Interreg Danube Region
Co-funded by the European Union
Be Ready

Urban heat islands vulnerability and risk assessment

(MUNICIPALITY OF GALAȚI)

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

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List of Abbreviations

BCR	Building Coverage Ratio
EER	Energy Efficiency Ratio
FAR	Floor Area Ratio
GIS	Geographic Information System
SCR	Street Canion Ratio
LST	Land Surface Temperature
UHI	Urban Heat Island

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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.

ABOUT THE REPORT

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

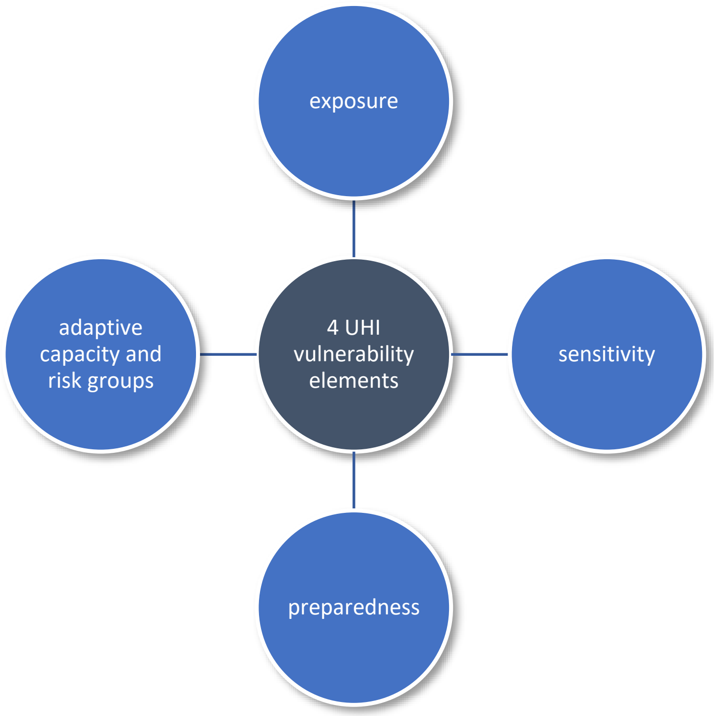

Figure 1: 4 UHI vulnerability elements

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 Galați

Municipality Galați

Region South-East of Romania

State

Country Romania

Statistical data

Surface Area (km2) 246,4 km^2

Population 217.851

Density 884 pop/ km2

GDP per capita (€) 10.943 € (2023)

Minimum Wage (€/year) 813 € (2025)

ABOUT THE CITY

*The **municipality of Galați** is located in the southeastern region of Romania, between latitude 45°26'22"N and longitude 28°2'4"E. Its total area is 246.4 km². Galați is the administrative capital of Galați County and serves as the main economic, political, administrative, and cultural center of the county.*

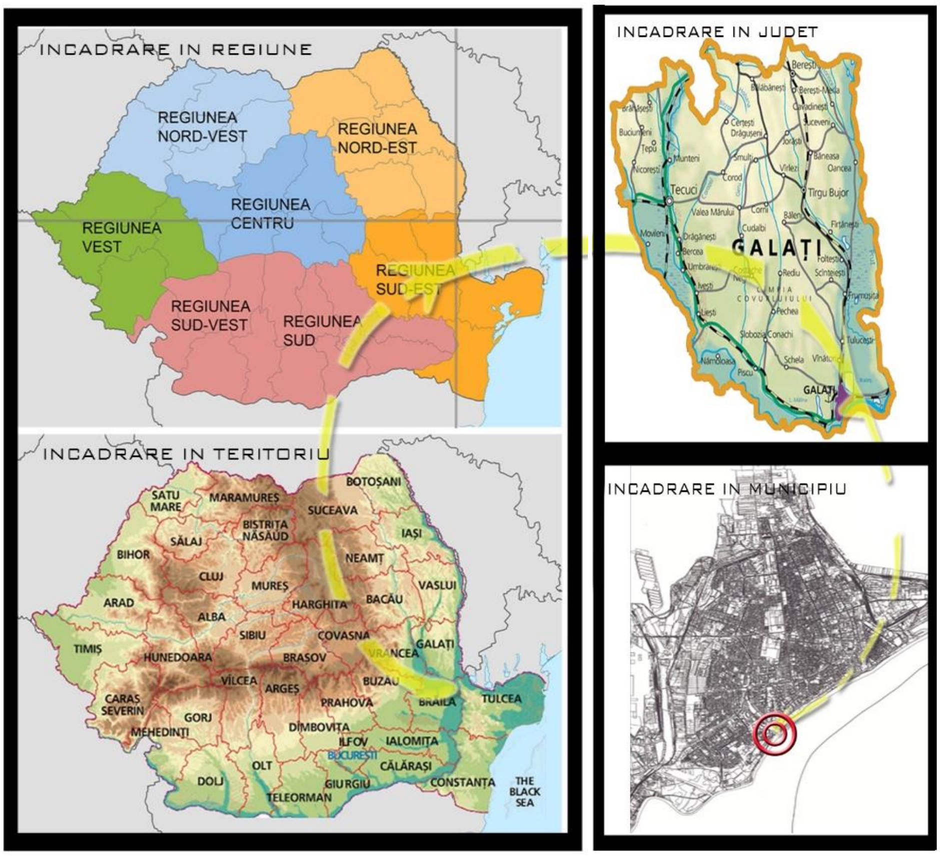

Figure 2 Graphical image of the location of the city on the country and the regional level

Geographically, Galați is situated at the southeastern edge of Romania, on the left bank of the Danube River, near the point where the river's course abruptly shifts from a south-north direction to a west-east direction. It is bordered by surface waters, as follows:

- *To the northeast and east: the Prut River and Lake Brateș*
- *To the southeast: the Danube River*
- *To the south: the Siret River*
- *To the west: Lake Cătușa, in the valley between the city and the Steel Plant(Steelworks)*

Galați County lies outside the Carpathian arc and occupies an area where the edges of the East European, South European, and, partially, Central European physical-geographic provinces intersect. This is reflected in the climate conditions, vegetation, soil cover, and geological structure.

The municipality of Galați is located in the southeastern part of the Covurlui Plain, on the left bank of the Danube River, near the point where the river's course shifts abruptly from south-north to west-east. It is spread across three terraces, ranging from 4 to 35 meters in altitude, 7 km downstream from

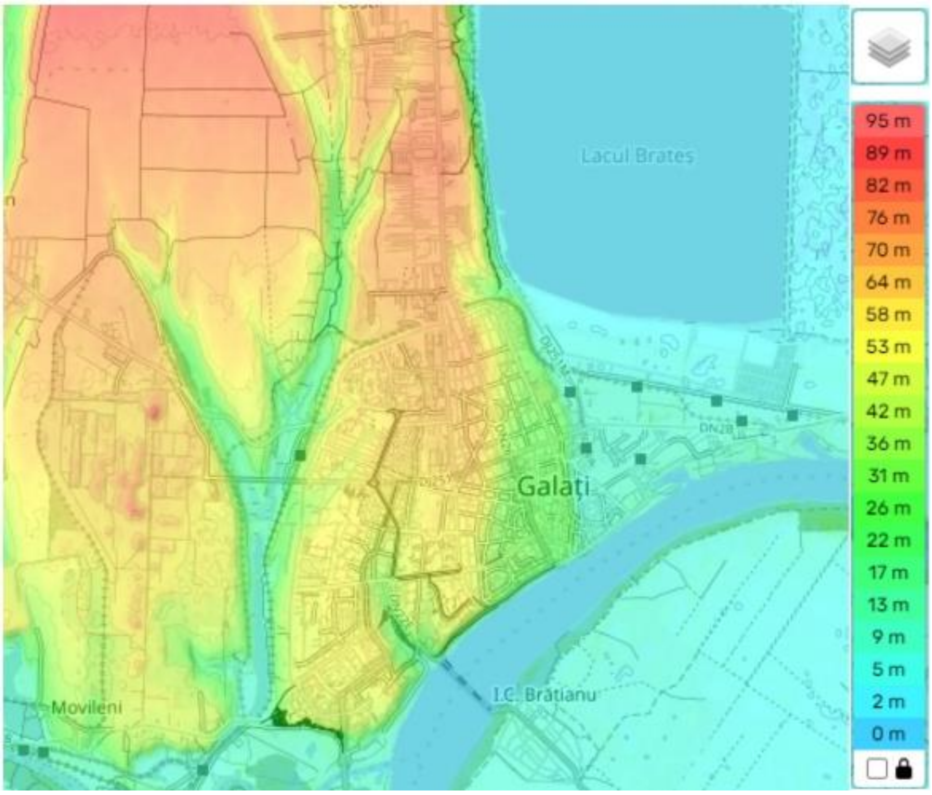

Figure 3 Relief of Galați Municipality, Source: https://en-gb.topographic-map.com/

the confluence of the Siret River with the Danube and 150 km upstream from the Danube's discharge into the Black Sea.

The relief of Galați consists of floodplain and rolling plains, with a maximum altitude of 94 meters, according to data derived from the digital elevation model presented by Jarvis et al. (2008). The city spans three terraces: The city valley, with altitudes between 3–7 meters, Two additional terraces, almost fan-shaped: the first at an altitude of 20–25 meters (the medieval city's core, now the city center), The second terrace, exceeding 40 meters in altitude (3the modern city).

The climate of Galați County is entirely continental. More than 90% of its area (the southern and central parts) falls within the plain climate zone, while the northern extremity (10%) belongs to the hill climate zone. In both zones, summers are very hot and dry, while winters are cold, marked by strong blizzards and intermittent warm and moist air advections from the south and southwest, causing occasional warming and snowmelt.

The floodplains of the Siret, Prut, and Danube rivers create a specific floodplain microclimate: more humid and cooler in summer, and more humid and less cold in winter.

As Galați County serves as a gateway to the northeast and southwest, it is influenced by eastern continental air masses and, to a lesser extent, southern ones. Western air masses are almost entirely absent, as they are blocked by the Carpathian Mountains.

The annual average temperature is 10°C. In summer, it averages 21.3°C, while in winter, cold air masses from the north and northeast cause temperature drops ranging between -0.2°C and -3°C.

In the graph below, the increasing incidence in the last decade of periods lasting over one hour with average temperatures above 33°C can be observed. These heatwaves affect to some extent all municipal sectors as well as the natural environment. Based on these heatwaves, the municipality should adapt certain activities and collaborate with partner public institutions to ensure preventive measures and minimize risks related to vegetation fires, public health, water supply, and other actions.

Temperature events exceeding 33 degrees Celsius with a duration of more than one hour

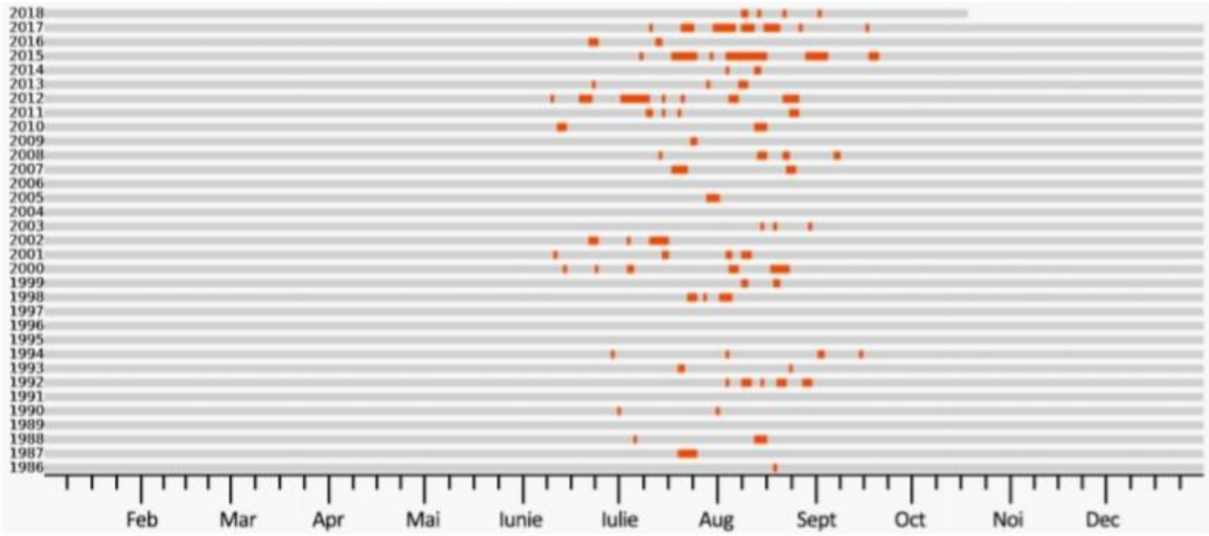

Figure 4 Analysis of the temporal distribution (1986-2020) of heat waves for the Municipality of Galați
Source: Action Plan for Sustainable Energy and Climate for the Municipality of Galați, prepared by S.C. Minex SRL Slobozia, approved by Local Council Resolution 629 on 24.11.2021

The analysis of the temporal distribution of cold waves reveals that periods of low temperatures (below -5°C) have become much more concentrated in the last two decades than in the past, when periods with low temperatures were shorter but more frequent.

Also, from the previous graph, it can be observed that starting from 2011, cold waves typically occur in the first 2 months of the year and less in the last two months, as was the case in the past.

Temperature events below -5 degrees Celsius with a duration of more than one hour

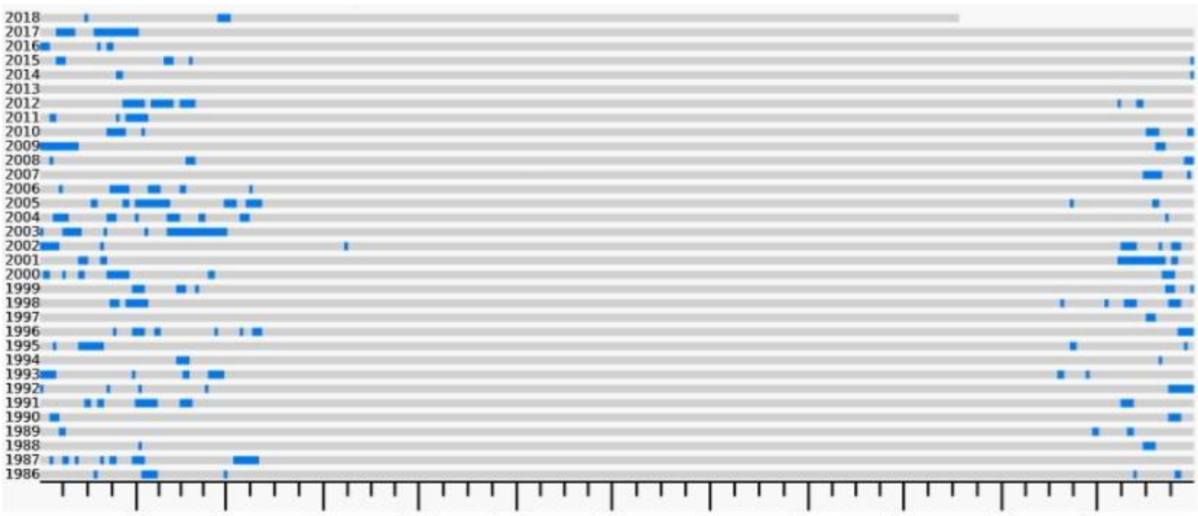

Figure 5 Analysis of the temporal distribution (1986-2020) of cold waves for the Municipality of Galați
Source: Action Plan for Sustainable Energy and Climate for the Municipality of Galați, prepared by S.C. Minex SRL Slobozia, approved by Local Council Resolution 629 on 24.11.2021

Urban risks

Geotehnical and geological risks

The geological survey for Galați Municipality highlights several geotechnical risks related to soil stability and moisture sensitivity. The urban area is predominantly covered by loess deposits which are classified into zones based on their depth and sensitivity to moisture. These deposits are particularly prone to instability when exposed to water, posing significant risks for construction and urban development:

- Loess deposits sensitive to moisture are categorized into depths of 0-5 m, 5-10 m, 10-15 m, and greater than 15 m. These areas are at risk of compaction and structural collapse if water infiltration occurs, making proper drainage and soil stabilization measures critical.
- Naturally or anthropogenically filled ravines represent additional geotechnical challenges. These filled zones may have weak soil consistency, leading to settlement or failure under load.
- Active ravines present risks of erosion and potential slope instability, especially in areas with significant water flow or surface runoff.
- Clayey-silty alluvium zones near rivers and water bodies indicate areas with soft soils, prone to settlement and reduced bearing capacity, particularly under heavy structures.

- Defense trenches (probable routes) and the proximity of temporary water bodies further compound risks by increasing water-related challenges, particularly in areas with inadequate drainage.
- Additionally, the presence of aquatic surfaces and their interaction with urban zones can exacerbate flooding risks, particularly in low-lying areas.

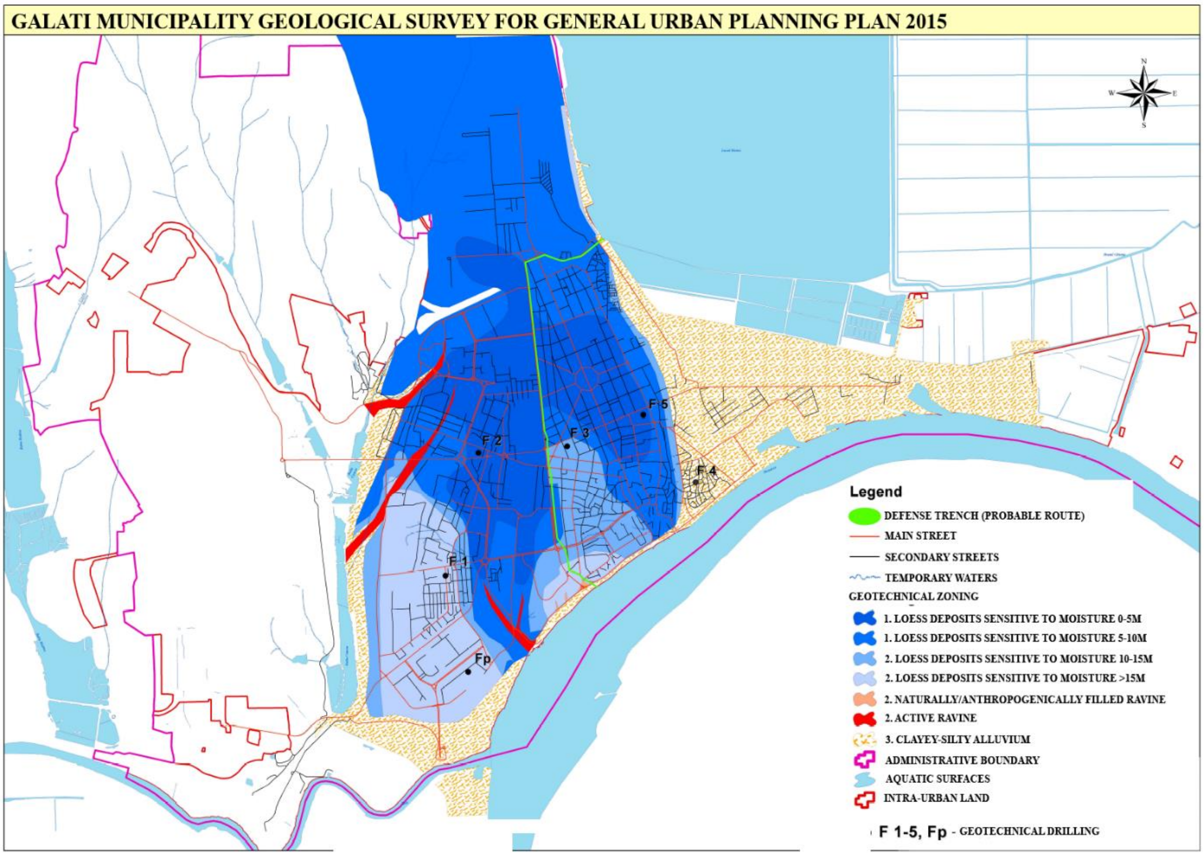

Figure 6 Excerpt from the geological study conducted for the 2015 General Urban Plan. Geotechnical zoning.

Seismic and flood risk

The map identifies two major risks in Galați Municipality:

Seismic Risk Zones: Areas prone to seismic activity, as indicated by the red cross-hatched zones. These regions are susceptible to ground shaking during earthquakes, which can lead to structural damage and infrastructure vulnerability.

These zones are primarily located in the central and eastern parts of the urban area, extending close to the administrative boundaries.

The areas include parts of the residential zones and sections along the city's periphery, indicating significant urban exposure to seismic hazards.

Flood Risk Zones: Areas at risk of flooding, as highlighted by the blue cross-hatched zones. These zones are adjacent to major water bodies and are prone to inundation during high water levels or extreme weather events.

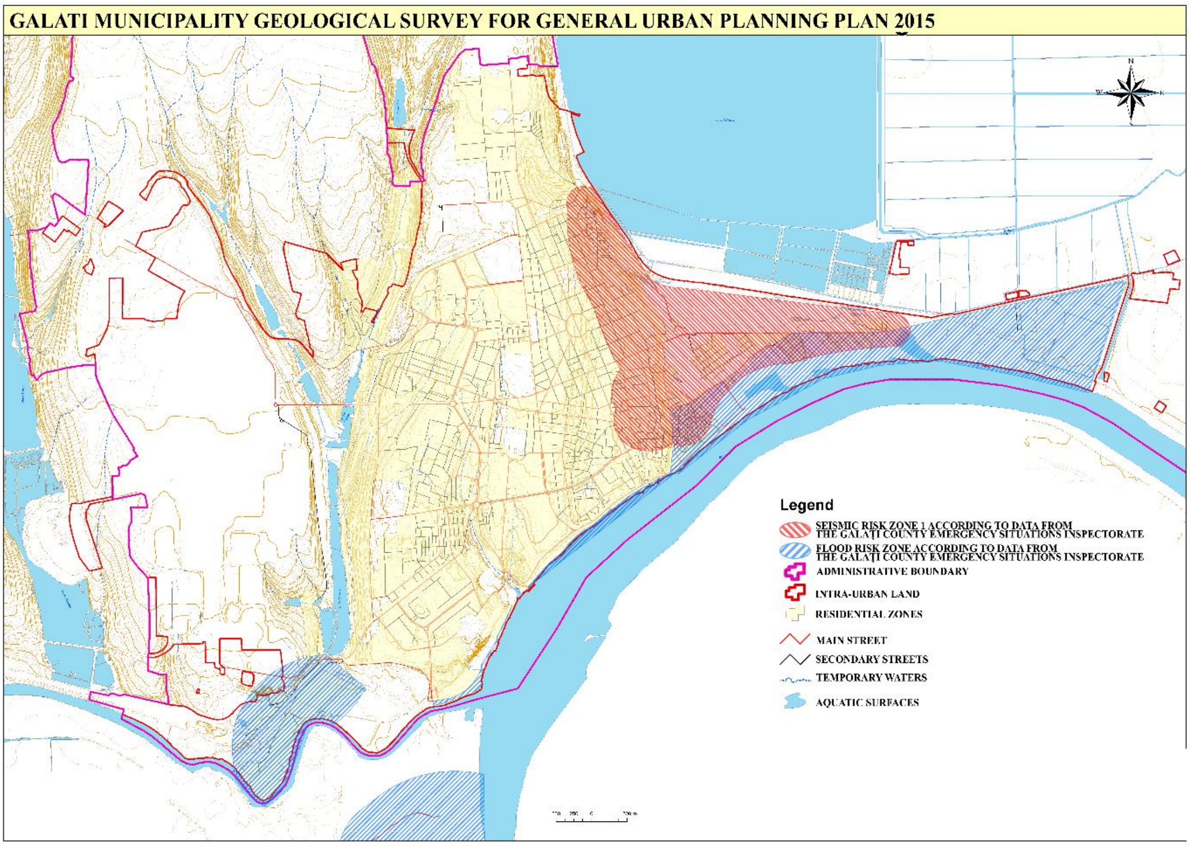

Figure 7 Excerpt from the geological study conducted for the 2015 General Urban Plan. Seismic and flood risk.

These zones are concentrated along the eastern boundary of the city, adjacent to the Danube River.

The flood-prone areas extend towards the southeastern part of Galați Municipality, encompassing low-lying regions close to the riverbanks and temporary water bodies.

Infrastructure and Land Use in Risk Areas

Intra-urban land and residential zones are located within both seismic and flood risk zones, emphasizing the vulnerability of inhabited areas.

Main streets and secondary streets traverse these risk zones, highlighting the potential impact on transportation and accessibility in case of natural disasters.

The map illustrates that Galați Municipality faces significant risks from both seismic activity and flooding. The overlap of these risks with residential and intra-urban zones underlines the need for disaster preparedness measures, including strict construction regulations in seismic zones and flood defenses for areas near the Danube River.

Heat risk

The four maps represent the heat risk categorization in Romania over different time periods (2020-2099) based on the SSP5-8.5 climate scenario. The color coding indicates different levels of heat risk associated with temperature increases and population vulnerability:

Yellow: Low risk

Orange: Moderate risk

Red: High risk

2020-2039 (Top Left) - Early

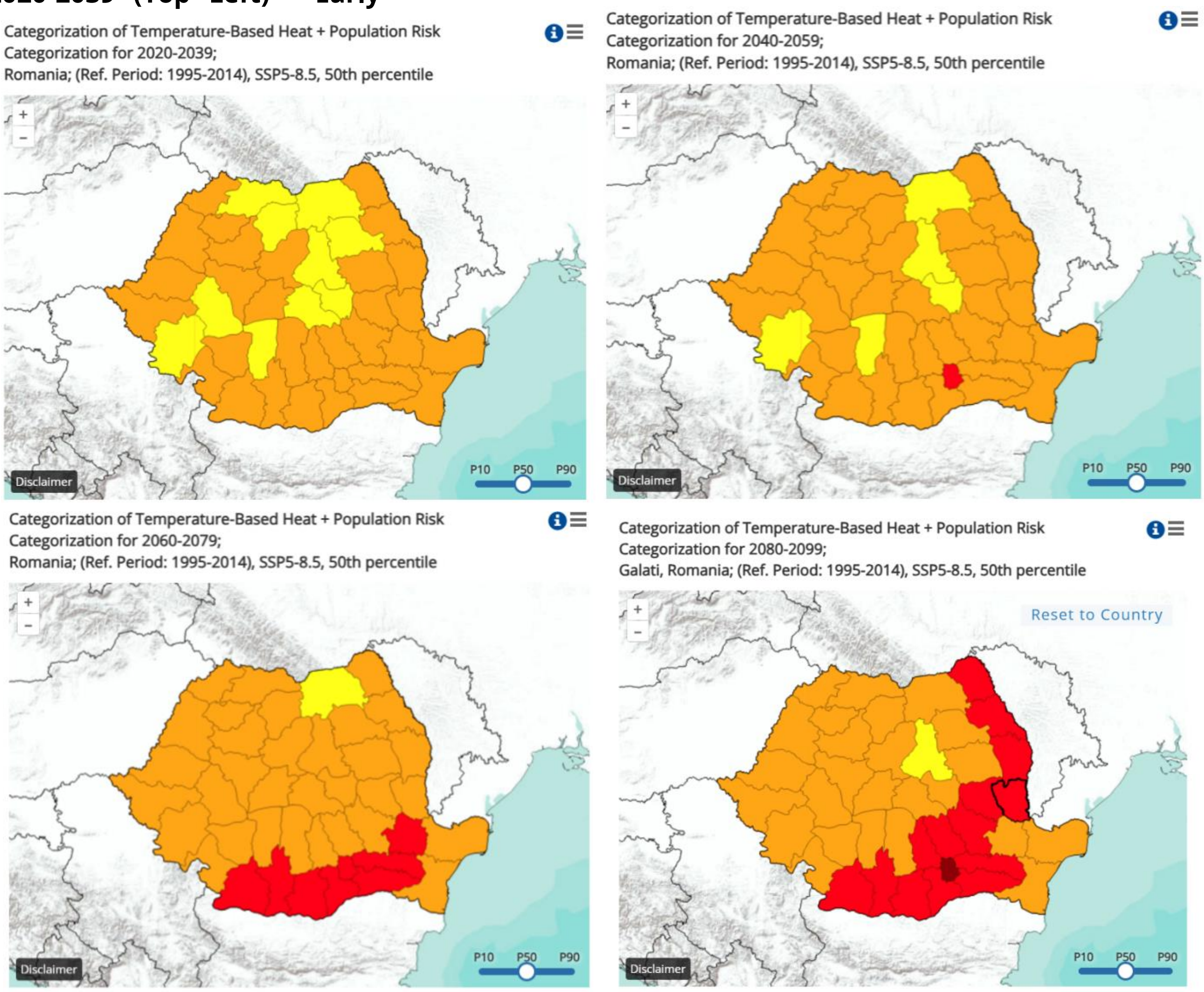

Figure 8 Heat risk, 8.5 scenario Source:https://climateknowledgeportal.worldbank.org/country/romania/heat-risk

Stage of Heat Risk Increase

- **Most of the country is categorized as moderate risk (orange).**

- Some low-risk (yellow) areas remain, particularly in the northwestern and central parts.
- The southeastern and eastern regions (including Galați) are already at moderate risk.

2040-2059 (Top Right) - Increasing Heat Risk

- The **moderate-risk areas expand**, covering most of the country.
- **Few low-risk (yellow) areas remain**, showing a **clear increase in heat risk**.
- A **small region in southern Romania is marked as high risk (red)**, indicating areas experiencing **extreme heat effects**.

2060-2079 (Bottom Left) - High-Risk Areas Expanding

- The **high-risk category (red) has significantly expanded**, covering **southern Romania**.
- The **remaining yellow areas are very limited**, meaning almost the entire country is facing **moderate to high heat risk**.
- The **southeastern and southern regions face the greatest impact**, likely due to **higher temperatures and urban heat effects**.

2080-2099 (Bottom Right) - Extreme Heat Risk in Eastern and Southern Romania

- **A significant portion of eastern and southern Romania is now in the high-risk (red) category**, including **Galați**.
- The **moderate-risk (orange) areas dominate the rest of the country**, meaning almost no areas are left at low risk.
- This map suggests **severe heat-related impacts**, especially in densely populated or urbanized regions.

The SSP5-8.5 scenario is part of the Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs) used in climate modeling to project future global warming and its impacts. It serves as a **reference scenario** to understand the worst possible climate outcomes if emissions are not controlled.

2. Methodology of the assessment

SUMMARY OF THE PROCESS

The assessment process began with the development of a preparatory plan focused on addressing Urban Heat Island (UHI) effects and climate change challenges in Galați. The plan was structured to involve local authorities, external experts, and stakeholders right from the outset of the preparatory activities, fostering a collaborative approach. Key stakeholders were identified early, including representatives from the municipality, environmental agencies, NGOs, businesses, and academic institutions. Each stakeholder's involvement was defined at specific stages, particularly during discussions, data collection, and coalition-building. The workshop included a key discussion on forming a local coalition in Galati and securing stakeholder commitments to mitigate UHI impacts in Galati, by signing a Local Coalition Pact.

PREPARATORY PHASE

In the initial phase, a preparatory plan was developed to address Urban Heat Island (UHI) effects and climate challenges in Galați as part of the BeReady Project. This plan included:

- Stakeholder Identification: Key stakeholders, such as local authorities, environmental experts, NGOs, businesses, and academic representatives, were identified. Their roles and stages of involvement were clearly defined.
- Planning and Objectives: The preparation focused on setting clear goals for stakeholder engagement, data collection, and coalition-building.
- Preparation Process: The project team prepared all logistical arrangements for workshops and activities to ensure the effectiveness of the assessment process.

EVENTS/ ACTIVITIES

The assessment of urban heat islands vulnerability and risk began with several organized events and activities. The first major event involving relevant stakeholders was the Local Methodology Workshop, held on the 23rd of September 2024 in Galați. This workshop included the participation of local authority representatives, external experts, and various stakeholders.

Before this workshop, a series of preparatory working meetings were conducted, during which, specialists provided crucial information, technical insights, and assistance to refine the methodology and ensure the assessment was grounded in accurate data and best practices.

Working meeting July 26, 2024

On July 26, 2024, a working meeting was held with the purpose of presenting an analysis of the methodology by specialists providing technical assistance to the project. The team's conclusions were as follows:

- The project will be a complex one, requiring the combined knowledge and expertise of multiple types of specialists.
- A multitude of difficult-to-obtain data is required, involving the processing of satellite data.
- They raised an alarm about the need to involve specialists who understand the process required for satellite data processing.
- They highlighted the necessity of disseminating questionnaires, which would require a considerable number of volunteers.

Working meeting September 10, 2024

On September 10, a working meeting was held to prepare for the local stakeholder workshop scheduled for September 23, 2024, during which participants were informed about the Workshop Organization Methodology.

The technical assistance specialists were assigned two sections within the workshop.

The first section will aim to introduce and explain the phenomenon of urban heat islands (UHI) to those unfamiliar with the term, followed by the presentation of the methodology. A chapter about the Municipality of Galați will be included to highlight the importance of identifying this phenomenon within the city.

The second section will focus on presenting the methods for data collection, data sources, data processing techniques, and mapping of UHI zones. The hope is that participants will contribute in some way to identifying the areas where the urban heat island phenomenon is present. The presentation of the UHI risk and vulnerability assessment methodology will emphasize the need to provide data and identify the resources required to determine UHI in the Municipality of Galați.

During the working meeting, the following were proposed for invitation to the workshop:

- Developers of the General Urban Plan (PUG) for the municipality
- The Street Repair Office
- The Romanian Environmental Association
- UAR - The Union of Romanian Architects (Galați branch)
- Members of the administrative apparatus of the Galați County Council
- Investors/developers

Organization of the Local Methodology Workshop in Galati

On 23 rd of September 2024 in Galați with the participation of local authorities representatives, external experts, and stakeholders, the a local methodology workshop took place. The process was structured around a one-day workshop which included the following activities:

Opening Session: Registration and networking followed by a welcome address by the Deputy Mayor.

Presentation of Goals: A detailed presentation on the BeReady Project goals, climate challenges, and UHI risk assessment methodology by the Project Manager and external experts.

Participatory Data Collection Session: Local stakeholders contributed to discussions on data collection and assessment indicators.

Coalition Building: Formation of a local coalition to mitigate UHI impacts, marked by the signing of a Local Coalition Pact. The document prepared by PP4 was translated into the local language (Romanian) to facilitate wider understanding and engagement. The coalition pact successfully received support from a diverse array of signatories, ensuring representation from all four helix groups. Part of the attendees signed the Local Coalition Pact. A total of 9 different stakeholders signed the Pact, besides Tehnopol Association and Municipality of Galati.The documents reflect the collective commitment to the coalition's objectives and outline the roles and responsibilities of each signatory.

The event concluded with a recap of outcomes and plans for further refinement of tools and ongoing collaboration.

Number of Events: The assessment process included the main workshop and multiple participatory sessions within the event.The organization of the project launch event, held on 23rd September 2024 in Galați at the Vega Hotel, Pegasus Hall, Galați was planned to coincide with the Organization of the Local Methodology Workshop (A1.2) to maximize efficiency and stakeholder engagement.

Table 1 Target group

Target group	**Organization**
Local authority	Galati Municipality
Regional authority	Galati Environmental Protection Agency Galati County Construction Inspectorate Order of Architects of Romania – „Dunarea de Jos" Branch
National authority	
Interest groups and NGOs	Open Hub Association - Creative Cluster Galati Tehnopol Association Galati Environmental Consultancy Center
Business support organizations	
Business Environment	Ecosal Public Service Galati Apa Canal SA Galati (Water and Sewerage Company) Transurb SA Galati (Public Transport Company) Thecon SRL (a private company)
Cross-border legal body	
General public	

Higher education and research organization	„Dunărea de Jos" University, Faculty of Engineering

Purpose of Events:

- To educate stakeholders about UHI challenges and methodologies.
- To engage participants in data collection processes.
- To form a coalition and establish commitments to mitigate UHI impacts.

Stakeholder Roles:

- Local Authorities: Provided strategic direction and represented the city's interests.
- Experts: Shared technical knowledge and tools for assessment.
- Community Organizations: Brought grassroots perspectives and contributed to coalition-building.
- Businesses: Discussed practical applications of mitigation measures.

Results of Events

- Awareness and Capacity Building: Stakeholders gained knowledge on UHI vulnerabilities and tools to address them.
- Commitment to Action: Nine stakeholders, including the Tehnopol Association and Galati Municipality, signed the Local Coalition Pact.
- Refined Methodology: Input from participants helped enhance the assessment process.

Key outcomes

- Stakeholders reached a deeper understanding of UHI effects, the role of various materials in exacerbating them, and vulnerable populations.
- The workshop fostered collaboration and commitments for sustainable urban development.
- A timeline for ongoing stakeholder involvement and tool refinement was established.

Figure 9 Opening presentation, Source: Municipality of Galati

Figure 10 Presentation Source: Municipality of Galati

Figure 11 Presentation Source: Municipality of Galati

The workshop featured visual tools, such as:
- Presentations detailing the assessment methodology.
- Maps and data visualizations to showcase UHI hotspots and potential mitigation strategies.
- A summary diagram illustrating the step-by-step process of stakeholder engagement and outcomes.

PRESENTATION OF THE URBAN HEAT ISLAND AND THE TOOLS OF THE ASSESSMENT METHODOLOGY

In order to identify the urban heat island, a presentation of the urban heat risk assessment methodology and self-assessment tools was made to partners and stakeholders who can provide the necessary data for evaluating the urban heat island risks.

The presentations aimed to introduce the urban heat island phenomenon, emphasizing the importance of understanding its causes and effects on the environment, human health, and the urban economy. During the presentations, the need for adopting mitigation and adaptation measures was highlighted to increase the resilience of cities to this phenomenon.

Another goal was to extend an invitation for collaboration to all partners and stakeholders, inviting them to provide technical and human resources.

The first section aimed to introduce and explain the urban heat island phenomenon for those unfamiliar with the term, followed by the presentation of the methodology. This section also included the presentation of statistical data about Galați Municipality.

The second section briefly revisited the tools and focused on presenting the methods for data collection, data processing, and mapping the UHI area. This presentation emphasized the need for providing data and the importance of identifying the necessary resources.

The first presentation was structured into five chapters:

Chapter 1 is an introductory section where we provided information about the purpose of the presentation, the importance of understanding the causes and effects of urban heat islands (UHI), as well as the significance of adopting mitigation and adaptation measures to enhance cities' resilience to this phenomenon.

Chapter 2 focuses on the urban heat island phenomenon, the factors that generate UHI, including controllable and uncontrollable variables. The slides were designed with diagrams to facilitate the understanding of the information. Clear images were used to illustrate the phenomenon.

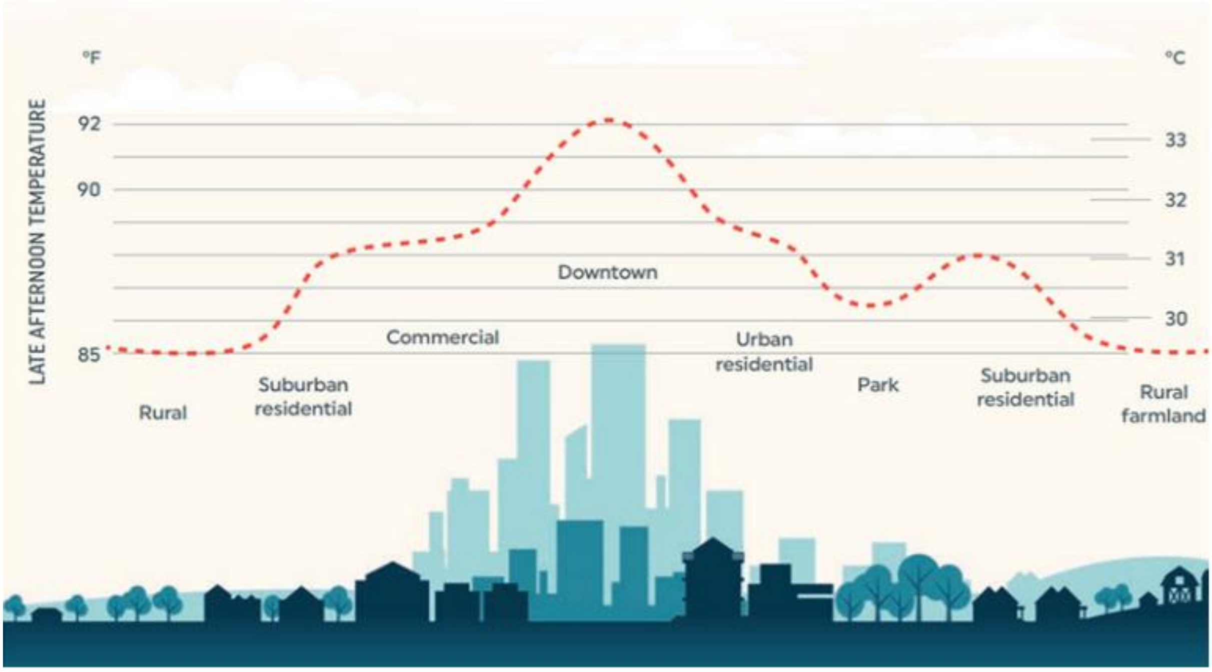

Figure 12 Example of images used for illustrating UHI phenomenon. Urban Heat Island Profile. Foster, 2020.

Chapter 3 presents the **METHODOLOGY FOR ASSESSING RISKS AND VULNERABILITY OF URBAN HEAT ISLANDS** for each tool individually. The slides are represented through logical, concise diagrams for each tool.

Chapter 4 provides information about **Galați Municipality in the context of the urban heat island**. For this presentation, we collected and prepared data on the current situation for the following parameters:

- Location
- Surroundings influencing the determining characteristics of UHI

- Relief
- Graphs showing the average temperature in Galați Municipality from 1979 to 2023
- Graphs showing precipitation in Galați Municipality from 1979 to 2023
- Graphs showing anomalies in temperature and precipitation in Galați Municipality from 1979 to 2023
- Wind speed and direction
- Graphs on heatwaves and cold spells
- General assessment of the main environmental risk factors at the local level (U.A.T)

Chapter 5 highlights the **importance of identifying UHIs in Galați Municipality** in a graphical format.

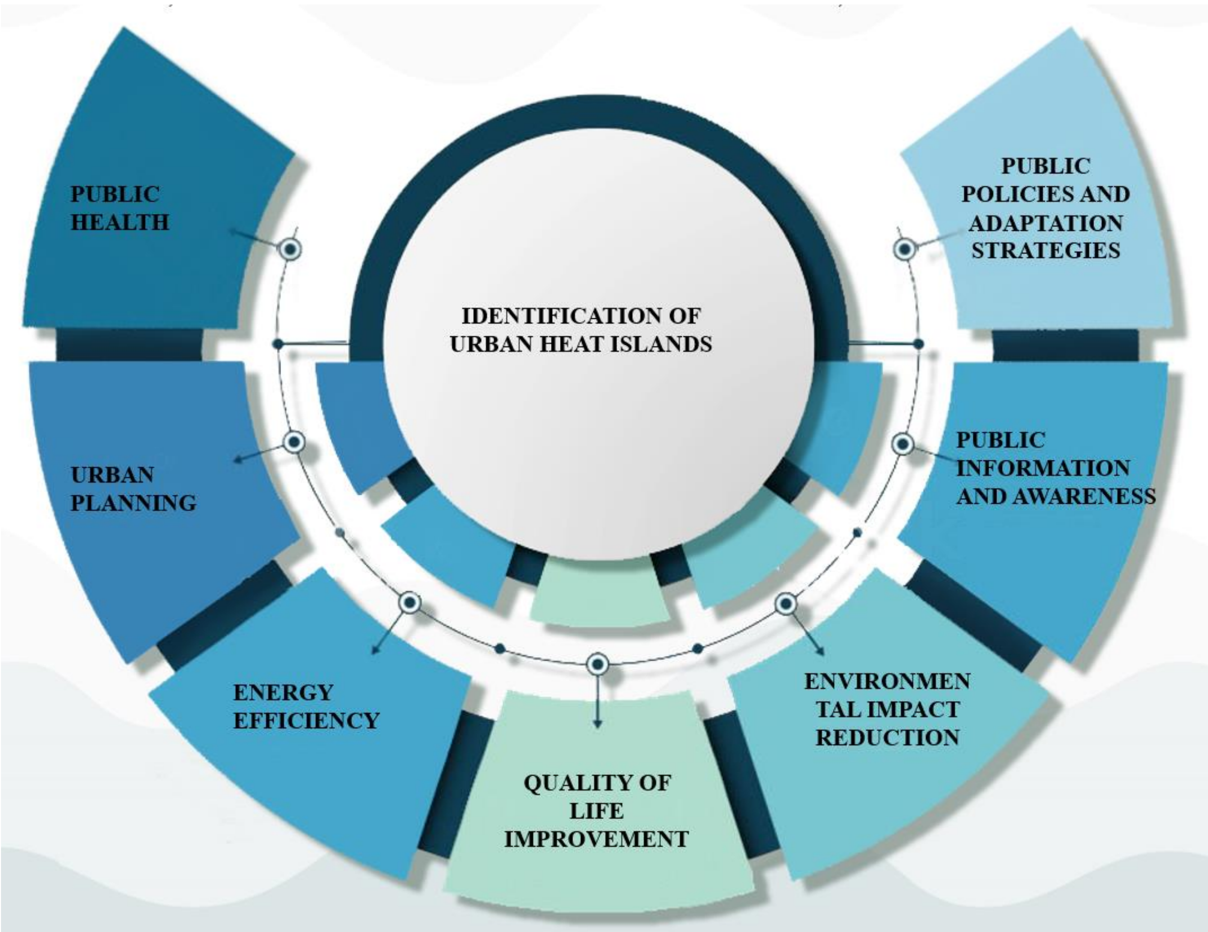

Figure 13 Importance of identifying UHIs in Galați Municipality

The second presentation was structured into 6 chapters, of which 4 chapters correspond to the tools presented in the methodology, each with 3 subchapters.

Chapter 1 outlined the purpose of the presentation: the methods for data collection, identifying sources of data, methods for data processing, and mapping the UHI area.

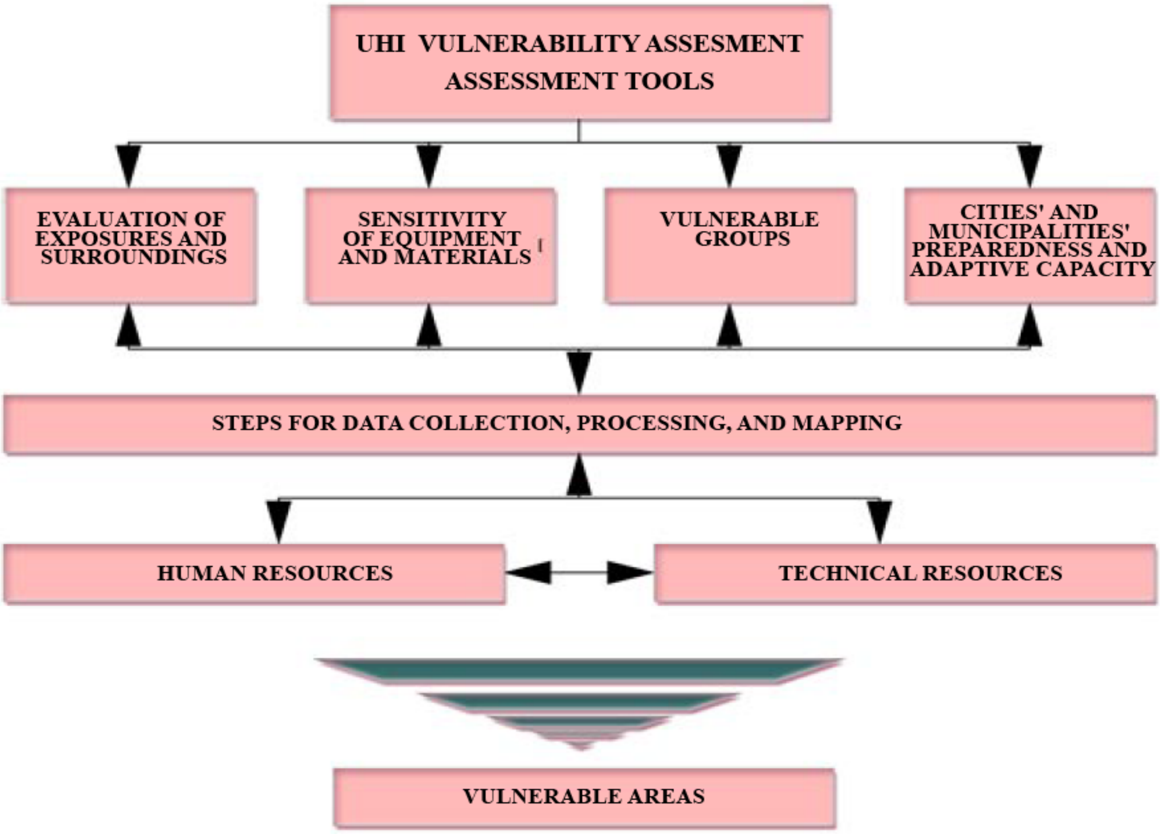

Figure 14 General framework for the methodology to identify the stages, technical and human resources needed for determining the urban heat island.

Chapter 2 presents each tool individually and is illustrated with informative images showing the final result of the analysis. For example:

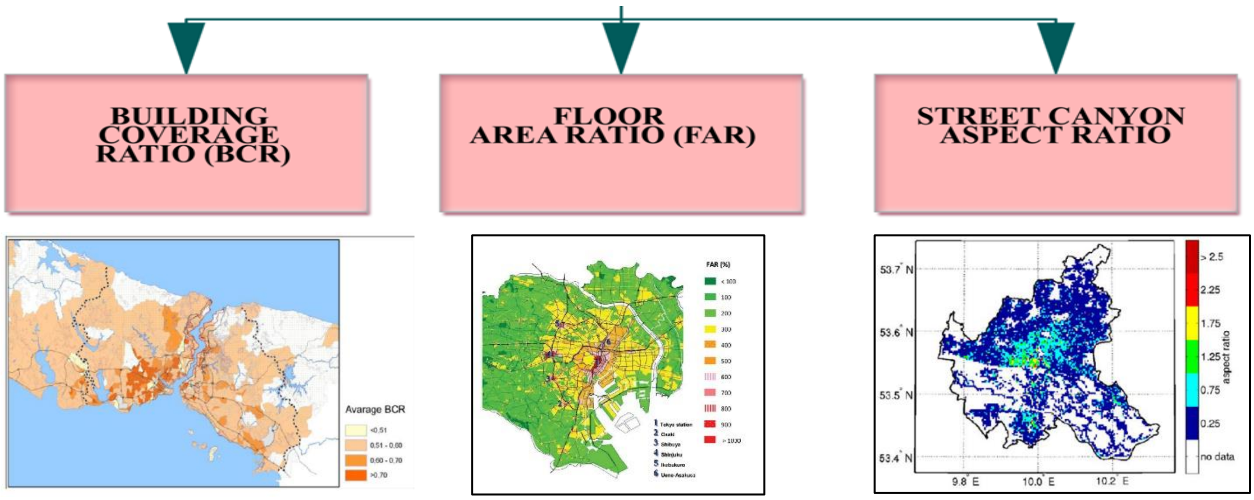

Figure 15 Example of informative images showing the final result of the analysis

The last slide for each tool presents a list of the technical and human resources required, along with an invitation for participants to identify other potential resources.

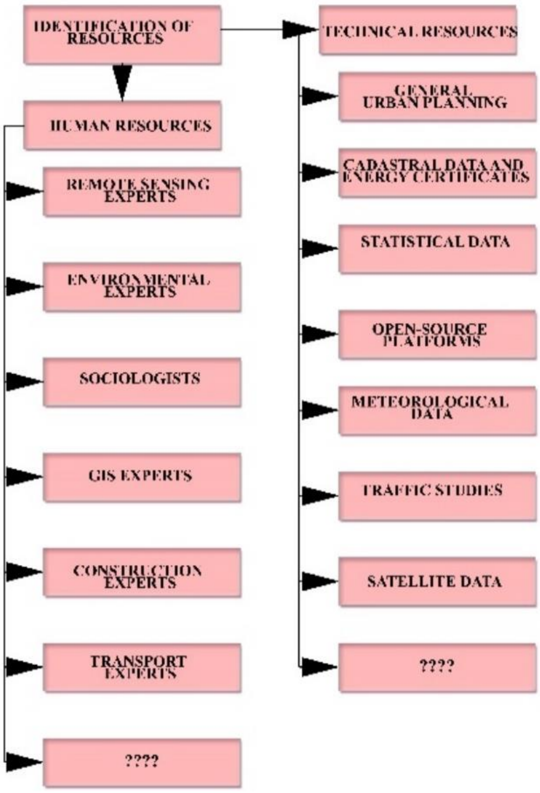

Figure 17 The list corresponding to TOOL 1

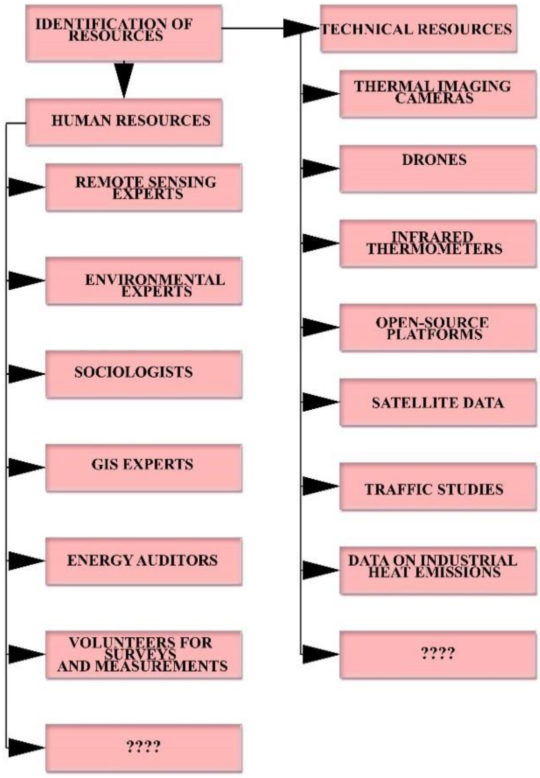

Figure 16 The list corresponding to TOOL 2

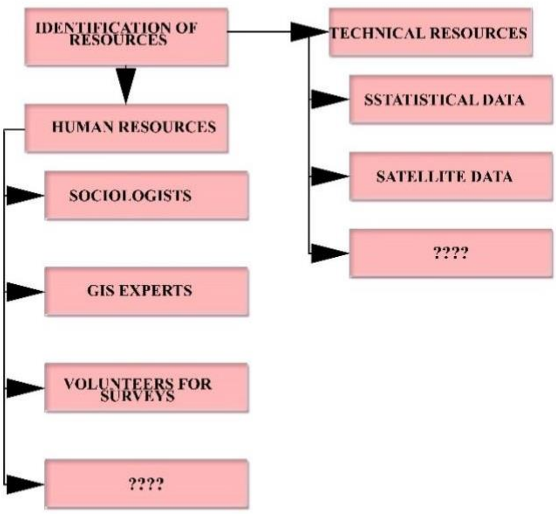

Figure 19 The list corresponding to TOOL 3

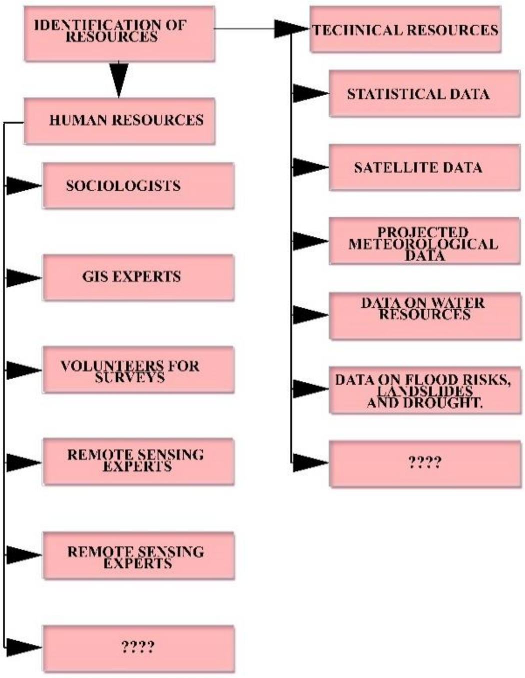

Figure 18 The list corresponding to TOOL 4

The final chapter summarizes the importance of community and institutional collaboration in managing the urban heat island.

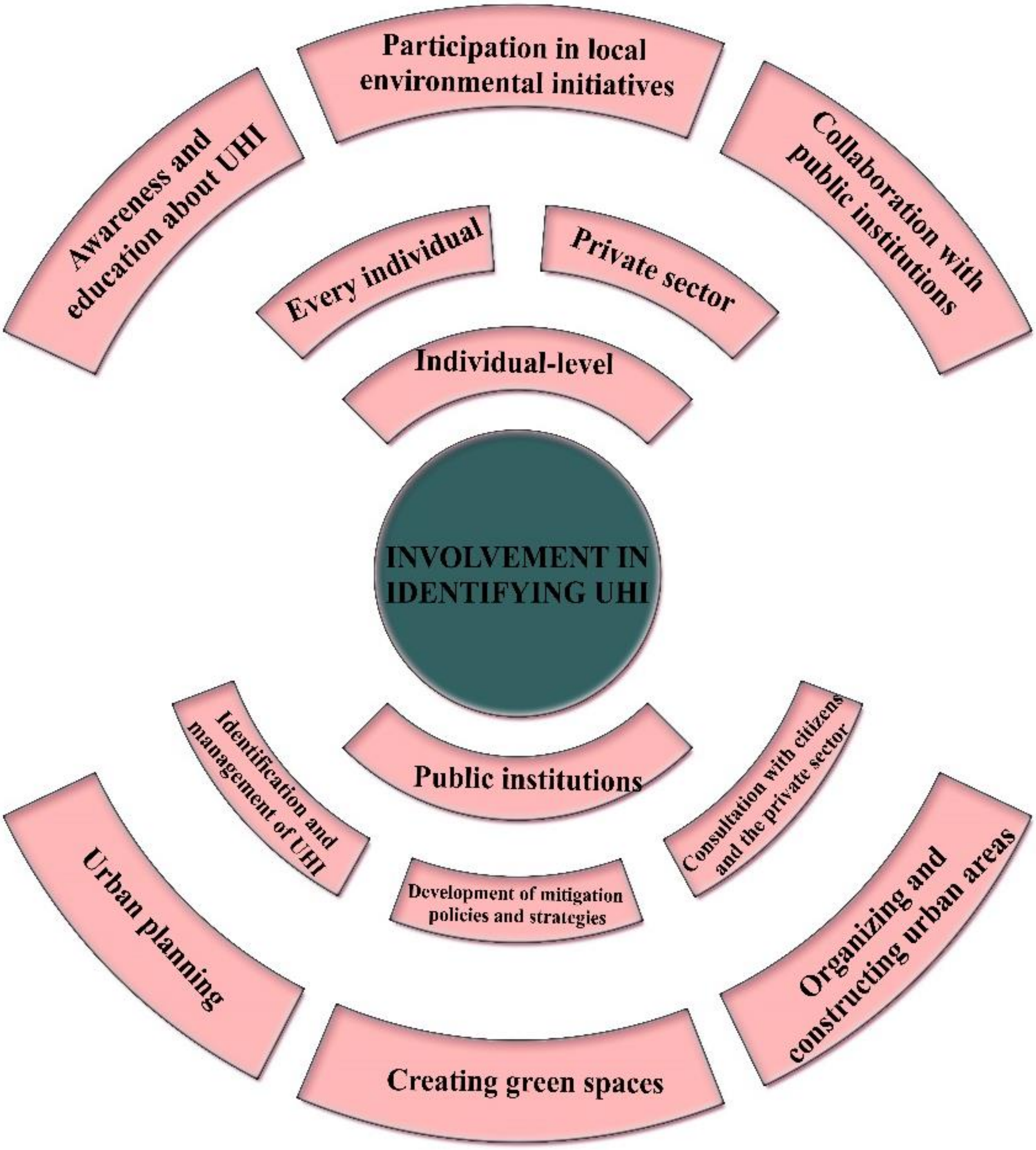

Figure 20 General framework that summarizes the importance of community and institutional collaboration in managing the urban heat island.

DATA REQUEST

Following the meeting in September, a document was created identifying the data providers as well as the necessary data.

Table 2 Resources

TECHNICAL RESOURCES		
Name of the institution/service that can provide data/information	**Type of data and information**	**Comments:** - Time interval - Format (Dwg, Gis, Xls, etc.)
URBAN PLANNING DEPARTMENT	• Built and developed area • Street canyon ratio • Permeable/impermeable surfaces • Land use • Traffic study of the Municipality of Galați	• DWG/CAD/SHP format • GIS format • XLS format • The information will be organized by neighborhoods. • Year 2023 • Year 2022
GREEN SPACES REGISTER	• Green space area • Tree canopy area	• DWG/CAD/SHP format • GIS format • XLS format • The information will be organized by neighborhoods. • Year 2023
STATISTICS INSTITUTE	• Population density of the Municipality of Galați per km² • Proportion of children under 5 years old in the total population • Proportion of people over 65 years old in the total population • Proportion of people living below the at-risk poverty threshold in the total population • Proportion of unemployed people in the total population • Proportion of women in the total population • Proportion of immigrants in the total population	• XLS format • Charts • The information will be organized by neighborhoods. • Year 2023

	• Proportion of people with low-skilled jobs in the employed population • Proportion of people living in social housing in the total population • Proportion of people with diseases such as diabetes, asthma, hypertension, obesity in the total population • Proportion of people receiving Disability Benefits for Adults (ADB) in the total population • Proportion of people receiving mental health services in the total population • Proportion of deaths in one year compared to the total population • Number of hospital beds per 1,000 inhabitants • Number of healthcare institutions of all types (private or public) per 1,000 inhabitants • Number of nursing homes • Number of social housing units	
GALAȚI ENVIRONMENTAL PROTECTION AGENCY	• Air temperature during the day and night • Surface temperature during the day and night • Solar radiation • Humidity • Wind speed and direction • Precipitation • Studies with and about temperature measurements in urban areas (Galați) and rural areas (any locality)	• Information structured by neighborhoods or maps in CAD/GIS/SHP format to extract data by neighborhoods, both for day and night • Period 2018-2023 • Night average and day average • Average for day/month period • Average for night/month period

URBAN TRANSPORT	• Energy consumption of transport - the amount of energy consumed by transport vehicles.	• Statistics on used/travelled streets/arteries
NATIONAL AGENCY FOR CADASTRE AND LAND REGISTRATION	• Energy consumption of buildings • Built and developed area • Land use	• Statistics organized by neighborhoods with information from energy performance certificates • GIS/SHP maps with this information

OBTAINING SATELLITE DATA

Since some information cannot be extracted from the data requested from public entities, it is necessary to obtain it from satellite data.

The tools in the methodology require the collection of satellite data. To extract the data, it is necessary to identify the filters and bands that must be applied to obtain the relevant information in this case.

From the research conducted, for example, to calculate albedo, it is necessary to:

- Choose the satellite;
- Select the type of satellite from those available (e.g., Landsat 8 or 9);
- Apply additional criteria, such as the day or night indicator.

Satellite images are generated, which can be downloaded, with each image being specific to a band. These images must be added into a GIS program. To convert the satellite images, a formula involving bands 2, 4, 5, 6, and 7, as well as solar elevation, will be used within the GIS program.

After applying the formula (for which the complete source of the necessary information has not yet been identified), a color palette image is generated. This image can be used for interpreting and analyzing data related to the urban heat island.

CHALLENGES

The challenges consist of:

1. **Obtaining data from local and national providers**

- Access to easily usable data and converting it into GIS or CAD format for map creation is limited.

2. **Lack of specialists in satellite image processing**

- Extracting and processing satellite images in GIS format is difficult due to the lack of experts with the necessary knowledge about:
- The spectral bands that need to be used;
- The formulas and specific methods to obtain the final image or thematic maps.

3. **Technical complexity**

- Using satellite data requires advanced technical knowledge to select the correct filters and bands, as well as applying relevant formulas in GIS programs.

4. **Processing satellite data**

- The process involves a series of complex technical steps, and the lack of experience with GIS platforms and tools further complicates these tasks.
- Processing satellite data requires specialized software (e.g., QGIS, ArcGIS) and sufficient computational resources, which are not always available.

5. **Insufficient documentation**

▪ The lack of a clear or accessible source for all the formulas and necessary steps (e.g., the formula for calculating albedo and/or emissivity) makes the analysis process difficult and can lead to incomplete results.

6. **Managing large volumes of data**

▪ Downloading and managing satellite images, each corresponding to different bands, can become overwhelming, especially for large urban areas or extended temporal analyses.

IDENTIFICATION OF NEEDS

By analyzing the type of data we can obtain, we have realized that we will not be able to obtain data for the following indicators, which are very important for identifying the Urban Heat Island (UHI):

- Surface temperature during the day and night
- Solar radiation
- Humidity
- Percentage of tree canopy coverage
- Vegetative coverage

These indicators are essential for a detailed evaluation of the urban heat island phenomenon, and the lack of precise and up-to-date data can hinder the analysis and the implementation of effective management measures.

Start of the development of the local UHI self-assessment report:

The initial phase involved identifying and requesting relevant datasets from key stakeholders and public institutions. Letters were sent to entities such as the Environmental Protection Agency of Galați, the Urban Planning Department, and the Regional Meteorological Center, requesting climate data from 2018-2023, including: Air and surface temperatures (day and night averages), Solar radiation, Wind speed and direction, Precipitation levels, Urban planning statistics (e.g., permeable/impermeable surfaces, land use, green spaces, and tree canopy coverage). Meetings with representatives of Galati Municipality departments were organized to discuss data availability. The team engaged with the external experts contracted for the risk asssesment report and facilitated data collection process. Self-assessment tools for UHI vulnerability indicators (exposure, sensitivity, preparedness, adaptive capacity) were integrated into the ongoing evaluation.

TIMELINE OF THE PROCESS

Table 3 Timeline of the process

Phase	Activity	Timeframe	Stakeholders Involved
Preparatory Phase	Develop the preparatory plan	February - March 2024	Local autthorities, external experts
Stakeholder Identification	Identify key stakeholders and engage them	April - June 2024	Municipality, public institutions, NGOs, businesses, academia

Logistical workshop arrangements	Prepare internal documents, acquire necessary logistical workshop organization services, secure venue and send workshop invitations.	July - September 2024	Internal tean, service providers, all stakeholders
Workshop and coalition-building	Conduct workshop and facilitate discussions; Draft Local Coalition Pact	September 2024	Relevant stakeholders
Pact finalization	Finalize and sign Local Coalition Pact	November 2024	All stakeholders
Data collection and analysis	Gather climate and urban data from public sources and relevant stakeholders	July - December 2024	Relevant stakeholders Public institutions External experts

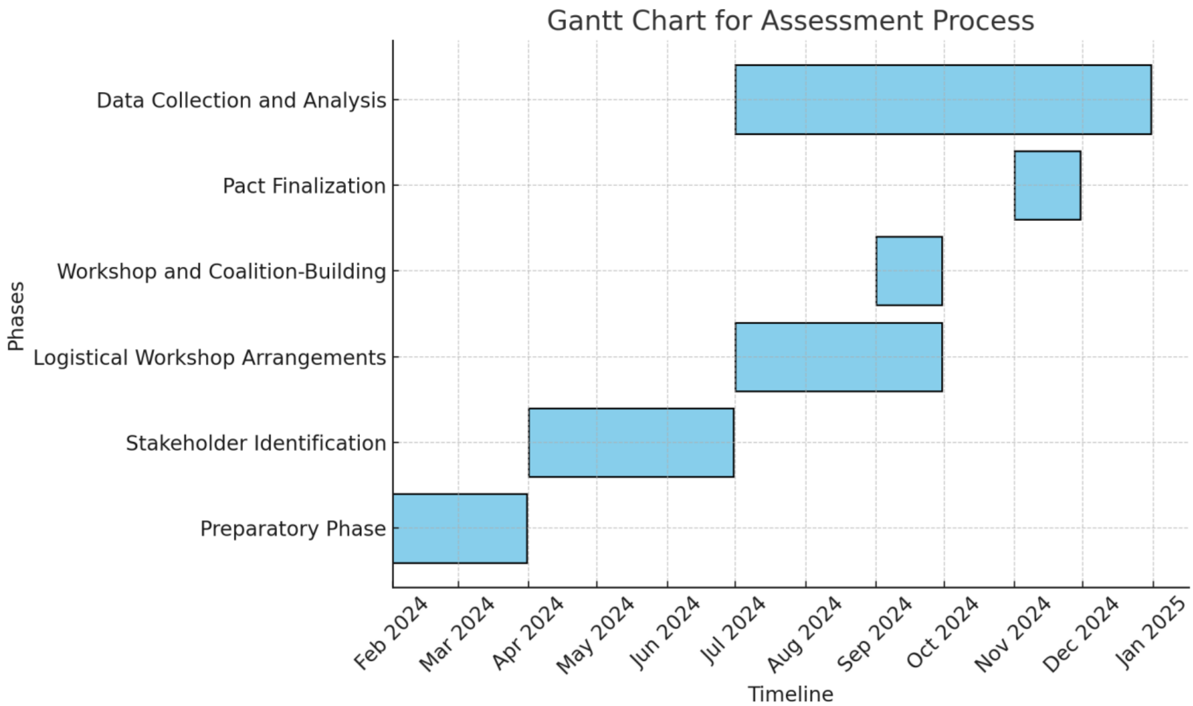

Chart 1 Gantt chart

3. Urban climate

GENERAL INFORMATION ABOUT URBAN CLIMATE TRENDS

Air Temperature

Taking the year 1979 as a reference, the average temperature reached a maximum value of 13.6°C, with an anomaly of 2.2°C. This observation leads to a clear conclusion: global warming is also affecting the climate of Galați. From 1979 to 2023, the average temperature has increased by 2.4°C.

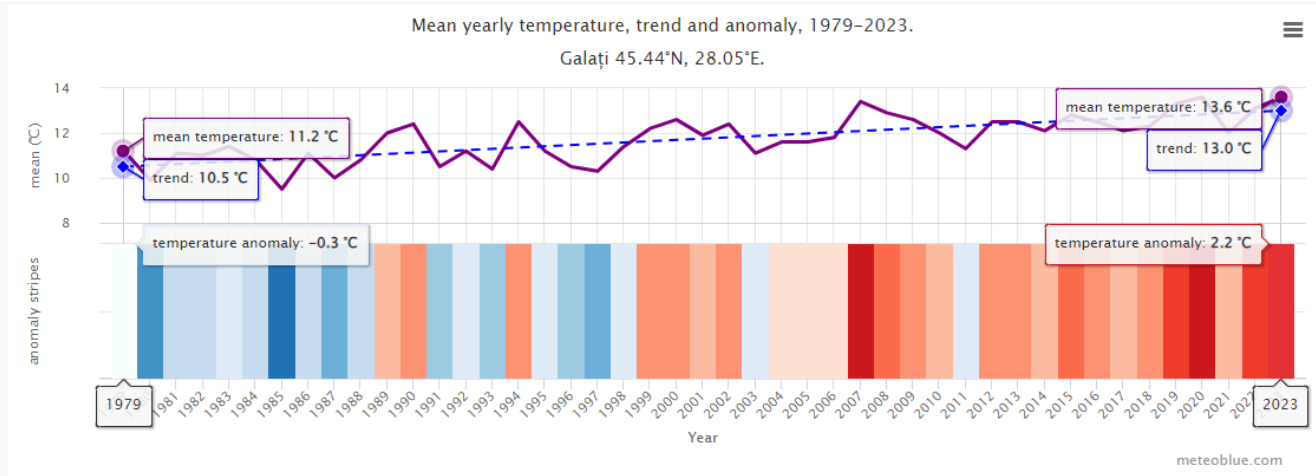

Figure 22 Evolution of the average temperature in the Municipality of Galați
Source: https://www.meteoblue.com/ro/climate-change/galați_românia_677697

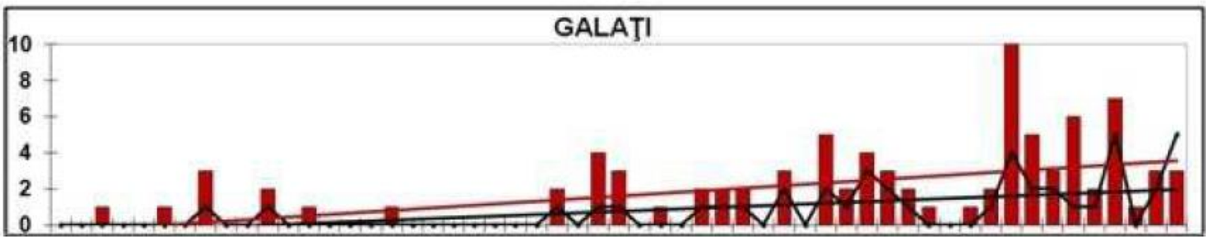

Figure 21 Variation of extremely hot consecutive days intervals (1961-2015): 1. maximum duration of intervals; 2. total number of intervals; 3. linear evolution of maximum duration; 4. linear evolution of the total number of intervals. . Source: Extreme heating in cities of the romanian plain. certainties and uncertainties about the factors of influence, Annals of the University of Bucharest – Geography Series · November 2020

The absolute maximum values extracted from the entire period (1961-2015) exceed 40˚C threshold.

Surface Temperature

The proximity of the aquatic surfaces (rivers and lakes) moderates the incidence of the extreme heat. Urbanized areas (red/purple) correspond with higher temperatures, confirming the urban heat island effect (UHI). Water bodies (blue) exhibit the lowest temperatures, due to their high heat capacity and evaporative cooling effect.

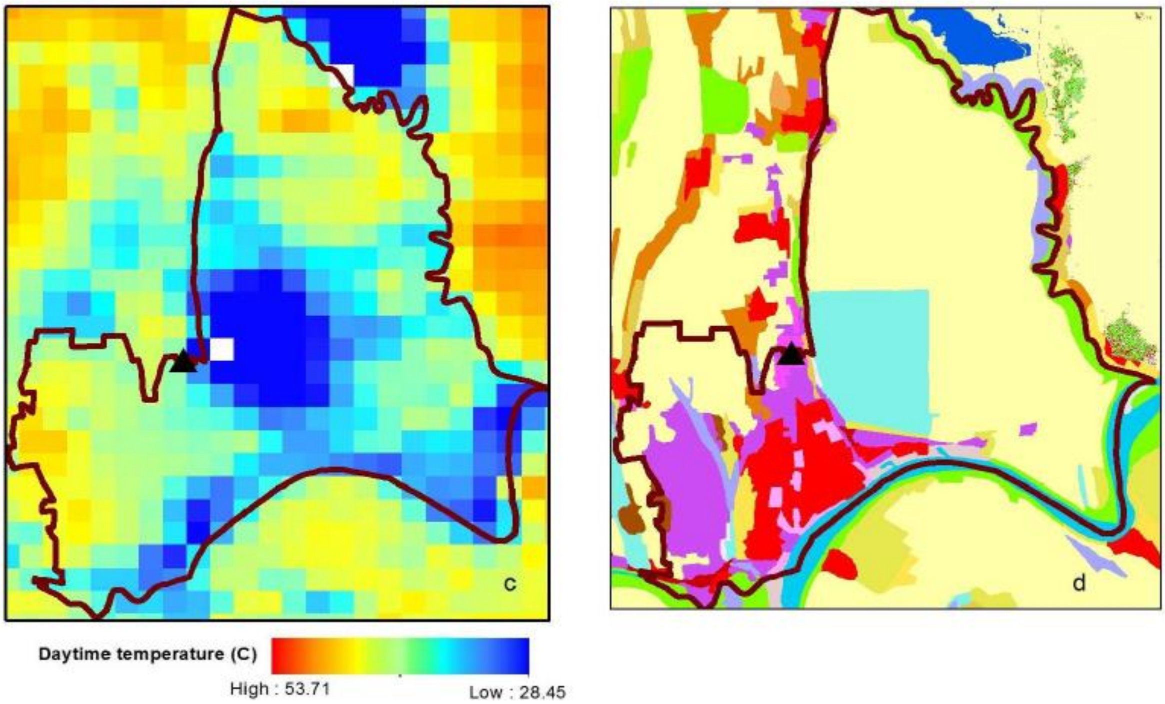

Figure 25 LST data for spatial variation of the temperature and distribution of the different types of surfaces. Source: Extreme heating in cities of the romanian plain. certainties and uncertainties about the factors of influence, Annals of the University of Bucharest – Geography Series · November 2020

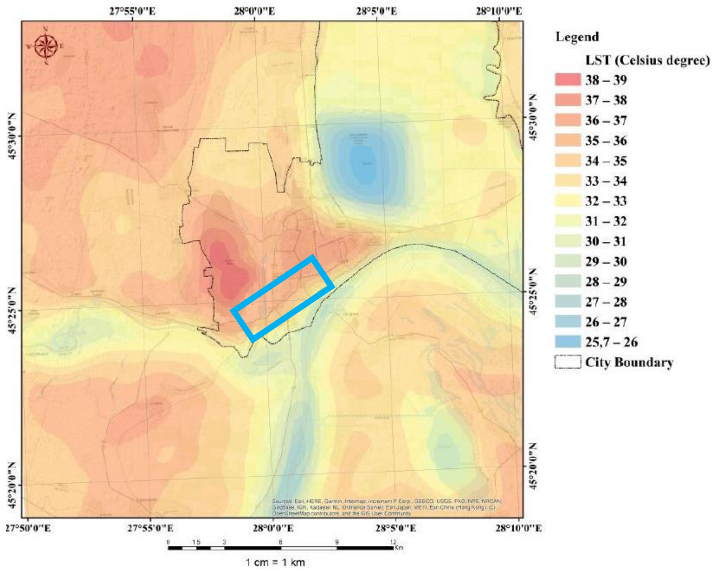

Figure 24 Summer daytime mean LST values (°C) in Galați city region. Source: Summer urban heat island of Galați city (Romania) detected using satellite products, https://www.researchgate.net/, 2020

Figure 24 Studied area. Summer daytime mean LST values (°C) in Galați city region. Source: Summer urban heat island of Galați city (Romania) detected using satellite products, https://www.researchgate.net/, 2020

The zoomed-in section (blue rectangle) in the images above represents an area with relatively high temperatures (35-36°C) based on the color gradient.

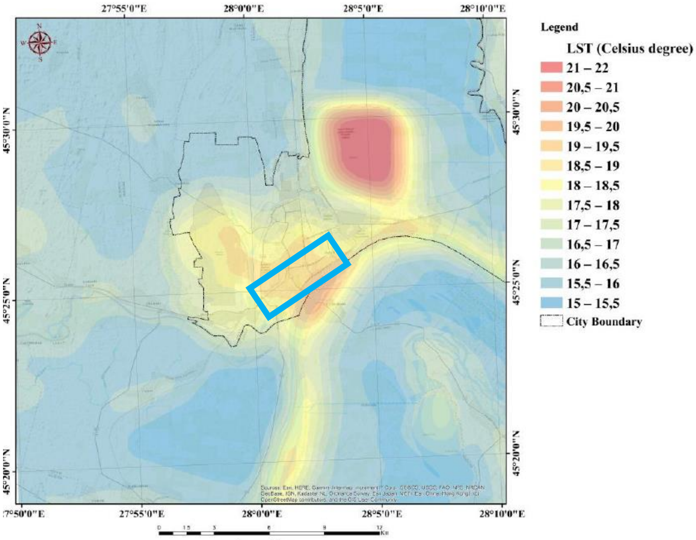

Figure 27 Summer nighttime mean LST values (°C) in Galați city region.Source: Summer urban heat island of Galați city (Romania) detected using satellite products, https://www.researchgate.net/, 2020

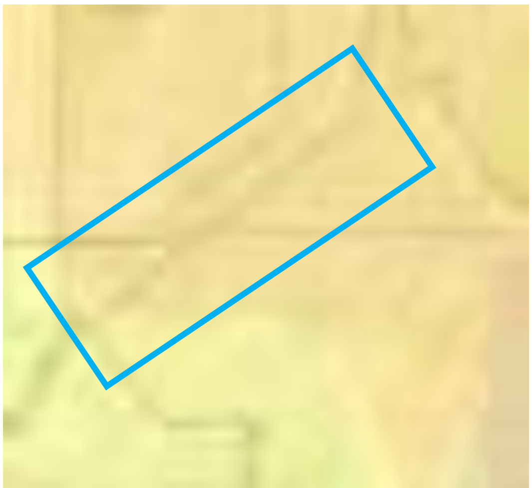

Figure 27 Studied area. Summer nighttime mean LST values (°C) in Galați city region.Source: Summer urban heat island of Galați city (Romania) detected using satellite products, https://www.researchgate.net/, 2020

The zoomed-in section (blue rectangle) in the images above highlights a specific area within the city, showing moderate nighttime temperatures based on its yellow shading.

The LST in this region is lower than the city center but still remains above the surrounding natural areas. Average LST within Galati urban area may reach 19-21°C for nighttime observations, compared with 15-17°C in the bordering areas.

If during the day the presence of water in the studied area of the Danube has a cooling effect, at night it has a warming effect.

The warmer Danube waters from the vicinity of the city represent a result of the low mixing of waters of Siret and Danube after their confluence, but also of the Danube riverbed morphology.

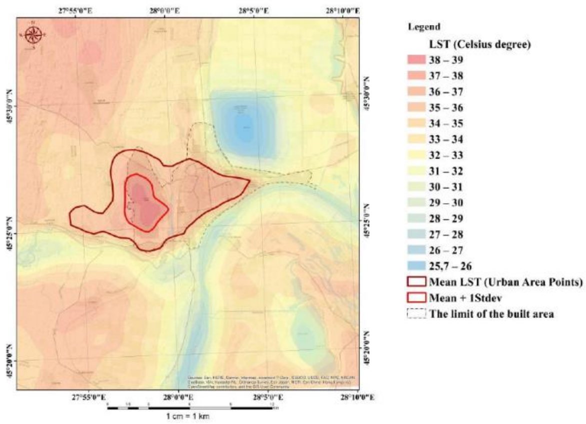

Figure 29 Daytime UHI limits. Source: Summer urban heat island of Galați city (Romania) detected using satellite products, https://www.researchgate.net/, 2020

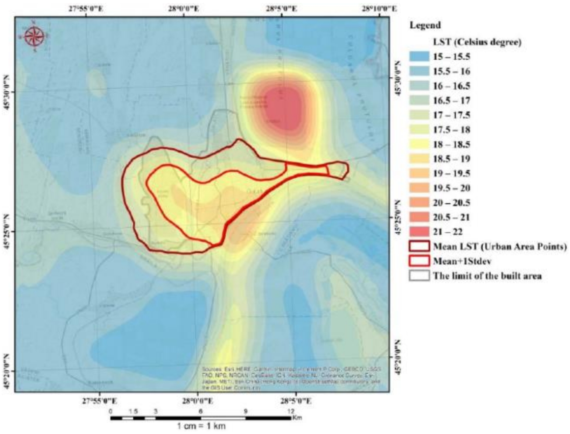

Figure 29 UHI limits (nighttime) Source: Summer urban heat island of Galați city (Romania) detected using satellite products, https://www.researchgate.net/, 2020

Therefore, as a direct consequence of this complex hydrological process we can consider that the Galați UHI, located near the Danube, is fuelled by the warmer air over the Danube during the summer nights.

Solar Radiation

According to the Fundamental study on the protection and conservation of the natural environment, natural and anthropogenic risks, carried out for the Urban Planning Documentation Update – General Urban Plan of the Municipality of Galați in November 2023 by DANIAS SRL regarding solar radiation, it ranges between 117 and 125 kcal/cm²/year, while the sunshine duration is between 2000 and 2150 hours per year.

In the first image below, we can observe that the radiation in Galati varies within two ranges: 300–350 W/m² and 350–400 W/m². The studied area falls within the 300–350 W/m² range.

Figure 30 Radiation in Municipality of Galati. Source https://www.meteoblue.com/ro/vreme/h%C4%83r%C8%9Bi/gala%c8%9bi_rom%c3%a2nia_677697#coords=13.01/45.43302/28.04061&map=solarIradiation~hourly~auto~sfc~none

Figure 31 Radiation in the studied area. Source https://www.meteoblue.com/ro/vreme/h%C4%83r%C8%9Bi/gala%c8%9bi_rom%c3%a2nia_677697#coords=13.01/45.43302/28.04061&map=solarIradiation~hourly~auto~sfc~none

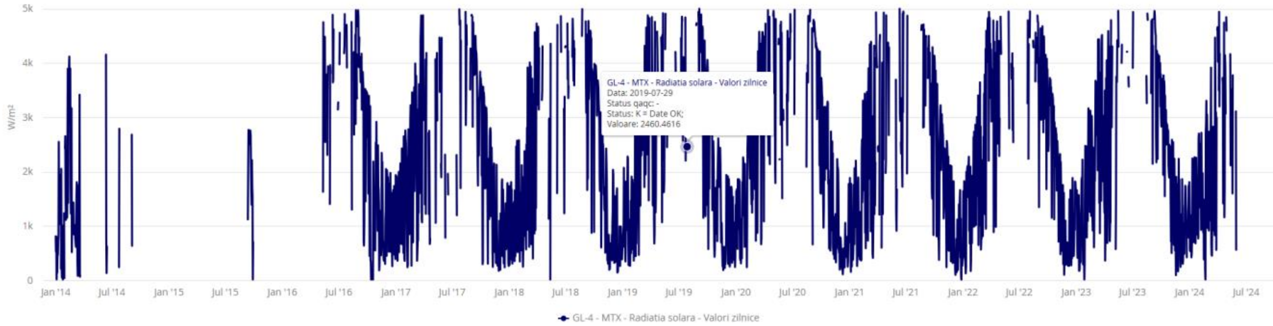

Figure 32 Solar Radiations, Daily values. 2014-2024. Source: https://www.calitateaer.ro/public/monitoring-page/reports-reports-page/?__locale=ro

Humidity

In the graph bellow humidity appears to be higher in the colder months and lower during the warmer months. Relative humidity is at its highest levels, consistently above 70-80%.

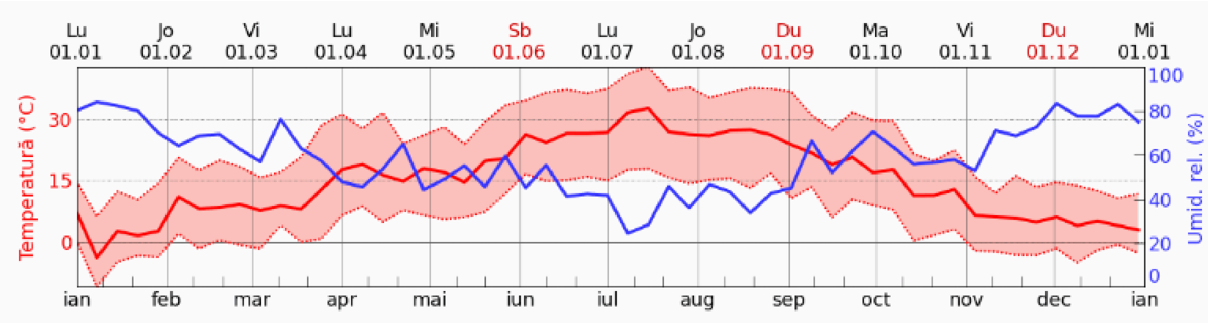

Figure 33 Temperature and Relativ humidity for 2024. Source https://www.meteoblue.com/ro/vreme/historyclimate/weatherarchive/gala%c8%9bi_rom%c3%a2nia_677697?fcstlength=1y&year=2024&month=1

Winter (January - February, December):

Relative humidity trend is high, remaining above 80%, particularly in January and December. During winter, low temperatures (below 5°C, often near 0°C) coincide with high humidity levels. This is typical because cold air has a lower capacity to hold moisture, so it often becomes saturated, leading to high relative humidity. The blue line is relatively stable, indicating fewer fluctuations in relative humidity.

Spring (March - May):

Relative humidity trend is graduayl declining, starting from around 70-80% in March to approximately 60-70% in May. Rising temperatures (from around 10°C in March to over 20°C in May) correspond to decreasing humidity. This is because warmer air can hold more moisture, so relative humidity drops even if the absolute moisture content remains similar.

Summer (June - August)

Relative humidity hrend drops. The values observed are typically below 60% and occasionally dropping near 50% in July and August. This coincides with the highest temperatures of the year (30-35°C). The heat causes significant drying, leading to lower relative humidity. While some days may be slightly humid, most are dry due to the high temperatures.

Autumn (September - November):

Relative humidity trend increases gradually from 60% in September to around 70-80% in November. Cooling temperatures (from 20°C in September to around 10°C in November) allow for a gradual rise in relative humidity. Moderate fluctuations are visible, particularly in September and October, reflecting the transitional nature of the season.

Lowest Humidity: July and August (50-60%), correlating with the hottest temperatures.

Highest Humidity: December and January (80-90%), coinciding with the coldest temperatures.

Stability: Winter months show the most consistent humidity levels, while summer and early autumn show greater variability.

In the graph below we can observe that the relative humidity shows fluctuations across the

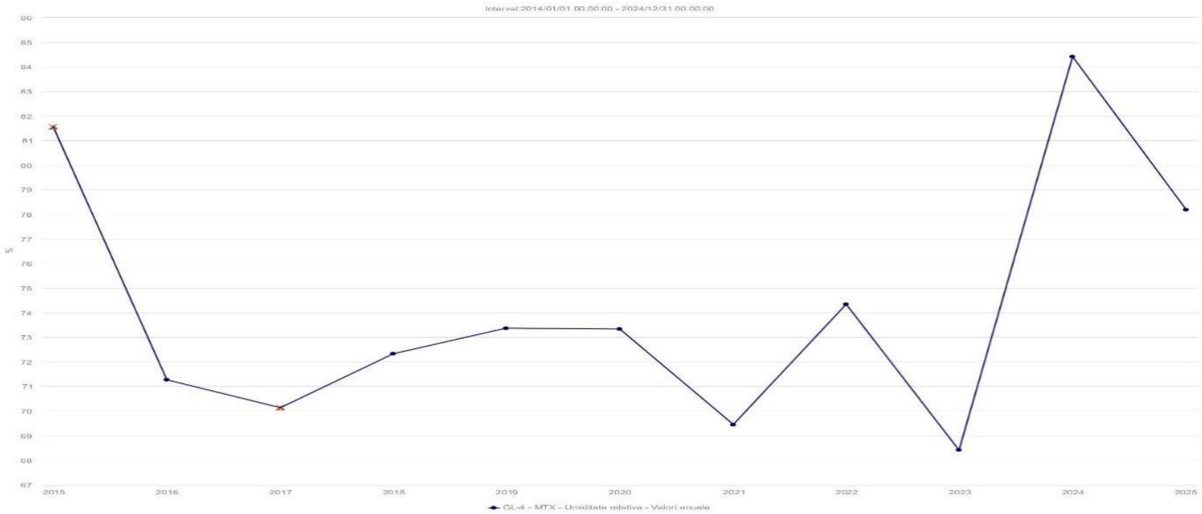

Figure 34 Relativ humidity 2015-2024. Source: https://www.calitateaer.ro/public/monitoring-page/reports-reports-page/?__locale=ro

years rather than a clear increasing or decreasing trend. There are notable **peaks and dips** that indicate significant variations in average relative humidity levels for certain years.

Significant Changes:

- 2015 to 2016: A sharp decline in relative humidity, dropping from a higher starting value (around 80% or above) to below 70%.
- 2017 to 2020: Relative humidity remains relatively stable, fluctuating slightly but staying within a range of approximately 70-75%.
- 2021: A significant dip is visible, marking one of the lowest points in the series, possibly dropping below 70%.
- 2023: A dramatic rise in relative humidity, reaching its highest value across the observed period (likely over 80%).
- 2024: A slight decrease following the 2023 peak, but the value remains higher than most other years in the dataset.

The graph suggests certain years (e.g., 2023) experienced much higher relative humidity compared to adjacent years. These variations might reflect changes in weather patterns, climate influences, or regional factors affecting moisture levels.

Wind Speed and Direction

Galați is situated in a morphological setting bordered by orographic structures, with the built-up area lying on gently sloping terrain at an altitude of 10 meters. The main morphological specifications influenced by low-altitude air currents are defined by the openness of the Danube Valley, which allows the greatest capacity for air mass transport directly over the urban area of the municipality, as well as by the valley of the Danube.

The proximity of the city of **Galați** to the southeast, near the Danube Valley, can have either a constructive or destructive effect on the speed of air mass movement, depending on the direction of flow. The plateau of **Galați** is positioned near the convergence zone of two significant wind corridors: the Danube Valley and the Prut Valley.

The predominant wind is the **Crivăț**, which accounts for 29% of the annual wind frequency. The second most common wind is the **Austrul**, coming from the south, with a frequency of 16%. It blows mostly during the summer and is relatively dry. Another less-known wind in the region, called the **Bălțăreț**, brings rain, while the **Coșava** is even less familiar.

The highest wind speeds are recorded in March, while the lowest occur in August. It is noticeable that wind speeds decrease during the summer and increase again during the colder months. The annual average wind speed during the studied period is 4.14 m/s.

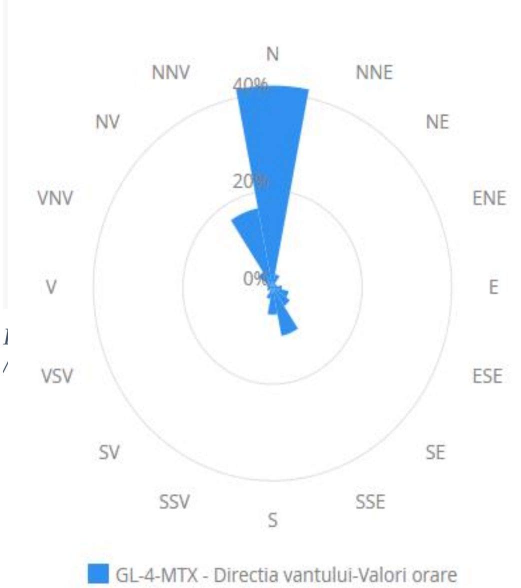

Figure 37 Wind directions. Hourly values between 2014-2024. Source: www.calitateaer.ro

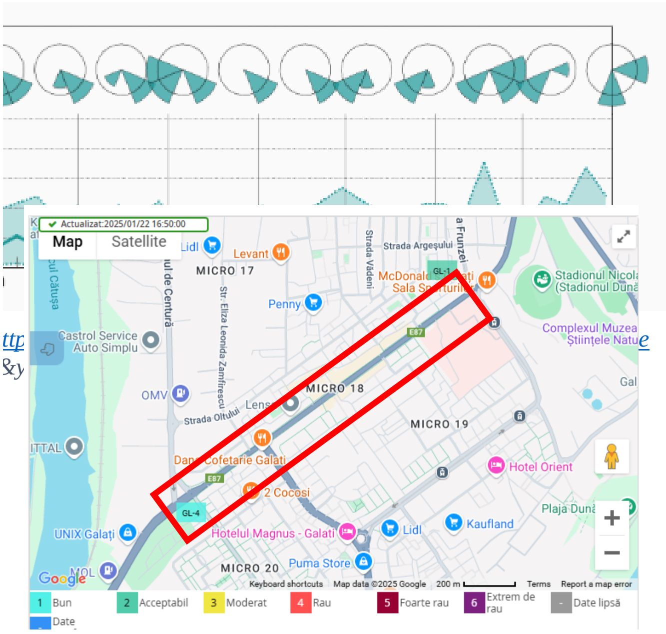

Figure 37 Studied area and localization of GL4 measuring point

According to the hourly records on www.calitateaer.ro for the GL4 point, the distribution of wind direction (%) for the period: 2013/12/31 24:00:00 - 2025/01/22 16:49:00 is as follows: 41.78 % N, 16.72% NNV and 10.21 %SSE.

Precipitation

According to the Fundamental study on the protection and conservation of the natural environment, natural and anthropogenic risks, carried out for the Urban Planning Documentation Update – General Urban Plan of the Municipality of Galați in November 2023 by DANIAS SRL the average annual precipitation amounts range from 400 to 550 mm, with an average of approximately 442.6 mm. Their distribution is very irregular, with alternating rainy and dry periods, and a high frequency of torrential rains, which is reflected in the rate and intensity of slope processes.

Based on historical data the precipitation trend in the Municipality of Galați is decreasing:

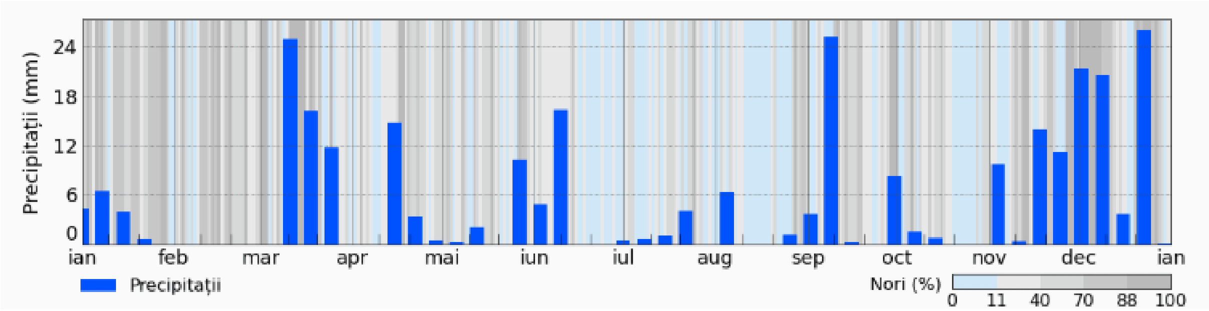

Figure 38 Precipitations(mm) for 2024. Source: https://www.meteoblue.com/ro/vreme/historyclimate/weatherarchive/gala%c8%9bi_rom%c3%a2nia_677697?fcstlength=1y&year=2024&month=1

In the following graph, temperature anomalies and fluctuations are distinctly highlighted, as well as the precipitation anomalies. Thus, the warmer periods are shown in red, and the cooler periods are shown in blue compared to the normal. Since, over the years, warmer periods have been increasing, this reflects global warming associated with climate change. Analyzing the driest year, namely 1996, June, when the lowest level of average precipitation was recorded with an

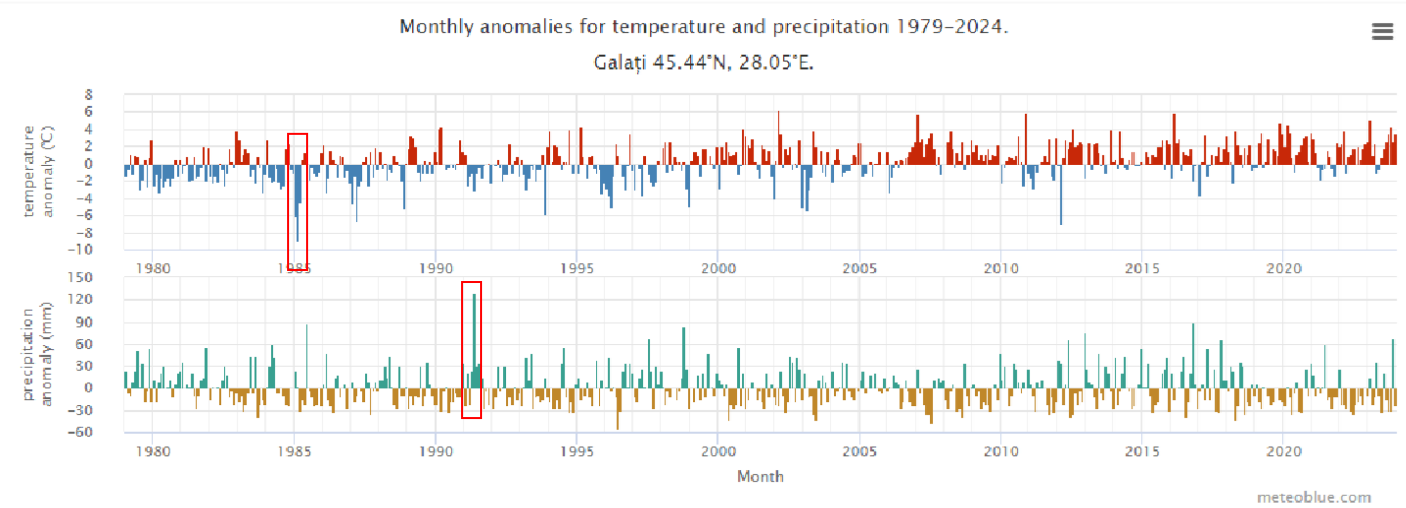

Figure 39 Monthly Temperature and Precipitation Anomalies - Climate Change Galați
Source: https://www.meteoblue.com/ro/climate-change/galați_românia_677697

anomaly of -54.0 mm compared to the 1979-2024 climate average, and the wettest month, May 1991, when the anomaly reached a value of +129.

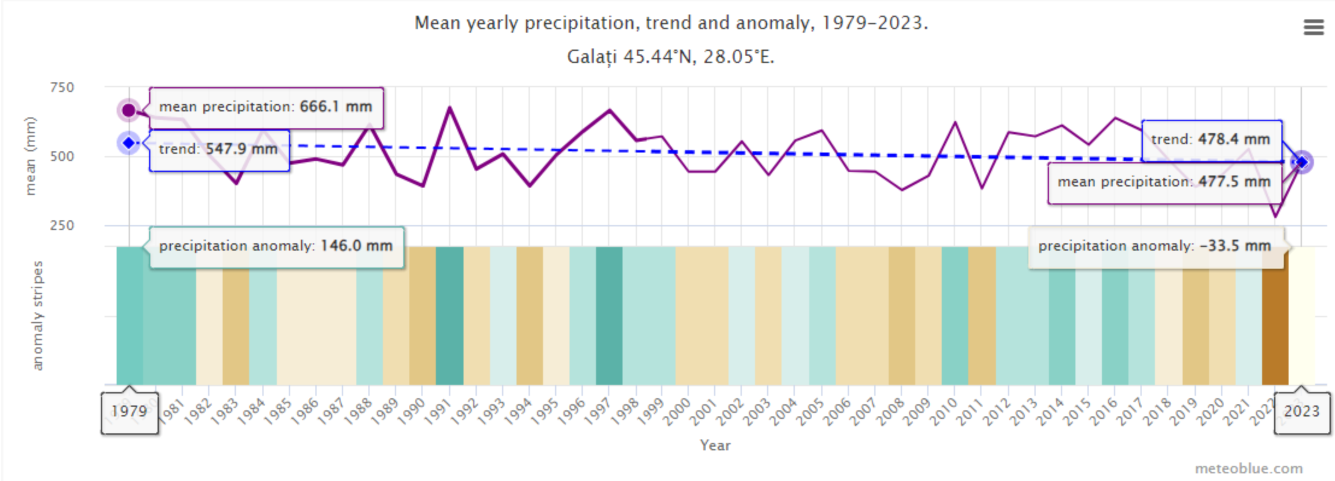

Figure 40 Annual variation of precipitation – Municipality of Galați 1979-2023
Source: https://www.meteoblue.com/ro/climate-change/galați_românia_677697

In the graph above, temperature anomalies for each month from 1980 to the present are represented. The anomaly indicates how much warmer or cooler each month was compared to the climate average for the 30-year reference period (1980-2010). Months shown in red were warmer, while those shown in blue were cooler than the climate average. An important observation is that most of the recent months are shown in red, indicating an increase in warmer temperatures over time, which reflects global warming associated with climate change. Regarding precipitation amounts, periods with fewer precipitation than the climate average are highlighted in brown, while periods with more precipitation are shown in green. This analysis allows for the observation of trends in the distribution of precipitation and can provide insights into local climate changes.

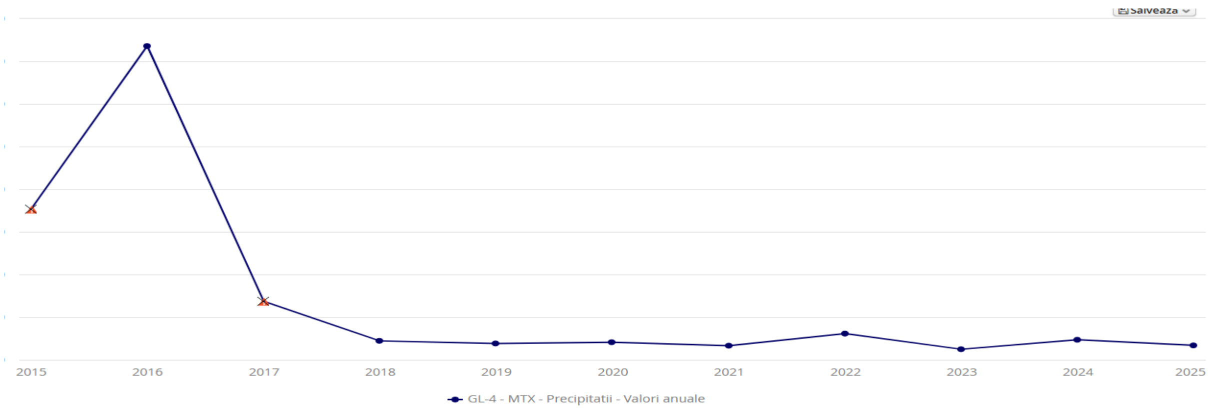

Figure 41 Precipitations 2015-2024. Source: https://www.calitateaer.ro/public/monitoring-page/reports-reports-page/?__locale=ro

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

EXPOSURE OF BUILDINGS AND SURROUNDINGS

Urban morphology/urban form

General description.

The studied area extends from the intersection of Brăilei Street with Dunărea Boulevard to the intersection of Brăilei Street with Frunzei Street and Stadionului Street and represents 0.067% from the total surface of Galati.

Figure 42 The boundary of the studied area – Urban Heat Island. Source: The Urban Planning Service of the Galați City Hall

*The total surface area of the studied zone is **16,3985.73 m^2**, of which:*

- *Green space surface: 16,372.21 **m^2***
- *Roads surface: 63,752.91 **m^2***
- *Pedestrian area surface 39,744.64 **m^2***
- *Building coverage: 44,115.97 **m^2***

The shape of the buildings is rectangular, with the long side oriented towards Brailei Street, forming a compact street front with very few openings in the NNW-SSE direction.

Brailei Street is oriented in the NNE-SSW direction and is located on the second terrace of the city, exceeding an altitude of 40 meters (the modern city).

The orientation of the buildings windows is in the NNE-SSW direction.

*- Windows facing towards the NNE direction would receive **morning sunlight**, which is generally less intense.*

- Windows facing the SSW direction would receive afternoon sunlight, which tends to be more intense, especially during summer months. The SSW orientation could contribute to higher interior temperatures due to more prolonged exposure to the sun, thus contributing to the urban heat island effect.

- Buildings with windows oriented towards the SSW direction tend to experience higher solar heat gain in the afternoon. This is especially true if there are no shades, blinds, or other measures to reduce the direct sunlight entering the building. As a result, the interior temperature may rise, leading to increased cooling demands, particularly during summer months.

- For the apartments with windows facing the SSW direction, depending on the building's insulation and window coverings, this orientation could increase the cooling load in warmer months. It might require more air conditioning or ventilation to keep the interior comfortable.

The distance between the buildings is on average 42 meters. The buildings have a height ranging from 4 meters to 32 meters. This elements may contribuite with airflow and ventilation, shading and solar exposure, radiation, reflectivity.

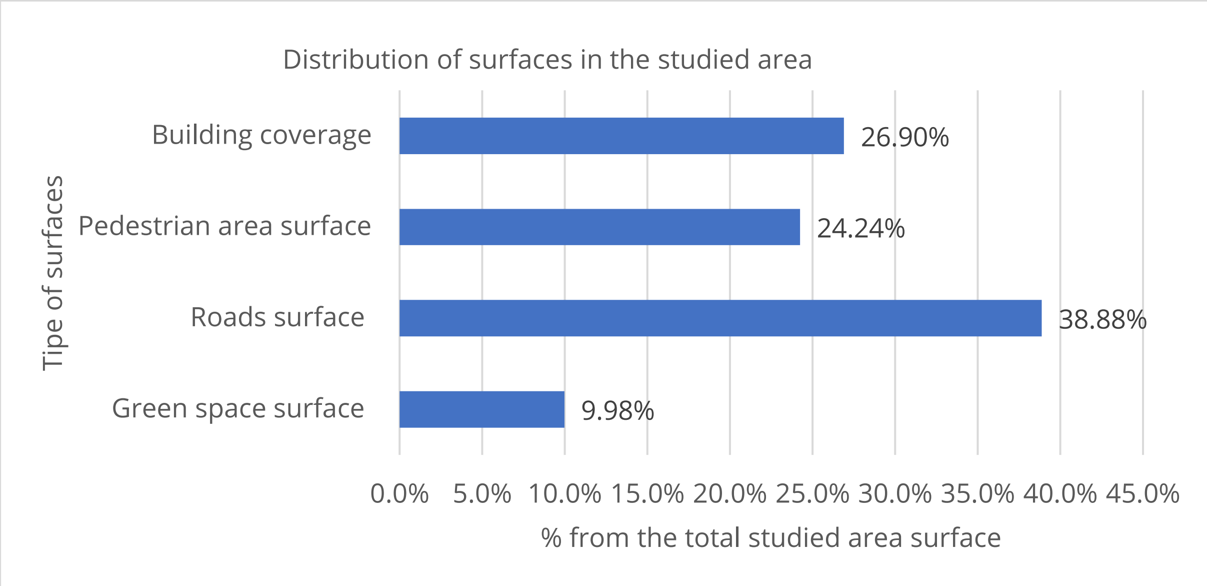

Chart 2 Distribution of surfaces in the studied area

The study area includes buildings with mixed functions, commercial spaces, and service facilities.

The built-up area of buildings in the study zone is approximately ***44,115.97 m²****, with a total developed area of around* ***319,558.12 m²****, distributed as follows:*

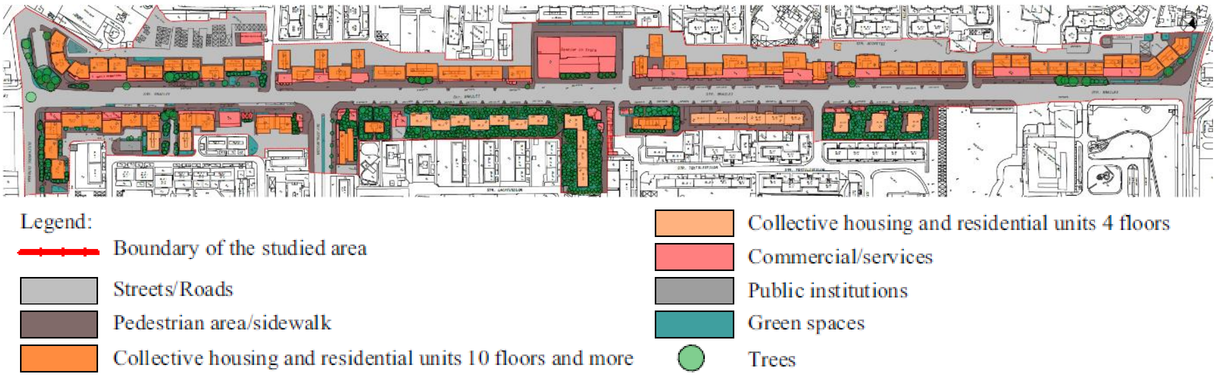

Figure 43 Studied surface

Table 4 Coverage and developed area

Tipe of building/function	*Building coverage area(**m²**)*	*Developed area(**m²**)*
Commercial/services:	13,379.56	27,750.31
Collective housing and residential units:	30,320.19	*291,391.59*
Public institutions:	*416.22*	*416.22*
Total	*44,115.97*	*319,558.12*

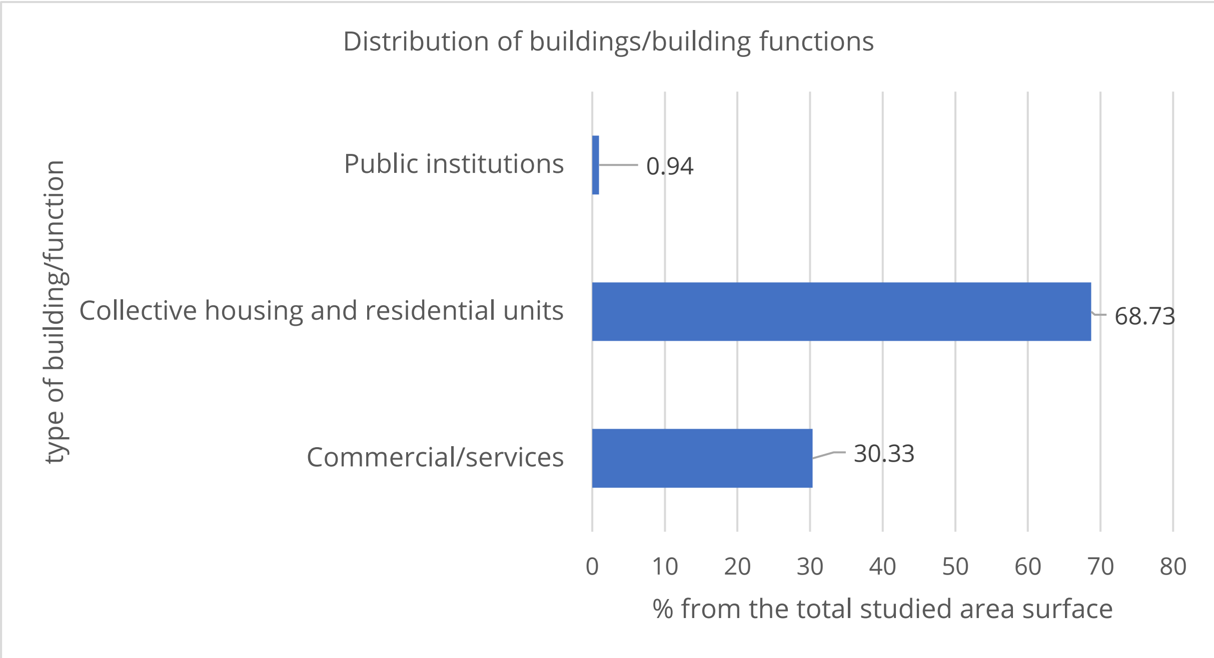

Chart 3 Distribution of buildings.building functions

*Within the study area, **62 apartment blocks** have been identified, comprising:*

- *6 blocks with 4 stories*
- *45 blocks with 10 stories*
- *11 blocks with 11 stories*

*The total number of apartments is **3,489**.*

Figure 44 Map of the construction period of buildings. Source: https://www.hartablocuri.ro/galati/

The buildings were constructed between 1961-1982, after the start of the constructions of the Steel Plant(Steelworks).

The height regime of buildings

The building height regime in the study area varies between a minimum height of 4 meters and a maximum height of 38 meters

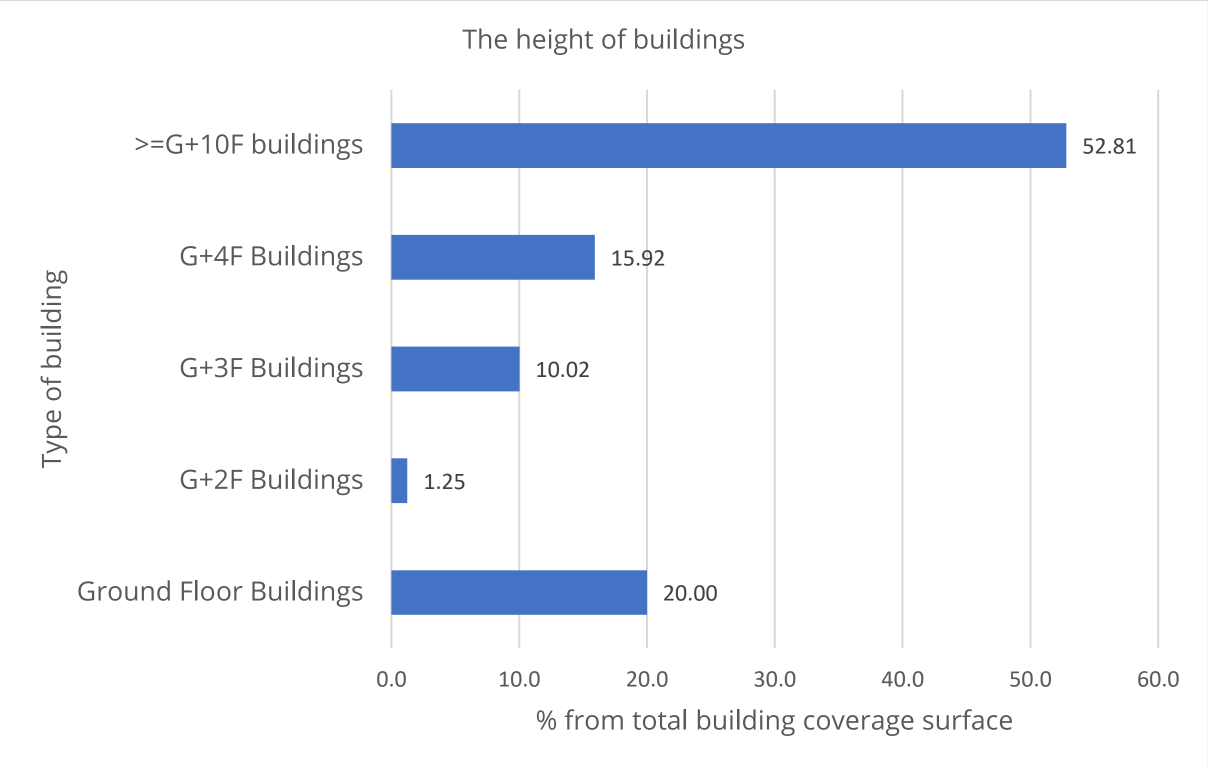

Chart 4 Percent of the height of buildings

From the table above, we can conclude :

- **Buildings with over 10 floors (≥G+10F)** account for **52.81%** of the total built-up area, indicating that these buildings dominate and occupy the largest portion of the built environment.
- **Buildings with 4 floors (G+4F)** represent 15.92%, making them the second most prevalent type in the built-up area.
- **Buildings with 3 floors (G+3F)** cover 10.02% of the total, reflecting a moderate contribution.
- **Buildings with 2 floors (G+2F)** account for only 1.25% of the built-up area, being the least represented category
- **Single-story buildings (Ground Floor Buildings)** make up 20% of the total area, having a significant presence but less than tall buildings
- The chart clearly shows a tendency toward taller buildings, with a dominant proportion (over half) represented by buildings ≥G+10F.
- Low-rise buildings (Ground Floor and G+2F) collectively account for only 21.25% of the total, highlighting a predominantly vertical urbanization.

- Buildings with 4 and 3 floors form a middle category, collectively representing almost 26%, indicating diversity in building types but favoring higher-density constructions.

Urbanization is primarily oriented toward taller buildings (over 10 floors), suggesting an intensive use of space to accommodate a larger population and maximize land utilization.

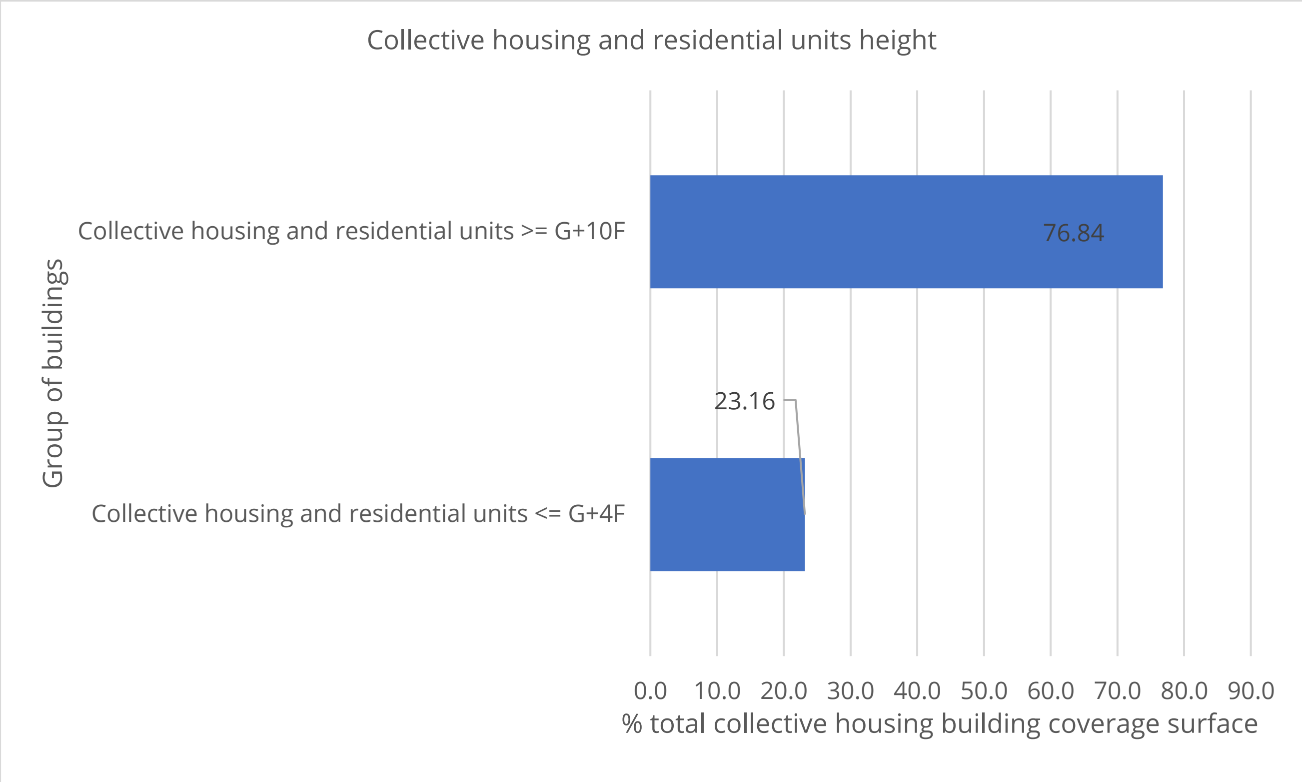

Chart 5 Percentage of different heights of the residential units

The chart presents the distribution of collective housing and residential units based on building height.

- **Collective housing and residential units with ≥G+10 floors** dominates the chart, representing 76.84% of the total collective housing building coverage surface. This indicates a strong preference for high-rise buildings in collective housing.
- **Collective housing and residential units with ≤G+4 floors** account for only 23.16% of the total surface, reflecting a significantly smaller portion of lower-rise collective housing.
- High-rise buildings (≥G+10F) dominate the landscape, making up more than three-quarters of the total, pointing to vertical urbanization.
- Lower-rise buildings (≤G+4F) form a minority, emphasizing a lesser focus on this type of housing.
- The overwhelming presence of ≥G+10F buildings demonstrates an urban environment geared toward high-density residential structures caused by the demand for the need for housing for the workers at Steel Plant(Steelworks).

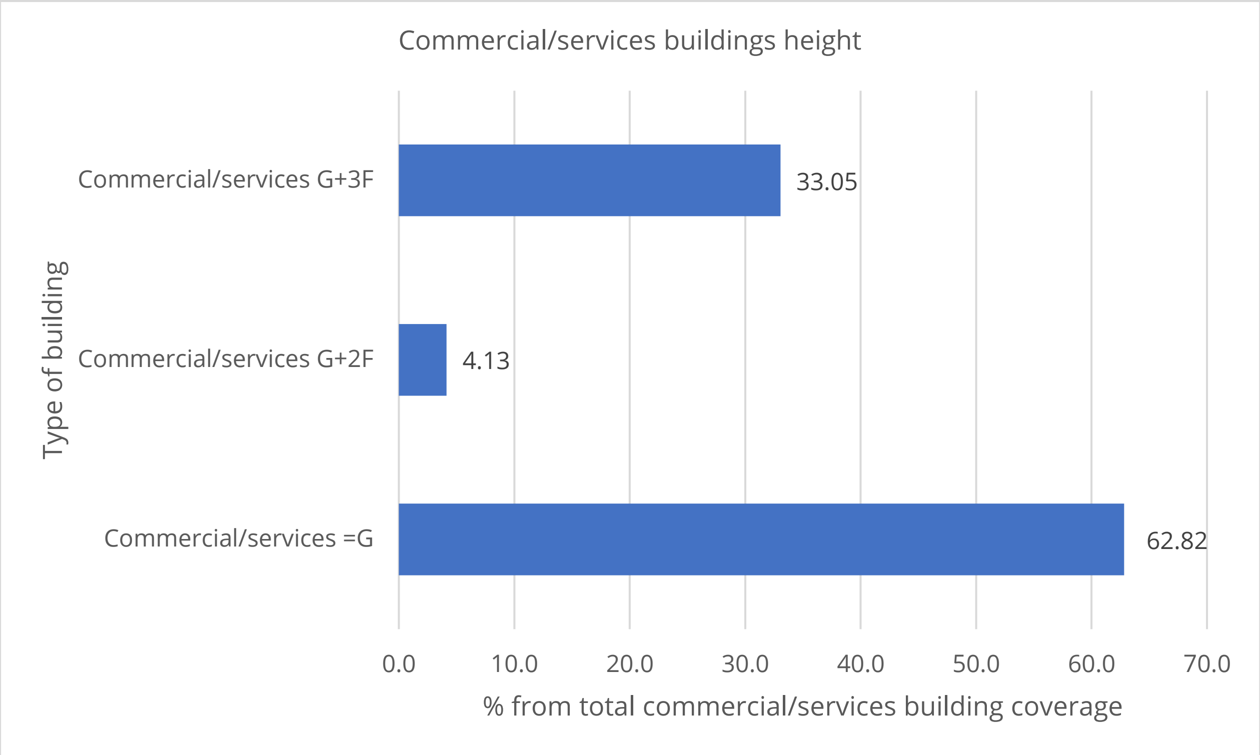

Chart 6 Percentage of different heights of the commercial/service buildings

The chart illustrates the distribution of commercial and service buildings based on height.

- **Ground Floor Commercial/Service Buildings (=G)** account for 62.82% of the total commercial and service building coverage, representing the majority. This indicates that single-floor commercial buildings dominate the landscape, likely due to their practicality and suitability for small businesses or retail spaces.
- **Commercial/Service Buildings with G+3 Floors** representing 33.05%, these buildings form a significant proportion of the total, showing a preference for multi-floor structures that likely accommodate offices or multi-purpose service areas.
- **Commercial/Service Buildings with G+2 Floors** a smaller share at 4.13%, suggesting that two-floor buildings are less common in this category.
- The dominance of ground-floor buildings suggests a focus on easily accessible commercial spaces, particularly for retail or customer-oriented services.
- The significant share of G+3 buildings points to a secondary trend of vertical development for services requiring more space or higher-density usage.
- The minimal percentage of G+2 buildings could indicate a preference for either fully single-floor or taller, multi-floor structures, possibly due to cost-effectiveness or urban design preferences.
- The chart reflects a clear trend favoring low-rise commercial development, particularly ground-floor structures.

- The presence of G+3 buildings adds diversity to the urban landscape, indicating areas where vertical development is used to accommodate more extensive services or businesses.

Limitation of the analysis.

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface. To create the maps, we created a 25x25m grid adapted to the studied area.

For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

Source of data for the assessment:

- *The Urban Planning Service of the Galați City Hall,*
- *https://www.hartablocuri.ro/galati/,*
- *The cadaster of buildings*
- Google earth/maps

Building coverage ratio (BCR)

The studied area has a total surface of 163,985.73 m², out of which the surface occupied by buildings is 44,115.97 m². The percentage ratio between the built-up area and the total area is 26.90%.

Table 5 Building coverage ratio for the total studied area

Total surface area of the studied zone(m^2)	163,985.73
Building coverage (m^2)	44,115.97
Building coverage ratio (BCR) %	26.90

The studied area has a total surface of 163,985.73 m², of which 44,115.97 m² is occupied by buildings. This represents 26.90% of the total area, meaning that a significant portion of the urban land is covered by buildings and infrastructure, which can contribute to the phenomenon of **urban heat island (UHI)**.

Construction materials, such as concrete and asphalt, absorb and store heat during the day. These materials, commonly found in built-up areas, release this heat gradually during the night, leading to higher nighttime temperatures compared to surrounding areas. This phenomenon can create a significant temperature difference between the city and the surrounding regions, affecting the local microclimate.

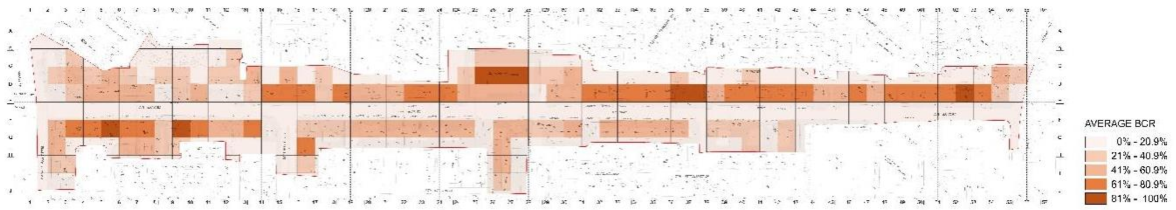

Figure 45 Building coverage ratio for the studied area

Limitation of the analysis:

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For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

Source of data for the assessment:

- *The Urban Planning Service of the Galați City Hall,*
- *The cadaster of buildings*
- Google earth/maps

Floor area ratio (FAR)

The studied area has a total surface of 163,985.73 m², out of which the buildings floor area is 319,558.12m². The percentage ratio between the floor area and the total area is 194.87%.

Table 6 Floor area ratio for the total studied area

Total surface area of the studied zone(m²)	163,985.73
Floor area (m²)	319,558.12
Floor area ratio (FAR) %	194.87

The high percentage ratio reflects intense urban development, characterized by a high density of multi-story buildings. Such density is typical in urban cores or areas with limited available land but a significant demand for residential, commercial, or service spaces. A high floor area density may contribute to the Urban Heat Island effect. The concentration of buildings and reduced green spaces can lead to heat retention and elevated temperatures, especially during the summer months. A high ratio often correlates with limited open spaces for vegetation or recreation. This can negatively impact air quality, water runoff, and the overall livability of the area. Areas with dense building coverage often house a large population or high economic activity, which can lead to increased traffic congestion, higher demand for public services, and stress on infrastructure systems like roads, water, and waste management. Dense vertical development can block natural light and airflow in lower levels of the area, leading to potential discomfort for residents and energy inefficiencies due to higher reliance on artificial lighting and ventilation systems. The high floor area intensifies demand on infrastructure and utilities, such as electricity, water, and sewage systems, requiring robust planning and maintenance to avoid overburdening the systems.

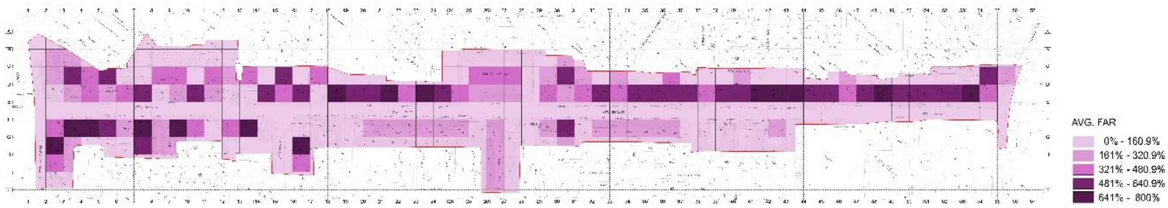


Figure 46 Floor area ratio for the studied area

Limitation of the analysis:

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis. In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface. To create the maps, we created a 25x25m grid adapted to the studied area. For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

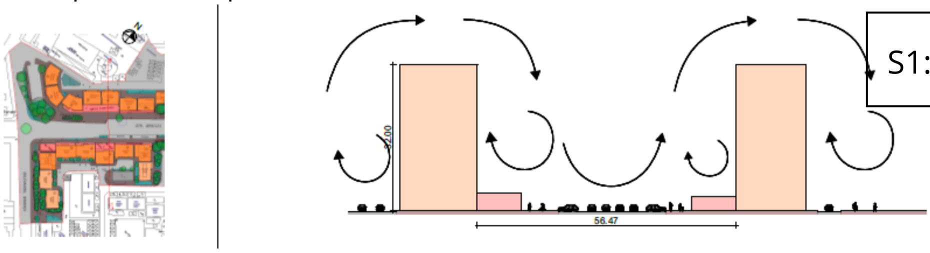
Source of data for the assessment:

- *The Urban Planning Service of the Galați City Hall,*
- *The cadaster of buildings*
- Google earth/maps

Street canyon aspect ratio

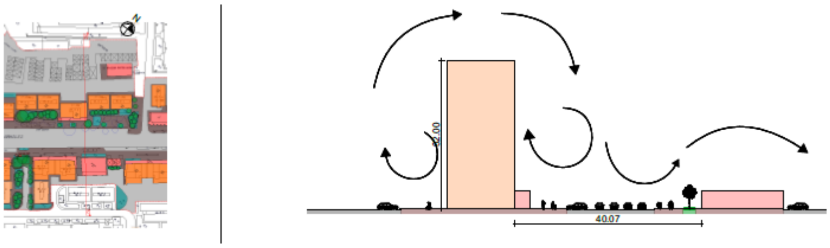
Street canyon is a narrow street with tall buildings along the street on both sides of it. It can be measured as an aspect ratio of average building height along the street and street width.

A street canyon refers to a street flanked by tall buildings on both sides, creating a canyon-like effect. This urban feature is important in studies related to urban planning, air quality, temperature, and pedestrian comfort because it influences airflow, sunlight penetration, and pollutant dispersion.



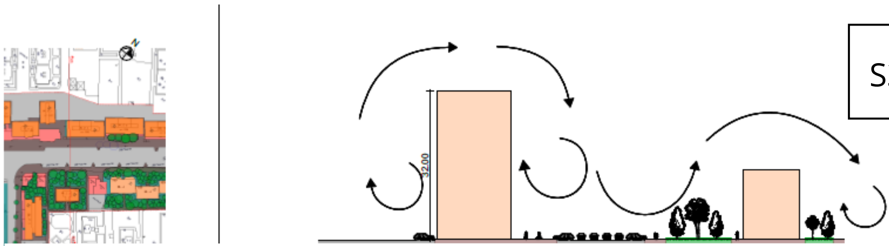
$$S1: \frac{32}{54.47} = 0.57 < 1$$

Figure 47 Street canyon section 1



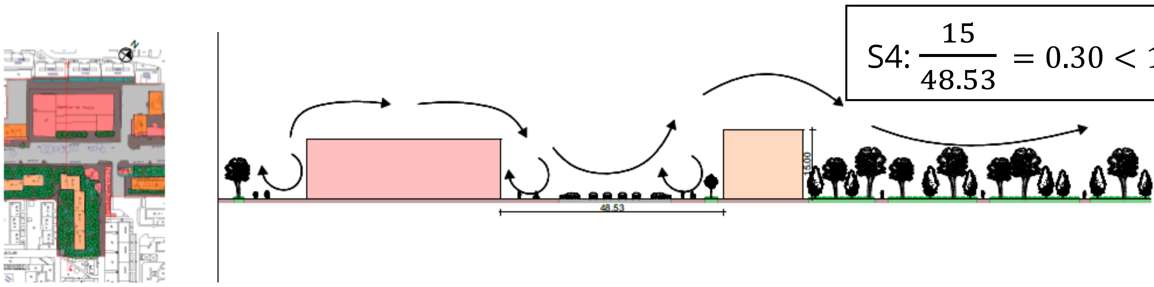
$$S2: \frac{32}{40.07} = 0.70 < 1$$

Figure 48 Street canyon section 2



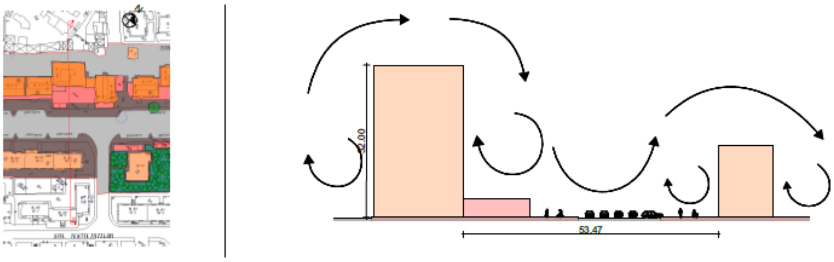
$$S3: \frac{32}{50.59} = 0.63 < 1$$

Figure 49 Street canyon section 3



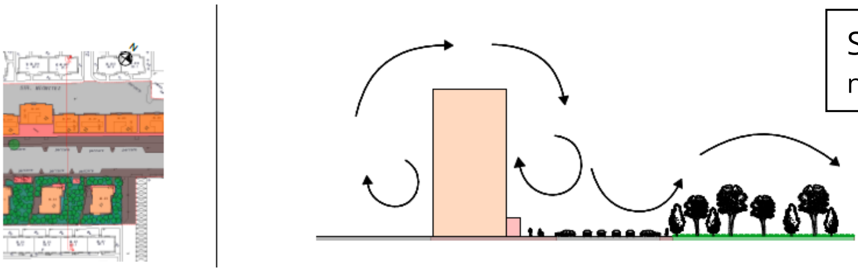
$$S4: \frac{15}{48.53} = 0.30 < 1$$

Figure 50 Street canyon section 4



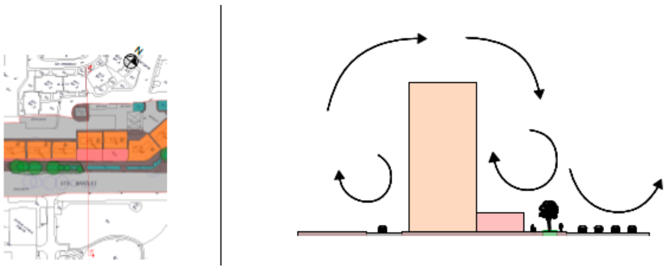
$$S5: \frac{32}{53.47} = 0.60 < 1$$

Figure 51 Street canyon section 5



S6: Calculation is not necessary

Figure 52 Street canyon section 6



S7: Calculation is not necessary

Figure 53 Street canyon section 7

Street Canion: The defining metric of a street canyon is the **aspect ratio**, which is the ratio of the average height of buildings along the street (H) to the street width (W):

Street Canion Ratio= $\frac{H}{W}$

The street canion ratio is less than 1 in every section studied. This means that the building height is still less than the street width, indicating that the street is not likely to form a classic urban canyon in the strict sense (where the building height is greater than the street width, i.e., SCR> 1).

However, heat trapping and shading effects may still occur, especially considering the variation in building heights (with one building being much shorter than the other). The SSE side with the taller building may experience more heat retention, particularly from direct sunlight.

Since the street is oriented SSE-NNW, the SSE-facing building will likely receive more sunlight throughout the day, especially in the morning, while the NNW-facing building may get more sunlight in the afternoon. This difference in sunlight exposure can cause temperature variation on the street.

he SSE-facing side with the taller building will probably have a greater impact on shading and heat retention during the day, as it could block sunlight from reaching parts of the street on that side.

The difference in building heights could also lead to different wind patterns on each side of the street. This could impact airflow and cooling efficiency along the street.

When the aspect ratio falls between 0.30 and 0.70, the buildings are tall enough to create a noticeable canyon effect, but the street is still relatively open.

- Lower end (0.30~0.30 0.30): Buildings are moderately tall compared to the street width, allowing more sunlight and air circulation.
- Higher end (0.70~0.70 0.70): The canyon effect becomes stronger, with reduced sunlight penetration and potentially limited airflow.

The geometry of a street canyon influences how pollutants from vehicles and other sources are dispersed. Poor ventilation within the canyon can lead to higher pollutant concentrations.

Classification of Street Canyons:

- **Shallow Canyon**: H/W<0.3 (Buildings are short relative to the street width).
- **Regular Canyon**: 0.3≤H/W≤0.70. (Typical range for balanced urban areas).
- **Deep Canyon**: H/W>0.7 (Tall buildings dominate, creating narrow streets with limited sunlight and airflow).

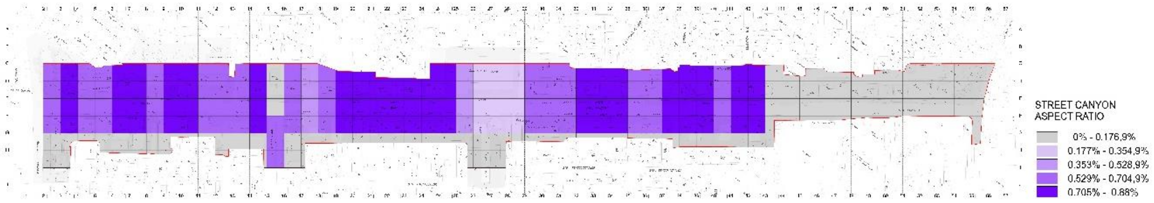


Figure 54 Street canyon surfaces

Limitation of the analysis.

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For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

Source of data for the assessment:

- *Google earth*
- *The cadaster of buildings*

Green urban spaces and vegetation

General description.

The area features a diverse array of trees, including linden, pines, acacias, fruit trees, and boxwood rows, contributing to both aesthetic appeal and ecological value. The southern side of the area is notably richer in vegetation, with denser and taller trees lining the sidewalk, in contrast to the sparser greenery on the northern side. This disparity enhances environmental comfort and visual appeal on the southern side, creating a more shaded and inviting atmosphere.

Overall, while green spaces and tree canopy coverage provide important environmental and social benefits, their relatively low percentage indicates room for improvement to enhance the ecological and urban quality of the area.

Limitation of the analysis.

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface. To create the maps, we created a 25x25m grid adapted to the studied area.

For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

Source of data for the assessment:

- *Google earth*
- *The cadaster of buildings*

Green coverage ratio

The studied area has a total surface of 163,985.73 m², out of which the surface occupied by green spaces is 16,372.21 m². The percentage ratio between the green spaces and the total area is 9.98%.

Table 7 The percentage ratio between the green spaces and the total studied area

Total surface area of the studied zone(m^2)	163,985.73
Green space surface (m^2)	16,372.21
Green coverage ratio %	9.98

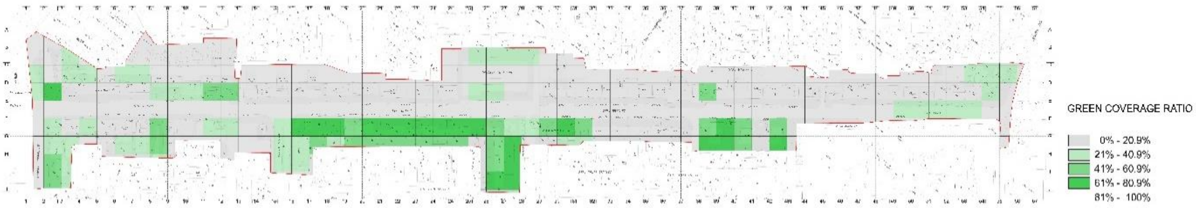

Figure 55 Green Coverage ratios in the studied area

Limitation of the analysis.

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For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

Source of data for the assessment:

- *Google earth*
- *The cadaster of buildings*

Tree canopy coverage

Along the street as well as behind the apartment buildings, a variety of trees can be observed: linden trees, pines, acacias, fruit trees, and rows of boxwood. The southern sidewalk is bordered by denser and taller trees compared to the northern one. The entire southern side is richer in green spaces and vegetation.

The studied area has a total surface of 163,985.73 m², out of which the surface occupied by the tree canopy is 18,401.80 m². The percentage ratio between tree canopy coverage and the total area is 11.22%.

Table 8 The percentage ratio between tree canopy coverage and the total studied area

Total surface area of the studied zone(m^2)	163,985.73
Tree canopy coverage (m^2)	18,401.80
Tree canopy coverage ratio %	11.22

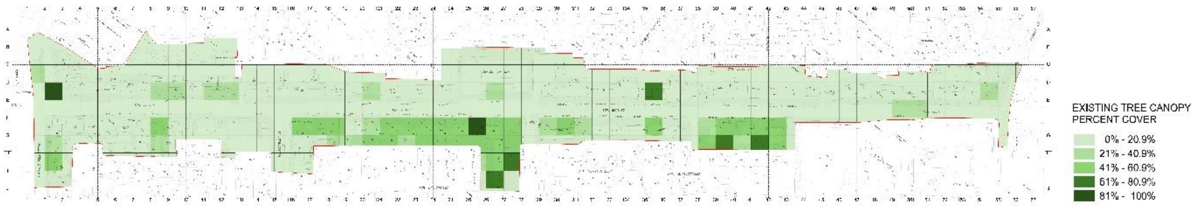


Figure 56 Tree Canopy coverage in the studies area

Limitation of the analysis.

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface. To create the maps, we created a 25x25m grid adapted to the studied area.

For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

Source of data for the assessment:

- *Google earth*
- *The cadaster of buildings*

Permeability of surfaces

General description.

The studied area covers a total of 163,985.73 m², with a stark imbalance between permeable and impermeable surfaces. Permeable surfaces, comprising 16,372.21 m² (9.98% of the total area), consist entirely of green spaces that support water infiltration and contribute to environmental cooling through evapotranspiration. In contrast, impermeable surfaces dominate the landscape, accounting for approximately 90% of the area. These include asphalt and buildings, which absorb and retain heat, significantly contributing to elevated local temperatures, particularly during the summer months.

The dominance of impermeable materials limits the area's ability to manage rainwater effectively, as the lack of infiltration results in rapid runoff, increasing the risk of urban flooding. Additionally, the absence of semi-permeable zones further emphasizes the reduced capacity for natural water management and thermal regulation.

This imbalance highlights the need for strategies to increase permeable surface coverage, such as introducing more green spaces or semi-permeable materials, to enhance the area's environmental resilience and mitigate urban heat island effects

Limitation of the analysis.

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface. To create the maps, we created a 25x25m grid adapted to the studied area.

For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

Source of data for the assessment:

- *Google earth*
- *The cadaster of buildings*

Share of permeable surfaces related to impermeable surfaces

The studied area has a total surface of 163,985.73 m², out of which the permeable surface is 16,372.21 m². The percentage ratio between the permeable surface and the total area is 9.98%.

Table 9 The percentage ratio between the permeable/impermeable surface and the total studied area

Total surface area of the studied zone(m^2)	163,985.73
Permeable surface (m^2)	16,372.21
Semi-permeable surface (m^2)	0
Impermeable surfaces (m^2)	147,613.52
Ratio of permeable surfaces %	9.98
Ratio of semi-permeable surfaces %	-
Ratio of impermeable surfaces %	90.02

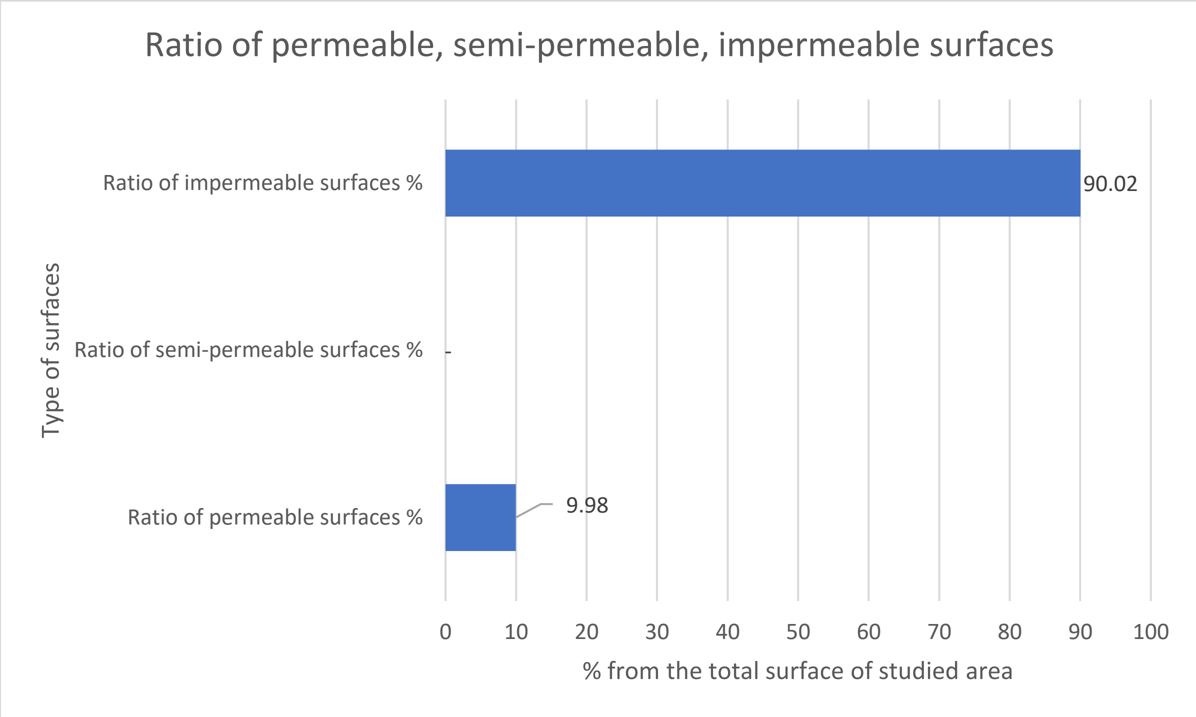


Chart 7 Ratio of permeable, semi-permeable, impermeable surfaces

Impermeable surfaces dominate (approximately 90%) and are representated by asphalt and buildings. These materials absorb and retain more heat than natural surfaces, leading to higher local temperatures, especially during summer. The lack of water infiltration into the soil results in rapid rainwater runoff, increasing the risk of urban flooding.

Permeable surfaces, such as green spaces, allow water to infiltrate the soil, reducing flood risks and contributing to local cooling through evapotranspiration. The low proportion of these surfaces indicates a reduced capacity for natural thermal regulation and carbon capture.

In the studied area are no semi-permeable zones.

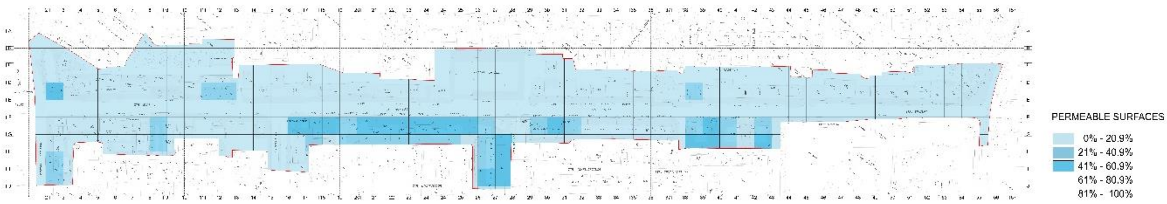


Figure 57 Permeable surfaces in the studied area

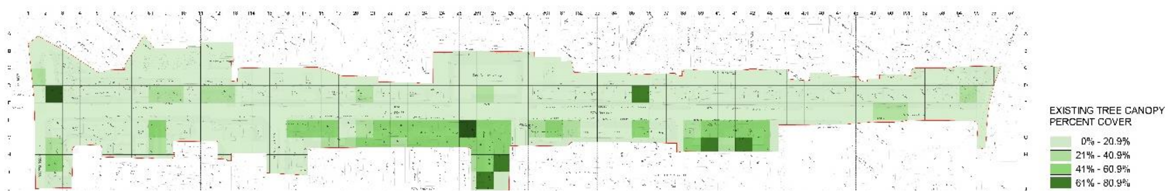


Figure 58 Impermeable surface in the studied area

Human activities

General description.

The street under analysis is a highly trafficked urban artery, serving as a key area for both residential and commercial activities. It hosts the Galați County Hospital, making it an essential location for medical services and public access. The street is lined with residential apartment blocks, totaling 3,849 apartments, accommodating a significant population density.

In addition to residential buildings, the area features numerous service and commercial establishments, contributing to its role as a mixed-use zone. Pedestrian sidewalks run along both sides of the street, providing connectivity for foot traffic, although their quality and usability may vary due to the intense vehicular activity.

The combination of heavy traffic, diverse land use, and high residential density highlights the importance of efficient urban planning to ensure accessibility, safety, and environmental quality in this busy area.

Limitation of the analysis.

The analysis of the described area faces several limitations, particularly regarding the assessment of population density, building energy consumption, and transportation energy use.

Accurate data on the number of residents per apartment or household is often unavailable or based on estimates. This can lead to discrepancies in calculating the actual population density.

Differences in building age, construction materials, insulation quality, and energy efficiency standards can significantly impact energy consumption but may not be fully accounted for in the analysis.

The number of occupants, their behavior, and energy usage habits (e.g., heating, cooling, and appliance usage) introduce variability that is difficult to quantify.

Access to precise data on energy consumption per building or apartment is often restricted due to privacy concerns and lack of monitoring infrastructure.

Traffic patterns and congestion levels vary throughout the day, week, or year, affecting energy use calculations.

The proportion of trips made by walking, cycling, public transit, or private vehicles may not be accurately represented, leading to potential biases in energy estimates.

Source of data for the assessment:

- *Google earth*
- *The cadaster of buildings*
- *https://browser.dataspace.copernicus.eu/*
- *Traffic Study for Galați Municipality – Projects:*
  - *"Modernization of Tram Lines and Roadway on Siderurgiștilor Street and 1 Decembrie Street"*
  - *"Modernization of Tram Lines and Roadway on Traian Vuia Street, Henri Coandă Street, and George Coșbuc Street (section between Henri Coandă Street and Alexandru Măcelaru Street)"*
  - *"Acquisition of Non-Polluting Transport Vehicles (Trams, Trolleybuses)"*
  - *"Intermodal Transport Center of Galați Municipality"*
  - *"Galați VELOCity"*
  - *"Modernization of the Transport Depot on George Coșbuc Boulevard"*

Population density

The two images represent **population density** for the years **2000** (first image) and **2025** (second image), highlighting changes in settlement patterns over time.

Population Density in 2000

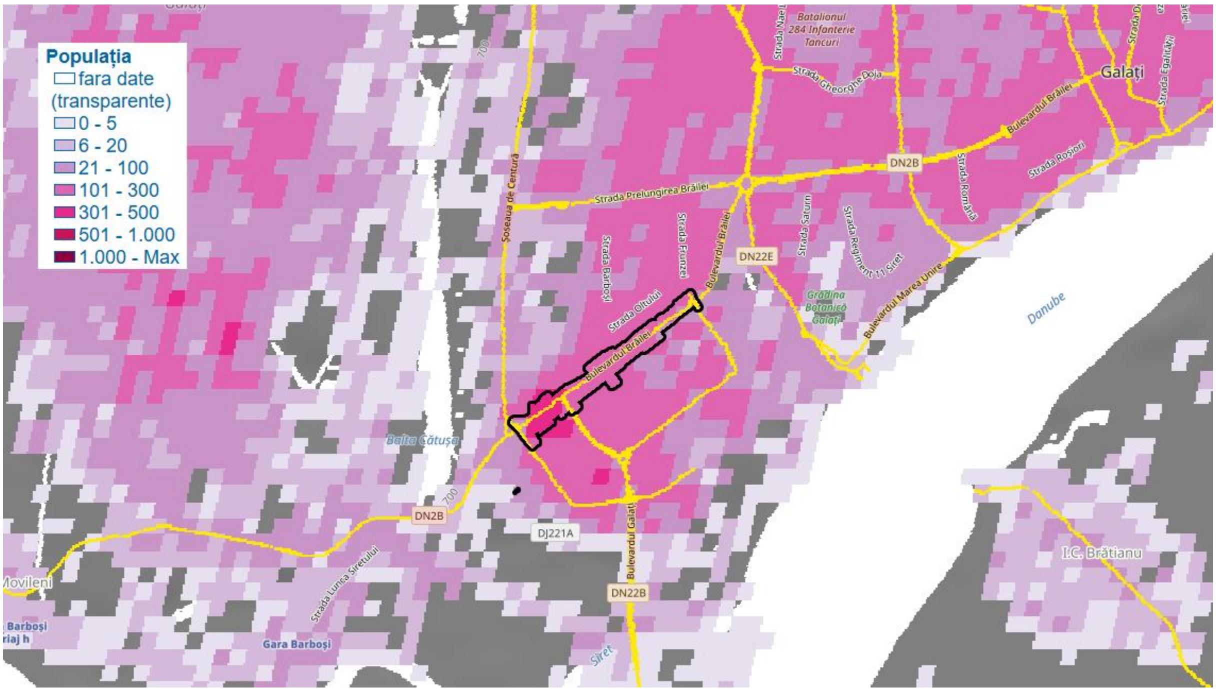


Figure 59 Population density in 2000. Source https://human-settlement.emergency.copernicus.eu/visualisation.php#

The delimited area has **a mix of low and medium population density**, with values predominantly in the **101–500 inhabitants per square kilometer range (light pink to medium pink)**. Some parts of the area appear **sparsely populated**, with **grey or nearly transparent sections**, indicating regions with little or no population data. The surrounding infrastructure (yellow roads) suggests **accessibility**, but the settlement density is **moderate**.

Population Density in 2025

The delimited area shows **an decrease in population density**, with a shift toward **light pink shades**, particularly in the **101–300 inhabitants per square kilometer range**. Compared to 2000, the area has **fewer light pink/grey sections**, indicating **expansion in residential settlements but a lower density per square kilometer range**. The development of **adjacent areas** and connectivity with the surrounding road network suggests **urban growth and densification**.

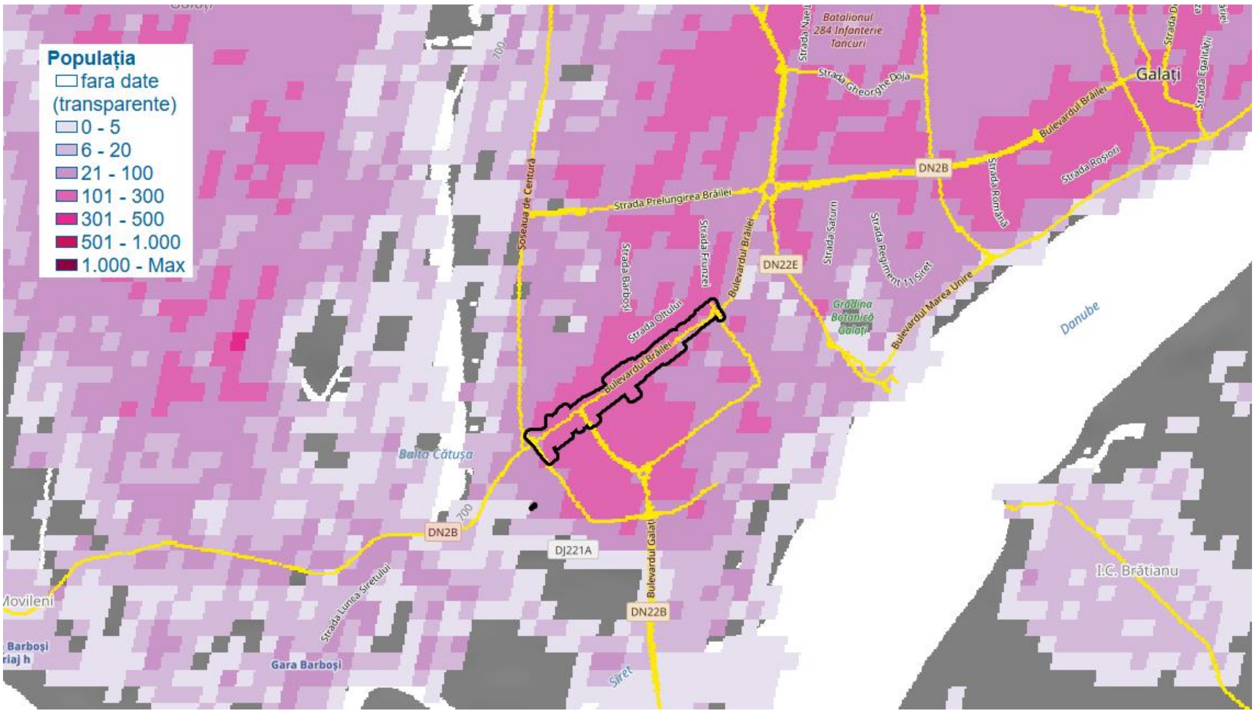


Figure 60 Population density in 2025. Source: https://human-settlement.emergency.copernicus.eu/visualisation.php#

The population density has increased within the delimited area from 2000 to 2025, with more areas falling into higher population categories. The urban expansion is evident, likely due to residential developments or improved infrastructure. This trend suggests that the area has become more urbanized over time, supporting a larger population.

Limitation of the analysis.

The analysis of the described area faces several limitations, particularly regarding the assessment of population density.

Accurate data on the number of residents per apartment or household is often unavailable or based on estimates. This can lead to discrepancies in calculating the actual population density.

The number of occupants, their behavior, and energy usage habits (e.g., heating, cooling, and appliance usage) introduce variability that is difficult to quantify.

Traffic patterns and congestion levels vary throughout the day, week, or year, affecting energy use calculations.

Source of data for the assessment:

- *Google earth*
- *The cadaster of buildings*
- https://human-settlement.emergency.copernicus.eu/visualisation.php#

Land use

The analyzed area presents a diverse land use distribution, reflecting a combination of residential, commercial, and public functions alongside essential infrastructure and green spaces.

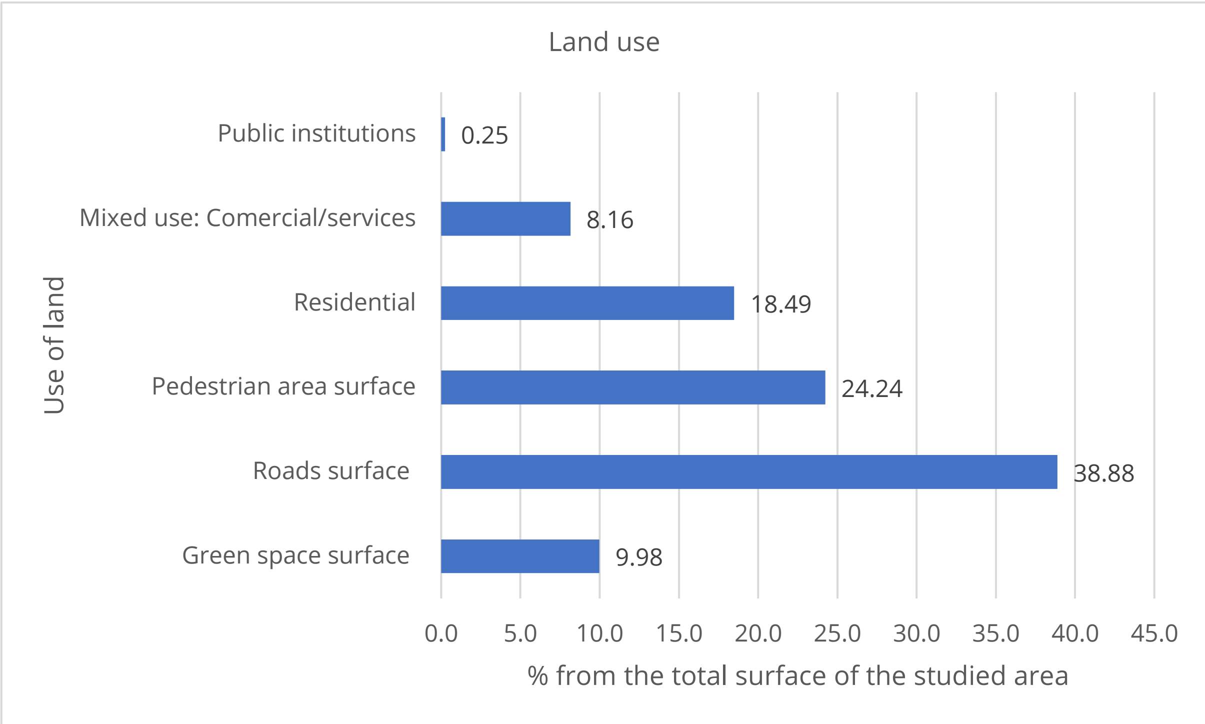


Chart 8 Percentage of land use

The breakdown of land use is as follows:

- **Public Institutions (0.25%)**: A small proportion of the area is allocated to public institutions, highlighting a limited presence of administrative or public service facilities.
- **Mixed-Use (Commercial/Services - 8.16%)**: This allocation supports economic activities, providing spaces for businesses, shops, and services that cater to both local residents and visitors.
- **Residential (18.49%)**: A significant portion of the area is dedicated to housing, emphasizing its role as a residential community.
- **Pedestrian Surfaces (24.24%)**: A substantial part of the land is designed for pedestrian use, promoting walkability and contributing to the overall accessibility and livability of the area.
- **Roads (38.88%)**: Roads dominate the land use, reflecting a car-oriented urban design. This extensive allocation to vehicular infrastructure supports connectivity but may also contribute to urban heat and reduced green space availability.
- **Green Spaces and Front Gardens (9.98%)**: Green areas, including front gardens, provide a balance to the built environment by enhancing aesthetic appeal, offering recreational opportunities, and contributing to environmental benefits like air purification and temperature regulation.

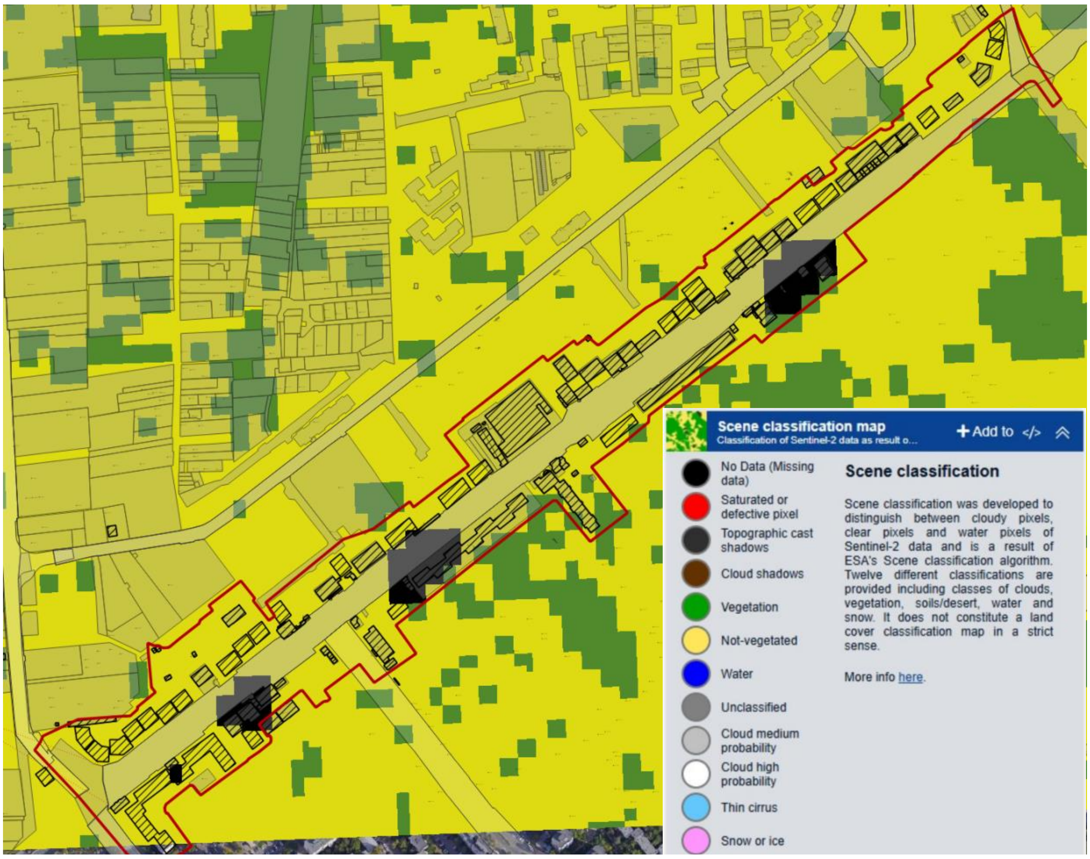


Figure 61 Land use, Source: https://browser.dataspace.copernicus.eu/

In the image above we can observe that there are only to distinctive surfaces, green an built one.

In the image bellow we can observ in the studied area(blue square) that there are 2 tipes of surfaces: continuous urban fabric and discontinouse dense urban fabric.

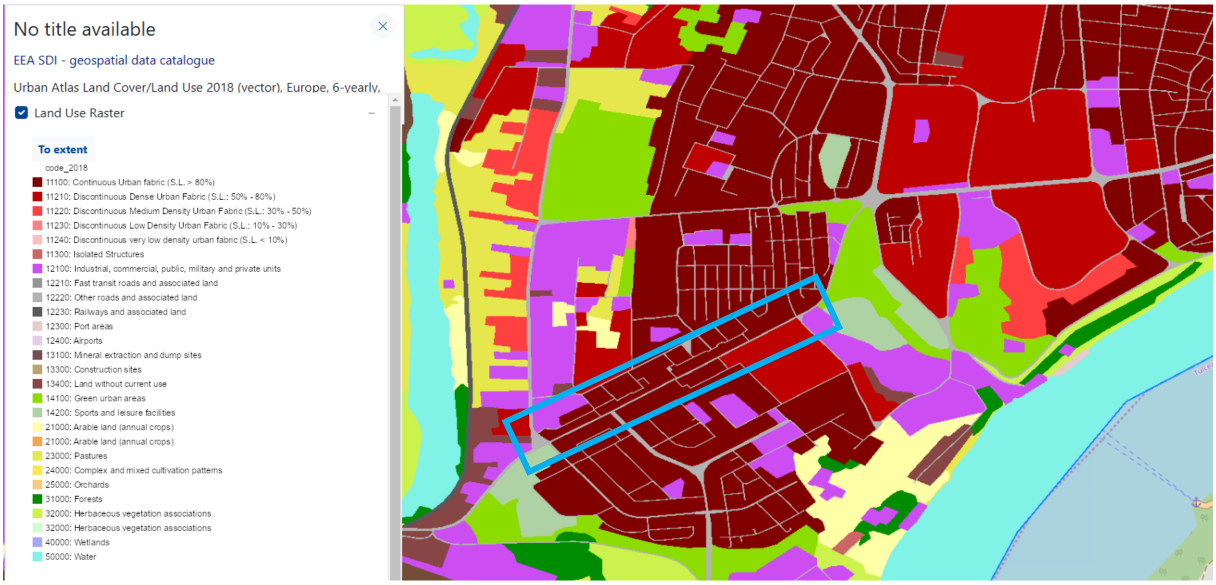


Figure 62 Land Use; Source https://data.europa.eu/geo-viewer/?catalog=eea-sdi&dataset=fb4dffa1-6ceb-4cc0-8372-1ed354c285e6&distribution=213e6e1a-887b-44f8-9ee7-9a7bc3782b1b&type=WMS&lang=en

Limitation of the analysis (missing data, outdated data, etc.).

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface. To create the maps, we created a 25x25m grid adapted to the studied area.

For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

Source of data for the assessment:

- *https://browser.dataspace.copernicus.eu/*
- *https://data.europa.eu/geo-viewer/?catalog=eea-sdi&dataset=fb4dffa1-6ceb-4cc0-8372-1ed354c285e6&distribution=213e6e1a-887b-44f8-9ee7-9a7bc3782b1b&type=WMS&lang=en*
- *The cadaster of buildings*
- Google earth/maps

Energy consumption of buildings

The table presents an analysis of **energy consumption** for r**esidential buildings in Galați Municipality**, focusing on **heating, cooling, hot water, and electricity usage**. It categorizes data based on **different dwelling types** (apartments in blocks and individual houses) and includes key indicators such as **specific energy consumption, total energy use, and heated/cooled areas**.

Table 10 Analysis of energy consumption for residential buildings in Galați Municipality. Source: Sustainable Energy and Climate Action Plan - Galați Municipality 2021

No.	Indicators[1]	Value	Energy consumption		Reporting value	
0	1	2=4/6	3	4	5	6
1	Specific annual energy consumption for heating and domestic hot water (kWh/m^2 per year)	146,64 kWh/m^2 per year	Total energy consumptio n for heating and domestic hot water by type of dwelling	667.841	The total heated usable area by type of housing (m^2), including:	4.561.07 9
		136,61 kWh/m^2 per year	- apartments in blocks 72.185	342.194	- apartments in blocks	2.540.91 2
		161,19 kWh/m^2 per year	- individual houses	325.647	- individual houses	2.020.16 7
2	The average annual specific energy consumption for heating by type of dwelling	146,64	The average energy consumptio pn for heating by type of dwelling	6,38	The average heated usable area by type of houses	40,26
		136,61	- apartments in blocks 72.185	4,86	- apartments in blocks	35,2
		161,10	- individual houses 41.102	9,04	- individual houses	49,15

[1] Sustainable Energy and Climate Action Plan - Galați Municipality 2021

3	The average annual specific energy consumption for cooling by type of dwelling with air conditioning (kWh/m^2 per year)	-	The average energy consumption by type of dwelling (MWh/year)	-	The average cooled usable area by tpe of dwelling with air conditioning	-
		-	- apartments in blocks	-	- apartments in blocks	-
		-	- individual houses	-	- individual houses	-
4	The annual specific electricity consumption (kWh/m^2 per year)	33,89	The total electricity consumption: dwellings	154.598	The total usable area: dwellings	4.561.079

Specific annual energy consumption for heating and domestic hot water (kWh/m^2 per year):

- Overall average: 146.64 kWh/m^2 per year
- Apartments in blocks: 136.61 kWh/m^2 per year
- Individual houses: 161.19 kWh/m^2 per year

Average annual specific energy consumption for heating by dwelling type:

- Apartments in blocks: 136.61 kWh/m^2 per year
- Individual houses: 161.10 kWh/m^2 per year

Annual specific electricity consumption: 33.89 kWh/m^2 per year

Total Energy Consumption by Type of Dwelling

Heating and domestic hot water: 667,841 MWh/year

- Apartments in blocks: 342,194 MWh/year
- Individual houses: 325,647 MWh/year

Electricity consumption for dwellings: 154,598 MWh/year

Heated and Cooled Usable Area by Dwelling Type

Total heated usable area (m^2): 4,561,079 m^2

- Apartments in blocks: 2,540,912 m^2
- Individual houses: 2,020,167 m^2

Average heated usable area per dwelling type (m^2):

- Apartments in blocks: 35.2 m^2
- Individual houses: 49.15 m^2

Cooling energy consumption and cooled area: Data is missing (not available).

Individual houses consume more energy per square meter (161.19 kWh/m^2) compared to apartments (136.61 kWh/m^2) due to larger surface exposure and higher heat loss.

Apartments in blocks represent a larger share of the heated area: 2,540,912 m² vs. 2,020,167 m² for individual houses, indicating a higher number of apartments in the city.

No data available for cooling energy consumption: The table does not provide values for cooling energy demand in buildings with air conditioning.

This table provides a comprehensive overview of energy consumption in residential buildings in Galați Municipality, emphasizing the differences between apartments and individual houses. The higher energy demand in houses suggests potential areas for energy efficiency improvements, such as better insulation, district heating, and renewable energy integration.

Studied Area:

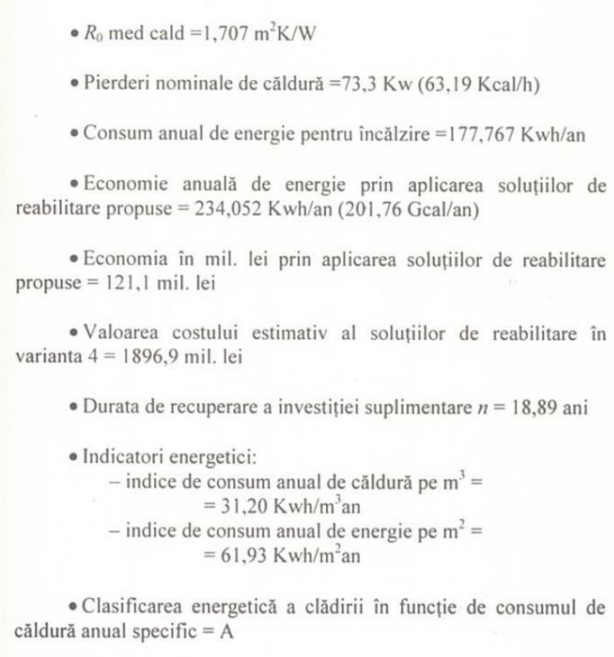
To estimate the energy consumption of a residential building, we consider:

1. Average consumption per apartment According to the Methodology for the Rehabilitation and Modernization of the Building Envelope and Heating & Hot Water Installations in Apartment Blocks with Large Panel Structures, indicative MP 019-2002:

- R_0 average thermal resistance = 1.707 m²K/W
- Nominal heat losses = 73.3 kW (63.19 Kcal/h)
- Annual energy consumption for heating = 177,767 kWh/year
- Annual energy savings by applying the proposed rehabilitation solutions = 234,052 kWh/year (201.76 Gcal/year)
- Savings in million lei by applying the proposed rehabilitation solutions = 121.1 million lei
- Estimated cost of the rehabilitation solutions in variant 4 = 1,896.9 million lei
- Payback period for the additional investment = 18.89 years

Energy Indicators:

- Annual heat consumption index per cubic meter = 31.20 kWh/m³·year
- Annual energy consumption index per square meter = 61.93 kWh/m²·year
- Energy classification of the building based on specific annual heat consumption = A



• R_0 med cald =1,707 m²K/W

• Pierderi nominale de căldură =73,3 Kw (63,19 Kcal/h)

• Consum anual de energie pentru încălzire =177,767 Kwh/an

• Economie anuală de energie prin aplicarea soluțiilor de reabilitare propuse = 234,052 Kwh/an (201,76 Gcal/an)

• Economia în mil. lei prin aplicarea soluțiilor de reabilitare propuse = 121,1 mil. lei

• Valoarea costului estimativ al soluțiilor de reabilitare în varianta 4 = 1896,9 mil. lei

• Durata de recuperare a investiției suplimentare n = 18,89 ani

• Indicatori energetici:
– indice de consum anual de căldură pe m³ = = 31,20 Kwh/m³an
– indice de consum anual de energie pe m² = = 61,93 Kwh/m²an

• Clasificarea energetică a clădirii în funcție de consumul de căldură anual specific = A

Figure 63 Calculation method

2. Average Apartment Surface Area in the Strada Brăilei Area, Galați
The average surface area of apartments varies depending on the number of rooms and layout. According to recent real estate listings:

- 2-room apartments: approximately 60 m²
- 3-room apartments: approximately 74 m²
- 4-room apartments: approximately 103 m²

Table 11 Annual Heating Consumption

Annual Heating Consumption (kWh/m²/year)			Annual Energy Consumption (kWh/m²/year)		
2-room apartments	**3-room apartments**	**4-room apartments**	**2-room apartments**	**3-room apartments**	**4-room apartments**
1872	1208.8	3213.6	3715.8	4582.82	6378.79

3. Total Annual Heating Consumption of a Residential P+10E Building

- **Composition per floor:**
  - 2 apartments (2 rooms) + 1 apartment (3 rooms) + 1 apartment (4 rooms) = 4 apartments per floor
- **Total in building:**
  - 10 floors × 4 apartments per floor = 40 apartments
- **Assuming a consumption of 8,166.4 kWh/year per floor:**
  - 10 floors × 8,166.4 = 81,664 kWh/year

4. Total Annual Energy Consumption of a Residential P+10E Building

- **Same composition per floor:**
  - 2 apartments (2 rooms) + 1 apartment (3 rooms) + 1 apartment (4 rooms) = 4 apartments per floor
- **Total in building:**
  - 10 floors × 4 apartments per floor = 40 apartments
- **Assuming a consumption of 18,393.21 kWh/year per floor:**
  - 10 floors × 18,393.21 = 202,325.31 kWh/year

5. Total Annual Heating Consumption of a Residential P+4E Building

- **Composition per floor:**
  - 1 apartment (2 rooms) + 1 apartment (3 rooms) + 1 apartment (4 rooms) = 3 apartments per floor
- **Total in building:**
  - 4 floors × 3 apartments per floor = 12 apartments
- **Assuming a consumption of 6,294.4 kWh/year per floor:**
  - 4 floors × 6,294.4 = 25,177.6 kWh/year

6. Total Annual Energy Consumption of a Residential P+4E Building

- **Same composition per floor:**
  - 1 apartment (2 rooms) + 1 apartment (3 rooms) + 1 apartment (4 rooms) = 3 apartments per floor
- **Total in building:**
  - 4 floors × 3 apartments per floor = 12 apartments
- **Assuming a consumption of 14,667.41 kWh/year per floor:**
  - 4 floors × 14,667.41 = 58,709.64 kWh/year

7. Total Annual Energy Consumption of a Non-Residential Building – Commercial Space
Energy Consumption Benchmarks for Commercial Spaces:

- 250-350 kWh/m²/year – for small, energy-inefficient commercial spaces with LED lighting and no optimized HVAC systems.

- 200-300 kWh/m²/year – for small retail stores with high lighting intensity and moderate climate control.
- 400-600 kWh/m²/year – for malls, hypermarkets, and large showrooms with multiple equipment, intensive HVAC systems, and heavy lighting usage.

8. Annual Energy Consumption Calculation for a Non-Residential Building – Commercial Space

Total Constructed Areas:

- Ground Floor Commercial Spaces: 8,405.26 m²
- P+2E Commercial Spaces: 1,656.45 m²
- P+3E Commercial Spaces: 17,688.60 m²

Annual Electricity Consumption (MWh/year)

Ground Floor – 8,405.26 m² (energy-inefficient, LED lighting)

- Minimum consumption: 8,405 × 250 = 2,101,000 kWh/year
- Maximum consumption: 8,405 × 350 = 2,942,000 kWh/year

P+2 – 1,656.45 m² (energy-efficient, LED lighting, optimized HVAC)

- Minimum consumption: 1,656 × 200 = 331,000 kWh/year
- Maximum consumption: 1,656 × 300 = 497,000 kWh/year

P+3 – 17,688.60 m² (mall/hypermarket, intensive HVAC usage)

- Minimum consumption: 17,688 × 400 = 7,075,000 kWh/year
- Maximum consumption: 17,688 × 600 = 10,613,000 kWh/year

Total Estimated Annual Electricity Consumption:

- Minimum: 9,507,000 kWh/year (9.5 GWh/year)
- Maximum: 14,052,000 kWh/year (14.05 GWh/year)

Annual Heating Consumption (kWh/year)

Ground Floor – 8,405.26 m² (energy-inefficient)

- Minimum consumption: 8,405 × 120 = 1,008,600 kWh/year
- Maximum consumption: 8,405 × 200 = 1,681,000 kWh/year

P+2 – 1,656.45 m² (energy-efficient)

- Minimum consumption: 1,656 × 80 = 132,500 kWh/year
- Maximum consumption: 1,656 × 150 = 248,500 kWh/year

P+3 – 17,688.60 m² (mall/hypermarket)

- Minimum consumption: 17,688 × 150 = 2,653,000 kWh/year
- Maximum consumption: 17,688 × 200 = 3,537,000 kWh/year

Total Estimated Annual Heating Consumption:

- Minimum: 3,794,100 kWh/year (3.79 GWh/year)
- Maximum: 5,466,500 kWh/year (5.47 GWh/year)

Total Energy Consumption of the Studied Area

A. Residential Buildings

Table 12 Energy Consumption of the Studied Area for residential buildings

Nr. crt	Building Type	No. of Buildings	Annual Heating Consumption (kWh/year)	Annual Energy Consumption (kWh/year)	Total Energy (kWh/year)

1	P+10E Residential Buildings	66	5,389,824.00	13,353,470.46	**18,743,294.46**
2	P+4E Residential Buildings	22	553,907.20	1,291,612.08	**1,845,519.28**

B. Non-Residential Buildings

Table 13 Energy Consumption of the Studied Area for non-residential buildings

Nr. crt	Building Type	Min. Annual Heating Consumption (kWh/year)	Max. Annual Heating Consumption (kWh/year)	Min. Annual Energy Consumption (kWh/year)	Max. Annual Energy Consumption (kWh/year)	Min. Total Energy (kWh/year)	Max. Total Energy (kWh/year)
1	Ground Floor (8,405 m²)	1.008.600	1.681.000	2.101.000	2.942.000	3.109.600	4.623.000
2	P+2 (1,656 m²)	132.500 kWh	248.500 kWh	331.000 kWh	497.000 kWh	463.500 kWh	745.500
3	P+3 (17,688 m²)	2.653.000	3.537.000	7.075.000	10.613.000	9.728.000	14.150.000

Energy Consumption Analysis for the Studied Area

The analyzed area has a total built-up area of **319,558.12 m²** and consists of **residential and non-residential buildings**. The total energy consumption and its distribution were assessed.

1. Total Energy Consumption in the Studied Area

Total annual energy consumption (residential + non-residential):

- Minimum: ≈ 31.85 GWh/year
- Maximum: ≈ 40.11 GWh/year

This consumption comes from two main sectors:

- **Residential buildings:**
  - Total energy consumption: 20.59 GWh/year
  - Percentage of total consumption: ~51.4%
- **Non-residential buildings:**
  - Total energy consumption: 13.3 – 19.5 GWh/year
  - Percentage of total consumption: ~48.6%

2. Energy Consumption Analysis by Building Category

A. Residential Buildings

The residential sector includes **88 apartments** (P+10E and P+4E), with a total estimated energy consumption of **20.59 GWh/year**.

Consumption distribution:

- **P+10E blocks (66 buildings): 18.74 GWh/year** (91% of the residential sector).

- **P+4E blocks (22 buildings): 1.85 GWh/year** (9% of the residential sector).

Observations:

- **P+10E buildings dominate energy consumption** due to their large surface area and higher energy demands.
- **P+4E buildings have significantly lower consumption** due to their smaller built-up area.
- **Most of the energy consumption comes from heating and electricity use in apartments.**

B. Non-Residential Buildings

Commercial buildings consume **between 13.3 GWh/year and 19.5 GWh/year**, depending on the energy efficiency of each subcategory.

Non-residential consumption distribution:

- **Ground Floor (8,405 m²) – small, inefficient buildings:**
  - Total consumption: 3.1 – 4.6 GWh/year
  - Main energy demand: Heating & HVAC.
- **P+2 (1,656 m²) – small, energy-efficient commercial buildings:**
  - Total consumption: 0.46 – 0.75 GWh/year
  - Lower consumption due to optimized lighting & HVAC.
- **P+3 (17,688 m²) – malls, large showrooms:**
  - Total consumption: 9.7 – 14.15 GWh/year
  - These are the most energy-intensive due to their large area, powerful equipment, and intensive HVAC use.

Conclusions & Possible Energy Efficiency Measures

- **The residential sector has the highest total energy consumption,** but large commercial buildings are the most energy-intensive per square meter.
- **P+10E apartment blocks have extremely high consumption**, and **thermal rehabilitation and heating system modernization could reduce energy demand.**
- **Malls and hypermarkets consume enormous amounts of energy**, and **solutions such as photovoltaic panels, optimized LED lighting, and high-efficiency HVAC systems could lead to major savings.**
- **Small, efficient commercial buildings demonstrate that modern technology investments drastically reduce energy use.**
- **Reducing overall energy consumption in the studied area can be achieved through:**
  - Thermal rehabilitation of P+10E buildings.
  - Smart energy management systems in malls and hypermarkets.
  - Transitioning to renewable energy sources (solar panels, heat pumps).
  - Modernizing lighting & HVAC systems in small and medium-sized commercial spaces.

Limitation of the analysis.

The analysis of the described area faces several limitations, particularly regarding the assessment of population density, building energy consumption, and transportation energy use.

Differences in building age, construction materials, insulation quality, and energy efficiency standards can significantly impact energy consumption but may not be fully accounted for in the analysis.

The number of occupants, their behavior, and energy usage habits (e.g., heating, cooling, and appliance usage) introduce variability that is difficult to quantify.

Access to precise data on energy consumption per building or apartment is often restricted due to privacy concerns and lack of monitoring infrastructure.

Source of data for the assessment:

- Sustainable Energy and Climate Action Plan - Galați Municipality 2021
- **Methodology for the Rehabilitation and Modernization of the Building Envelope and Heating & Hot Water Installations in Apartment Blocks with Large Panel Structures**, indicative **MP 019-2002**:
- International and European standards:
  - **ASHRAE** (American Society of Heating, Refrigerating and Air-Conditioning Engineers) – energy consumption standards for commercial buildings.
  - **EU Directives on Energy Performance of Buildings (EPBD)** – regulating maximum energy consumption for commercial spaces.
  - **BREEAM & LEED Certifications** – set efficiency benchmarks for energy-efficient buildings.
- **Studies and Reports on Energy Consumption:**
  - **EN 16798-1** (European Standard for Energy Performance of Buildings) – provides energy consumption values for commercial buildings based on their purpose.
  - **"Energy Consumption in Office and Retail Buildings"** study by the **EU Building Stock Observatory** – offers typical consumption values for non-residential buildings.
  - **ADEME Guidelines** (French Agency for Environment and Energy) – consumption benchmarks for tertiary sectors (offices and commercial buildings).
- **Energy Consumption Insights from Romania:**
  - **Reports from ANRE & Transelectrica** regarding energy use in non-residential buildings.
  - **Data from energy audits of commercial buildings in Romania** showing specific consumption values.

Energy consumption of transportation

Traffic Analysis at Brailei-Otelarilor Intersection

A2 Brailei-Otelarilor	A / Strada Brailei - Nord-Est	
	B / Strada Brailei - Sud- Vest	
	C / Strada Otelarilor - Sud-Est	

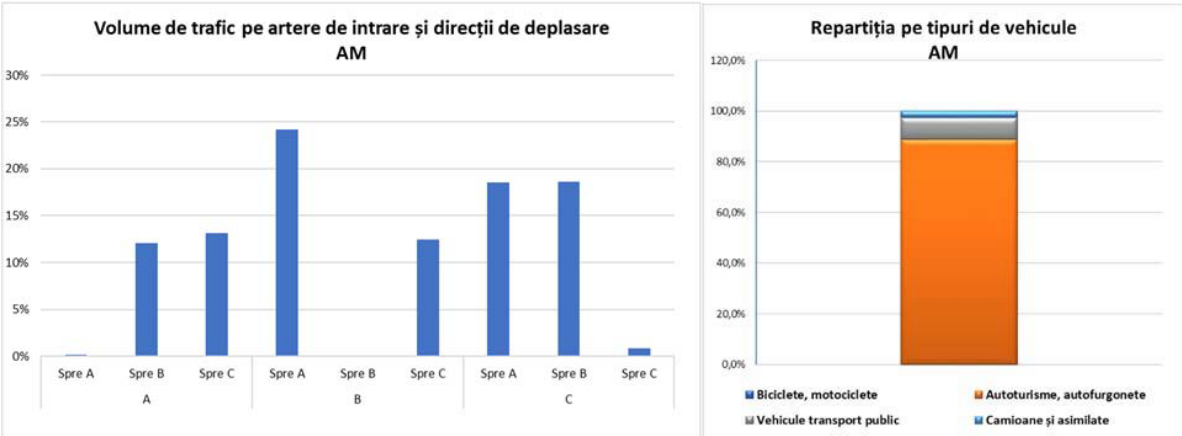


Figure 64 Traffic study

The Brailei-Otelarilor intersection is a key traffic point, with three main entry roads:

- **A / Strada Brailei - North-East**
- **B / Strada Brailei - South-West**
- **C / Strada Otelarilor - South-East**

Traffic Volume Analysis

The bar chart on the left shows the traffic volume based on entry roads and movement directions. Key observations include:

- The highest traffic movement is towards **Point A** from another road, suggesting high traffic inflow from this direction.
- Traffic towards Point B and C is more evenly distributed but still shows notable movement.
- The lowest percentage of vehicles is observed moving towards Point C, indicating less traffic volume in that direction.

Vehicle Type Distribution

The second chart on the right displays the distribution of vehicle types in the intersection. Key findings:

- Passenger cars and vans (orange bar) dominate traffic flow, making up the vast majority of vehicles.
- Public transport vehicles (gray section) have a smaller share, indicating limited bus or tram presence.

- Trucks and similar heavy vehicles (blue section) represent a small portion, suggesting limited freight traffic in the morning period.
- Bicycles and motorcycles (light blue section) have a minimal presence, showing a low reliance on two-wheel transport in this area.

The **Brailei-Otelarilor intersection** experiences a high traffic volume, particularly towards **Point A, with a dominance of private vehicles**. Public transport and bicycles are less common, indicating that traffic planning improvements could focus on reducing congestion and encouraging alternative transport modes.

Traffic Analysis at Brailei-Mioritei Intersection

A3 Brailei-Mioritei	A / Strada Brailei - Nord-Est	
	B / Mioritei	
	C / Strada Brailei - Sud-Vest	

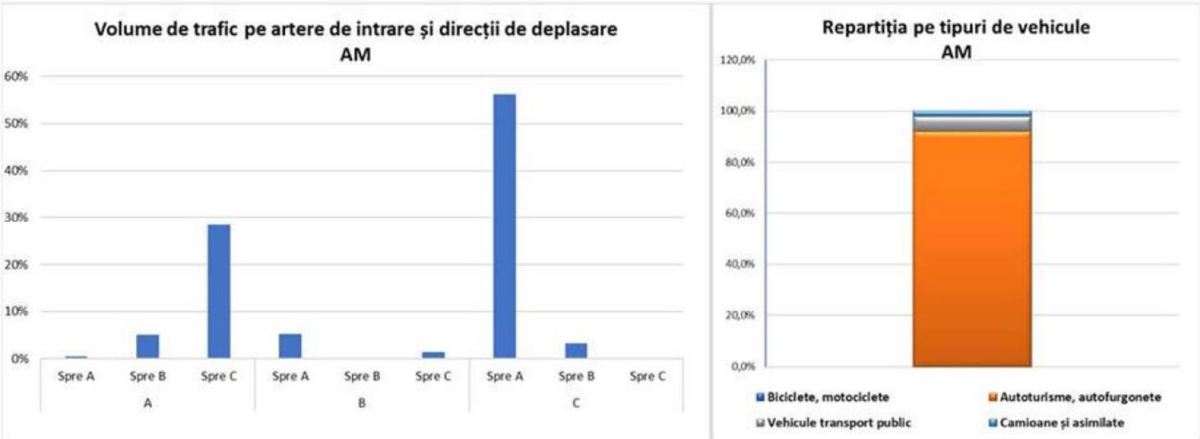


Figure 65 Trafic study.

The **Brailei-Mioritei intersection** is a key traffic point, with three main entry roads:

- **A / Strada Brailei - North-East**
- **B / Mioritei**
- **C / Strada Brailei - South-West**

Traffic Volume Analysis

The bar chart on the left illustrates **traffic volume by entry road and direction of movement**. Key observations include:

- A **high concentration of traffic moves towards Point A**, indicating significant inbound flow from other roads.
- Traffic towards **Point C** is also notable, though significantly lower than Point A.
- Traffic towards **Point B is minimal**, suggesting less vehicular movement in that direction.

Vehicle Type Distribution

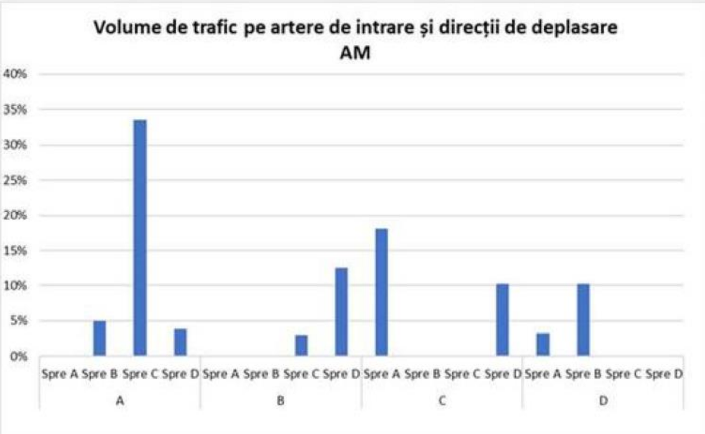
The second chart on the right shows the **distribution of vehicle types** at the intersection. Key findings:

- **Passenger cars and vans (orange bar)** account for the majority of vehicles, reflecting private transportation dominance.
- **Public transport vehicles (gray section)** have a small share, indicating a limited presence of buses or trams.
- **Trucks and similar heavy vehicles (blue section)** constitute a minor percentage, suggesting that freight traffic is not a major factor in this intersection.
- **Bicycles and motorcycles (light blue section)** have a negligible presence, showing low reliance on two-wheel transport in the area.

The **Brailei-Mioritei intersection** experiences **high traffic volumes towards Point A**, predominantly from private vehicles. Public transport and bicycle usage remain low, highlighting a **potential need for improved alternative transportation options**.

Traffic Analysis at Brailei-Stadionului Intersection

A4 Brailei-Stadionului	A / Strada Stadionului - Nord
	B / Strada Brailei - Sud-Vest
	C / Strada Stadionului - Sud-Est
	D / Strada Brailei - Nord-Est



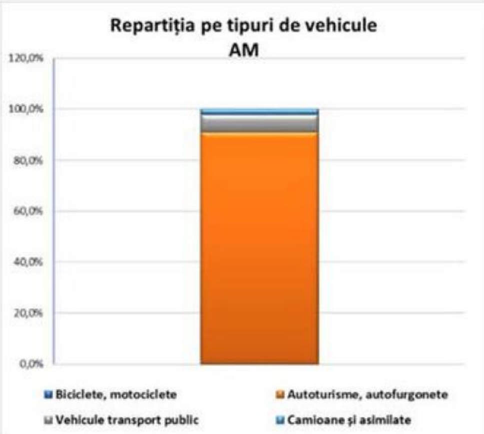


Figure 66 Traffic study

The **Brailei-Stadionului intersection** is a significant traffic hub with four main entry roads:

- **A / Strada Stadionului - North**
- **B / Strada Brailei - South-West**
- **C / Strada Stadionului - South-East**
- **D / Strada Brailei - North-East**

Traffic Volume Analysis

The bar chart on the left illustrates **traffic volume by entry road and movement direction**. Key observations include:

- The **highest traffic volume is at Point A**, with over **30% of total movement** concentrated in this direction.
- Points **B, C, and D** have significantly **lower traffic flow**, though moderate movement is observed.
- Traffic flow appears to be **more evenly distributed** at Points B, C, and D compared to the dominant traffic movement towards Point A.

Vehicle Type Distribution

The second chart on the right displays **vehicle type distribution** within the intersection. Key findings:

- **Passenger cars and vans (orange bar)** represent the vast majority of vehicles, indicating a heavy reliance on private transportation.
- **Public transport vehicles (gray section)** have a limited presence, suggesting a minor role in this intersection.
- **Trucks and heavy vehicles (blue section)** account for a small percentage, showing **low freight traffic activity** in this area.
- **Bicycles and motorcycles (light blue section)** are barely represented, indicating a **lack of alternative transport modes** in the area.

The **Brailei-Stadionului intersection** sees **heavy traffic towards Point A**, while the other directions experience **moderate and lower volumes**. The **dominance of private vehicles** suggests a **need for improved public transport or cycling infrastructure** to balance traffic flow and reduce congestion.

Traffic Parameters, Workday, Peak Hour, 2017

Average Delay per Vehicle

This parameter indicates the average delay experienced by each vehicle when crossing a specific intersection, compared to an ideal scenario where travel occurs without stops and at the maximum allowed speed.

Number of Stops per Vehicle

The number of stops per vehicle is calculated by dividing the total number of stops by the number of vehicles passing through the intersection within a given time unit.
A stop is recorded when a vehicle's speed drops below 3 m/s.
A vehicle is considered to have restarted when its speed exceeds 4.5 m/s.

Average Speed

The average speed is calculated by dividing the total distance traveled by the total travel time over a specific section of the transport network (road, intersection, zone, etc.).

Table 14 Traffic Parameters, Workday, Peak Hour

Intersection Name	Delay / vehicle (s/veh)	Stops / vehicle (nr)	Average Speed (km/h)
A2. Str. Brăilei – Str. Oțelarilor	26.0	0.86	22
A3. Str. Brăilei – Str. Mioriței	12.0	0.43	34
A4. Str. Brăilei – Str. Stadionului	66.5	0.39	10

To calculate the Energy Consumption of Transportation, we will use the following general formula:

$$E = \frac{d}{v} \times P$$

Where:

E = Energy consumption (in MJ or kWh)
d = Distance traveled (in km)
v = Average speed (in km/h)
P = Power consumption of the vehicle (in kW)
Average trip distance: We assume a typical trip distance per intersection of **1 km** for simplicity.
Average fuel consumption:

- Passenger cars: **0.3 MJ per vehicle per second** (approx. **8 liters/100 km** of gasoline).
- Heavy vehicles/trucks: **0.6 MJ per vehicle per second**.
- Public transport (buses/trolleys): **0.5 MJ per vehicle per second**.

Vehicle type distribution: Based on the bar chart from previous images, the fleet consists of:

- **80% passenger cars**
- **15% heavy vehicles**
- **5% public transport vehicles**

Table 15 Energ consumption

Nr	Intersection	Energy consumption(MJ)	Energy consumption(kWh)
1	A2. Str. Brăilei – Str. Oțelarilor	58.09	16.13
2	A3. Str. Brăilei – Str. Mioriței	37.58	10.44
3	A4. Str. Brăilei – Str. Stadionului	127.80	35.50

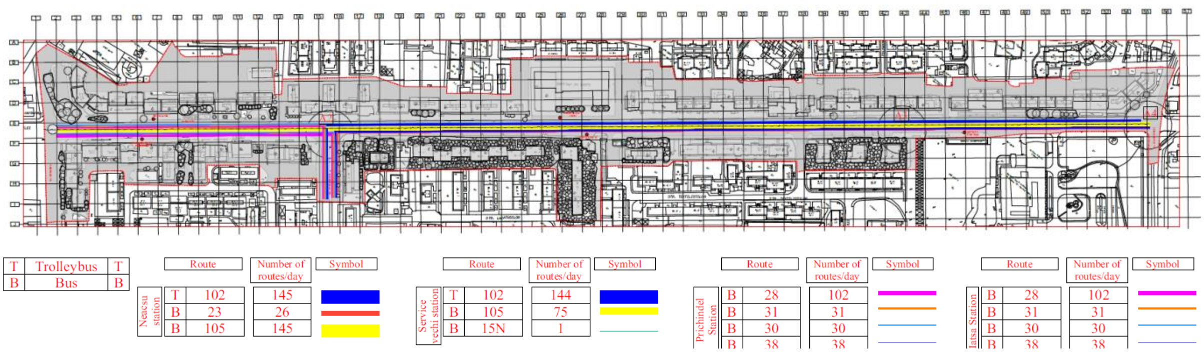


Figure 67 Public transportation

Limitation of the analysis.

Outdated data.

The analysis is based on data from a specific period (workday, peak hour, 2017). This provides a snapshot of traffic conditions but does not account for seasonal variations, long-term trends, or changes in traffic patterns over time. The results might not reflect typical traffic patterns during different times of the year or outside peak hours.

The calculation of energy consumption is based on a simplified formula that assumes a constant trip distance of 1 km for all vehicles. This oversimplifies the reality, as the actual trip distance can vary significantly for different vehicles and intersections, leading to inaccuracies in the total energy consumption.

The analysis does not account for possible future developments such as population growth, urban expansion, or changes in infrastructure (e.g., new roads, public transport improvements). These factors could significantly alter traffic patterns and energy consumption over time.

The energy consumption calculation does not account for factors such as vehicle acceleration, idling time, or the use of alternative fuels (e.g., electric vehicles). These factors can impact the overall energy consumption and the accuracy of the results.

Source of data for the assessment:

- *Traffic Study for Galați Municipality (2017)– Projects:*
  - *"Modernization of Tram Lines and Roadway on Siderurgiștilor Street and 1 Decembrie Street"*
  - *"Modernization of Tram Lines and Roadway on Traian Vuia Street, Henri Coandă Street, and George Coșbuc Street (section between Henri Coandă Street and Alexandru Măcelaru Street)"*
  - *"Acquisition of Non-Polluting Transport Vehicles (Trams, Trolleybuses)"*
  - *"Intermodal Transport Center of Galați Municipality"*
  - *"Galați VELOCity"*
  - *"Modernization of the Transport Depot on George Coșbuc Boulevard"*

SENSITIVITY OF EQUIPMENT AND MATERIALS

In the area we identified, using street view and field survey, 2095 Air Conditioning Units. There are no Industrial Machinery. From the total of 2095 units approximatively 30% are in poor working condition.

Table 16 Equipment

Indicators - equipment	Values	Measurement unit	Notes
Operational hours	8	h/day	
Heat output	16000	BTUs	
Density of eq uipment	0.012	Number of units per m2	- 1.2 unit on 100m^2 - Moderate number of units - Minimal heat emission
Proximity to sensitive areas	0	m	Close to Residential Zones Higher impact on human comfort
Cooling load and efficiency	7.5	EER =Cooling energy (in BTU) to input electrical energy (in watts)	
Maintenance status	29.97%	%	29.97% poor functioning
Surface area of equipment	1.17	m^2	Minimal heat emission

Table 17 Surface materials

Surface materials	*Type of material*	Surface condition	Albedo coefficient	Surface temperature
Roads	*Asphalt -impermeable*	*Very good*	0.05-0.10	/
Pedestrian area surface	*asphalt*	*Very good*	0.05-0.10	/
	Ceramic tiles	*Fair*	0.05-0.15	/
Roofs	*Bituminous membrane*	*Good*	0.05-0.15	/
	Metal	*Good*	0.10-0.20	/
	Glass skylight	*Good*	*0.20 - 0.40*	/
Green spaces	*Grass/land -permeable*	*Fair*	0.20-0.30	/

Limitation of the analysis (missing data, outdated data, etc.).

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered just with the surface temperature.

At the city level, this analysis of the street and sidewalk surfaces would be very difficult to carry out without conclusive data from the transport service.

Source of data for the assessment:

- *The cadaster of buildings*
- Google earth/maps
- Field survey

Albedo (Reflectivity) Coefficient

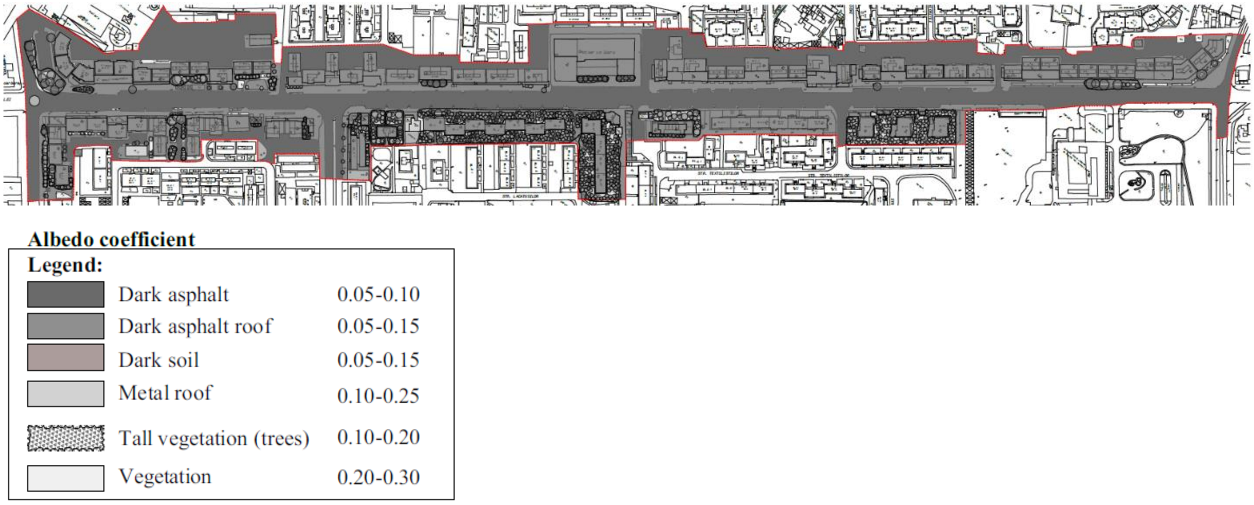


Figure 68 Albedo coefficient

The key values are:

- **Dark asphalt & dark asphalt roofs** (0.05 - 0.15): Low reflectivity, high heat absorption.
- **Dark soil** (0.05 - 0.15): Similar to asphalt, retains heat.
- **Metal roofs** (0.10 - 0.25): Moderate reflectivity, absorbs less heat than asphalt.
- **Tall vegetation (trees)** (0.10 - 0.20): Provides cooling effects, moderate reflectivity.
- **General vegetation** (0.20 - 0.30): Highest reflectivity, contributing to lower surface temperatures.

Dark asphalt (gray-colored sections) dominates the streets and paved areas, indicating a low albedo and high heat retention.
Buildings with various rooftops (possibly dark asphalt roofs or metal roofs) are scattered throughout the area.
Vegetation elements (trees and green spaces) appear in clusters, mainly around residential zones and intersections.
The dominance of dark asphalt surfaces suggests a high urban heat island (UHI) effect, where heat absorption increases local temperatures.
Green spaces and tree coverage contribute to localized cooling, but their presence is limited in certain areas.
Potential Mitigation Strategies: Increasing vegetation cover, incorporating reflective surfaces, or using lighter-colored materials in urban design could help reduce heat accumulation.
Limitation of the analysis (missing data, outdated data, etc.).

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface. To create the maps, we created a 25x25m grid adapted to the studied area.

For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

The analysis does not account for seasonal variations in albedo:

- Snow cover in winter can temporarily increase reflectivity.
- Moisture content (after rain or during humid conditions) can affect albedo properties.
- Vegetation changes (leaf coverage in different seasons) impact urban heat retention.

A year-round study would be required to capture these seasonal effects.

High-resolution satellite or aerial imagery could provide **more precise albedo values** for different materials.

Source of data for the assessment:

Data provided from the scientific partner.

Thermal Conductivity

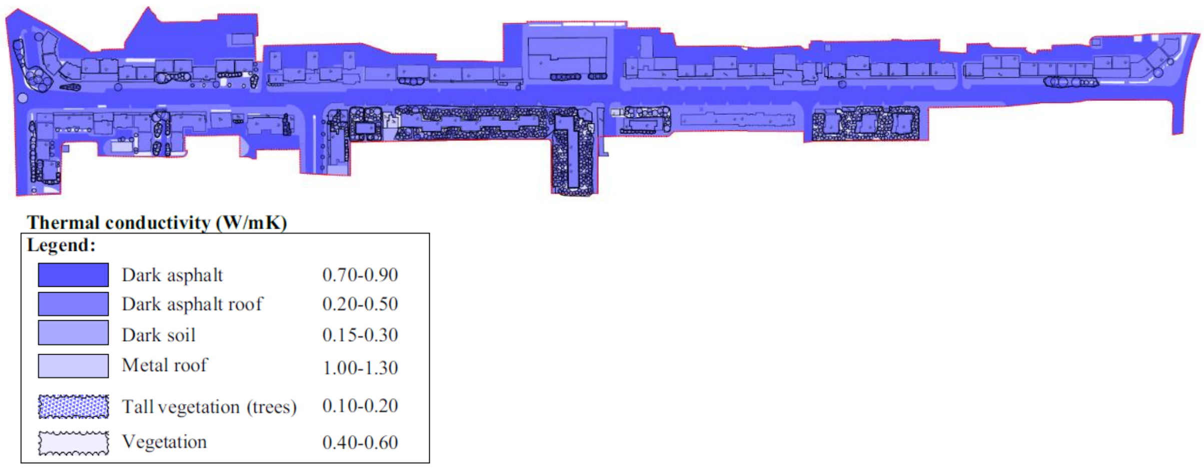


Figure 69 Thermal conductivity

Thermal conductivity measures how well a material conducts heat. **Higher values mean greater heat transfer**, while **lower values indicate better insulation properties**.

Dominant Surface Types and Their Thermal Conductivity

From the first image, the urban area is **predominantly covered with dark asphalt (deep blue), buildings, and some vegetation areas**. Based on the legend:

- **Dark asphalt (0.70 - 0.90 W/mK)**
  - This material is **widely present** in the streets and roadways.
  - **High thermal conductivity**, meaning it **absorbs and transfers heat efficiently**, contributing to **urban heat buildup**.
- **Dark asphalt roofs (0.20 - 0.50 W/mK)**
  - Present on many **building rooftops**.
  - Lower conductivity compared to roads, meaning it **retains some heat but transfers less than asphalt surfaces**.
- **Dark soil (0.15 - 0.30 W/mK)**
  - Found in **unpaved areas**.
  - **Moderate insulation** properties, **not as heat-absorbing as asphalt** but still retaining warmth.
- **Metal roofs (1.00 - 1.30 W/mK)**
  - If present, these **have the highest thermal conductivity**, meaning they **rapidly absorb and release heat**.
  - Metal surfaces can cause **thermal discomfort** due to **high heat transfer rates**.
- **Vegetation & Trees (0.10 - 0.60 W/mK)**
  - **Tall vegetation (trees)** (0.10 - 0.20 W/mK) provides the **best insulation** and helps **mitigate urban heat**.
  - **Low vegetation** (grass, shrubs) (0.40 - 0.60 W/mK) **absorbs less heat than asphalt** but **more than trees**.

The **dominance of dark asphalt** (high thermal conductivity) means that this area experiences **strong heat absorption and transfer**, leading to **higher surface and air temperatures**.

Building rooftops with asphalt or metal surfaces further **contribute to heat retention**, making urban cooling strategies necessary.

Vegetation, especially trees, acts as a thermal barrier, reducing heat buildup by **offering lower conductivity values** and **shading heat-absorbing surfaces**.

The urban area analyzed has **a high thermal conductivity due to dark asphalt and built-up surfaces**, leading to **strong heat absorption and heat transfer effects**. **Enhancing vegetation and using better surface materials** can help **reduce the impact of urban heat islands** and improve **thermal comfort in the city**.

Recommendations

Increase vegetation coverage → More **trees** can lower overall thermal conductivity, improving **urban cooling**.

Use reflective or insulated materials for roofing → Metal and asphalt roofs could be replaced or coated with **cooling materials**.

Implement permeable surfaces → Reducing **asphalt dominance** by incorporating **vegetated areas, green roofs, or light-colored paving** could **help control heat transfer**.

Limitation of the analysis (missing data, outdated data, etc.).

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface. To create the maps, we created a 25x25m grid adapted to the studied area.

For each resulting square, all indicators were calculated, they were grouped in 5-point rating classification scale. The darkest color representing the highest value.

In reality, **material aging, wear, and environmental conditions** can **alter actual thermal conductivity**:

- **Weathered asphalt** may absorb and retain heat differently.
- **Deteriorated metal roofs** may have varying heat dissipation rates.
- **Moisture content in soil and vegetation** can **influence heat transfer rates**.

The study **does not account for seasonal variations** that affect thermal conductivity:

- **Winter conditions (snow and ice)** can temporarily **alter** thermal properties by adding an insulating layer.
- **Vegetation changes** (e.g., trees shedding leaves in autumn) can influence **heat absorption and cooling effects.**

A higher-resolution dataset (e.g., satellite thermal imaging or field-based infrared measurements) could provide **more accurate thermal assessments.**

Source of data for the assessment:

Data provided from the scientific partner.

Heat Capacity

In the two tables below some differences in temperature and overall Increase in Q can be observed.

Table 18 Heat capacity in 2000

Material	Total Area (m^2)	Density (kg/m^3)	Specific Heat (J/kg·°C)	April 2000 ΔT (°C)	July 2000 ΔT (°C)	Oct 2000 ΔT (°C)	April 2000 Q (J)	July 2000 Q (J)	Oct 2000 Q (J)
Concrete	43,700.00	2400	880	12.5	23.5	13	1,152,828,000	2,156,212,800	1,242,331,200
Sheet Metal	416.22	7850	466	12.5	23.5	13	18,834,375	35,250,825	20,296,163
Asphalt	102,986.05	2300	915	12.5	23.5	13	271,446,660	508,019,081	292,648,387
Ceramic	511.5	2500	1000	12.5	23.5	13	1,601,531	2,996,738	1,727,625
Vegetation	16,372.21	1500	1300	12.5	23.5	13	33,312,056	62,308,938	35,933,944
Coronament (Vegetation)	18,401.80	1000	4186	12.5	23.5	13	96,164,358	180,007,493	103,773,334

Table 19 Heat capacity in 2023

Material	Total Area (m^2)	Density (kg/m^3)	Specific Heat (J/kg·°C)	April 2023 ΔT (°C)	July 2023 ΔT (°C)	Oct 2023 ΔT (°C)	April 2023 Q (J)	July 2023 Q (J)	Oct 2023 Q (J)
Concrete	43,700.00	2400	880	14	26	15	1,455,723,655	2,714,112,761	1,559,497,313
Sheet Metal	416.22	7850	466	14	26	15	23,789,281	44,375,333	25,520,247
Asphalt	102,986.05	2300	915	14	26	15	304,019,293	567,889,543	325,301,877
Ceramic	511.5	2500	1000	14	26	15	1,790,250	3,329,500	1,910,625
Vegetation (Soil)	16,372.21	1500	1300	14	26	15	44,646,479	83,288,660	47,887,240
Coronament (Vegetation)	18,401.80	1000	4186	14	26	15	107,886,607	200,843,193	115,628,178

The primary driver of changes in thermal energy storage between 2000 and 2023 is the difference in average monthly temperatures (ΔT). The data indicates that, in general, 2023 temperatures are estimated to be higher, particularly in April and July. This directly translates into higher Q (thermal energy storage) values for all materials in all months of 2023 compared to 2000. The greater the temperature difference (ΔT), the more thermal energy is stored in a material.

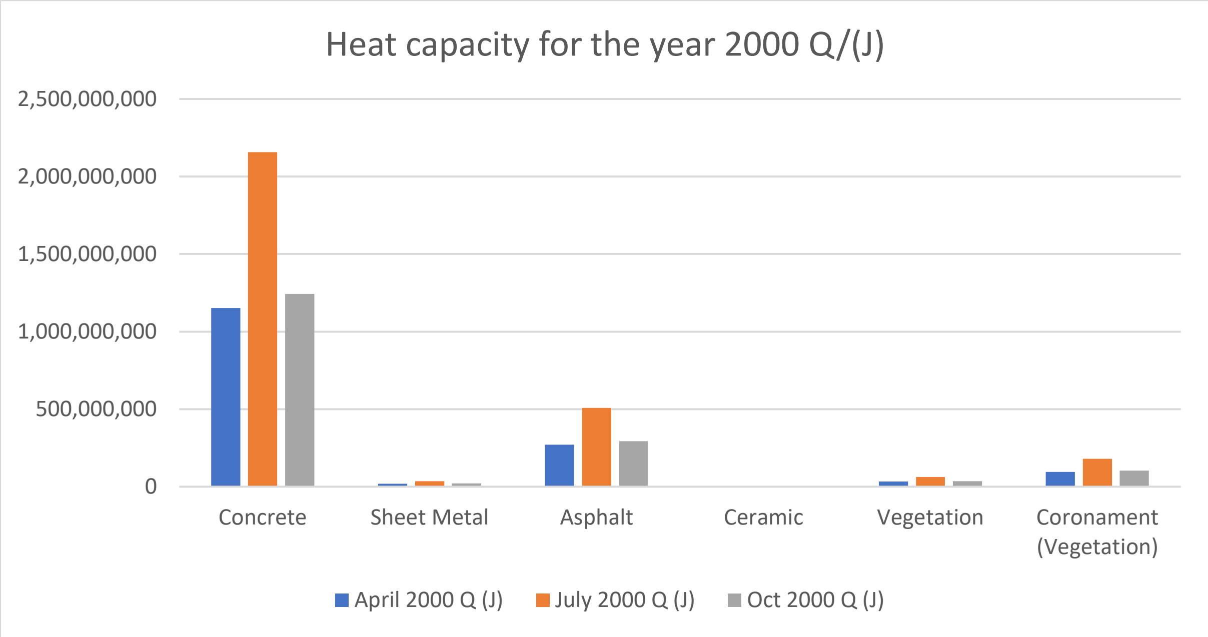


Chart 10 Heat capacity, 2000

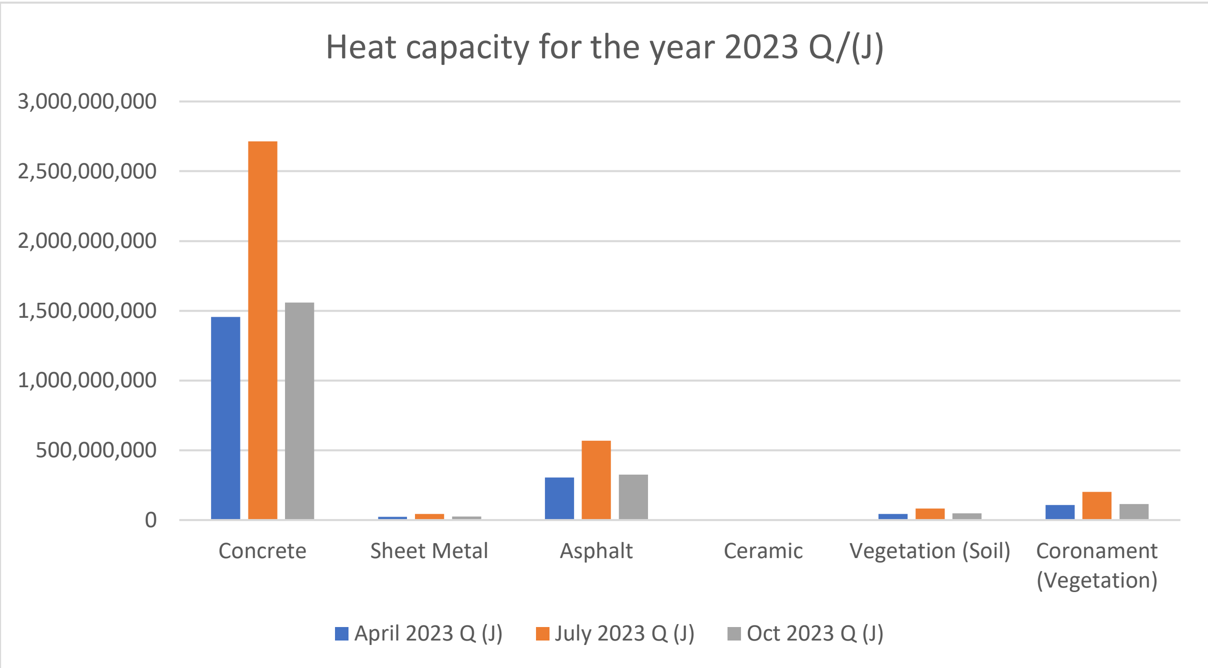


Chart 9 Heat capacity, 2023

Since concrete is extensively used in both commercial and residential buildings, it shows the highest absolute increase in thermal energy storage. This suggests that even small changes in ambient temperature can significantly impact the total heat load of buildings made with concrete, exacerbating the urban heat island effect.

Asphalt exhibits the second-largest absolute change in thermal energy storage due to its widespread use in roads and pedestrian areas. Increased heat absorption by asphalt surfaces contributes to higher surface temperatures and increased radiative heat, further intensifying the urban heat island effect.

While the absolute increase in thermal energy storage for metal sheets is relatively small, the percentage change is substantial. This is because metal has a lower specific heat capacity, meaning even a small temperature change has a more pronounced effect on the energy stored per unit area.

Ceramic surfaces have the lowest impact, primarily due to their lower overall quantity compared to other materials.

Green spaces also show increased thermal energy storage in 2023. This can have both positive and negative implications. On one hand, vegetation helps mitigate the urban heat island effect through evapotranspiration, but on the other hand, increased thermal energy storage means the vegetation itself is warmer.

The rise in thermal energy storage for all materials in 2023 suggests that the study area is experiencing an overall increase in heat load. This could lead to higher energy consumption for cooling, increased discomfort for residents, and potential health risks during heat waves.

The analysis highlights the necessity of adaptation strategies to mitigate the impact of climate change on the built environment. These strategies could include:

- Using more reflective materials for building surfaces and pavements to reduce solar heat absorption.
- Increasing vegetation cover to provide shade and promote evapotranspiration.
- Improving building insulation to reduce heat transfer.
- Implementing cool pavement technologies to lower surface temperatures.

Limitation of the analysis.

The analysis primarily focuses on temperature differences (ΔT) and heat energy storage in various materials but doesn't account for other influencing factors like urban design, humidity, or wind, which all play a significant role in the urban heat island effect and thermal storage.

The analysis assumes that the materials' properties (density, specific heat, etc.) have remained unchanged since the structures have been built. In reality, materials can undergo physical degradation, modification, or improvement (e.g., concrete cracking, asphalt resurfacing), which could affect thermal energy storage capacity.

Source of data for the assessment:

- *The Urban Planning Service of the Galați City Hall,*
- *https://www.hartablocuri.ro/galati/,*
- *The cadaster of buildings*
- Google earth/maps

Surface Temperature

S.C. Cretu et al. (2020). *Summer Urban Heat Island of Galați City (Romania) Detected Using Satellite Products*. https://www.researchgate.net/publication/347462405 indentify as foloows:

Daytime UHI Structure

The **highest LST values** are observed in **industrial areas** (SIDEX platform) and **residential zones**.

The **UHI is most intense during heat waves**, with urban temperatures **exceeding 35-37°C**, while **peri-urban areas remain around 30-32°C.**

The **Danube River and Brateș Lake** create strong thermal contrasts. The industrial area experiences **the highest LST, up to 10°C warmer** than nearby water bodies.

Nighttime UHI Structure

The **UHI weakens at night**, with maximum temperatures recorded over water surfaces rather than industrial areas.

The **Danube River retains heat**, warming the urban atmosphere during the night, leading to a secondary UHI effect.

The UHI **limit becomes irregular** due to varying water surface temperatures.

Seasonal and spatial Intensity of UHI

During summer, **UHI intensity is highest at 2-2.5°C** when comparing urban vs. rural temperatures.

Urban areas are significantly warmer than surrounding agricultural and rural zones.

The industrial area remains hotter during the day, while the city center retains heat at night.

Impact of Land Cover

Dense urban areas, especially industrial zones, exhibit the highest temperatures.

Vegetation does not significantly cool the city, likely due to placement in low-altitude areas or proximity to water.

Water bodies have dual effects: cooling during the day but warming the air at night.

Conclusions and recommendations

The UHI effect is strongest during the day, fueled by industrial and residential zones.

Water surfaces moderate daytime temperatures but intensify nighttime heat.

A permanent meteorological monitoring system is necessary for better UHI assessment.

Future urban planning should consider **expanding green infrastructure and reflective materials to mitigate UHI effects.**

Limitation of the analysis.

The analysis focuses mainly on temperature data and land cover but does not include other potentially relevant factors, such as air quality, wind patterns, or human activities, that can influence the UHI effect. Without this additional data, the analysis may miss important interactions and dynamics.

While satellite data provides valuable insights, it may lack the precision and detail that ground-level measurements can offer. For example, local variations in temperature due to microclimates, urban heat pockets, or specific building materials might not be fully captured by satellite imagery.

The analysis highlights UHI intensity during summer, but it does not explore how the UHI effect changes across seasons or in response to different weather events. A more robust study would track UHI dynamics over a longer period, considering variations in seasonal temperature trends, precipitation, and extreme weather events.

Source of data for the assessment:

S.C. Cretu et al. (2020). *Summer Urban Heat Island of Galați City (Romania) Detected Using Satellite Products*. https://www.researchgate.net/publication/347462405

Emissivity

Data requested/ assistance from the scientific partner.

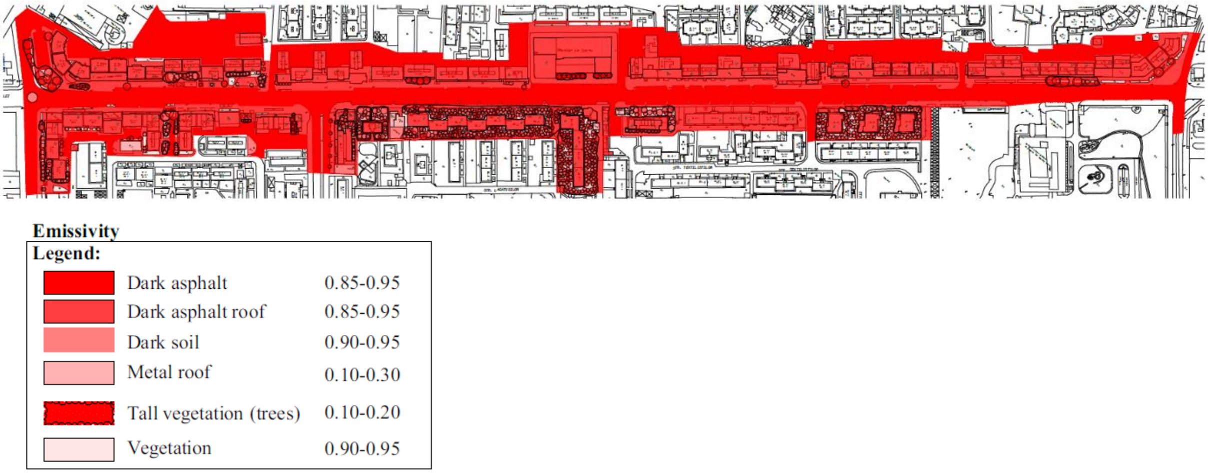


Figure 70 Emissivity

The image above represents an urban surface map with different materials, and the second image provides the emissivity values for these materials. Emissivity refers to the ability of a surface to emit thermal radiation, with values ranging from 0 (perfect reflector) to 1 (perfect emitter). Higher emissivity values indicate greater heat radiation emission, contributing to urban heat island effects.

From the first image, the primary surface coverage is dark asphalt (deep red color), covering roads and public spaces, and some built-up areas.

- Dark asphalt & dark asphalt roofs (0.85 - 0.95) → Most surfaces in the image fall into this category, meaning they absorb and emit a high amount of heat, contributing to higher urban temperatures.
- Dark soil (light red) (0.90 - 0.95) → Some areas may consist of bare ground or unpaved regions, also having a high emissivity similar to asphalt.
- Metal roofs (light pink) (0.10 - 0.30) → If present, these surfaces would have low emissivity, reflecting more heat and retaining less thermal energy.
- Vegetation (textured red and pale pink areas) (0.10 - 0.95) → Green spaces, particularly tall trees, have lower emissivity (0.10 - 0.20), helping mitigate urban heat. However, low vegetation surfaces (grass, shrubs) may still have high emissivity (0.90 - 0.95), similar to soil.
- The dominance of **high-emissivity surfaces (asphalt, dark soil, and vegetation)** suggests that this area is prone to **absorbing and releasing significant heat**, especially **during the night**, leading to **higher overall temperatures**.
- **Limited low-emissivity surfaces (like metal roofs)** means **less reflective cooling**, further enhancing heat retention.
- **Vegetation provides some cooling effects**, but **low vegetation still emits heat**, making tall trees a crucial factor in reducing urban heat buildup.

Recommendations

- Increase reflective surfaces → Using lighter-colored materials or coatings on roads and rooftops can reduce heat absorption.
- Expand tall vegetation coverage → Trees have low emissivity and provide shading, significantly lowering surface temperatures.
- Use high-albedo coatings on roofs and pavements → This would help reflect more sunlight rather than absorbing and emitting heat.

Limitation of the analysis.

The analysis relies heavily on data provided by the scientific partner. The analysis appears to be based on surface maps and emissivity values. While these provide useful information about heat absorption and emission, they do not offer ground-level measurements or data on actual temperature variations. Without on-the-ground observations, the results may not fully capture localized variations or factors affecting the urban heat island effect. While the emissivity values for specific materials are provided, the analysis does not mention if these values are representative of all materials within the study area. Variations in material quality, age, and condition could impact their emissivity, but the data provided might be too generalized or averaged, overlooking these nuances.

Field measurements using **thermal imaging** could improve the accuracy of emissivity estimates.

Source of data for the assessment:

Data provided from the scientific partner.

Material Condition

Table 20 Indicators for surface materials

Surface materials	*Type of material*	Surface condition	Albedo coefficient	Surface temperature
Roads	*Asphalt -impermeable*	*Very good*	0.05-0.10	-
Pedestrian area surface	*asphalt*	*Very good*	0.05-0.10	-
	Ceramic tiles	*Fair*	0.05-0.15	-
Roofs	*Bituminous membrane*	*Good*	0.05-0.15	-
	Metal	*Good*	0.10-0.20	-
	Glass skylight	*Good*	*0.20 - 0.40*	-
Green spaces	*Grass/land -permeable*	*Fair*	0.20-0.30	-

Roads & Pedestrian Areas (Asphalt)

- Asphalt surfaces have **low albedo (0.05-0.10)**, meaning they **absorb most of the solar radiation and retain heat**.
- This contributes to **urban heat island (UHI) effects**, as asphalt is widely used in cities.

Pedestrian Area (Ceramic Tiles)

- Ceramic tiles have a **slightly higher albedo (0.05-0.15)** than asphalt, but still **retain significant heat**.
- Their **"Fair" surface condition** suggests **some degradation**, which could lower reflectivity further over time.

Roofs

- **Bituminous membrane roofs** have a **low albedo (0.05-0.15)**, meaning they **absorb a lot of heat**, which increases indoor cooling demands.
- **Metal roofs (0.10-0.20 albedo)** reflect slightly more heat than asphalt but still contribute to **heat buildup**.
- **Glass skylights have the highest albedo (0.20-0.40)**, meaning they **reflect more sunlight**, reducing heat absorption.

Green Spaces

- **Grass/land areas** have an albedo between **0.20-0.30**, meaning they reflect **significantly more sunlight than built surfaces**.
- **Permeable surfaces (like soil and grass) help reduce heat retention**, acting as natural cooling zones.

Low albedo materials (asphalt, bitumen, ceramic tiles) contribute to higher surface temperatures and urban heat islands (UHI).

Higher albedo materials (glass skylights, vegetation) help reduce heat absorption, making cities more thermally comfortable.

Metal roofs, while reflecting more than bitumen, can still heat up due to high thermal conductivity.

Limitation of the analysis (missing data, outdated data, etc.).

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

It was not possible to determine the surface temperature for each surface represented by a different material. We were unable to extract and process satellite images. At the municipal level, obtaining these values would be even more difficult.

Source of data for the assessment:

- *The cadaster of buildings*
- Google earth/maps
- Field survey

Coverage Area

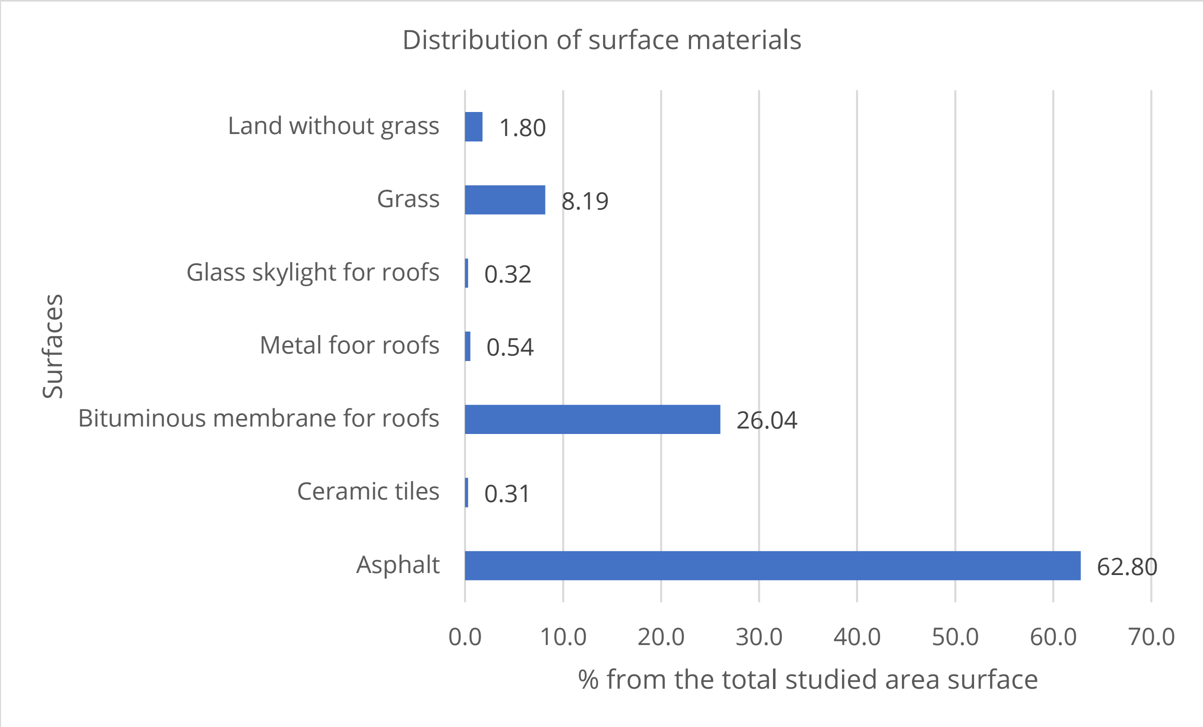


Chart 11 Distribution of surface materials in studied area

Asphalt is the most dominant surface material, covering 62.80% of the studied area. This suggests that the area is heavily urbanized, with significant portions dedicated to roads, parking lots, or other paved surfaces.

The second most prevalent material is bituminous membranes, accounting for 26.04% of the surface. This indicates widespread use of this material for roofing for residential and commercial buildings.

Grass covers 8.19% of the area, reflecting green spaces such as lawns. While not dominant, its presence suggests some balance between urban development and natural or semi-natural spaces.

Areas of bare land (without grass) make up a smaller portion, at 1.80%, pointing to zones that may be undeveloped or in transition.

Glass skylights and metal roofs represent 0.32% and 0.54%, respectively, indicating limited use of these materials only on 3 commercial buildings and the public services one.

Ceramic tiles are the least represented surface material, covering just 0.31% of the area. They are used on some entrance stairs to some buildings.

The chart highlights the predominance of impermeable materials such as asphalt and bituminous roofing membranes, which may impact water runoff and urban heat.

The limited percentage of grass and natural surfaces reflects a predominantly urban or industrialized environment, with some efforts for greenery.

The small proportions of other materials, like glass skylights, metal roofs, and ceramic tiles, suggest they are niche choices in this area.

Limitation of the analysis (missing data, outdated data, etc.).

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

In the absence of satellite images and their GIS processing for the calculations, we used a cadastral format in cad format. We identified and vectorized each surface.

Source of data for the assessment:

- *The cadaster of buildings*
- Google earth/maps

Vegetative Cover

The studied area has a total surface of 163,985.73 m², out of which the surface occupied by the tree canopy is 18,401.80 m² to which an additional 1,243 m² of other green spaces is added. The percentage ratio between vegetative coverage and the total area is 11.97%.

Table 21 Vegetative cover

Total surface area of the studied zone(m^2)	163,985.73
Vegetative Cover (m^2)	19,644.80
Vegetative Cover ratio %	11.97

A. Calculation of the Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI) is a widely used measure for quantifying vegetation health and density using sensor data. It is calculated from spectral data at two specific bands: red and near-infrared. Spectral data typically come from remote sensors, such as satellites.

This matrix is popular in the industry due to its accuracy. It has a high correlation with the actual condition of vegetation on the ground. The index is easy to interpret: NDVI will have a value between -1 and 1. An area with nothing growing in it will have an NDVI of zero. NDVI increases proportionally with vegetation growth. An area with dense and healthy vegetation will have an NDVI of one. NDVI values below 0 suggest a lack of dry land. An ocean, for instance, will produce an NDVI of -1.

The NDVI (Normalized Difference Vegetation Index) helps us analyze satellite images to identify and evaluate different land surface characteristics, such as:

- **Vegetation health monitoring** – Detecting drought, plant diseases, and water stress.
- **Precision agriculture** – Optimizing irrigation, fertilization, and harvesting.
- **Forest management** – Identifying deforested areas and vegetation growth.
- **Land mapping** – Distinguishing vegetated areas from built-up or arid regions.
- **Climate change monitoring** – Tracking the impact of temperature variations on vegetation.

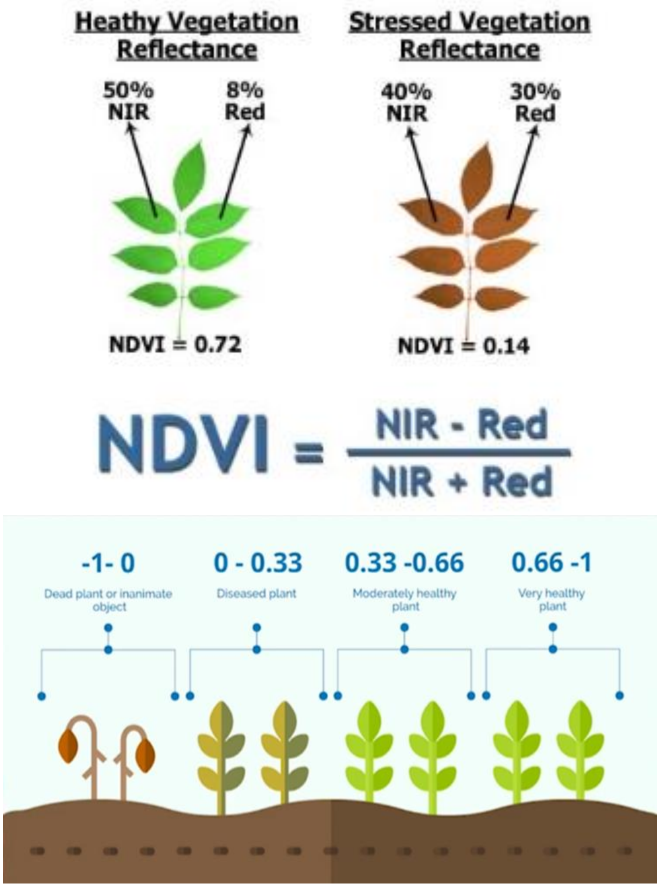


Figure 71 Normalized Difference Vegetation Index (NDVI)

In the images bellow analyzing NDVI (Normalized Difference Vegetation Index) Maps for April, July, and October 2024, we can extract de following:

1. Vegetation Distribution

- Built-up areas are well-defined, with little vegetation inside the marked perimeter.

2. Vegetation Evolution Over Time

April

- Vegetation is present but relatively sparse, with a predominance of low-growing plants and weakly vegetated areas.
- A few areas with dense vegetation are observed, but they are limited in extent.

July

- Vegetation growth is evident, indicating a peak development season.
- Densely vegetated areas (dark green) are more pronounced, suggesting either seasonal planting or the growth of existing vegetation.
- Some areas that were sparsely vegetated in April may have been covered by active vegetation.

October

- A significant decline in active vegetation is observed due to the seasonal cycle.
- However, compared to April, more active vegetation appears to remain, suggesting either the presence of perennial species or better maintenance of green spaces.

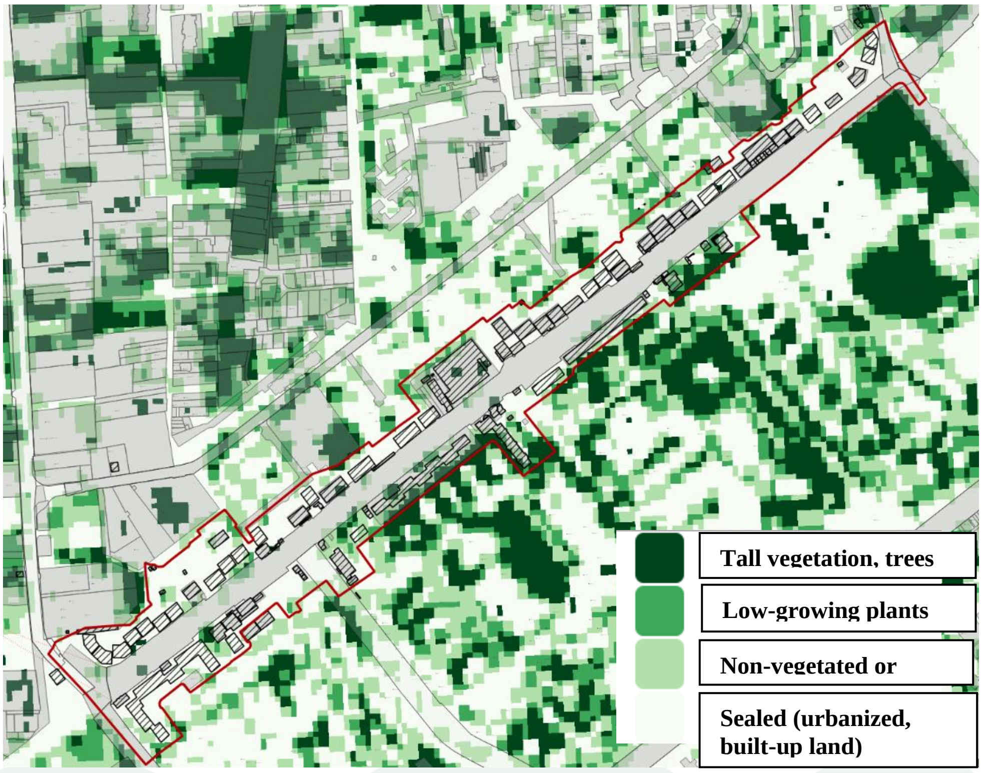
3. Impact on the Urban Environment

- Urban areas remain relatively constant in terms of vegetation, indicating a possible lack of intervention in green spaces.
- The presence of perennial vegetation around the site suggests a good capacity for mitigating the urban heat island effect. However, in certain areas, replanting or maintenance measures may be necessary.

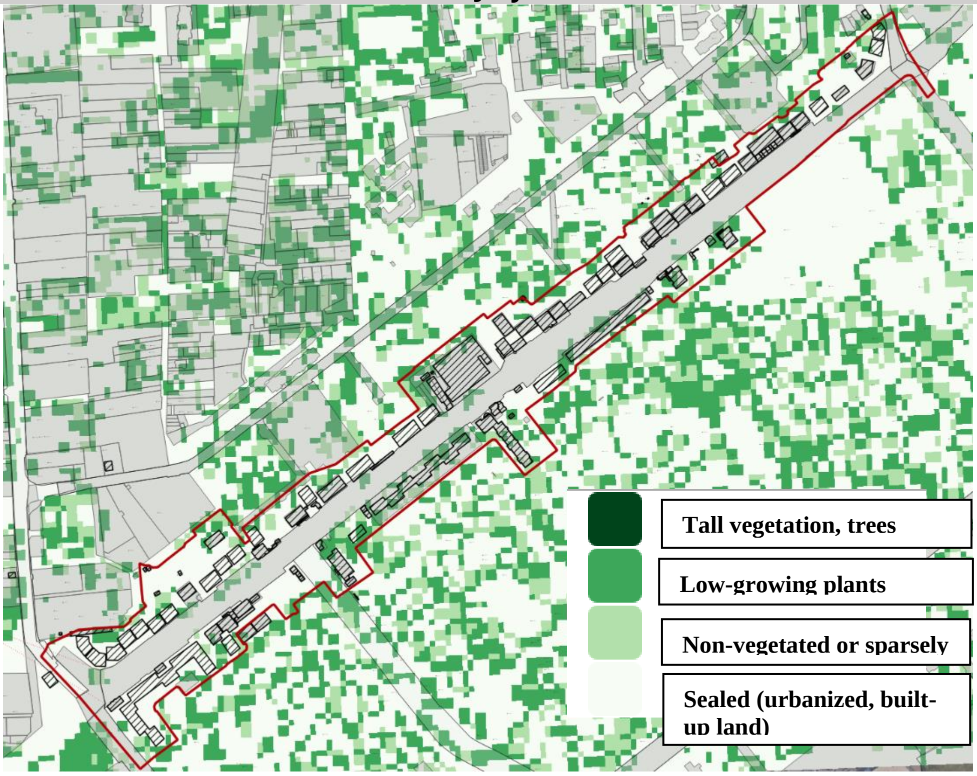
Normalized Difference Vegetation Index (NDVI) -source https://www.copernicus.eu/en

Studied area :Projected resolution: 10 m/px **2024**

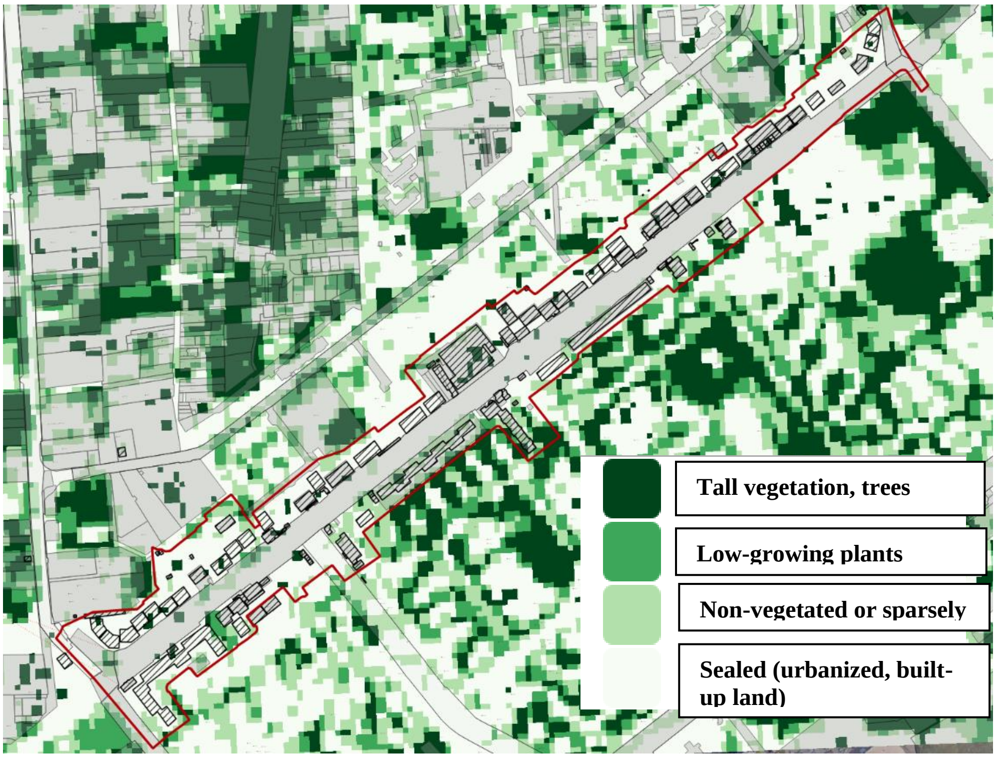
April



July



October



Based on this NDVI analysis, a natural seasonal dynamic of vegetation is observed, with a peak during the summer months and a decline in the colder season. If environmental conditions are to be improved, planting species resistant to seasonal changes and actively maintaining green spaces around the studied area should be considered.

B. Color Infrared Vegetation (CIR) Imaging

Color Infrared Vegetation (CIR), also known as false-color infrared imaging, is an image processing technique that highlights vegetation and other land features using the near-infrared (NIR) spectrum, along with the visible red and green bands.

Detection and Analysis of Vegetation Health

CIR imaging helps us analyze satellite images to identify and assess various characteristics of the studied surface, such as:

- Healthy vegetation strongly reflects near-infrared (NIR) light and appears bright red in CIR images.
- Vegetation affected by disease, drought, or pollution appears in darker shades of red or even brown.

Detection of Wetlands and Water Bodies

- Water absorbs nearly all NIR radiation and appears very dark (blue-black) in CIR images, helping to identify rivers, lakes, and wetland areas.

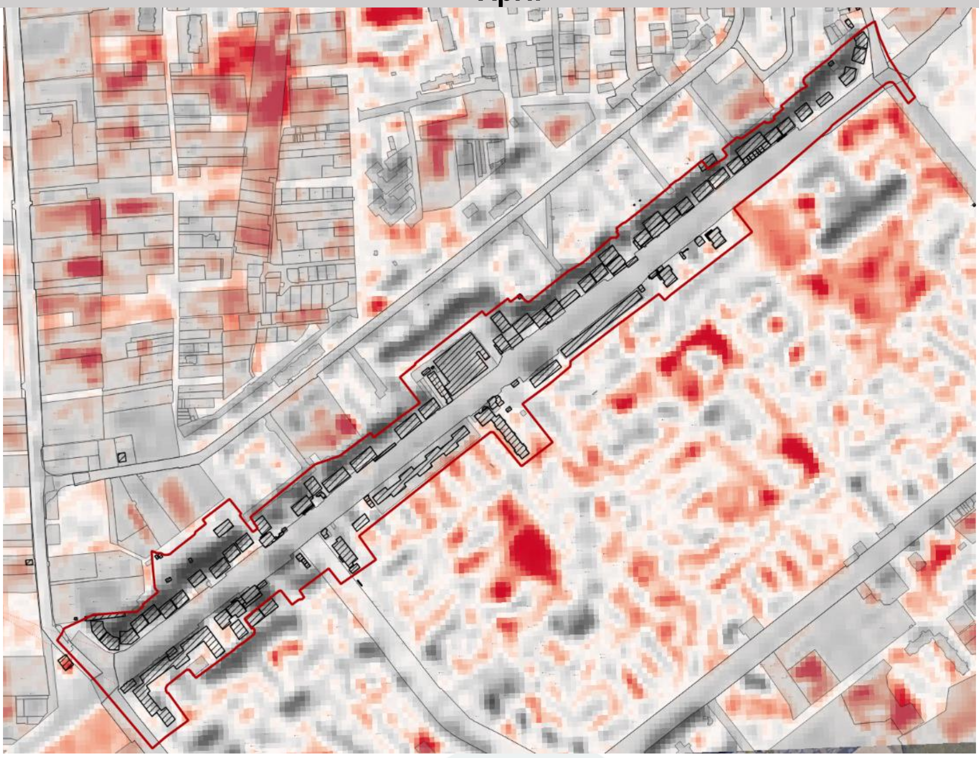
Identification of Urban and Built-up Areas

- Buildings, roads, and other artificial surfaces appear in gray, blue, or violet shades, allowing a clear distinction from vegetated areas.

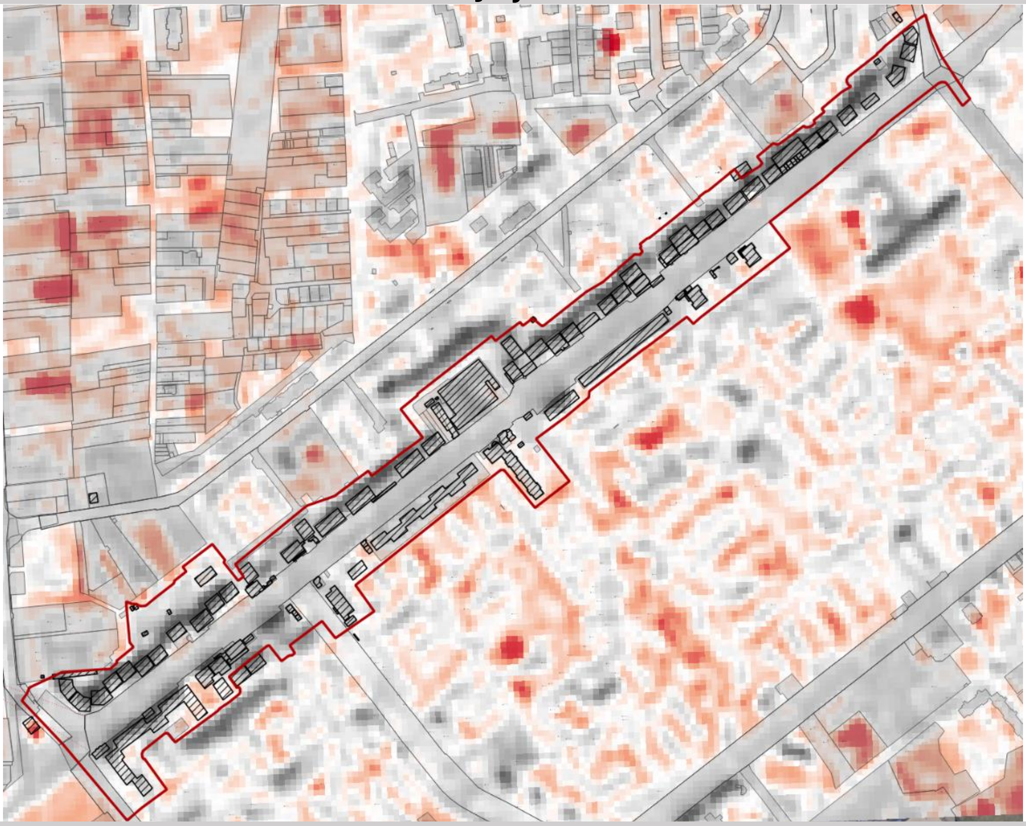
Normalized Difference Vegetation Index (NDVI) source https://www.copernicus.eu/en

Studied area :Projected resolution: 10 m/px 2024

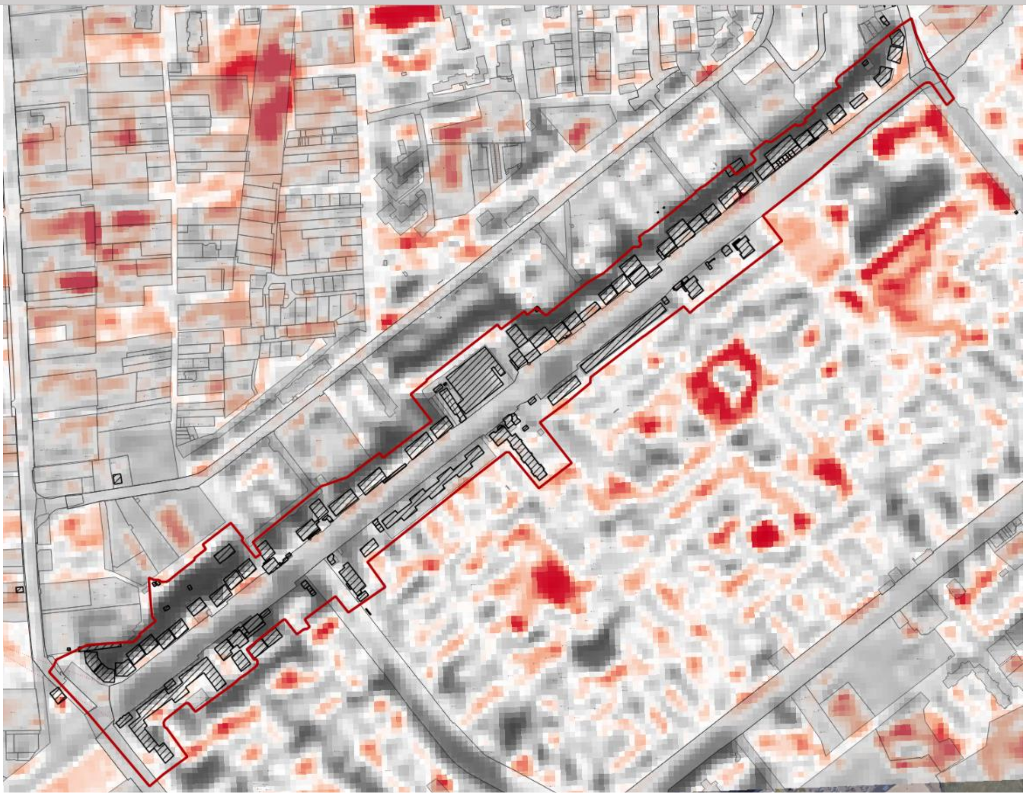
April



July



October



Legend

	Bright Red → Healthy vegetation (reflects a high amount of near-infrared light)
	Orange / Yellow → Less healthy or stressed vegetation
	Beige / Brown → Bare soil or dry vegetation
	Black → Water (high absorption of NIR)
	White / Gray → Urban areas, roads, buildings (high reflectance of visible light)

April (First Image) – Early Growth Phase

Vegetation is **present but sparse**, with scattered bright red areas, indicating **patches of healthy plants**. Many areas appear **light red or orange**, suggesting **less dense or stressed vegetation**, due to early seasonal growth. The built-up areas remain consistent (gray/white), with little vegetation inside them. Some **bare soil areas (beige/brown) are visible**, indicating land under preparation for planting.

July (Second Image) – Peak Vegetation Growth

The **amount of bright red areas has significantly increased**, indicating **maximum vegetation density and health** during summer. Many areas that were **light red/orange in April** now appear **darker red**, suggesting strong plant growth. Some previously **bare soil areas** are now covered in **vegetation**, implying successful seasonal plant growth. The urban/built-up areas remain unchanged (gray/white).

October (Third Image) – Vegetation Decline

A **significant reduction in bright red areas** is observed, indicating a decline in active vegetation due to the seasonal cycle. Many areas have **turned beige/brown**, suggesting **dry vegetation or bare soil**, as plants enter dormancy or shed leaves. Some **red patches remain**, likely representing **perennial plants or areas with continued maintenance**. The built-up areas remain **constant** throughout all three images, confirming a lack of major urban changes.

The images clearly illustrate the seasonal vegetation cycle, with minimal vegetation in April, peak growth in July, and a decline in October. Urban areas remain stable, with vegetation mostly concentrated outside or in designated spaces. The July image suggests optimal vegetation health, while April and October indicate transitional phases. Potential improvements could include strategic planting of perennial species to maintain green coverage in colder months and reduce the urban heat island effect.

c. LAI (Leaf Area Index)

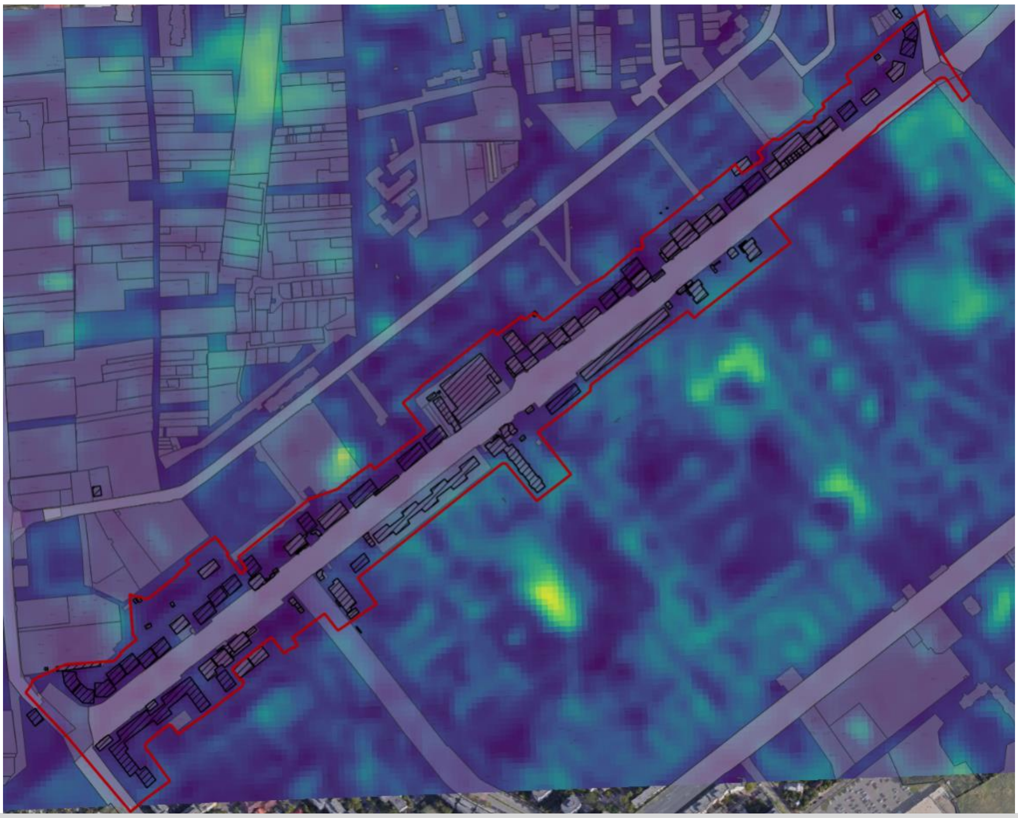
LAI (Leaf Area Index) is an indicator used to measure the **total leaf area per unit of ground surface area**. It is expressed as a **dimensionless value** and typically ranges between **0 and 6**:

LAI=Total Leaf Area/ Ground Surface

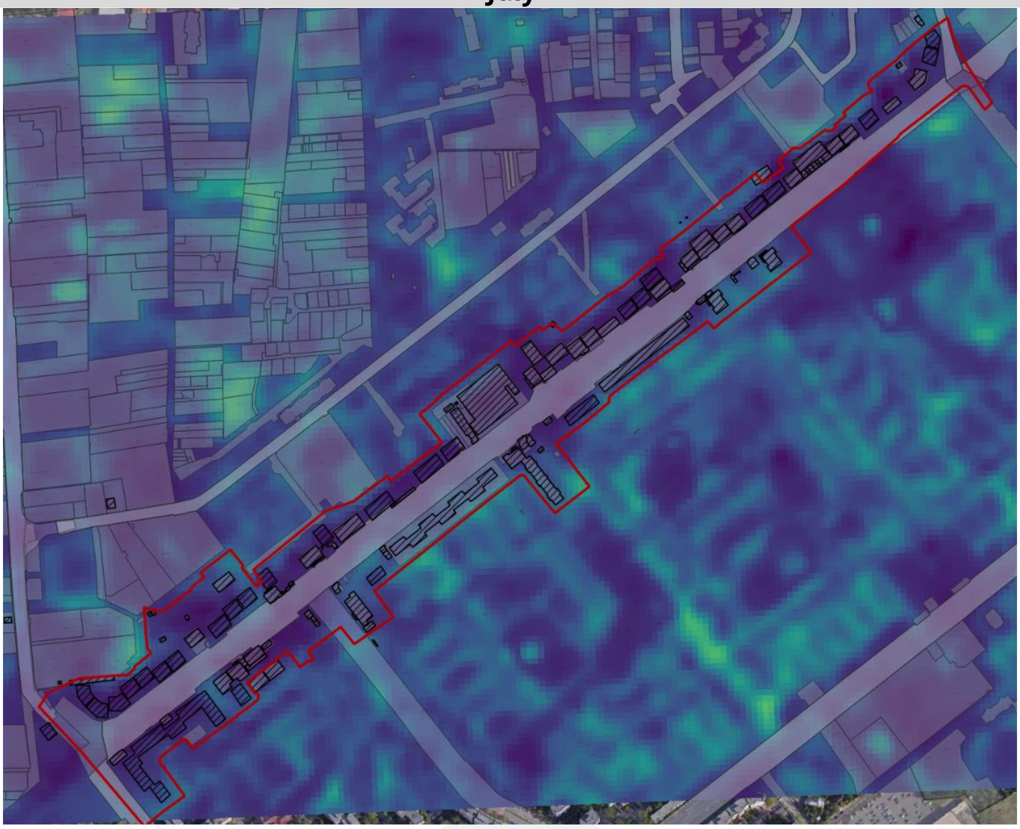
Normalized Difference Vegetation Index (NDVI) source https://www.copernicus.eu/en

Studied area :Projected resolution: 9 m/px **2024**

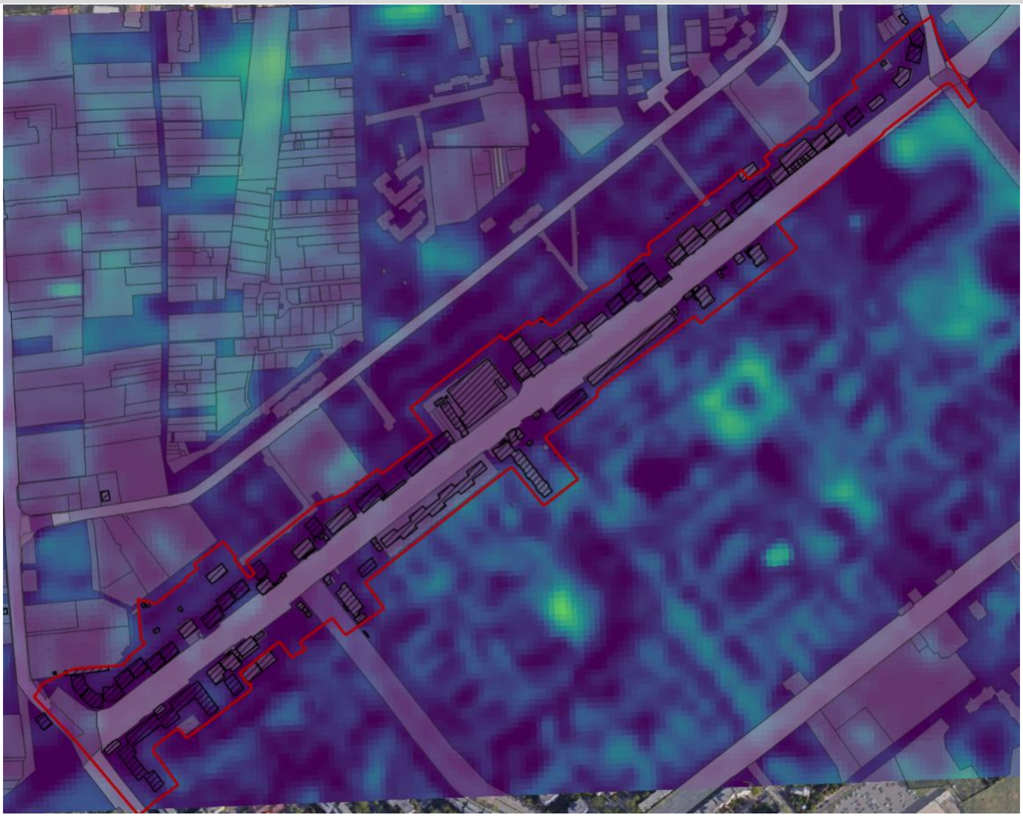
April



July



October



April (First Image) – Early Growth Phase

The map is **dominated by dark purple and blue tones**, indicating **low vegetation density**. Some **green and yellow patches** are present, suggesting areas with **moderate to dense vegetation**, but they are limited. Built-up and bare soil areas are clearly defined, confirming minimal vegetation presence in urban zones. This phase likely represents **early spring vegetation growth**, with plants beginning to develop but not yet reaching peak coverage.

July (Second Image) – Peak Vegetation Growth

The **amount of green and yellow areas has increased significantly**, indicating **higher LAI values** and **maximum vegetation density** during summer. Many areas that were **dark blue in April now appear green**, suggesting **successful seasonal plant growth**. The built-up areas (dark purple) remain consistent, with vegetation mainly present outside the urbanized zones.

The increase in vegetation density aligns with the **peak growing season**, where plants reach their full leaf area.

October (Third Image) – Vegetation Decline

The **green and yellow patches have decreased**, indicating **a reduction in leaf area** as vegetation begins to **shed leaves** in preparation for colder months. Some areas have reverted to **blue and purple tones**, signifying **a transition to sparse vegetation or bare soil**. Certain regions still maintain **moderate vegetation cover**, likely due to **perennial plants** or areas with **better maintenance**. This pattern is characteristic of **autumn**, where **deciduous plants lose foliage**, reducing the overall LAI.

The analysis highlights a **clear seasonal variation** in vegetation cover, with minimal growth in **April**, peak density in **July**, and **declining vegetation in October**. **Urban areas remain stable**, confirming that vegetation growth occurs primarily in open spaces. **July presents the highest LAI values**, reflecting **maximum canopy development**, while **October and April show transitional phases**. The goal is to **improve year-round vegetation cover** and strategies such as **planting evergreen species** or **maintaining green spaces** can help **mitigate seasonal declines**.

Analysis of the three methods from above(A, B, C):

The overall **seasonal pattern is consistent**, with vegetation **lowest in April, peaking in July, and declining in October**. The **representation method is consistent across all images**, meaning the observed differences are **actual seasonal variations** and not due to differences in data visualization. The **color contrast remains uniform**, making it easy to compare vegetation changes over time. No **drastic anomalies or errors** in representation are evident, suggesting a reliable NDVI analysis.

Limitation of the analysis (missing data, outdated data, etc.).

Considering that the studied surface represents only 0.067% from the total surface of Galati, we encountered no problems in carrying out the analysis.

Still:

The analysis is based on data collected over three specific months (April, July, and October). This may limit the ability to fully capture year-round variations in vegetation health and coverage, especially for areas with fluctuating climate or vegetation growth patterns outside the studied months. The lack of winter data means that the coldest season's impact on vegetation is not fully considered.

The analysis is based on data collected over three specific months (April, July, and October). This may limit the ability to fully capture year-round variations in vegetation health and coverage, especially for areas with fluctuating climate or vegetation growth patterns outside the studied months. The lack of winter data means that the coldest season's impact on vegetation is not fully considered.

While the analysis looks at overall vegetation health and coverage, it does not distinguish between types of vegetation (e.g., trees, shrubs, grass, etc.) or their specific contributions to mitigating urban heat island effects. Understanding the role of different plant species in terms of canopy structure and shading would provide a more nuanced view of how green spaces impact the urban environment.

Source of data for the assessment.

- Google earth
- The cadaster of buildings
- Satelite: Sentinel-2 - L2A - Normalized Difference Vegetation Index (NDVI), Based on bands 8,4
- Satelit: Sentinel-2 - L2A - Color Infrared (vegetation), Based on bands 8,4,3
- Qgis

VULNERABLE GROUPS

A community's exposure to heat as well as social and health factors may increase its vulnerability to extreme heat within the urban heat islands. Some groups are more vulnerable than others to heat impact, their health and well-being being affected more than that of the general population. They include the elderly, children, people in poor health, as well as low socio-economic status groups, for example those on low incomes or unemployed.

Vulnerable groups within urban areas are disproportionately affected by the health risks posed by urban heat. Elderly people, who often have reduced heat tolerance and limited mobility, find themselves at greater risk. As people age, their bodies become less efficient at regulating temperature, making them more susceptible to heat-related illnesses such as heat exhaustion and heatstroke. During extreme heat events, elderly individuals may be reluctant to leave their homes, leading to social isolation. This isolation can have adverse effects on mental and physical health.

Children and babies are especially vulnerable to heat and heat-related illnesses, due to being unable to effectively protect themselves from the heat without assistance.

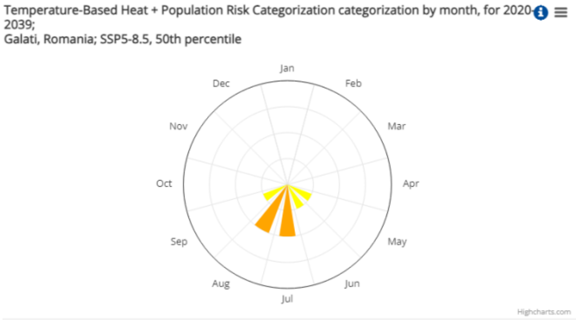
In many low-income households in urban areas, without access to air conditioning during extreme heat events, residents must endure dangerously high indoor temperatures, putting their health and well-being at risk. On the other hand, the use of AC could lead to financial strain because of the higher energy bills.

Socio-economic indicators

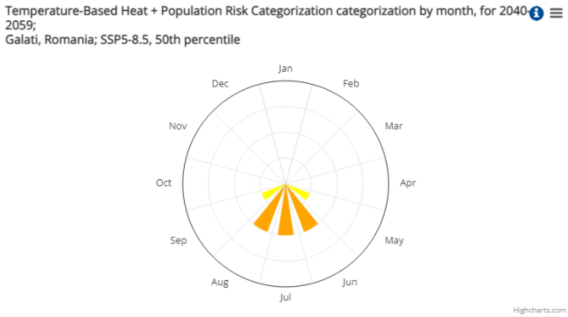
The demographic data for Galati, at municipal and county level, are extracted from the Census in 2021, available on the following links:

https://www.recensamantromania.ro/
https://www.recensamantromania.ro/rezultate-rpl-2021/rezultate-definitive-caracteristici-demografice/
https://www.recensamantromania.ro/rezultate-rpl-2021/rezultate-definitive-caracteristici-economice/

The images present an evolutionary projection of temperature-based heat risk and population vulnerability in Galați under the SSP 8.5 scenario, which represents a high-emission, high-warming



% National Population Below Poverty Threshold - Romania	
$1.90	0
$3.20	0
$5.50	0
Identified Age Vulnerabilities - Romania	
Very young, 0-4yrs	M: 309.4 Thousand F: 327.81 Thousand
Age Group 65+	M: 3.48 Million F: 2.52 Million



% National Population Below Poverty Threshold - Romania	
$1.90	0
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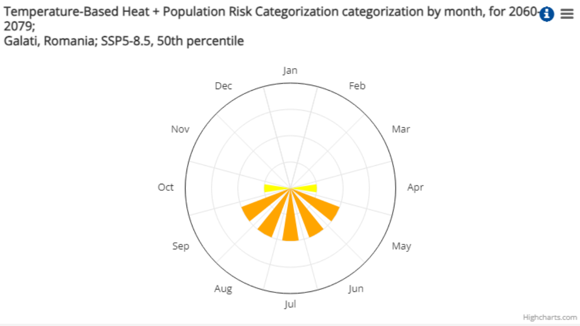

% National Population Below Poverty Threshold - Romania	
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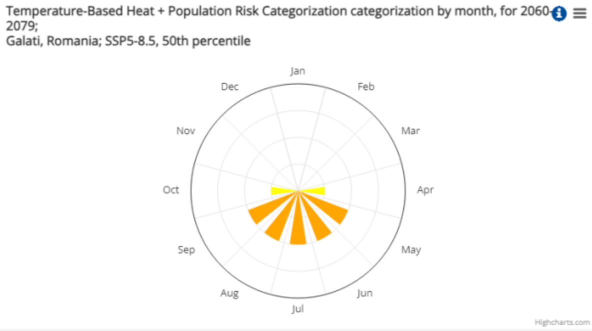

% National Population Below Poverty Threshold - Romania	
$1.90	0
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$5.50	0
Identified Age Vulnerabilities - Romania	
Very young, 0-4yrs	M: 309.4 Thousand F: 327.81 Thousand
Age Group 65+	M: 3.48 Million F: 2.52 Million

Figure 72 Temperature, Heat and Population risc. Scenario 8.5. Source: https://climateknowledgeportal.worldbank.org/country/romania/heat-risk

pathway for climate change. The analysis spans four timeframes:2020-2039, 2040-2059, 2060-2079, 2080-2099.

The polar charts display the seasonal distribution of extreme heat events. Heat risk is concentrated in summer months (June - September), with July and August showing the highest risk levels.

Over time, the intensity and duration of extreme heat events increase:

- In 2020-2039, heat risk is moderate, with some spikes.
- By 2040-2059, risk levels increase in frequency and intensity.
- By 2060-2079, the high-risk period extends into May and September.
- In 2080-2099, extreme heat spans a more prolonged period, with peak risks in mid-summer.

The data suggests that under SSP 8.5, Galați will experience a significant rise in extreme heat events, with more frequent and intense heatwaves by 2080-2099. Vulnerable populations, especially the elderly and young children, will face heightened health risks. Urban planning and policy interventions must prioritize cooling strategies, public health measures, and infrastructure adaptation to mitigate the long-term impacts of climate change.

Young people

From a population of 217.851 inhabitants, the structure of young people age groups is:

- 0-4 yo: 9.419 persons

- 5-9 yo: 10.437 persons

- 10-14 yo: 11.649 persons

- 15-19 yo: 10.594 persons

Elderly people

From a population of 217.851 inhabitants, the structure of elderly people age groups is:

- 65-69 yo: 18.359 persons

- 70-74 yo: 13.234 persons

- 75-79 yo: 7.465 persons

- 80-85 yo: 5474 persons

- ≥ 85 yo: 3512 persons

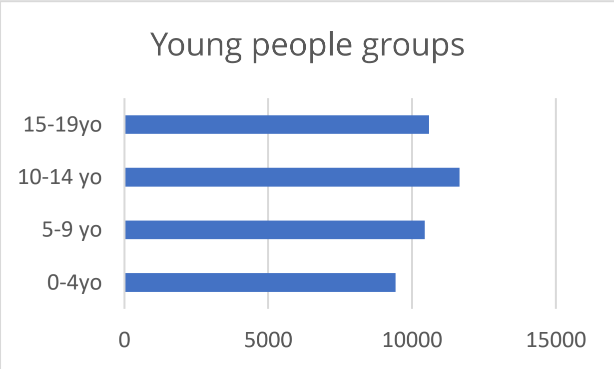

Chart 12 Structure of young people. Source: https://www.recensamantromania.ro/rezultate-rpl-2021/rezultate-definitive-caracteristici-demografice/

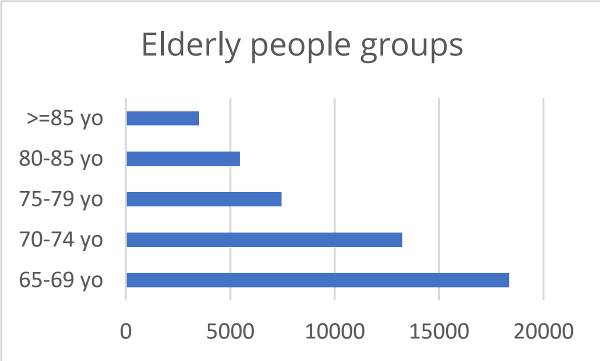

Chart 13 Structure of elderly people https://www.recensamantromania.ro/rezultate-rpl-2021/rezultate-definitive-caracteristici-demografice/

Limitation of the analysis (missing data, outdated data, etc.).

The demographic data for Galați is based on the 2021 Census, which may not reflect the most recent population trends or shifts. Demographic structures can change rapidly, especially in terms of migration patterns, birth rates, or mortality rates, meaning that the analysis may not account for more current population dynamics.

Source of data for the assessment:

- Census:
    - https://www.recensamantromania.ro/
    - https://www.recensamantromania.ro/rezultate-rpl-2021/rezultate-definitive-caracteristici-demografice/
    - https://www.recensamantromania.ro/rezultate-rpl-2021/rezultate-definitive-caracteristici-economice/
- *https://climateknowledgeportal.worldbank.org/country/romania/heat-risk*

Poverty rate

According to the website https://climateknowledgeportal.worldbank.org, 4.16% of the population in Galați County has a poverty rate below $1.90 per day.

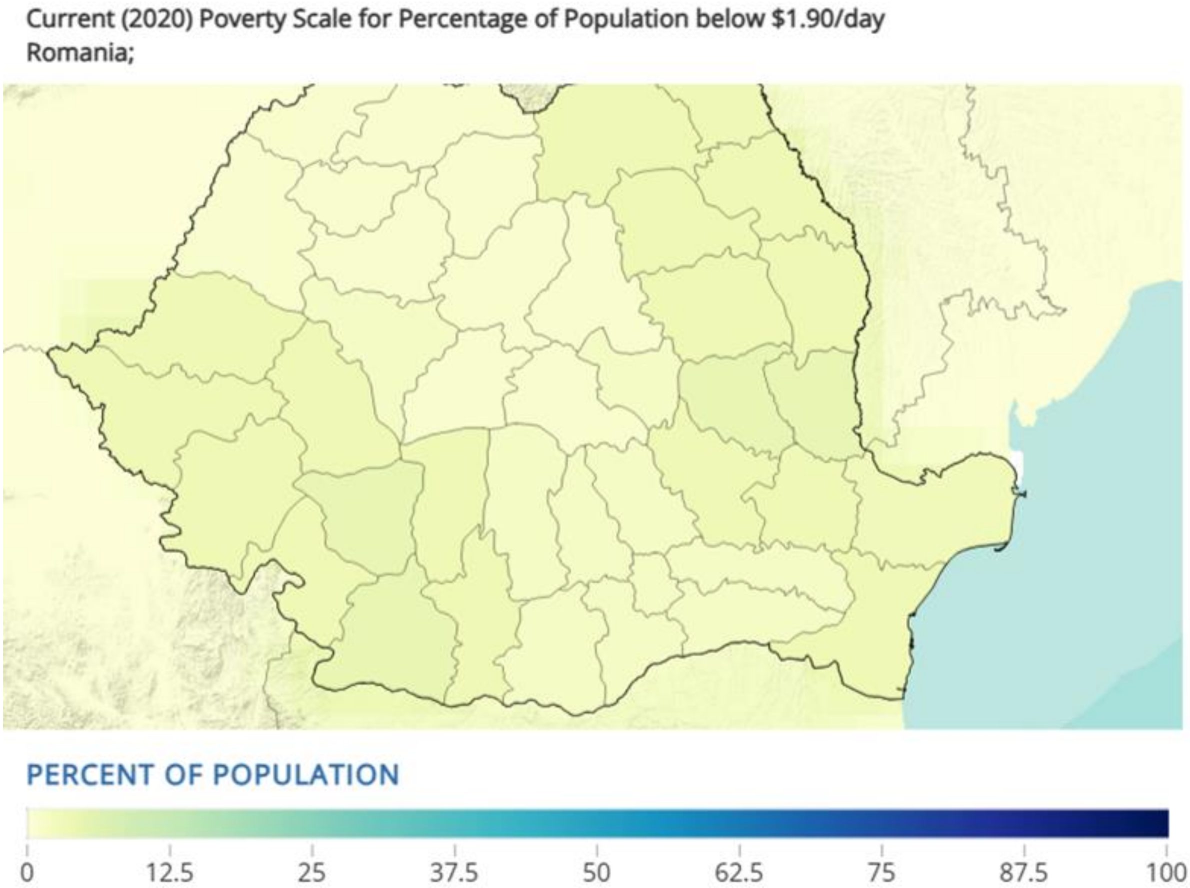

Figure 73 Source: https://climateknowledgeportal.worldbank.org/country/romania/heat-risk

Limitation of the analysis (missing data, outdated data, etc.).

The analysis relies on data sourced from the World Bank's Climate Knowledge Portal for 2020.

The poverty threshold used here ($1.90 per day) aligns with the international extreme poverty line used by the World Bank. However, this definition may not reflect the broader or more nuanced experiences of poverty in Galați County, where local conditions (such as cost of living and access to basic services) could make this threshold either too low or not fully representative of poverty in the region.

The data provided focuses on Galați County but does not specify whether it applies to the entire county uniformly or if there are significant disparities in poverty rates between urban and rural areas within the county. There could be significant variations in poverty levels depending on location, and the analysis does not differentiate between these possible differences.

Source of data for the assessment:

- *https://climateknowledgeportal.worldbank.org/country/romania/heat-risk*

Unemployment rate

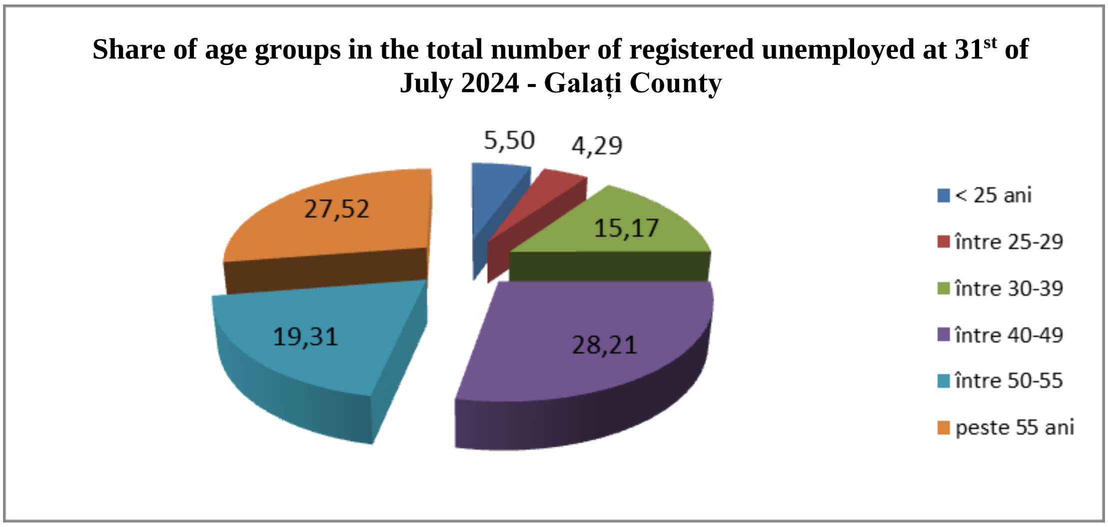

Figure 74 Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.anofm.ro/galati/wp-content/uploads/sites/20/2024/02/Comunicat-de-presa-somaj-iulie-2024.pdf

Unemployed people with secondary education have the highest share in the total number of unemployed people registered in the records of Galati County Agency for Employment (40.80%), followed by those with primary education (23.81).

Unemployed people with lower education levels (primary education and no education, secondary education, vocational education/arts and crafts) represent 88.88% of the total number of registered unemployed people, those with secondary education (high school and post-high school) represent 8.49%, and those with higher education represent 2.63%.

Limitation of the analysis (missing data, outdated data, etc.).

The text does not provide a comparative perspective on how the unemployment rate or the distribution of educational levels among the unemployed has changed over time. Without a historical comparison, it's difficult to assess whether these trends are improving or worsening.

The data provided appears to focus solely on the number of unemployed individuals who are registered with the Galati County Agency for Employment. This might exclude people who are unemployed but not registered with the agency, such as discouraged workers, people in the informal economy, or those who have stopped looking for work. This could underestimate the true unemployment rate.

Source of data for the assessment:

- www.anofm.ro/galati/wp-content/uploads/sites/20/2024/02/Comunicat-de-presa-somaj-iulie-2024.pdf

Gender

According to the Census in 2021, Galati city has a population of 217.851 inhabitants, out of which 102.570 male and 115.281 female.

Immigrated people

At county level, out of a population of 496.892 inhabitants, 844 people are foreign citizens.

Low-skilled jobs

At county level, out of 182.083 active/occupied people, 21.398 persons have low-skilled jobs.

Social housing

At municipal level, there are 1.294 social housing units, mainly apartaments in residential buildings.

Density of population

In Galati city, the density of population is 880 inhabitants/km2.

Retired people

At municipal level, from a total of 217.851 inhabitants, 59.933 persons are retired people.

Health conditions

Ill people

In 2023, at county level, 206.857 ill people were registered, from which:

- 76.255 cases of hypertensive diseases;
- 25.991 cases of ischemic heart disease;
- 12.948 cases of cerebrovascular diseases.

Disabled people

Number of people with disabilities by county, 31st of March 2022

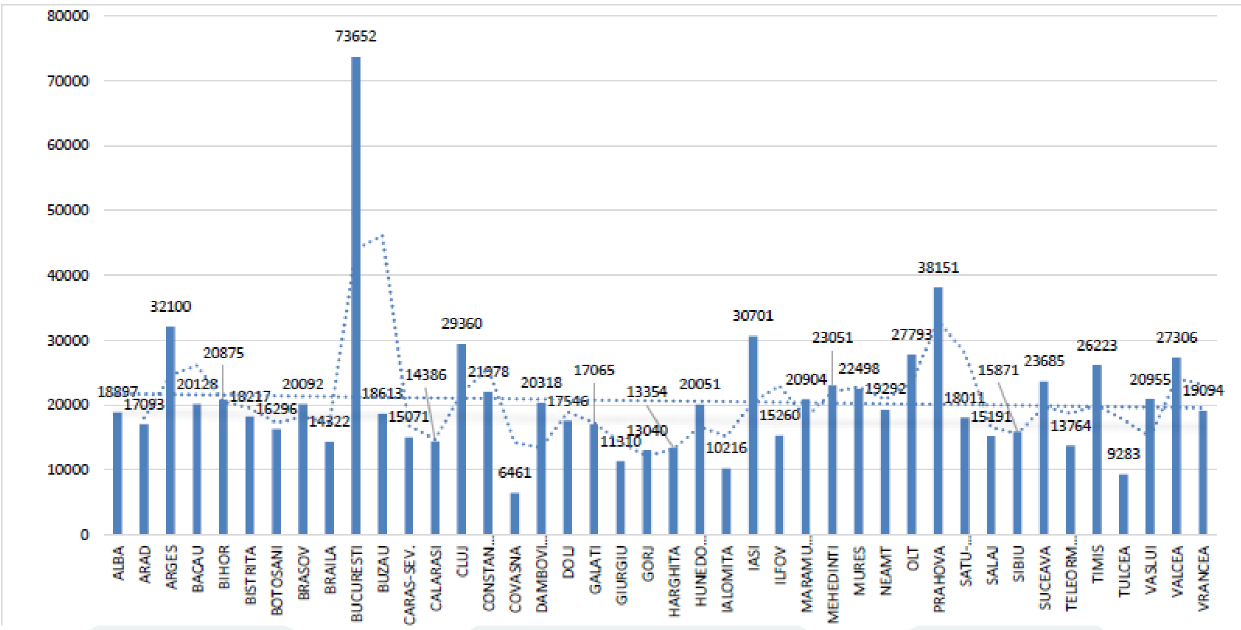

Chart 14 People with disabilities by couty. Source: https://www.recensamantromania.ro/

In Galati county, 17.065 persons with disabilities are registered, out of which 8.487 women and 1.498 children.

Mortality rate

According to the National Institute of Statistics - Demographic events publication,in 2023, at Galati county level, 6.797 deceased persons were registered, from which 3.719 men and 3.078 women, at urban level 3.421 persons and at rural level 3.376 persons. The mortality rate in 2023 was 10,8% (urban 9,4% and rural 12,8%).

Limitation of the analysis (missing data, outdated data, etc.).

The demographic data for Galați is based on the 2021 Census, which may not reflect the most recent population trends or shifts. Demographic structures can change rapidly, especially in terms of migration patterns, birth rates, or mortality rates, meaning that the analysis may not account for more current population dynamics.

A qualitative assessment was not carried out as part of the preparation of this report. A trial assessment is not planned.

Source of data for the assessment:

- www.anofm.ro/galati/wp-content/uploads/sites/20/2024/02/Comunicat-de-presa-somaj-iulie-2024.pdf
- National Institute of Statistics - Demographic events publication

Infrastructure

General description of medical infrastructure of Galați Municipality

In 2023, the medical infrastructure in Galați Municipality showcased a diverse array of healthcare units, reflecting a balance between public and private ownership. The city housed 8 public hospitals, providing essential medical services. Additionally, there was 1 private healthcare unit focused on day hospitalization, indicating the presence of specialized care in a private setting.

Outpatient services were offered through various facilities, including 1 public specialty outpatient clinic and 7 hospital-integrated outpatient clinics, which emphasize the availability of advanced and continuous care. Smaller medical dispensaries (4 public units) and mental health centers (2 public units) further contributed to the community's healthcare needs.

Specialty medical centers showed a mix of ownership, with 1 public center and 5 private centers, while dialysis services were supported by 1 private workpoint. Private general medical offices were prevalent, numbering 59, compared to 17 public school medical offices and 1 public student medical office, highlighting the emphasis on accessible healthcare for educational institutions. Family healthcare was minimal, with 1 public family medical office reported.

The private sector was particularly active in dental and specialty medical offices, with 279 private dental offices and 440 private specialty medical offices, compared to only 3 public dental offices. Pharmaceutical services were split, with 8 public pharmacies and 62 private pharmacies, along with 1 public pharmaceutical point and 123 private pharmaceutical points, ensuring broad coverage for medication needs.

Laboratory services were robust, with 35 public medical laboratories and 87 private laboratories. Additionally, specialized facilities such as 1 public dental technology laboratory and 1 public blood transfusion center were operational. Other medical offices included 5 public units and 1 private unit, further complementing the city's healthcare offerings.

In summary, Galați Municipality's healthcare infrastructure in 2023 reflected a significant private sector presence, particularly in outpatient and specialty services, alongside a solid foundation of public healthcare facilities, ensuring a comprehensive network for residents.

Table 22 Categories of healtcare units

Categories of healthcare units	Forms of ownership	Periods Year 2023 UM: Number Number
Hospitals	Public ownership	8
Healthcare units (including units equivalent to hospitals) with day hospitalization only,	Private ownership	1
Specialty outpatient clinics	Public ownership	1
Hospital-integrated outpatient clinics	Public ownership	7
Medical dispensaries	Public ownership	4
Mental health centers	Public ownership	2
Specialty medical centers	Public ownership	1

Interreg Danube Region Co-funded by the European Union Be Ready

-	Private ownership	5
Workpoints of dialysis centers	Private ownership	1
General medicine medical offices	Private ownership	59
School medical offices	Public ownership	17
Student medical offices	Public ownership	1
Family medical offices	Public ownership	1
-	Private ownership	119
Dental offices	Public ownership	3
-	Private ownership	279
Specialty medical offices	Private ownership	440
Pharmacies	Public ownership	8
-	Private ownership	62
Pharmaceutical points	Public ownership	1
-	Private ownership	123
Medical laboratories	Public ownership	35
-	Private ownership	87
Dental technology laboratories	Public ownership	1
Blood transfusion centers	Public ownership	1
Other types of medical offices	Public ownership	5
-	Private ownership	1

Hospitals capacity*

Table 23 Categories of healthcare units-Hospitals

Categories of healthcare units	Forms of ownership	Periods	Periods
		Year 2023	Year 2023
		UM: Number of beds	UM: Number of beds/1000 inhabitants
		Number	Number
In hospitals, including in health centers with hospital beds - beds for continuous hospitalization	Public ownership	2627	12.6
In hospitals, including in health centers with hospital beds - beds for day cases	Public ownership	120	0.55

According to available data, in the European Union, in 2022, there were on average 516 hospital beds per 100,000 inhabitants, which represents a decrease from 563 beds per 100,000 inhabitants in 2012.(https://www.euractiv.ro/eu-elections-2019/la-nivelul-ue-sunt-2-3-milioane-de-paturi-de-spital.-cate-sunt-in-romania-67825?utm_source=chatgpt.com).

This reduction reflects not only the fact that the data on hospital beds only cover beds for inpatient care (excluding beds for day care and outpatient care), but also the scientific and technological developments that have reduced the average length of hospitalization for inpatient procedures or replaced these procedures with those offered through day care or outpatient care.

Over the past decade, the city of Galați has made significant strides in enhancing the quality of medical services through the implementation and development of various projects and initiatives. Here are some of the key developments:

'Sf. Apostol Andrei' Emergency County Clinical Hospital Galați

In the last three years, the hospital has undertaken numerous investment projects, including the modernization of the integrated outpatient clinic and the provision of advanced medical equipment.

'Elisabeta Doamna' Psychiatric Hospital Galați

Over the past five years, a new building for the outpatient clinic has been constructed, and an existing building has been modernized. Currently, works are underway to modernize and rehabilitate other sections of the hospital.

Infectious Diseases Hospital Galați

Renovation works have been carried out on the integrated outpatient clinic, equipping it with state-of-the-art medical equipment.

'Sf. Ioan' Children's Emergency Clinical Hospital Galați

Investments have been made in the modernization and expansion of pediatric departments, as well as in the provision of cutting-edge medical apparatus. Currently, expansion works are underway for the outpatient clinic, with plans for the expansion of the Emergency Department and the construction of a new hospital wing.

Pneumophthisiology Hospital Galați

Investments have been made in the modernization of electrical installations and ventilation systems, including the renovation of patient rooms.

These initiatives reflect the commitment of the authorities and institutions in Galați to continuously improve the quality of medical services, ensuring that patients receive appropriate care and optimal treatment conditions.

Limitation of the analysis (missing data, outdated data, etc.).

The public information found on the website of the National Institute of Statistics is from 2023 and may be considered slightly outdated.

Source of data for the assessment.

- *National institute of statistics : http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table*

Health centres*

Table 24 Categories of healthcare units-Health centres

Categories of healthcare units	Forms of ownership	Periods	Periods
		Year 2023	Year 2023

		UM: Number	UM: Number of beds/1000 inhabitants
		Number	Number
In hospitals, including in health centers with hospital beds - beds for continuous hospitalization	Proprietate publica	2627	12.06
In hospitals, including in health centers with hospital beds - beds for day cases	Proprietate publica	120	0.55
Dialysis centers - beds associated with dialysis stations for outpatient services	Proprietate publica	5	0.02
Workpoints of dialysis centers - beds associated with dialysis stations for outpatient services	Proprietate privata	44	0.20
In healthcare units (including units assimilated to hospitals) only with day hospitalization.	Proprietate privata	5	0.02

Limitation of the analysis (missing data, outdated data, etc.).

The public information found on the website of the National Institute of Statistics is from 2023 and may be considered slightly outdated.

Source of data for the assessment.

- *National institute of statistics : http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table*

Retirement houses

Limitation of the analysis (missing data, outdated data, etc.).

No data available.

Social housing

Limitation of the analysis (missing data, outdated data, etc.).

No data available.

Conclusions

The SSP 8.5 scenario suggests increasing extreme heat events in Galați over time, particularly during summer months. The high-emission scenario predicts prolonged heatwaves by the end of the century, affecting urban residents the most.

- Elderly individuals have reduced heat tolerance and may experience heat stress more severely.

- Young children cannot regulate body temperature efficiently, making them prone to heat-related illnesses.
- Low-income populations may lack access to cooling mechanisms such as air conditioning, exacerbating their exposure to extreme heat.
- The unemployed and those with poor health conditions are particularly at risk due to limited mobility and lack of access to health services.

Mitigation Measures

Enhancing Green Infrastructure:

- Increase tree coverage and green spaces: Planting more trees, particularly in areas with high population density, to reduce surface temperatures and provide shade.
- Green roofs & vertical gardens: Implementing vegetation on rooftops to enhance natural cooling.
- Permeable surfaces: Replacing impermeable asphalt with grass-covered or permeable pavement to reduce heat absorption.

Community-Oriented Solutions:

- Cooling shelters: Establishing public cooling centers for vulnerable groups during heatwaves.
- Energy-efficient housing programs: Supporting low-income households with financial aid for energy-efficient cooling systems.
- Public awareness campaigns: Educating residents about heat risks and emergency response measures.

Policy and Governance Approaches:

- Heat action plans: Integrating urban heat mitigation into municipal climate action strategies.
- Monitoring and early warning systems: Deploying heat monitoring stations to predict extreme heat events.
- Collaboration with healthcare services: Ensuring emergency services and hospitals are prepared for heat-related health issues.

Concluding remarks:

We believe that analyzing vulnerable groups within the framework of an urban assessment tool would be significantly more effective when considering the city as a complex, interconnected mechanism. A city's socio-spatial structure inherently shapes the distribution and living conditions of vulnerable populations, making it essential to integrate this perspective into the analysis.

Every municipality possesses a fundamental understanding of where vulnerable groups are concentrated within its territory. Local authorities are aware of the neighborhoods that predominantly accommodate these populations, including low-income communities, elderly residents, and other at-risk groups. These areas often correspond with districts characterized by lower-quality housing, limited access to essential services, and reduced adaptive capacity to environmental stressors such as extreme heat.

By incorporating this urban mechanism perspective, the identification and support of vulnerable groups can be streamlined, allowing for targeted interventions that align with existing municipal knowledge and planning strategies. This approach ensures that vulnerability assessments are both contextually relevant and actionable, facilitating the development of localized solutions tailored to the specific needs of different urban districts.

Vulnerability Index

PREPAREDNESS AND ADAPTIVE CAPACITY OF CITIES AND MUNICIPALITIES

Institutional factors

Governance structures

The public administration authorities of Galați Municipality are the Local Council, as the deliberative authority, and the Mayor, as the executive authority. The Mayor, Deputy Mayors, City Manager, Secretary of the Municipality, and the Mayor's specialized apparatus form the functional structure known as the Galați City Hall. The organizational chart of the Mayor's specialized apparatus and the Local Community Public Service for Population Records is presented in accordance with the institution’s organizational chart.

The total number of positions in the Mayor’s specialized apparatus and the Local Community Public Service for Population Records (SPCLEP) is 476, of which 440 are public positions and 36 are contractual positions.

The public positions are structured as follows: 52 management public positions and 388 execution public positions.

The organizational chart has been structured into departments, services, offices, and compartments as follows:

- **Infrastructure Development and Public Works Directorate**
  - **External Projects and Financing Service**
    - Fundraising, Financing, and Documentation Preparation Compartment
    - Project Implementation and Management Compartment
  - **Investments Service**
  - **Work Coordination and Interventions Office**
  - **Street and Building Repairs Service**
    - Street Repairs, Traffic Safety, and Traffic Lights Office
    - Building Repairs and Maintenance Office
- **Public Utilities Community Services Directorate**
  - **Public Utilities Service**
    - Water, Sewerage, and District Heating Compartment
    - Public Lighting Compartment
    - Urban Transport Compartment
  - **Public and Private Domain Administration Service**
    - Sanitation Compartment

- Public and Private Domain Administration Compartment
- **Environmental Protection Compartment**
- **Monitoring and Regulation Unit Compartment**
- **Financial and Accounting Directorate**
  - **Budget Service**
    - Budget Preparation Compartment
    - Budget Reporting Compartment
  - **Financial Service**
  - **Expense Accounting Service**
  - **Revenue Accounting Service**
    - Revenue Accounting Compartment
    - Receipts and Payments Compartment
    - Tariffs and Prices Compartment
  - **Administrative, Initiation, Tracking, and Records Office for Own Procurement Activities**
- **Directorate of Taxes, Fees, and Other Local Revenues**
  - **Service for Taxes, Fees, and Other Local Revenues - Individuals**
  - **Service for Taxes, Fees, and Other Local Revenues - Legal Entities**
  - **Service for Monitoring, Enforcement, and Fines**
  - **Service for Data Processing and Counter Payments**
  - **Compartment for Appeals and Judicial Liquidations**
  - **Internal Registry and Operational Archive Compartment**
- **Patrimony Directorate**
  - **Patrimony Records and Cadastre Service**
    - Patrimony Records and Management Office
    - Cadastre Office
  - **Land Leasing, Concessions, and Sales Service**
    - Land Leasing, Concessions, and Sales Compartment
    - Authorizations and Licenses Compartment
  - **Housing and Spaces Administration Service**
    - Homeowners' Associations Compartment
- **Public Relations and Document Management Directorate**

- **IT Office**
- **Public Relations and One-Stop Counter Service**
- **Education, Culture, Tourism, Sports, Religion, Health, and Events Service**
    - Public Events Compartment
    - Sports Compartment
    - Education, Culture, Tourism, Religion, and Health Compartment
- **Quality Management, Decision Transparency, and Investors Service**
    - Mayor's Report and Decision Transparency Compartment
    - Quality Management and Internal Control Compartment
    - External Relations and Investors Office

- **Chief Architect Institution**
    - **Construction Authorization Service**
        - Requests/Issuance Records for Urbanism Certificates/Building Permits Compartment
        - Urbanism Certificates Compartment
        - Building Permits Compartment
        - Utilities Compartment
    - **Permits and Receptions Office**
        - Receptions and Demolitions Compartment
        - Permits Compartment
    - **Urban Planning Office**
        - Urban Planning Plans Compartment
        - Urban Nomenclature Compartment
- **Urban Marketing Office**
    - **Database Compartment**
    - **Urban Promotion Compartment**
- **Mayor's Cabinet**
- **Legal and Legality Service**
- **Human Resources and Payroll Service**
- **Press Office**
- **Internal Audit Office**
- **Mayor's Control Body Service**

- **Financial Management Control, Health, and Safety at Work Office**
  - Financial Management Control Compartment
  - Health and Safety at Work Compartment
- **Mayor's Control Body**

- **Corporate Governance Compartment for Public Enterprises**
- **Public Procurement Service**
- **Defense and Civil Protection Office**
- **Guardianship Authority Service**

Structures coordinated and guided by the Secretary of Galați Municipality include:

- **Local Public Administration Service**
- **Agricultural Registry, Land Fund, and Archive Office**
- **Permanent Apparatus of the Local Council**

The **Urban Authority** acts as a Level II Intermediate Body (IB) for the 2014–2020 Regional Operational Program (ROP) for the sustainable urban development of Galați Municipality during the 2014–2020 programming period of the European Structural and Investment Funds (ESIF).

The **Local Community Public Service for Population Records** of Galați Municipality is organized under the authority of the Local Council of Galați Municipality. It is structured as a service-level entity comprising the following:

- **Civil Status Service**
- **Population Records Service**

Legislative and regulatory regimes

A. In Galați municipality, adaptation to climate change and the management of urban heat island effect are addressed through a national legislative and strategic framework with local applicability. At the regional level, in the case of Galați municipality, there are several strategies and plans aligned with national regulations that can influence the approach to climate change and urban heat island effect. These regulations are developed within the South-East Region, which includes Galați County and other counties in the southeastern part of Romania. Here are some of the relevant regional documents and regulations:

1. Regional Development Plans

This plan is an essential document for the sustainable development of the region and includes specific measures to address climate change and reduce environmental risks. The South-East Regional Development Plan (PRD Sud-Est) includes strategies for:

- Promoting renewable energy and energy efficiency to contribute to reducing greenhouse gas emissions.

- Measures to reduce climate change-related risks, including investments in green infrastructure (green spaces, green roofs, nature-based solutions for drainage).
- Prevention and management of environmental risks within urban and rural development projects, ensuring that urban planning complies with environmental protection requirements.
- Reducing flood and drought risks through water prevention and management measures.

2. National Strategy on Climate Change Adaptation for 2022-2030 and the National Action Plan for Implementing the National Strategy on Climate Change Adaptation

This regional strategy aims to reduce greenhouse gas emissions and promote adaptation solutions in response to climate change. It includes measures to combat the urban heat island effect and protect against extreme phenomena such as drought and floods. Key actions include:

- Urban green infrastructure: Developing parks, gardens, and green corridors in cities in the region to reduce local temperature and increase resilience to heatwaves.
- Strengthening water infrastructure: Measures to protect flood-prone areas and manage rainwater through innovative urban drainage solutions.
- Promoting sustainable mobility and reducing road traffic to minimize emissions and improve air quality.

3. Flood and Drought Risk Management Plans (PMRI)

These plans are developed at the regional level to assess and prevent flood risks, considering climate change and its impact on the South-East region. They include specific protection and prevention measures such as:

- The construction and maintenance of dikes and dams to protect vulnerable communities from floods.
- Restoration of water ecosystems (e.g., lake filling and floodplain areas) to improve water retention capacity and prevent floods.
- Early warning systems for floods and other extreme weather phenomena to ensure rapid and effective interventions.

4. National Climate Change Risk Management Plan

This plan applies at the national level but has regional implications. It includes measures to prevent climate-related risks, such as prolonged drought, heatwaves, and extreme weather events, and aligns with regional plans. Key measures include:

- Increasing the resilience of infrastructure and communities to climate change.
- Nature-based solutions for managing environmental risks, such as ecosystem restoration and promoting sustainable agriculture.

5. Cross-border Cooperation Projects

The South-East Region participates in numerous cross-border projects aimed at managing climate change and environmental risks in collaboration with neighboring countries such as Bulgaria and the Republic of Moldova. These projects include:

- Joint climate change adaptation and cross-border environmental risk reduction plans.
- Collaboration for water protection and flood prevention in shared river basins.
- Implementation of common ecological solutions, such as protecting water ecosystems and increasing water retention capacity in riparian regions.
- European projects and funding for sustainable development – the South-East Region benefits from European funds to implement nature-based solutions, create urban green spaces, and protect biodiversity, all contributing to climate change adaptation.

B. At the local level, within Galați municipality, the authorities are responsible for implementing climate change adaptation measures and combating the urban heat island effect, in alignment with the national legislative framework. Some relevant local regulations and documents include:

1. The National Integrated Energy and Climate Change Plan 2021-2030 (PNIESC): This national plan sets objectives and measures for reducing greenhouse gas emissions and promoting renewable energy. Although it is a national document, its implementation has regional implications, including in Galați County. PNIESC includes specific measures for reducing emissions in sectors such as energy, transport, and industry.

2. Sustainable Development Strategy of Galați County: This strategy includes long-term objectives aimed at the sustainable development of Galați County. Measures include:

- Promoting sustainable agricultural practices to combat drought risks and increase resilience to climate change.
- Improving water resource management and using it efficiently, especially in the context of climate change that may affect water availability.
- Creating new green spaces and urban regeneration to reduce the urban heat island effect and contribute to the adaptation of cities and villages in the county.

3. Cross-border Projects with the Republic of Moldova and Bulgaria: Galați County is involved in cross-border projects aimed at managing environmental risks and adapting to climate change. These projects include collaborations on:

- Water protection and flood risk management in cross-border areas.
- Implementing ecological solutions to combat the effects of climate change, including promoting green infrastructure and protecting water ecosystems.

4. Sustainable Urban Mobility Plans: These plans include measures to reduce carbon emissions, promote public transport, and encourage active mobility, all contributing to mitigating the urban heat island effect.

5. Land Use and Urban Planning Plans: Infrastructure projects that consider green areas, reduce land sealing, and create public spaces with vegetation can help mitigate the effects of heat islands.

6. Water Management and Waste Management Policies: These include measures for water conservation and the use of nature-based solutions for urban drainage, aiming to reduce flood risks and protect the urban environment.

7. Green Space Development Strategies: Creating and maintaining parks, gardens, and green avenues that enhance the city's cooling capacity.

8. Regional Carbon Emission Reduction and Climate Change Adaptation Strategy: This includes adaptation measures and climate risk reduction across the region, promoting sustainable solutions such as sustainable mobility, urban regeneration, and the use of green infrastructure to combat heat island effect.

9. Flood and Drought Risk Management Plans: These regional plans aim to reduce flood and drought risks through protection and prevention measures, including the use of green infrastructure solutions and water management in the region's cities.

10. Cross-border Cooperation Projects: The South-East Region participates in cross-border projects, especially with the Republic of Moldova and Bulgaria, which include joint climate change adaptation and environmental risk management measures for urban locations, including Galați.

Policies and plans

At the level of Galați Municipality, the following strategic documents exist: the Sustainable Urban Mobility Plan, the Sustainable Development Strategy 2021-2027 of Galați Municipality, and the Climate and Sustainable Energy Action Plan of Galați Municipality.

At the European, national, regional, and county levels, the following strategic documents exist: the 2030 Agenda for Sustainable Development, the European Commission Work Program for 2020, the European Union Youth Strategy for the period 2021-2027, the National Strategy for Romania's Sustainable Development 2030, the Romania 2030 Territorial Development Strategic Concept, and the National Strategy on Climate Change and Economic Growth Based on Reduced Carbon Emissions.

Institutions

No data available.

Social factors

Social connections

No data available.

Community cohesion

No data available.

Self-learning/self-organizing capacities of communities

No data available.

Available skills and knowledge

No data available.

Economic factors

Public financial resources

No data available.

Household income

No data available.

Access to financial resources

No data available.

Insurance contracts

No data available.

Technological factors and scientific knowledge

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

No data available.

Ability to use the innovations

No data available.

Availability of information on adaptation to climate change

No data available.

5. Conclusions

The study confirms the presence of UHI effects in Galați, with elevated temperatures in urban areas compared to surrounding rural regions.

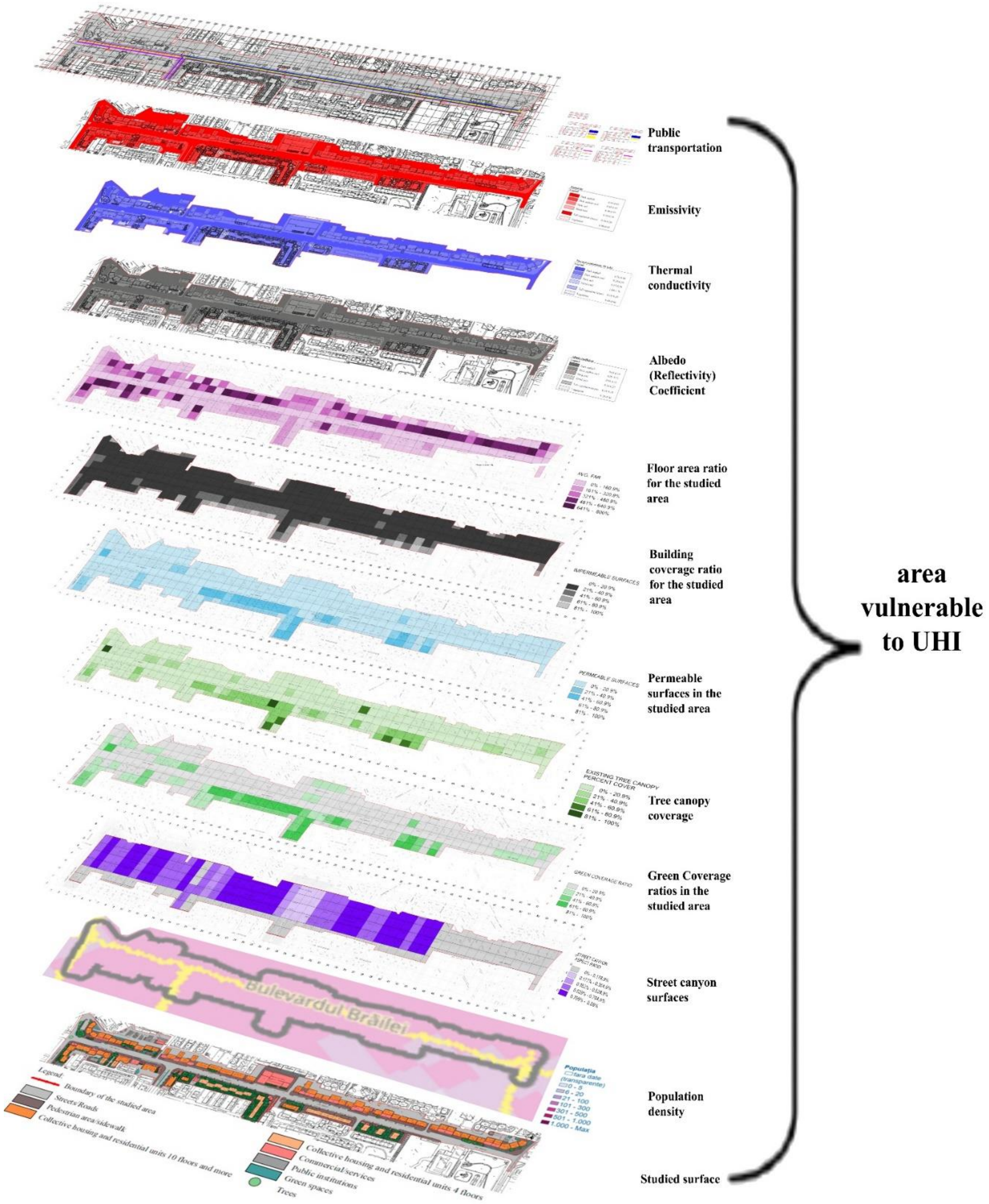

Figure 75 Overlapping layers to identify area vulnerable to UHI

Temperature data analysis shows a rising trend in summer heatwaves, with heat events exceeding 33°C lasting longer over the past decades.

Nighttime temperatures remain elevated due to heat retention in built environments, especially in areas with dense construction.

Main contributing factors to the UHI:

High-density urbanization, asphalt roads, and concrete buildings contribute to heat accumulation.

The study area has a high Building Coverage Ratio (BCR) of 26.9% and Floor Area Ratio (FAR) of 194.87%, indicating intensive land use.

The street layout and building heights create urban canyons that trap heat and limit airflow, exacerbating heat accumulation.

A low proportion of vegetated areas reduces the natural cooling effect, making urban areas more vulnerable to extreme heat.

Temperature trends and climate risks:

The frequency and intensity of extreme heat events are projected to increase significantly under the SSP5-8.5 climate scenario.

The presence of water bodies (such as the Danube) has a cooling effect during the day but contributes to warming at night.

Satellite-based Land Surface Temperature (LST) analysis confirms temperature hotspots in urbanized areas.

Socioeconomic vulnerabilities:

The study highlights specific vulnerable groups, including children (0-4 years), elderly residents (65+), and low-income populations.

Urban areas with higher population densities and lower economic resilience are at greater risk of UHI-related health impacts.

Analysis and Conclusions:

- **The most vulnerable areas to UHI** are those with a combination of **high built density, large impermeable surfaces, low albedo, and reduced green coverage**.
- **Major contributing factors to the UHI effect** include **high emissivity, thermal conductivity of materials, lack of green spaces, and dense structures limiting air circulation**.

Recommendations for mitigation and adaptation can be grouped in four categories:

- **Increase green infrastructure**

Implement vegetation-based cooling strategies, such as urban parks, tree planting, and green roofs.

- **Improve building materials and urban design**

Use reflective materials, cool roofs, and lighter pavement colors to reduce heat absorption. Using high-albedo materials for sidewalks and building facades. Developing permeable pavements to reduce heat accumulation.

- **Enhance public awareness and preparedness**

Engage communities in UHI adaptation measures and provide heat risk information.

- **Urban planning adjustments**

Modify zoning policies to integrate UHI mitigation strategies, especially in highly developed areas to optimize air circulation and reduce overheating..

Challenges Identified

- **Lack of satellite data processing expertise:** Difficulty in acquiring and analyzing remote sensing data for precise temperature monitoring.
- **Limited stakeholder engagement:** Need for broader collaboration among local authorities, businesses, and residents.
- **Infrastructure constraints:** Current urban infrastructure does not sufficiently support climate adaptation strategies.

The UHI study in Galați underscores the urgency of addressing urban overheating through integrated mitigation strategies. By improving green infrastructure, adapting urban design, and fostering stakeholder collaboration, the city can enhance resilience to rising temperatures and extreme heat risks.

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Annexes