people are relatively satisfied with their lives. We are also witnessing a faster aging of the population.

In the previous year, according to the share of disposable income in the primary income of households, four statistical regions ranked below the national average, which was 88.8%: Central Slovenia (84.2%), Gorenjska (87.6%), Southeastern Slovenia (88.2%) and Primorje-Notranjska region (88.7%).

According to this indicator, as a rule, regions with an above-average primary income per capita rank below the average. The inhabitants of these regions generate a higher primary income (from labor and capital) compared to the inhabitants of other regions, while their disposable income is relatively reduced in the redistribution process.

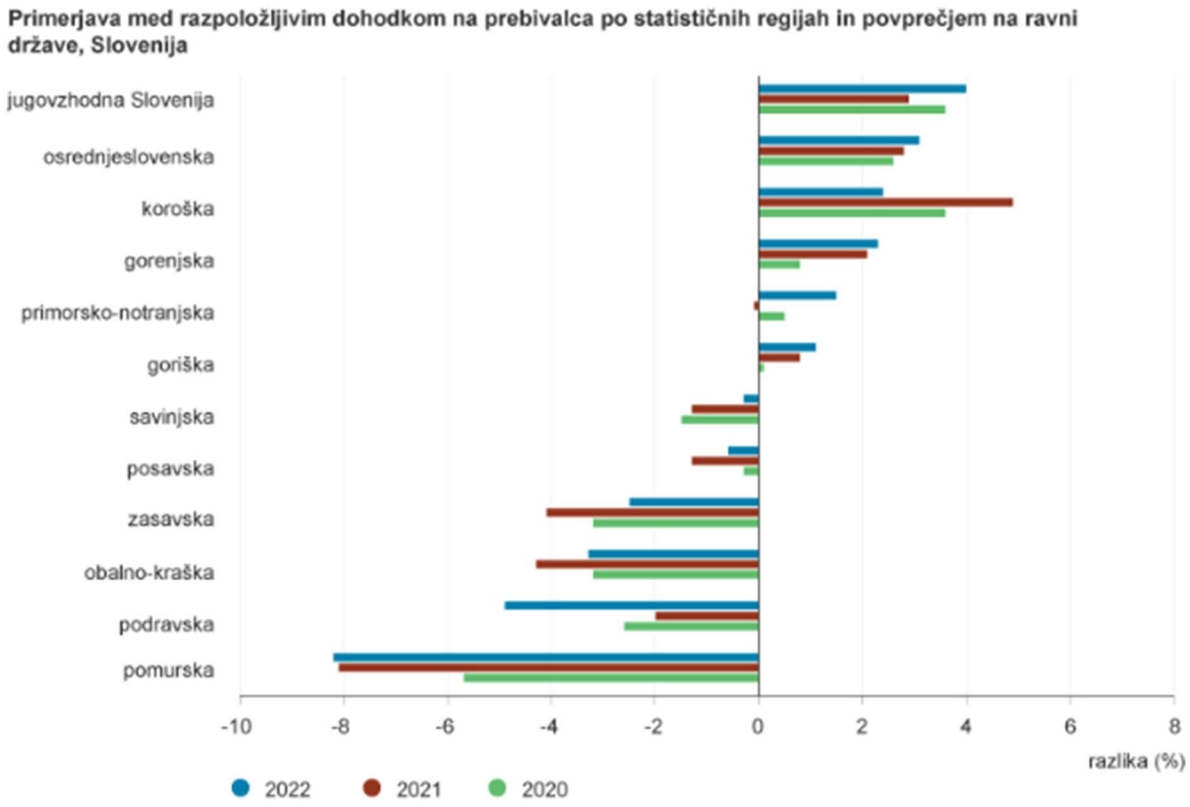

Figure 47: Comparison between disposable income per capita by statistical region, source: https://www.stat.si

The minimum wage for work performed after January 1, 2025 is 1,277.72 €. Income inequality has been the second lowest in the EU for many years, and wealth inequality the fourth lowest in the euro area. The gross disposable income of households has actually increased in the period 2020-2023, to which the government's measures to mitigate the consequences of the epidemic also made a significant contribution. Financial position of households in Slovenia in 2022 and 2023 tightened but remains better than the EU average. Otherwise, it was the share of households that could not cover in 2022 unexpected costs in the amount of the poverty risk threshold, smaller than the EU average, but less households than before the epidemic faced with financial problems.

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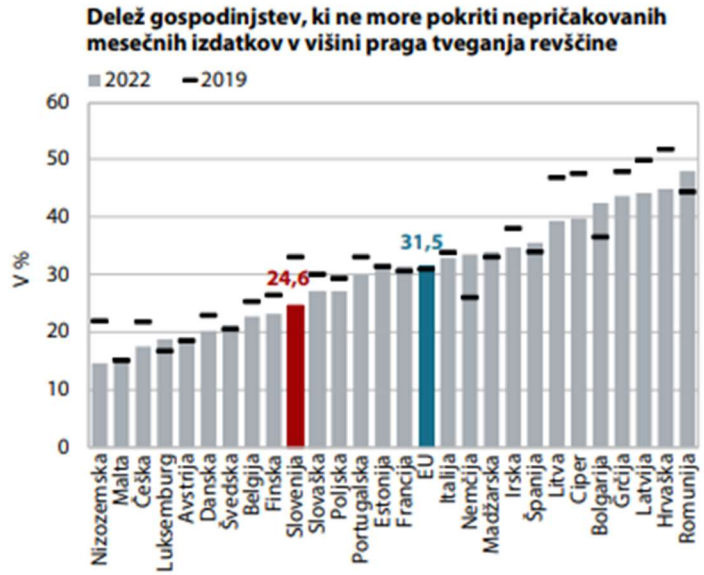

Figure 48: The share of households that cannot cover unexpected monthly expenses in the amount of the poverty risk threshold, https://www.umar.gov.si/fileadmin/user_upload/razvoj_slovenije/2024/slovenski/POR_2024_01.pdf

Access to financial resources

Consumption in households shows that the share is for health increased to 3.0% in 2022 (2018: 2.6%). Overburdened with housing costs and housing deprivation prevail in the economically weaker households living in apartments of poor quality and are poorly energy efficient. Energy consumption has increased only in transport, but in industry and households reduced due to the energy crisis (high prices, savings with energy products). Use of energy for heating has decreased over a longer period due to more economical use, energy rehabilitation of buildings, greater efficiency of heating devices and other measures for greater efficiency, as well as under the influence of warmer winters. In the structure of energy use in households, the share of heating oil decreased, but the use of electricity increased. In the year 2022, energy use in households decreased by a tenth mainly due to less use of wood (problems with supply pellets and relatively high growth in their prices). Households spend a lot of money on housing, transportation, food, and health services.

Social transfers, however, are from the high level they reached during the epidemic and (realistically) maintained also in 2022, considerably reduced despite some measures to mitigate the consequences of high energy prices and floods in 2023. Effectiveness of social transfers in prevention of poverty in the period 2010-2021 was good, in the last two years later, it got worse. The impact of social transfers on poverty reduction is declining. The social transfers are managed by Centers for social work (CSD), which are the central professional institution in the field of social care. Numerous experts and institutions note that the social legislation is extremely complex, outdated and needs necessary comprehensive reforms.

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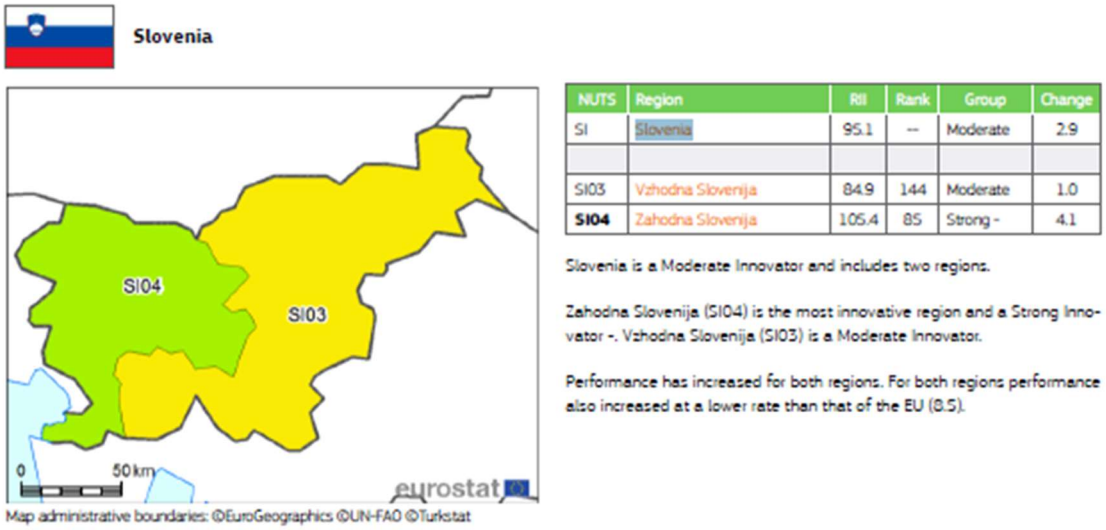
Technological factors and scientific knowledge

Availability of technological, social, institutional, environmental and other innovations

The European Commission's Regional Innovation Scoreboard 2023 identifies Slovenia as a moderate innovator, performance has increased in both regions, but Zahodna Slovenija is the most innovative regiona and a strong innovator.



NUTS	Region	RII	Rank	Group	Change
SI	Slovenia	95.1	--	Moderate	2.9
SI03	Vzhodna Slovenija	84.9	144	Moderate	1.0
SI04	Zahodna Slovenija	105.4	85	Strong -	4.1

Slovenia is a Moderate Innovator and includes two regions.

Zahodna Slovenija (SI04) is the most innovative region and a Strong Innovator -. Vzhodna Slovenija (SI03) is a Moderate Innovator.

Performance has increased for both regions. For both regions performance also increased at a lower rate than that of the EU (8.5).

Figure 49: Regional performance within countries, source: https://op.europa.eu/en/publication-detail/-/publication/c849333f-25db-11ee-a2d3-01aa75ed71a1/language-en

Availability of information on adaptation to climate change

The availability of information on adaptation to climate change will improve with the preparation of A climate change adaptation strategy for the Gorenjska region, where also an action plan will be prepared. The important factor regarding the availability of information's is newly established Climate office for municipalities and regions. Hopefully the Office will strengthen the climate resilience of Slovenian municipalities (and regions) in the long term, help them manage climate risks and integrate adaptation to climate change into municipal and regional plans and spatial acts. Also other projects play an important role in building capacity of City of Kranj, such as ongoing Interreg projects Danube Be Ready and Central Europe CICADA4CE and Urbio BAUHAUS, which concentrate on the adaptation of the cities to climate changes based on the ecosystem solutions and on the approaches to increase the biodiversity in the city, which is disappearing due to the consequences of climate change.

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5. Conclusions

A comparison of maps of population density and building coverage ratio (BCR) showed that the highest population density is in the area of multi-apartment neighbourhoods, such as the entire Planina neighbourhood, Šorlijevo naselje, the Zlato polje area and the edge areas of Drulovka and Stražišče. While the BCR map showed that these areas do not have the largest BCR, but rather it is in the areas of industrial, economic, business and commercial zones. This result can be attributed to the fact that these areas are intended for activities where investors/owners strive for the greatest possible use of space (larger halls/facilities). The densely populated areas are residential areas that were planned and built in the 70s and 80s, during socialism, respecting the human needs. The exception is the area of the old city centre, where the BCR and population density are relatively high. This can be attributed to the historical design of the old city centres and the geographical characteristics of Kranj (a conglomerate pier between the rivers Kokra and Sava). The old city centre also stands out on the energy efficiency map of buildings, which is logical, since it is an older building stock with low energy efficiency. The buildings are also culturally protected, which limits their development. Multi-apartment neighbourhoods stand out in terms of energy efficiency, which can be attributed to the trend in the last 20 years, when energy rehabilitation of multi-apartment buildings was carried out due to state subsidies. Areas with individual buildings are less energy efficient.

Analyses are supplemented through individual tools. Reflectivity coefficient can be easily connected with high BCR and impermeable surfaces, which indicates where the most risky areas are, subjected to the negative effects of heat waves and as such are recognized as UHI. Green areas present the opposite above mentioned facts, so green city systems offer shelter to vulnerable groups because the temperature is lower there, the humidity is higher etc.

The purpose of the analysis is to determine the areas that are most vulnerable and are marked as UHI, to further develop the measures for adaptation. Using the simple manual method of overlaying maps and data, two areas emerged as potential UHI areas, as most of the gathered data at these locations overlapped.

Figure 50: Overlapping process, source: City of Kranj

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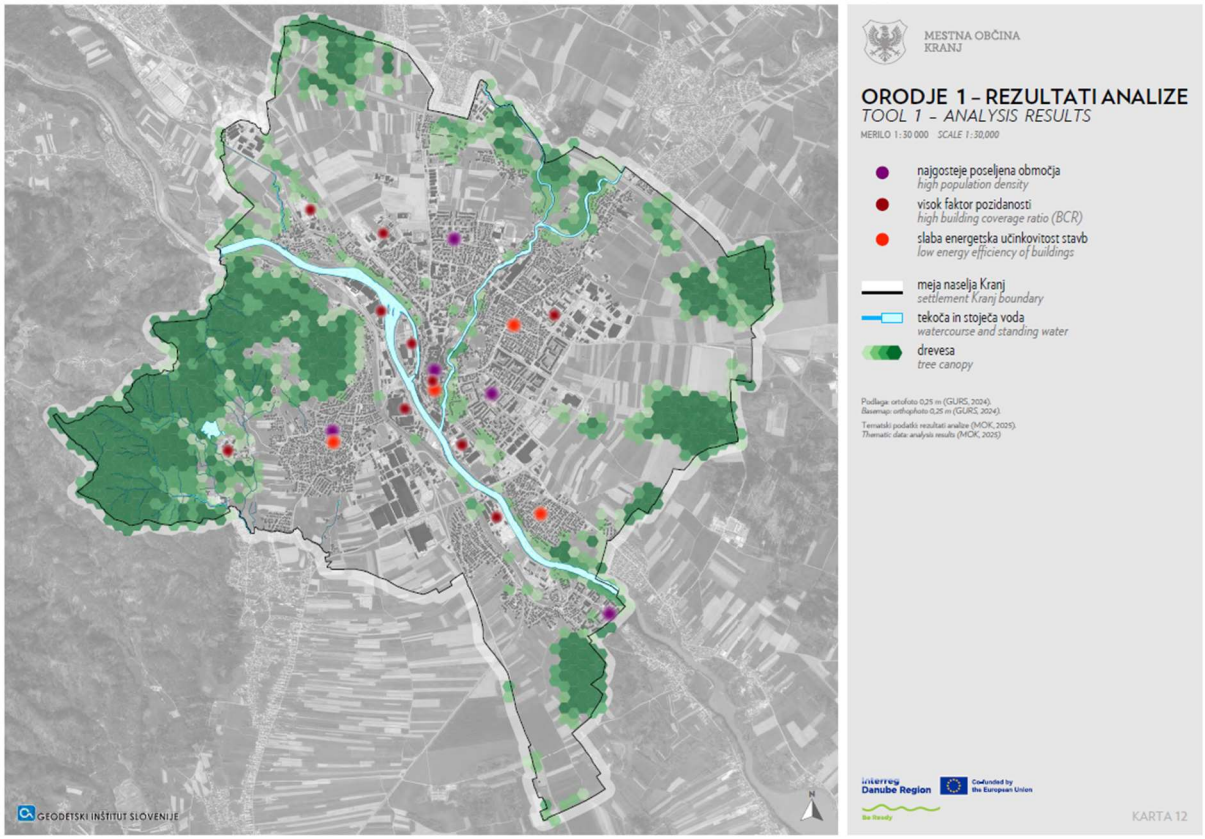

Figure 51: Analysis results are shown as result of simple manual method of overlaying maps and data. Source: City of Kranj, Geodetic Institute of Slovenia, 2025

Taking into account vulnerable groups, these areas are neighbourhood Planina and the old city center. One of these two areas will be treated as a pilot area in the continuation of the project, where further and more detailed analysis can be done, which we could not perform at the level of the Kranj settlement due to the large area. In relation to the old city centre as a pilot area, we can already point out a limitation regarding cultural heritage. Regarding the Planina pilot area, we can highlight the problem of land belonging to multi-apartment buildings as a possible challenge.

Figure 52: Old city center Kranj as potential pilot area. Source: City of Kranj, photo: Primož Hieng.

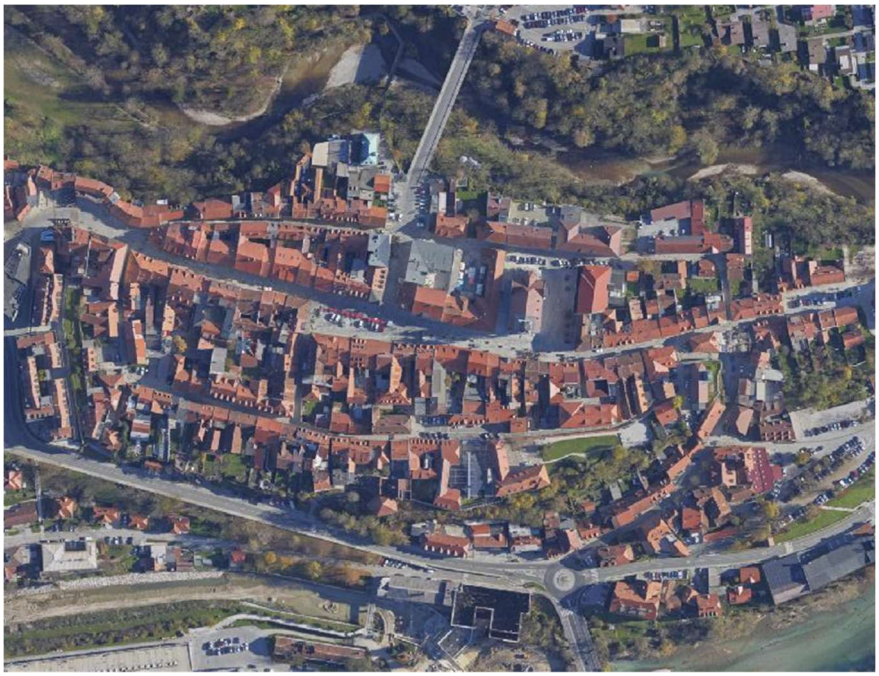

Figure 53: Old city center Kranj as potential pilot area. Source: City of Kranj

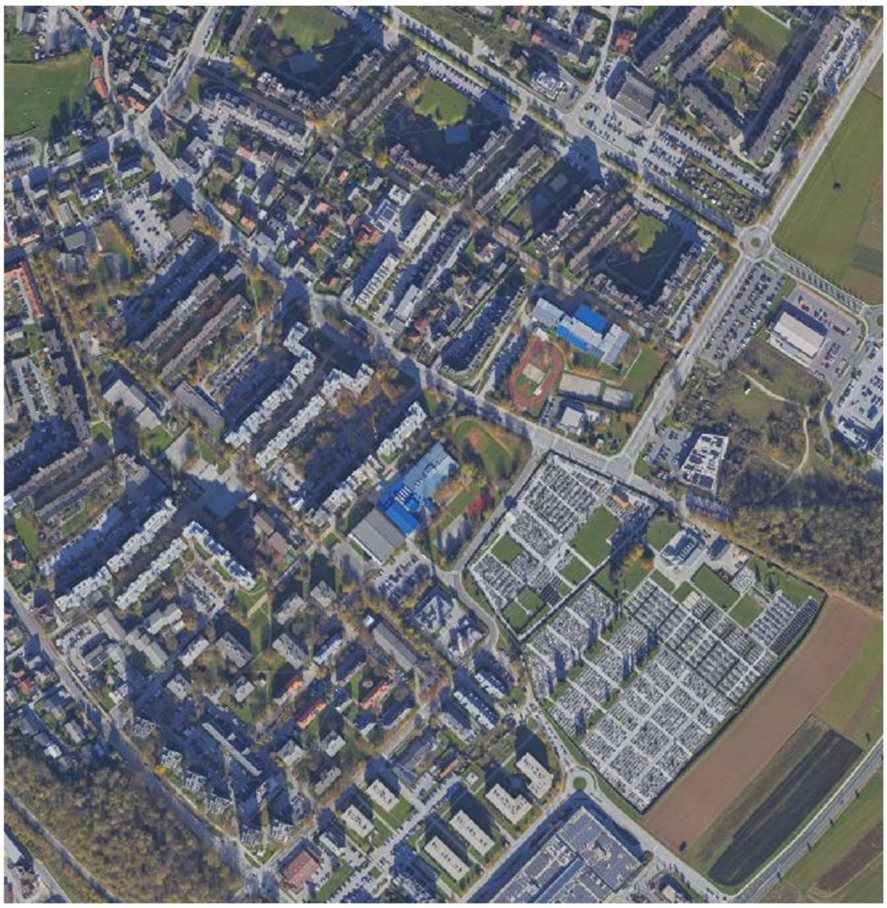

Figure 54: Planina neighbourhood as potential pilot area. Source: City of Kranj

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