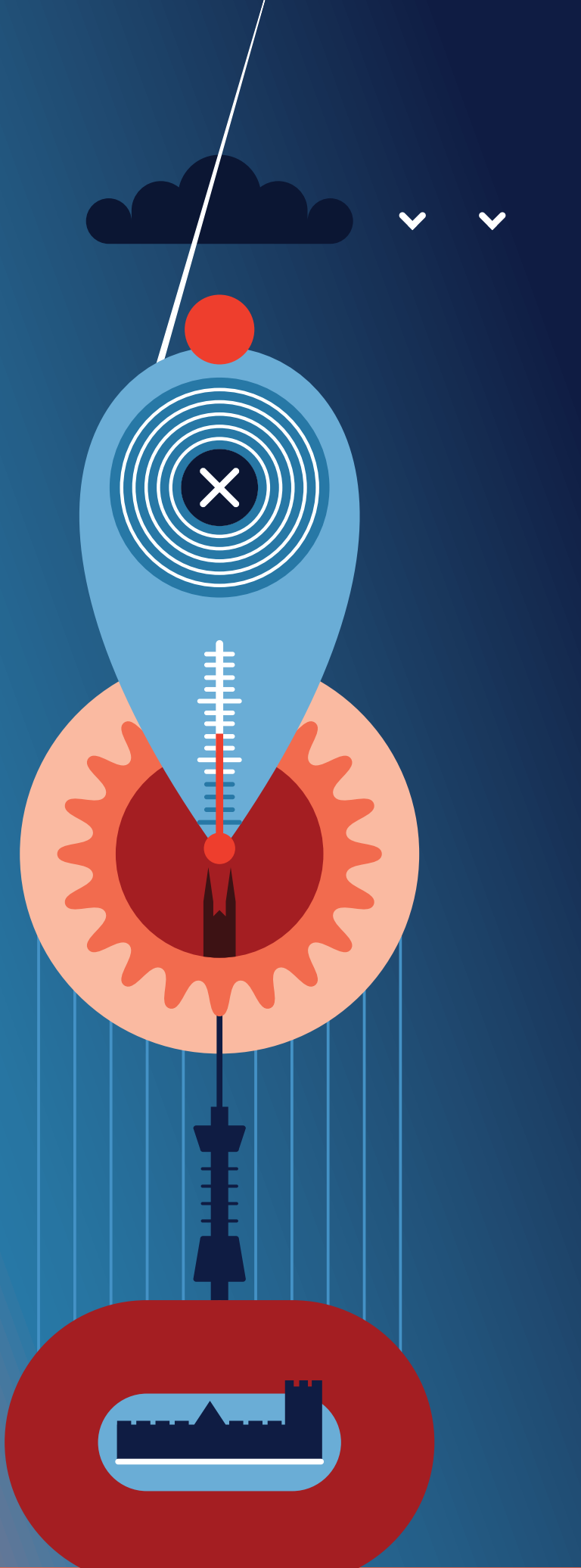
Programme

CITY OF ZAGREB

ON CLIMATE CHANGE MITIGATION, CLIMATE CHANGE ADAPTATION AND OZONE LAYER PROTECTION OF THE CITY OF ZAGREB

2025. – 2028.



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Zagreb, October 2025.

Pursuant to Article 19 Item 1 of the Climate Change and Ozone Layer Protection Act (Official Gazette 127/19) and Article 41, Item 6 of the Statute of the City of Zagreb (Official Gazette of the City of Zagreb 23/16, 2/18, 23/18, 3/20, 3/21, 11/21 – consolidated text and 16/22), the City Assembly of the City of Zagreb, at its 40th session on 23 January 2025, adopted the following

PROGRAMME
on Climate Change Mitigation, Climate Change Adaptation and Ozone Layer Protection of the City of Zagreb 2025-2028

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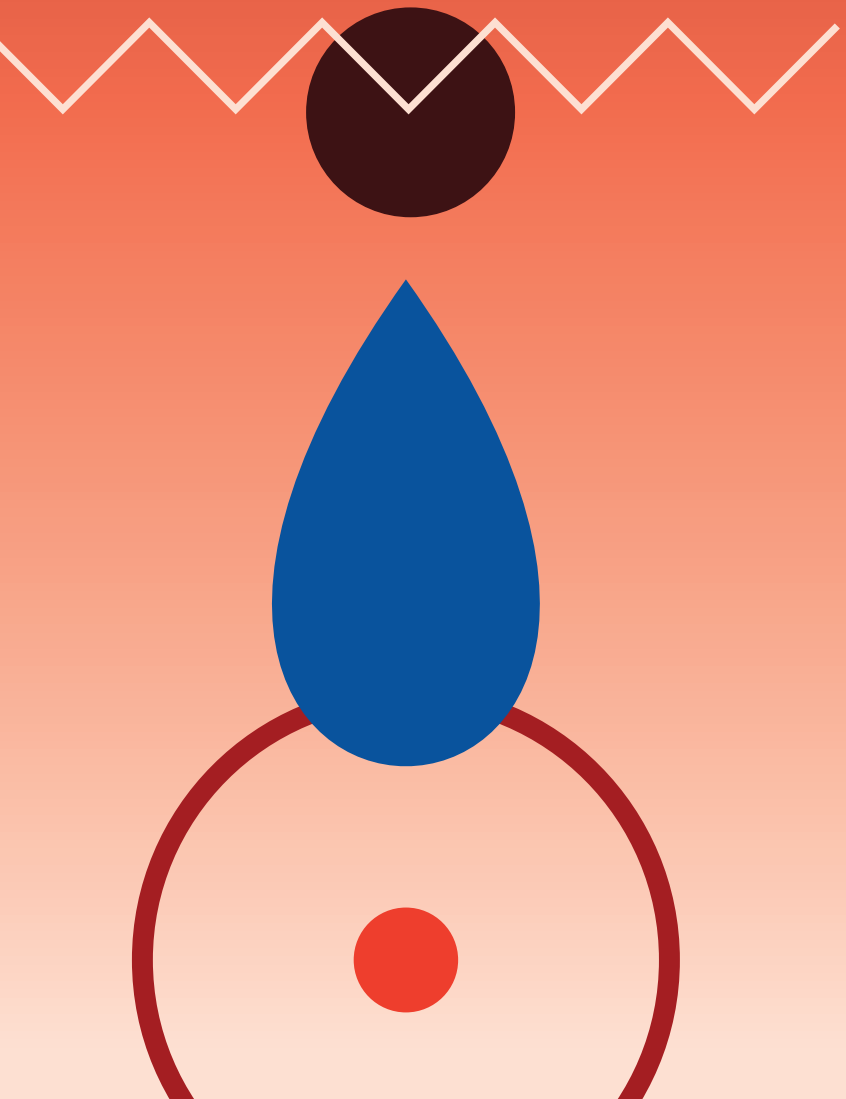
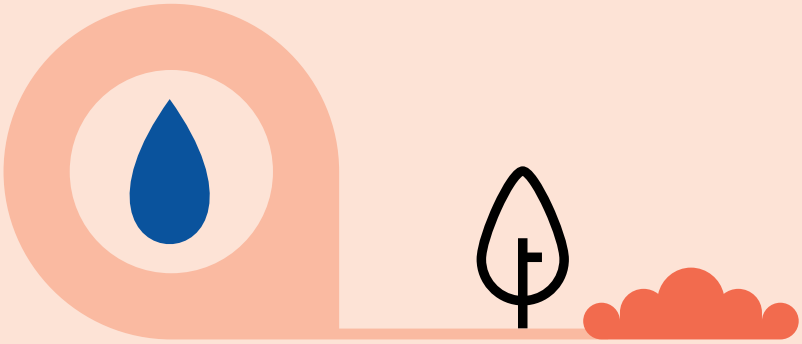


1

Introduction



Programme on Climate Change Mitigation, Adaptation and Protection of the Ozone Layer of the City of Zagreb 2025-2028 (hereinafter: Programme) was prepared on the basis of Article 19 of the Climate Change and Ozone Layer Protection Act (Official Gazette 127/19).

The City of Zagreb, like many other urban centers around the world, is facing the serious consequences of human-induced climate change. In recent decades, we have witnessed an increase in mean and maximum temperatures, an extension of hot periods, an increase in the number of tropical nights, and frequent and intense weather disasters such as torrential floods, droughts, storm winds and extreme precipitation. These climate changes not only endanger the quality of life for the citizens of Zagreb, but also have long-term negative consequences for the infrastructure, ecosystems and economic stability of the city.

Given these challenges, it has become necessary to take concrete measures to mitigate these impacts and ensure that the city adapts to future climatic conditions. By implementing this Programme, the City of Zagreb strives to reduce greenhouse gas emissions, increase the city's resilience to climate change and ensure quality of life for its citizens in the face of new, intensifying climate conditions. This programme includes a series of strategic activities that will enable climate change adaptation, improve sustainability and ecological balance, and create a city that is economically stable, socially responsible and adaptable to new climate challenges.

By implementing measures to reduce emissions, conserve natural resources and rationally use energy, the City of Zagreb has the opportunity not only to mitigate the negative effects of climate change, but also to take advantage of the benefits that may arise from new climate conditions.

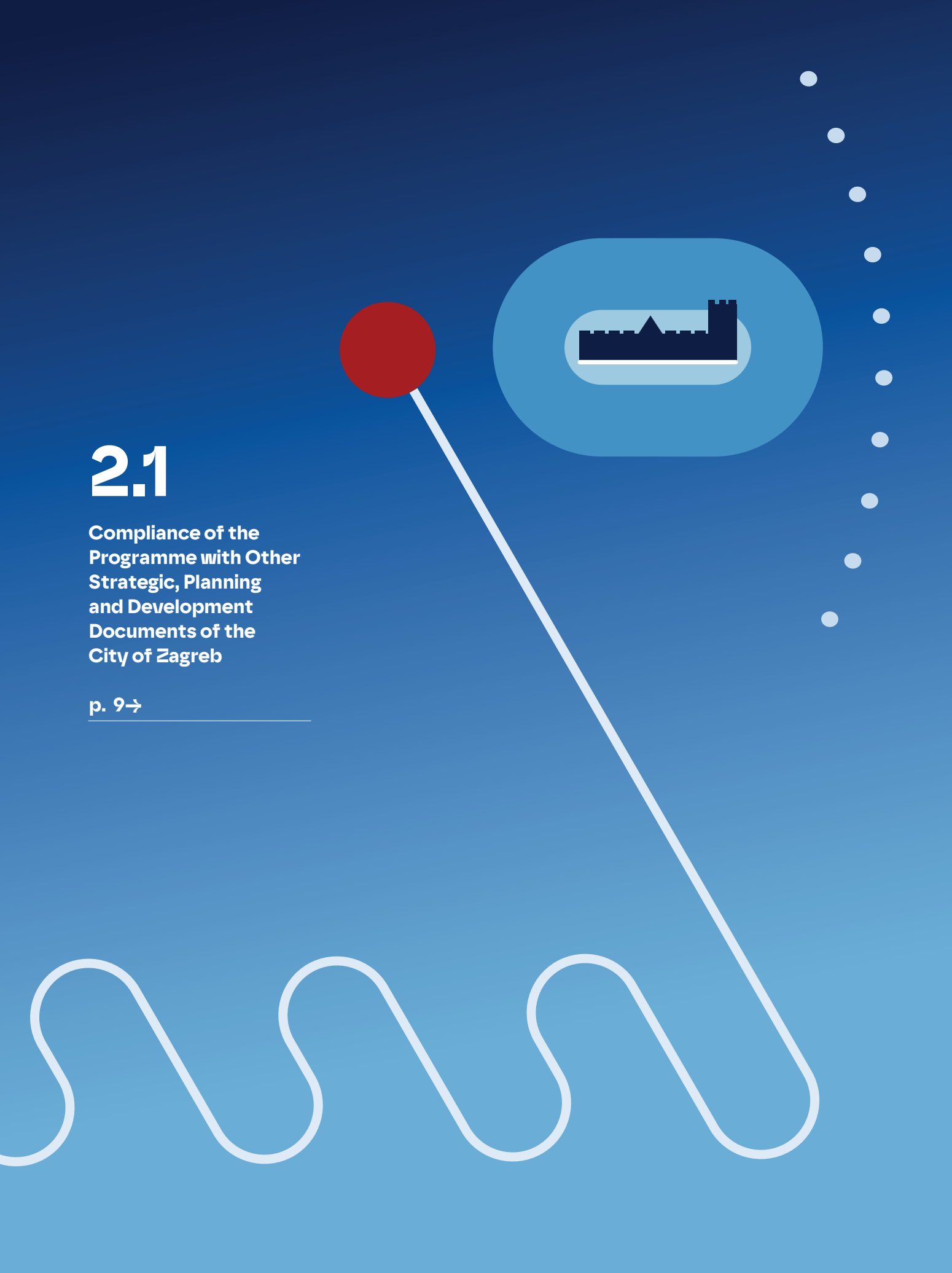
In this way, the City of Zagreb can become even more resilient, sustainable and comfortable to live in, ensuring the health and well-being of its citizens, while at the same time taking an important step towards responsible and sustainable development for future generations.

For the area of the City of Zagreb, the programme sets out a description of the current and projections of the future climate, assessment of the impact of climate change, analysis of risks and vulnerabilities from climate change, assessment of greenhouse gas emissions, a list of climate change adaptation measures and climate change mitigation measures, as well as deadlines, activities, obligors and implementation costs for the period from 2025 to 2028.

The programme was developed by the City Office for Economy, Environmental Sustainability and Strategic Planning of the City of Zagreb.

2

Legislative Framework in the Field of Climate Change



2.1

Compliance of the Programme with Other Strategic, Planning and Development Documents of the City of Zagreb

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Mitigation and adaptation to climate change impacts for sustainable development are based on an integrated approach that includes reducing greenhouse gas emissions, strengthening the resilience of communities and ecosystems, and implementing policies and practices that support long-term environmental, economic and social stability.

Key elements of this approach include alignment with the objectives of global agreements such as the Paris Agreement on climate change (in force since 4 November 2016, confirmed by the EU on 5 October 2016 and by the Republic of Croatia on 17 March 2017). For a long time, the Republic of Croatia has been exposed to the negative effects of climate change, which affect ecosystems, economic sectors and human health and cause significant economic losses.

The umbrella law governing climate change in the Republic of Croatia is the Climate Change and Ozone Layer Protection Act (Official Gazette 127/19), which entered into force on 1 January 2020. This law establishes competence and responsibility for climate change mitigation, climate change adaptation and ozone layer protection; documents on climate change and ozone layer protection, monitoring and reporting of greenhouse gas emissions, emissions trading system, aviation activity, sectors outside the greenhouse gas emissions trading system, the Union Registry, ozone-depleting substances and fluorinated greenhouse gases, financing of climate change mitigation, climate change adaptation and ozone layer protection, information system for climate change and ozone layer protection, and administrative and inspection supervision. At the same time, it transposes into the Croatian legal order several European directives such as Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, Directive 2009/28/EC on the promotion of the use of energy from renewable sources (RES) and the like.

Strategic documents on climate change and protection of the ozone layer (Art. 10 of the Act) are the following:

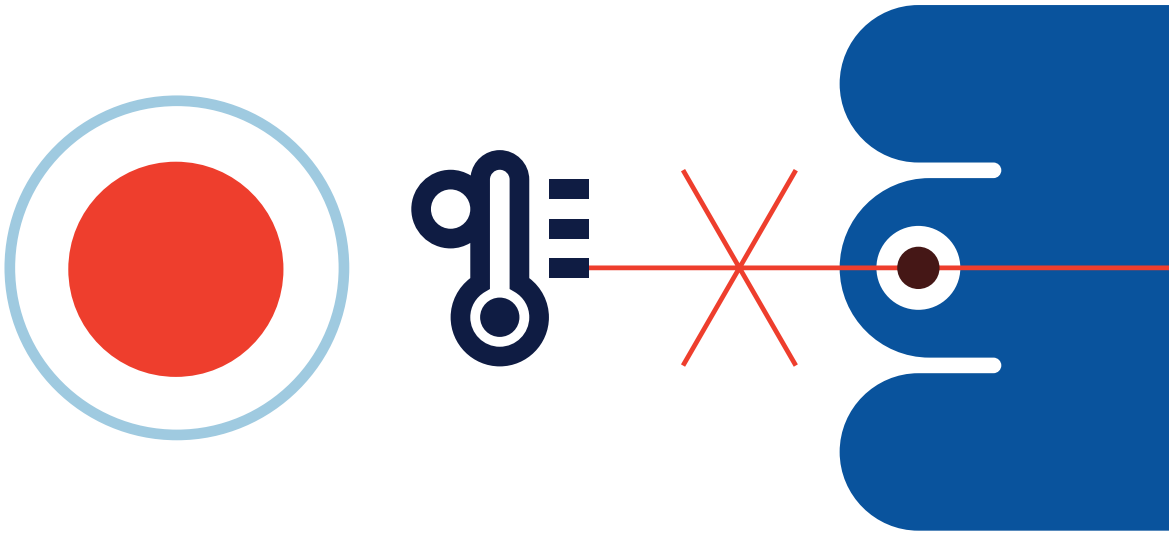
- Low-Carbon Development Strategy of the Republic of Croatia until 2030 with an Outlook to 2050 (Official Gazette 63/2021)
- Climate Change Adaptation Strategy in the Republic of Croatia for the Period until 2040 with an Outlook to 2070 (Official Gazette 46/2020)
- Action Plan for the Implementation of the Low-Carbon Development Strategy of the Republic of Croatia
- Action Plan for the Implementation of the Climate Change Adaptation Strategy in the Republic of Croatia
- Integrated Energy and Climate Plan of the Republic of Croatia
- National Development Strategy of the Republic of Croatia until 2030 (Official Gazette 13/21).

Based on the Low-Carbon Development Strategy, the Action Plan for the Implementation of the Low-Carbon Development Strategy for a five-year period is adopted, and based on the Adaptation Strategy, the Action Plan for the Implementation of the Climate Change Adaptation Strategy for a five-year period is adopted.

Climate Change Adaptation Strategy in the Republic of Croatia for the Period until 2040 with a View to 2070 (hereinafter: Climate Change Adaptation Strategy) sets goals, measures and priorities for the implementation of climate change adaptation measures in the Republic of Croatia and contains:

- climate models and projections of the future climate
- assessment of the impact of climate change on society and the environment
- vulnerability and risk assessment
- priority measures and activities
- international obligations and international cooperation of the Republic of Croatia
- scientific research guidelines in the field of impact assessment and adaptation to climate change
- assessment of the means of implementation
- cost-benefit analysis of the implementation of climate change adaptation measures
- monitoring and evaluation framework with indicators.

National development documents and development documents of individual areas and activities must be aligned with the principles, basic objectives, priorities and measures set out in the Low-Carbon Development Strategy and the Climate Change Adaptation Strategy.



2.1

Compliance of the Programme with Other Strategic, Planning and Development Documents of the City of Zagreb

In the process of drafting the Programme on Climate Change Mitigation, Climate Change Adaptation and Ozone Layer Protection of the City of Zagreb, the key elements from the existing strategic, planning and development documents were carefully considered and integrated. The analytical background included the following key documents, the purpose of which is to understand in detail and address the challenges related to the field of climate adaptation:

- City of Zagreb Air Protection Program for the period from 2022 to 2026 (Official Gazette of the City of Zagreb 3/22).
- City of Zagreb Development Plan for the period 2021 2027 (Official Gazette of the City of Zagreb 3/24).
- Master Plan of the Transport System of the City of Zagreb, Zagreb County and Krapina-Zagorje County
- Sustainable Energy and Climate Action Plan of the City of Zagreb (SECAP) (Official Gazette of the City of Zagreb 13/19)
- Spatial Plan of the City of Zagreb (Official Gazette of the City of Zagreb 3/18 consolidated text)
- The Zagreb Urban Agglomeration Development Strategy Action Plan until the End of 2027 (Official Gazette of the City of Zagreb 37/23)
- Spatial Plan of the Medvednica Nature Park (Official Gazette 89/14)
- Spatial Development Strategy of the Republic of Croatia (Official Gazette 106/17)
- Report on the Spatial Situation of the City of Zagreb (Official Gazette of the City of Zagreb 20/22)
- Programme for the Promotion of Sustainable Development of Agriculture and Forestry in the City of Zagreb in the period from 2024 to 2027 (Official Gazette of the City of Zagreb 21/24).

By analysing and synthesizing these documents, the Programme recognizes and connects previously recognized challenges related to climate change and lays the foundations for proactive action with the purpose of long-term sustainability and resilience of the City of Zagreb.

3

General Information About the Area

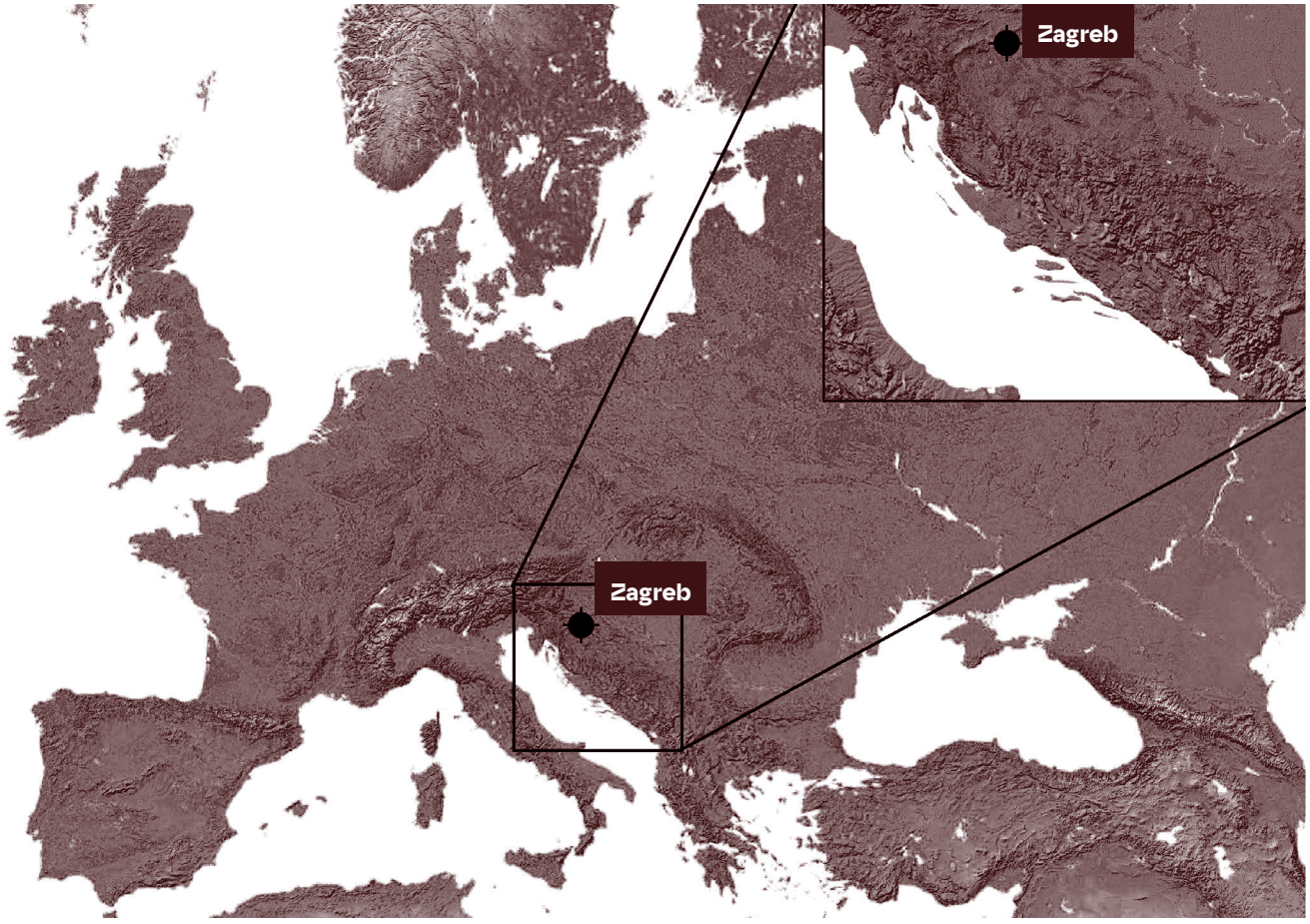
3.1

Geographical Characteristics

The city of Zagreb is located in the Croatian inland, in the area of the Pannonian Plain (Figure 3.11). In addition to lying at the junction of the alluvial plain of the Sava River and Medvednica Mountain Massif, the city extends at an altitude of about 122 m in the south to 1035 m at the top of Sljeme, the highest peak of Medvednica. The city borders two counties: Zagreb County on the east, south and west sides and Krapina-Zagorje County in the north. In addition, the City of Zagreb is the political, cultural and economic center of Croatia and an important hub of transport and communication routes connecting the north and south, as well as the east and west of the country.

The area of the City of Zagreb is 641.22 km2, which makes up about 1.13% of the total area of the Republic of Croatia. The City itself consists of 68 settlements divided into 17 city districts.

Figure 3.1-1
Geographical Position of Zagreb

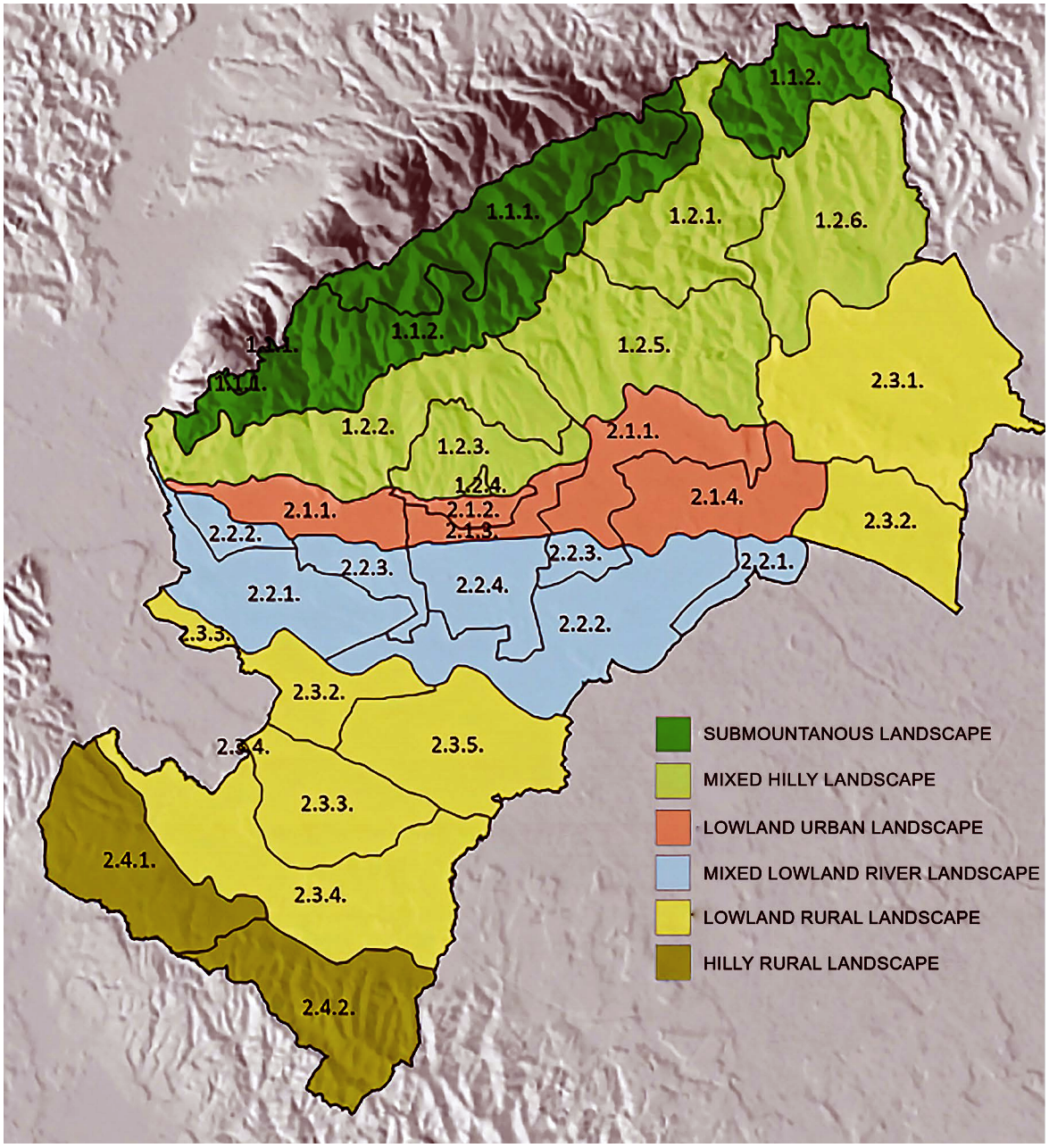


3.2

Main Relief Characteristics

The city of Zagreb is located in the Peripannonian area on the optimal direction of communication with the Mediterranean. The city reaches the southern slopes of Medvednica in the north, while in the south it extends to a plain area along the Sava River. Most of Zagreb is located in a lowland area, at an altitude of up to 200 meters above sea level (Figure 3.21).

Figure 3.2-1
General Landscape Types in the City of Zagreb [1]



Due to their geographical position in temperate latitudes, all four seasons alternate in Zagreb. Medvednica Mountain, which extends in the southwest-northeast direction, significantly affects the city climate. It acts as a barrier to airflow, so northwest winds are rare, while winds from the northeast and west-southwest directions are dominant. Also, the passage of air over Medvednica leads to a fan effect, in which the air is heated and brings warm air to the city. During winter, temperature inversion conditions develop in the lowlands, when cold air settles in the lower parts of the city, while higher altitudes of Medvednica record warmer temperatures.

The area of the City of Zagreb is divided into two landscape regions: sub-Pannonian and Pannonian, each of which is divided into sub-units - general landscape types (Figure 3.21) [1]. Additional, specific criteria of urban landscapes such as density and degree of construction, historical development and manner of settlement formation, urban matrix and patterns, urban density, types and morphology of construction, functions and facilities, structure and use of space, parcelling, etc. played an important role. In this way, two general landscape types were distinguished in the Sub-Pannonian Landscape Region (1), and four general landscape types were distinguished in the Pannonian Landscape Region (2) (Table 3.21).

Figure 3.2–1
Landscape Types in the City of Zagreb

Landscape Region	Type Code	General Type
Sub-Pannonian landscape region	1.1.1.	submountanous landscape
	1.1.2.	
	1.2.1.	mixed hilly landscape
	1.2.2.	
	1.2.3.	
	1.2.4.	
	1.2.5.	
	1.2.6.	
Pannonian landscape region	2.1.1.	lowland urban landscape
	2.1.2.	
	2.1.3.	
	2.1.4.	
	2.2.1.	mixed lowland river landscape
	2.2.2.	
	2.2.2.	
	2.2.3.	
	2.2.3.	
	2.2.4.	
	2.3.1.	lowland rural landscape
	2.3.2.	
	2.3.3.	
	2.3.4.	
	2.3.5.	
	2.4.1.	hilly rural landscape
	2.4.2.	

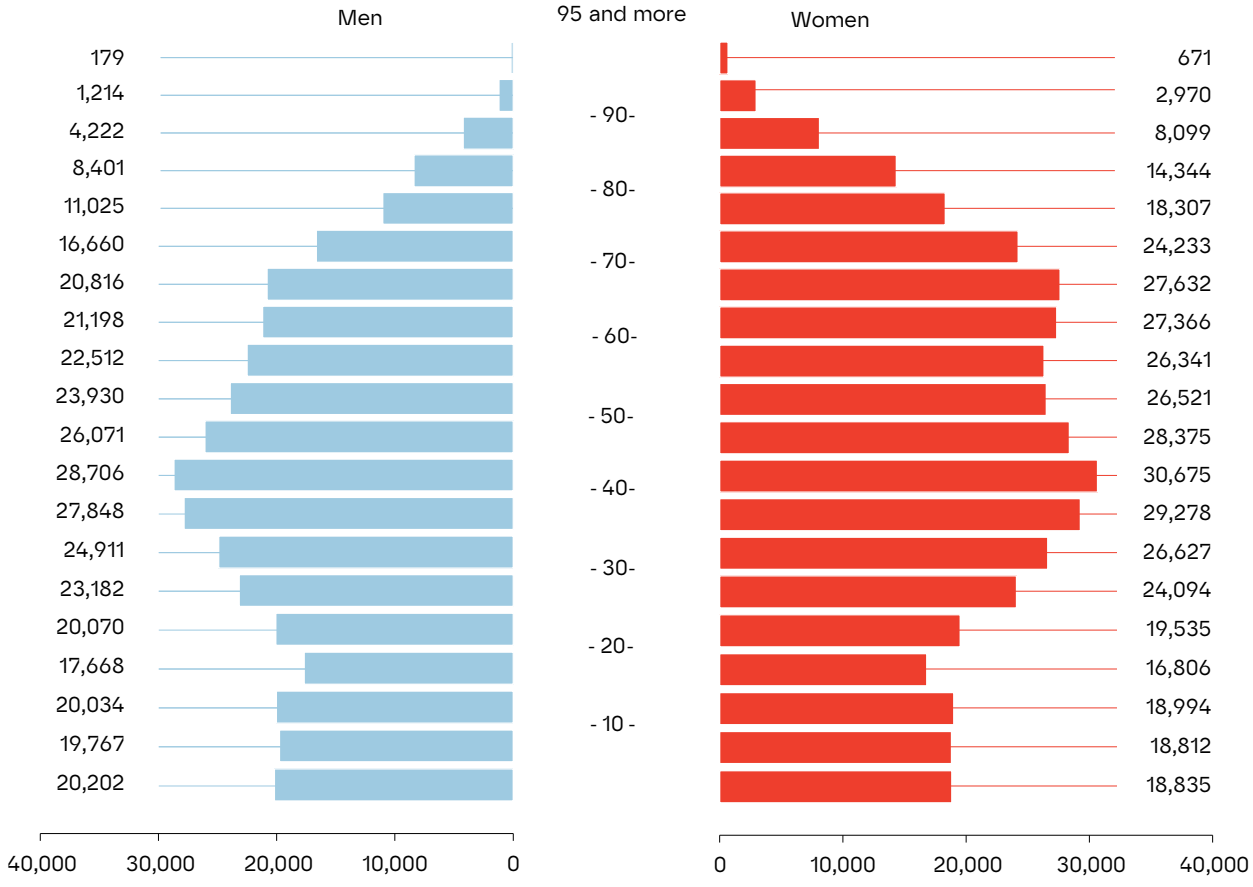
3.3

Population

According to the 2021 Census, the City of Zagreb had a population of 767,131, which accounts for 19.8% of the total population of the Republic of Croatia. Compared to the 2011 Census, there was a 2.9% decrease. The population structure reveals that women make up 53.3% of the total population and men 46.7%. The largest demographic is the 40 to 44 age group (Figure 3.31) accounting for 7.7% of the population. [2] [3]

According to data from March 2023, a significant share of the employed population in the City of Zagreb has educational qualifications from vocational secondary schools, accounting for 46.1% of the total workforce, while 33.7% of employees have graduate or postgraduate degrees. The largest number of persons in Zagreb are employed in wholesale and retail trade; repair of motor vehicles and motorcycles and in the manufacturing industry. The registered unemployment rate, as of March 2023, was 2.6% [4].

Figure 3.3–1
Demographic structure of the population of the City of Zagreb according to the 2021 Census



3.4

Administrative-Territorial Characteristics

As the capital of the Republic of Croatia the City of Zagreb is a special and unique, territorial and administrative unit whose position, scope and organization are regulated by the City of Zagreb Act (Official Gazette 62/01, 125/08, 36/09, 119/14, 98/19 and 144/20). The City of Zagreb is a local self-government unit that also has the position of a regional self-government unit – county. These powers allow Zagreb to independently manage its economic, social and cultural development and implement its own policies according to the needs of the local population.

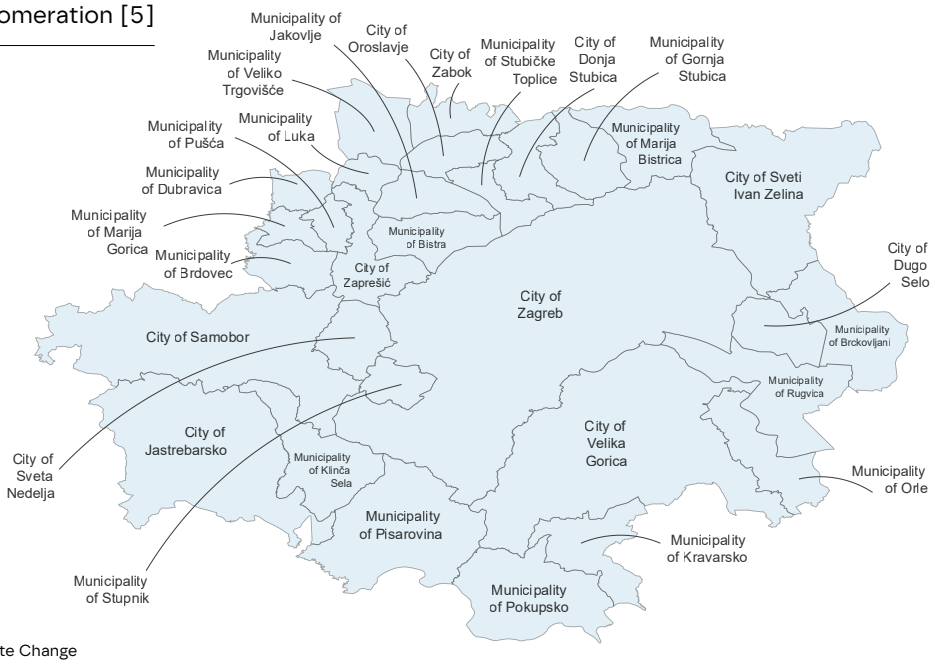
The City of Zagreb is divided into 17 city districts, which are further divided into 218 local committees. The urban agglomeration of Zagreb (Figure 3.41) was established in 2016 and includes the City of Zagreb as the center of the agglomeration and another 29 local self-government units: 7 from the area of Krapina-Zagorje County and 22 from the area of Zagreb County, i.e. 11 cities and 19 municipalities are part of it: City of Zagreb, City of Donja Stubica, City of Dugo Selo, City of Jastrebarsko, City of Oroslavje, City of Samobor, City of Sveta Nedelja, City of Sveti Ivan Zelina, City of Velika Gorica, City of Zabok, City of Zaprešić, Municipality of Bistra, Municipality of Brckovljani, Municipality of Brdovec, Municipality of Dubravica, Municipality of Gornja Stubica, Municipality of Jakovlje, Municipality of Klinča Sela, Municipality of Kravarsko, Municipality of Luka, Municipality of Marija Bistrica, Municipality of Marija Gorica, Municipality of Orle, Municipality of Pisarovina, Municipality of Pokupsko, Municipality of Pušća, Municipality of Rugvica, Municipality of Stubičke Toplice, Municipality of Stupnik and Municipality of Veliko Trgovišće.

It is the largest urban area in the Republic of Croatia, the only one that in addition to extending beyond one county also includes parts of two more counties. In the financial period of 2021-2027, the same coverage of urban agglomeration was maintained for the continuity of cooperation established in the previous financial period of 2014-2020.

The agglomeration area is 2911.3 km2, and according to the 2011 Population, Household and Housing Census, 1,086,528 inhabitants lived in its area, comprising slightly more than a quarter (25.35%) of the total population of the Republic of Croatia. According to the results of the 2021 Census, 1,051,045 inhabitants live in the Zagreb Urban Agglomeration area, which is 3.3% less than in 2011, however, it accounts for 27.1% of the total population of Croatia.

Zagreb urban agglomeration includes a large number of local self-government units with marked differences in the number of inhabitants, population density, level of development expressed by the index of development, availability of public and social infrastructure and position (physical/spatial, transport and economic) within the agglomeration.

Figure 3.4–1
Coverage of the Zagreb Urban Agglomeration [5]



Considering that this is the largest urban area in Croatia, the Zagreb Urban Agglomeration area is strongly marked by anthropogenic influence, and consequently faced with numerous challenges of nature and environmental conservation. As expected, the processes of urbanization, over-exploitation of natural resources and habitat depletion are the fastest in central areas central and slower in the peripheral areas of the agglomeration. On the other hand, in the area of agglomeration there are spacious natural and partly cultivated areas with ecological characteristics of national importance - Medvednica and Žumberak - Samoborsko Gorje nature parks. The Medvednica Nature Park, covering a total area of 17,938 ha, is an area of significant biological value, containing eight protected forest reserves. The Žumberak - Samoborsko gorje Nature Park, with a total area of 33,300 ha, only partly falls within the scope of the Zagreb Urban Agglomeration (13,250 ha). It is characterized by well-preserved nature, forests, streams, waterfalls, pastures, traditional rural estates and other values.

The urban agglomeration of Zagreb is an area that stands out for its diversity and richness of its natural, rural and anthropogenic landscapes. The natural conditions of the area have largely determined the historical development and diversity of the landscape as we know it today. Its visual quality has a special meaning, and the richness of landscape diversity and the preservation of natural resources ensure quality development potential. The pressure predominantly affecting landscape units is the careless urban expansion to undeveloped areas (in terms of space, design and content).

3.5

Basic Economic Characteristics

According to data published by the Financial Agency (FINA) for the period from 2019 to 2023 [6], the City of Zagreb was the leader in the Republic of Croatia in 2023 by several key business indicators. Entrepreneurs from Zagreb accounted for a significant share of revenues (49.5%), number of entrepreneurs (32.9%), employees (37.2%), exports (43%), total revenues (49.5%) and profits (48.1%) of the Republic of Croatia. Entrepreneurs of the City of Zagreb also achieved a third of the Croatian gross domestic product.

According to the National Classification of Activities, the majority of business in the area of the Zagreb Chamber of Commerce in 2021 was carried out in wholesale and retail trade. This was followed by professional, scientific and technical activities, other service activities, construction, information and communication and processing industry. It is notable that, although most companies in the Zagreb Chamber of Commerce operate in the wholesale and retail sector, they account for almost half of the total Croatian exports.

3.6

Basic Characteristics of Agriculture

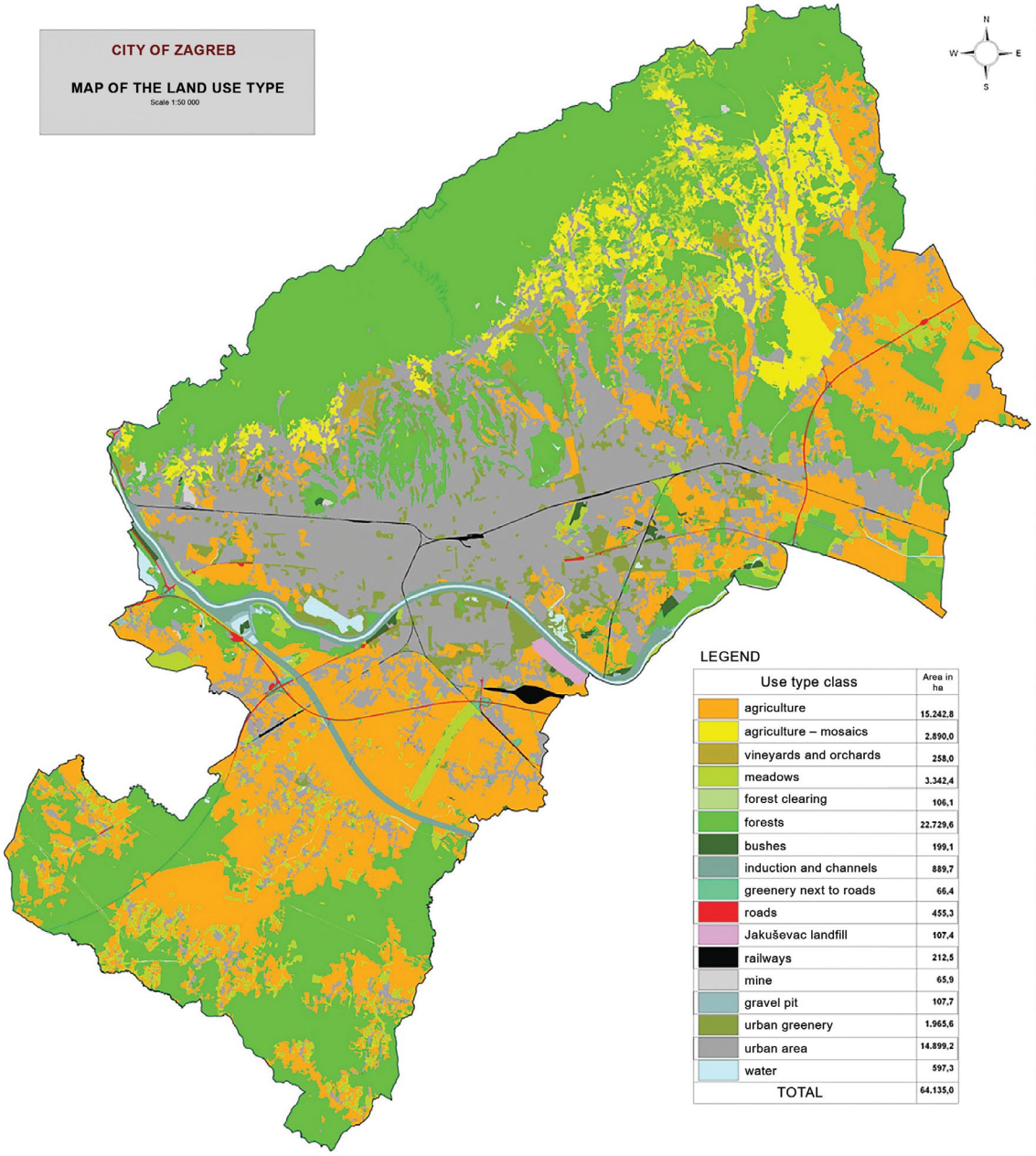
The City of Zagreb is known for its urban environment, but agriculture plays a significant role in its wider area. Agricultural activities are concentrated mainly in the surrounding rural areas and peripheral parts of the city, where arable land, orchards, vineyards and farms are located.

The surface area of agricultural land outside the General Urban Plan (GUP) of the settlements of Zagreb and Sesvete, where the majority of the existing agricultural production

takes place, is 14,300 ha; most of it is in the northeastern and southern part of the City of Zagreb. The fragmentation of agricultural parcels, as well as unresolved proprietary and legal relations, negatively affect the possibilities of more intensive agricultural production. In the area of the City of Zagreb, fragmented small estates prevail, and the most common are those up to 1 ha in size (Figure 3.61) [7]. Of the areas of agricultural land outside the GUP of Zagreb and Sesvete covering 14,264 ha, 25% consist of areas suitable for vegetable growing, 39.6% are areas suitable for field farming, 12.6% are areas suitable for livestock, 11% are areas suitable for viticulture and 11.8% are areas suitable for fruit growing.

According to the Paying Agency for Agriculture, Fisheries and Rural Development, the number of agricultural holdings in 2023 was 6478, of which the largest part was related to family farms, 6023 of them, and field and vegetable and fruit production as the most common type of agricultural production.

Figure 3.6–1
Map of the Land Use Type by the City of Zagreb



3.7

Forest Land and Forests in General

Forests in the area of the City of Zagreb cover almost a third of the total area, and according to the data of the public forest owner and the Ministry of Agriculture of the Republic of Croatia from 2021, there are a total of 19,264.39 ha of forests in the area of the City of Zagreb. The Republic of Croatia owns 8798 ha of forests, and private (legal and natural) persons own 10,466.39 ha of forests, of which 10,190.70 ha are landscaped and 275.69 ha are landscaped. It should also be noted that the areas vary slightly when we overlap cadastral data, forest management plans and spatial planning documents. In that case, the total forest area is 20,090 ha, the public forest owner manages 8710 ha, management programmes for private forests were adopted for an area of 10,950 ha, and the Faculty of Forestry and Wood Technology manages 430 ha. The forest cover of the City of Zagreb is dominated by deciduous forests that include various species such as sessile oak, hornbeam, maple, ash, chestnut, yew and linden. In the higher mountain areas, beech trees take on a leading role, and with altitude they are mixed with coniferous forests, where spruce and fir are common. Fruit trees have the lowest share in the forests of the City of Zagreb, but their presence significantly contributes to the biodiversity of these forest stands.

The Medvednica Nature Park, with an area of 17,938 ha, is one of the most important natural areas in the vicinity of Zagreb. Forests form the dominant ecological element of the area, covering 81% of its total area, which corresponds to 14,550 ha. Within the administrative boundaries of the City of Zagreb, the Medvednica Nature Park covers an area of 8438.13 ha, with forests and forest lands owned by the Republic of Croatia occupying an area of 5914.22 ha. On the edges of the park, lawns cover slightly larger areas, although they are rare within the Medvednica forest complex.

There are 22 forest parks in Zagreb and almost all of them are located along the slopes of Medvednica, and they often reach all the way to the urban center. The most prominent among them is Maksimir Forest Park, which is also a monument of landscape architecture. The largest forest park, Dotrščina, covering an area of 200 ha, is both a site for scientific research and field teaching for forestry students, while also representing an important memorial site of the city of Zagreb. The Granešina Forest Park covering an area of 38 ha within the Grad Mladih complex (formerly Pionirski Grad), which is protected as cultural heritage. The Pantovčak Forest Park is specific in that it is located within the complex of the Office of the President of the Republic of Croatia.

The General Urban Plan of the City of Zagreb (Official Gazette of the City of Zagreb 16/07, 8/09, 7/13, 9/16, 12/16 - consolidated text, 17/24, 19/24 – consolidated text) distinguishes two categories of forests that are protected by its measures:

1. Forest Parks: Jelenovac, Vrhovec; Tuškanac – Dubravkin put – Cmrok, Zelengaj, Kraljevec, Pantovčak and Prekrižje, and
2. City Forest Parks: Grmoščica, Lisičina, Zamorski breg, Šestinski Dol, Mirogoj – Črleni Jarek, Remete – Remetski Kamenjak, Dotrščina, Miroševečina, Dankovečina, Čulinečina, Oporovečina, Novoselčina and Granešina.

In the General Urban Plan, both categories are planned as park forests marked with the designation Z2.

3.8

Basic Traffic Characteristics

The City of Zagreb is the most important and the largest traffic center and the origin and destination of most road and rail traffic flows with more than 30% of the total traffic in the Republic of Croatia. It is located in the southwestern part of the Pannonian Plain, at the intersection of the Alpine, Dinaric, Adriatic and Pannonian areas.

The city is a key point in the Central European-Adriatic transport route and is connected to three main corridors. To the west, Zagreb is connected to Ljubljana and Western Europe by road; eastern roads lead to Southeast Europe and the Middle East, while the southwestern direction leads through Gorski Kotar to Kvarner, Istria, Lika and Dalmatia. Southeast of Zagreb lies the Franjo Tuđman Airport, the largest and busiest airport in Croatia, significant for development at the regional, national and international level with more than 3,700,000 passengers in 2023. Although for the most part the airport belongs to the territory of Velika Gorica, some parts, such as the approach and departure area, cover the area of the City of Zagreb. Given the above and the position of the Republic of Croatia at the intersection of three European regions, the City of Zagreb as the capital of the country has a strategically important transport position. In addition to being the busiest airport in the country, the City of Zagreb is also an important railway and road hub. The city is thus the branching point of the A1 (Zagreb – Rijeka), A2 (Zagreb – Krapina – Macelj border crossing), A3 Bregana – Zagreb – border crossing Lipovac), A5 (Zagreb – Varaždin, Goričan border crossing) and the A11 motorway (Zagreb – Velika Gorica – Sisak). Within the city area, the longest part of the A3 motorway is the part that belongs to the Zagreb bypass. The most important city roads are avenues: Slavonska, Jadranska, Dubrovačka, Držićeva, Hrvatske Bratske Zajednice – Holjevčeva – Velikogorička, followed by the streets: Grada Vukovara, Heinzelova, Savska, Dubrava, Branimirova, Maksimirska, Aleja Grada Bolonje, Zvonimirova and Medveščak. This basic transport network is complemented by other city streets that have different profiles and roles within the city transport system. Bridges over the Sava River are crucial for maintaining uninterrupted traffic flows between the left and right banks of the river, namely the old part of the city and Novi Zagreb, while also carrying many important utility lines. Zagreb's road and pedestrian bridges across the Sava River are: Podsused Bridge, Jankomir Bridge (old and new), Jadran Bridge, Sava Bridge ("the Blue Bridge"), Youth Bridge and Homeland Bridge.

3.8.1 Public Transport System

The public transport system of the City of Zagreb includes various forms of transport, including trams, buses, railways, funiculars and cable cars. Public passenger transport in the city area is mainly performed by two key operators: Zagreb Electric Tram (ZET) with a share of 95%, and HŽ with 5%.

The ZET lines network has been designed to suit the spatial distribution of the population and the needs of the overall transport demand. In the central part of the city, which is characterized by high passenger traffic density, a dense network of tram and bus lines has been developed, while in the peripheral, less populated parts of the city, transport is mainly realized by buses.

In addition to traditional public transport, a form of taxi transport that can be ordered by phone/app or taken directly at a taxi stop is becoming increasingly popular. This form of transport is most often used within the city, but also to connect Zagreb with its wider surrounding areas. There is a diverse range of taxi companies on the market, allowing riders more flexibility in choosing a service, either through direct taxi stops or ride-order apps. Increased availability of taxi transport contributes to the flexibility and efficiency of the urban transport system, especially in situations where public transport is not available or does not meet passenger needs.

In the City of Zagreb, the operation of ZET takes place by:

- 459 bus vehicles, with an average age of 10.5 years
- 266 tram vehicles, of which 142 are low-floor, with an average age of 30.4 years
- cable cars
- funiculars
- 31 vehicles for the transport of persons with disabilities and children developmental difficulties
- buses for transporting school children
- tourist trams
- tourist sightseeing buses
- tourist trains
- tourist electric vehicles.

The total length of tram tracks in the city of Zagreb amounts to 133.69 km (comprising 116 km of regular traffic operation and about 17 km of depot tracks). Passenger transport by trams is largely carried out on streets where there is a network of tramways with road motor traffic, so there are occasional heavy loads, common and limited traffic areas. In current traffic conditions, the regulation of conflict points on the main tram corridors is achieved by a signalling-lighting system that does not recognize the priority of tram traffic, which is why the speed of tramways on some tram sections has been reduced, which directly affects the quality of tram traffic, questioning the choice of trams for daily transport and travel.

Intercity and international bus traffic takes place through the Zagreb Bus Station. Given the number of platforms, of which there are 44, and more than 175,000 buses departing (or arriving) annually, it is the largest

bus station in this part of Europe. Given the year of construction of the existing bus station and the trend of increasing the number of tourists in the city of Zagreb, the modernization of the Zagreb Bus Station is one of the most important elements of the development of the transport system of the City of Zagreb.

The lines operated by international passenger trains connect the City of Zagreb, Zagreb County and Krapina-Zagorje County with Germany, Austria, Switzerland, Slovenia, Hungary, Bosnia and Herzegovina and Serbia. Freight trains connect the area in question with the rest of Europe, and are especially directed towards the eastern and southeastern parts of Europe.

Trains of regional importance are most often long-distance and also serve passengers from the Zagreb, Zagreb and Krapina-Zagorje counties during commuting.

Railway lines of local importance are operated by suburban and urban trains, serving primarily to connect the population, commuting and carrying out various activities and services. The city railway line of local importance operates on the route Dugo Selo - Zagreb - Glavni Kolodvor (main train station) - Savski Marof, i.e. Harmica. Freight traffic of local importance from the Zagreb marshalling yard serves the stations Podsused - Tvornica, Zagreb - Resnik, Savski Marof, Zaprešić, Sesvete, Zagreb - Western Station, Velika Gorica, Zagreb - Klara, Hrvatski Leskovac, Dugo Selo and Zagreb - Žitnjak.

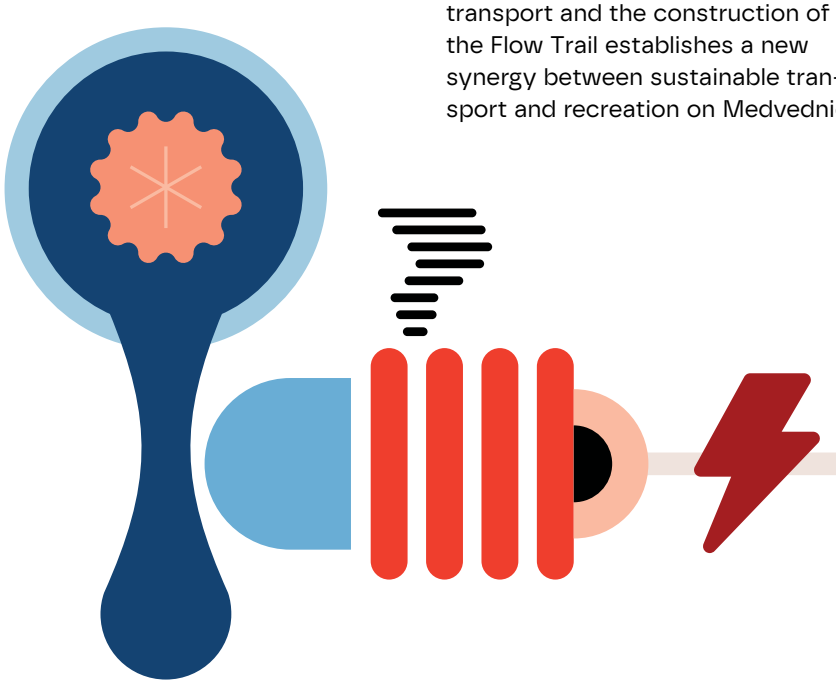
The funicular connects Zagreb's districts of Gornji Grad and Donji Grad and is legally protected as a cultural monument, as it has retained its original external appearance, construction and most of the technical properties given to it by the builders at the end of the 19th century. Data from the Statistical Yearbook of the City of Zagreb data indicate that the funicular carries between 700 and 750 thousand passengers per year.

The new Sljeme Cable Car connects Gračansko Dolje with the peak of Sljeme, with an intermediate station at Brestovac. The aerial route of the cable car is just over five kilometres long and offers passengers an impressive panoramic view of Zagreb and its surroundings. The maximum speed of the cable car is 6 m/s, which allows quick transport to the Lookout in about 16 minutes. The cable car has a capacity of 1,500 passengers per hour, which are transported in 84 modernly equipped cabins, each with ten seats. The height difference between the lower and upper station is 754 meters, and the heights of the columns vary from 6.05 to 43.51 meters, depending on the terrain configuration.

Since 2024, cable car transportation for citizens of the City of Zagreb has been free of charge, which further encourages the use of public transport and contributes to sustainable urban transportation. In addition, with the aim of sustainable development and preservation of natural resources, it is planned to develop content for visitors based on the sustainable use of natural beauties and resources of Medvednica. This includes taking measures to restrict car traffic in the area, encouraging the use of public transport and bicycle lanes, and creating new facilities and services that allow visitors to enjoy nature without adversely affecting the environment. This approach contributes to preserving ecological balance, reducing CO_2 emissions and promoting sustainable tourism of Medvednica.

The Flow Trail cycling project on Medvednica, with a total length of 9 km, starting at the arrival station of the Sljeme cable car, descending above the lower station of the old cable car and ending in front of the tunnel, is planned for 2025. It fits perfectly into the wider strategy of the City of Zagreb for developing sustainable tourism and improving outdoor activity infrastructure.

The combination of free cable car transport and the construction of the Flow Trail establishes a new synergy between sustainable transport and recreation on Medvednica.



Citizens of Zagreb can now easily reach mountain trails without using cars, which reduces traffic and CO_2 emissions in this environmentally sensitive area. In addition, access to the peak of Sljeme by cable car allows more visitors to enjoy nature, and the Flow trail will provide active rest and recreation for cycling lovers, all in accordance with the principles of sustainable development.

The combination of free cable car and modern outdoor trails also contributes to the further popularization of Medvednica as a destination that promotes health, recreation and environmental protection, thus creating a unique offer for citizens and tourists who want to enjoy nature, but also reduce their ecological footprint.

The "Traffic Management Centre" project, with an allocated budget of EUR 10,000,000.00, aims to establish automatic traffic management of the City of Zagreb and improve public urban transport, preparation of documentation, traffic lights at intersections and pedestrian crossings, sound equipment for guiding the blind and visually impaired, dynamic signalling, preparation of expert bases for the implementation of development transport-infrastructure and logistics projects and programmes, traffic plans for the development of urban and suburban mobility, studies, reviews and revisions of project documentation. By connecting new intersections, a quarter of the city's traffic light network will be integrated into the system, making Zagreb a true smart city.

The "Improving Cycling Transport and Mobility (ZGCU)" project, worth EUR 71,000.00, foresees the preparation of an annual almanac, educational materials for the European Mobility Week, upgrading the user application for cyclists and project documentation for a bicycle garage. The aim of the Project is to increase the use of a type of transport with zero CO_2 emissions in the urban and suburban areas of the City of Zagreb and Zagreb County, to create preconditions for the development and improvement of cycling infrastructure in the area of the Zagreb Urban Agglomeration, to create positive effects on the environment and to enable unobstructed and safer bicycle traffic in the east-west direction, which will also result in better flow and reduced travel time. The trail is planned to feature additional equipment, including lighting, e-bike chargers, rest areas, parking facilities, information signs, traffic counters, arranging access to bridges and arranging accesses and connections to the existing cycling and road infrastructure.

Furthermore, the implementation of two capital infrastructure projects is underway: the "Greenway" project and the "Bicycle Highway" project.

The "Greenway" project involves the construction of a cycling route following the course of the Sava River from the border with the Republic of Slovenia to Lijevi Dubrovčak with a total length of 132 kilometres. The route will be equipped with lighting, e-bike chargers, rest areas, parking lots, information labels and traffic counters. The design also includes the arrangement of access points and connections to the existing cycling and road infrastructure. The project is part of sustainable urban and regional mobility projects that promote sustainable transport, improve traffic safety and ensure better connectivity of cycling routes in the city of Zagreb and Zagreb County. At the end of 2019, a location permit for the Project was obtained and co-financing was approved from the European Union at the highest level of support, amounting to HRK 5,724,926.25, for the design of the entire trail and the construction of one phase of the trail 1660 meters in length.

The "Bicycle Highway – Zagreb East" project plans the construction of a cycling corridor along the railway line from the Student Center to Dugo Selo with a total length of 22.3 kilometres. The aim of the project is to connect with the existing cycling infrastructure and create a single continuous network, as well as to improve the overall cycling traffic in the city of Zagreb and its surrounding areas. Traffic and technological documentation at the implementation level was prepared for the pilot project of the section "Bicycle Highway – Zagreb East" from Zavrtnica Street to Svetice Street, with a length of 1201 meters.

Currently, an improvement of the public transport fleet is being carried out, which includes the delivery of 11 used trams, 60 used buses and the first 20 new low-floor trams, and a contract for the procurement of an additional 20 new low-floor trams has been signed. In November 2024, a public procurement was launched for four electric buses with the required charging system. At the beginning of 2025, works on the revitalization of the funicular are planned. In the following years, it is also planned to purchase an additional 60 used buses, 40 new low-floor trams and 62 electric buses with appropriate charging infrastructure. Overall, the goal is to increase the number of working trams and buses, in line with the planned expansion of the timetable.

The technical characteristics of electric buses ensure a driving autonomy of at least 300 kilometres on a single charge, and the charging system will be located at the Podsused bus depot. These buses, with

zero CO_2 emissions, significantly contribute to the reduction of pollution in green zones, which is especially important for the sports and recreation centers Jarun and Sljeme. The procurement of zero-carbon vehicles is an important step towards getting acquainted with new technologies and processes necessary for the systematic decarbonization of public transport.

As part of the extension of the tram network, works are currently being carried out on the expansion of the Sarajevo Road (from Zapruđe to Ranžirni Kolodvor), with the extension of Heinzelova (from Zvonimirova to Savišće) scheduled next. Efforts are also being made to modernize and reconstruct rectification stations and power lines, as well as to repair tramways and switch assemblies.

The "Public Bicycle System" project, worth EUR 8,000,000.00 for a four-year period, includes the construction of new terminals and bicycle racks, as well as the procurement of bicycles. The project contributes to the promotion of sustainable transport and further improves mobility in the city.

3.9

Water Management Systems

Pursuant to the Water Act (Official Gazette 66/19, 85/21 and 47/23) and the Water Services Act (Official Gazette 66/19), the activity of public water supply and public drainage is performed by public water service providers. Water service providers perform water supply activities in the water supply area, and wastewater drainage activities in the agglomeration area. At the same time, we refer to the area that includes one or more water supply areas and the agglomeration as a service area. According to the Regulation on Service Areas (Official Gazette 70/23), the City of Zagreb is part of Service Area 11 (except for the settlement of Veliko Polje) together with the cities of Jastrebarsko, Samobor and Sveta Nedelja and the municipalities of Stupnik, Klinča Sela and Žumberak in Zagreb County.

In the area of the City of Zagreb, the service of public water supply and public drainage is provided by ViO d.o.o. Zagreb.

The water supply of the City of Zagreb relies on seven key water wells, among which Mala Mlaka, Petruševec, Sašnjak and Strmec are of the greatest importance. In the area of the City there are buried water sources, beneath the alluvial deposits of the Sava River, which are rich in groundwater, purified by natural filtration. The systems draw water from a total of 44 wells, ensuring water supply for the inhabitants of the City. The total pipeline network extends over 3,800 kilometres, connecting seven different water sources. Every day, about 310,000 m3 of water is pumped from these sources, ensuring water supply for an area of about 800 km² and for about 900,000 inhabitants [8].

The drainage system of the City of Zagreb, mostly constructed as a mixed system, includes about 2220 km of pipelines and a central wastewater treatment plant [8]. Upon the adoption of the Decision on unilateral termination of the Concession Agreement for the Infrastructure Facilities Project for the construction of the Central Wastewater Treatment Plant of the City of Zagreb (Official Gazette of the City of Zagreb 3/24), Vodoopskrba i odvodnja d.o.o. took over the use and management of the Central Wastewater Treatment Plant of the City of Zagreb on 5 August 2024, after it had been under the management of the private concessionaire "Zagrebačke otpadne vode d.o.o." for 24 years. The Central Wastewater Treatment Plant – CUPOVZ of the City of Zagreb is the largest wastewater treatment plant in the Republic of Croatia, with a designed and built capacity of 1.2 million ES (330,000 m³/d), and the possibility of expanding to 1.5 million ES (442,000 m³/d). At the CUPOVZ, secondary (Stage II) wastewater treatment is carried out, with an upgrade to tertiary (Stage III) treatment planned for the future.

3.10

Flooding and Flood Protection

The city of Zagreb is located in the Sava River Basin, specifically in the small basin known as Zagrebačko Prisavlje. Hydrologically, the area of Zagreb County is characterized by the Sava River basin and its tributaries, as well as the Krapina River, which partially encompasses the borders of the City of Zagreb. In addition to these rivers, streams from the slopes of Medvednica and Vukomeričke Gorice can also pose a potential flood hazard.

The main facilities of the flood protection system in the area are the following: Sava embankments; Sava-Odra relief canal; retention basins on the Medvednica streams and the Kuniščak and Savica weirs. [9]

In the city of Zagreb itself, there are many streams that flow from Medvednica to the urban parts of the city. From the northwestern slopes of Medvednica, eight streams flow into the Krapina River, while from the southern and southeastern slopes, as many as 42 streams flow into the Sava River. The total length of the watercourse within the City of Zagreb is 496.22 km, of which 304.01 km is maintained. Streams from the southern, southwestern and eastern slopes of Medvednica form a densely branched hydrographic network with large longitudinal falls, which, along with high rainfall intensities and mountainous terrain, causes torrential floods accompanied by strong erosion processes and deposits in the lower parts of the watercourse.

To prevent flooding, retention systems have been built to receive and drain water from the stream area. On the slopes of Zagrebačka Gora, 19 retention basins were built, with a total retention volume of about 2.2 million m³. Among them are large dams such as Čokot, Črnomerec, Jazbina, Lagvić, Pusti Dol, Sopot, Štefanovac II and Trnava, and small dams such as Bidrovec I and II, Branas III and V, Dubravica I, Fučkov Jarak, Jelenovac IISS, Jezerčica, Kuniščak, Kustošak E and F III, Vidovec I and II. Also, a meliorative canal network of 114.35 km in length was built, of which 67.50 km is maintained, which includes the catchment area of Novi Zagreb and Sesvete [10].

The most significant changes in the area, primarily the regulation of the Sava River and the construction of the Sava-Odra Canal, occurred between two planning periods in response to the catastrophic floods of 1895 and 1964. An example of planned flood defence development is the planning of mountain retentions, which began as early as 1953, and construction starting in 1976. [9]

On July 25, 2020, Zagreb was hit by a storm that produced one of the largest recorded torrential floods in the city's history. In a heavy downpour in a few hours, more rain fell on the city than the average fall in the whole of July. Medvednica streams quickly swelled and overloaded the city's sewers, flooding parts of the city. The wider city center was hardest hit, especially Ilica, Donji Grad and Trnje, but the torrent flooded buildings and streets in many suburbs, including Buzin, Črnomerec, Jankomir and Maksimir. The storm stopped car traffic and public transportation in many places, and city services had to rescue people trapped in flooded apartments and cars. The majority of the measured precipitation fell in a very short time period, particularly at the Zagreb-Grič location, where 58.9 l/m² fell between 9:00 p.m. and 10:00 p.m., which exceeded the previous maximum of one-hour precipitation from 1976, which can be expected at that location once in more than 100 years. An additional 18.1 l/m² fell over the next hour, bringing the two-hour rain intensity to 77 l/m², which can be expected once in over 400 years. [9]

3.11

Protected Natural Assets

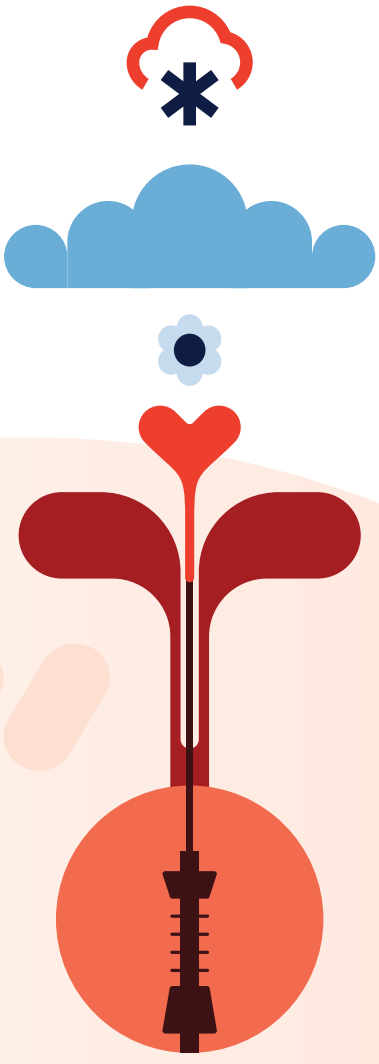
In the area of the City of Zagreb, there are a number of protected natural areas that are under the supervision of the public institution “Priroda Grada Zagreba” (until October 2023, the name of the institution was “Javna ustanova Maksimir”). Protected natural areas include 18 monuments of park architecture, two significant landscapes and five areas of the ecological network “Natura 2000” of international importance.

Monuments of landscape architecture, including botanical gardens and various parks such as Maksimir Park, Ribnjak Park and Zrinjevac Park, are not only key urban oases and recreational areas for citizens, but also contribute significantly to mitigating the impact of urban heat islands that often occur in urban centres [11].

The most important is the protected area of the Medvednica Nature Park, which is a vital habitat for diverse forest vegetation and is of exceptional geomorphological formation. The park is under the management of the public institution “Medvednica Nature Park”. Within the park there are seven special forest vegetation reserves, the Dotrščina forest and the significant landscapes of Lipa and Goranec. In addition, the geomorphological monument Veternica is located in the Medvednica area.

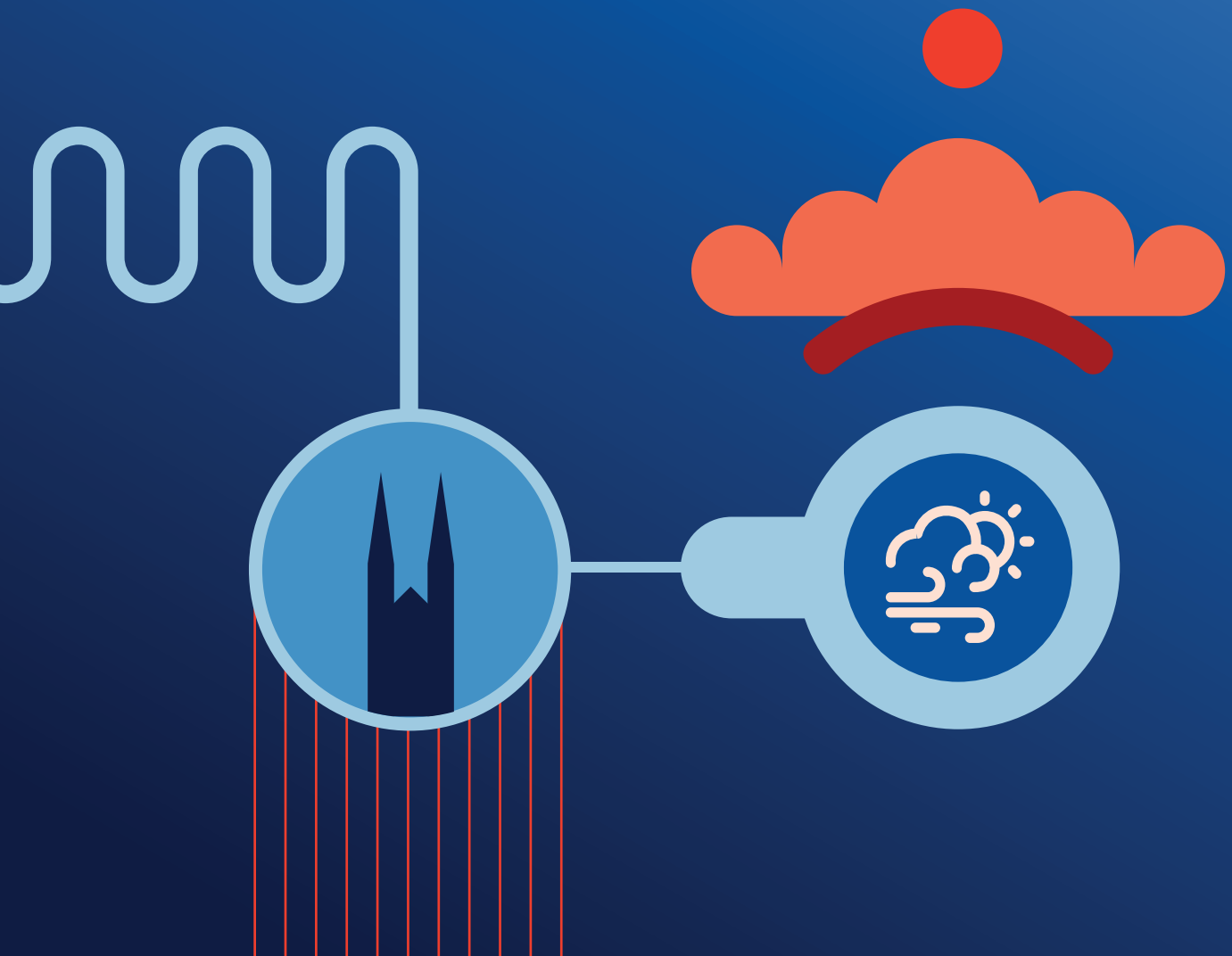
In the area of the Medvednica Nature Park there are also special forest vegetation reserves such as Bliznec – Šumarev Grob, Gračec – Lukovica – Rebar and Pušinjak – Gorščica.

Protected individual trees, such as the field maple in Cerje and the service tree in Gračani, are also part of the natural heritage of the City of Zagreb.



4

Climate Change



4.1

Overview of the Expected Climate Change in the City of Zagreb

The analysis of data measured in the period from 1981 to 2023 relating to the climatic conditions of the City of Zagreb shows a significant increase in mean temperature, number of hot days (Tmax ≥ 30 °C) and tropical nights (Tmin > 20 °C). The climate of Zagreb has changed from a temperate humid climate to a temperate climate with hot summers, which is reflected in the rise in the temperature of the warmest month (July) above 22 °C. Also, the climate of Medvednica no longer corresponds to the humid snow-forest climate, but is classified as a humid temperate climate, given that the average monthly temperature of the coldest month, January, has risen and now does not fall below −3 °C.

A survey of the temperature characteristics of the city of Zagreb [12] confirmed that there is an urban heat island phenomenon in Zagreb, where the measured temperatures reflect the influence of the surrounding urban structures. The warmest parts of the city are those with densely built-up areas and a lack of green spaces.

Analysis of data obtained from RegCM climate model simulations, with a spatial resolution of 12.5 km and using four global climate models (CNRM-CM5, EC-Earth, MPI-ESM, HadGEM2) for the location of the City of Zagreb showed the following expectations for future climate periods P1 (2011-2040) and P2 (2041-2070):

- an increase of the mean annual temperature in the P1 period in the range from 0.9 °C; to 1.7 °C; and in the P2 period in the range from 2.1 °C; to 3.4 °C;
- an increase of the mean annual minimum temperature in the P1 period in the range from 1.0 °C; to 1.7 °C; and in the P2 period in the range from 0.7 °C to 1.6 °C;
- an increase of the mean annual maximum temperature in the P1 period in the range from 0.9 °C; to 1.7 °C; and in the P2 period in the range from 2.1 °C; to 3.4 °C;
- an increase in the mean annual number of tropical nights (Tmin > 20 °C) in the P1 period in the range of 4.5 to 16.6 and in the P2 period in the range of 9.3 to 45.7;
- an increase in the mean annual number of hot days (Tmax ≥ 30 °C;) in the P1 period in the range of 11.2 to 16.2 and in the P2 period in the range of 15.2 to 39.1;
- an average annual precipitation will not change significantly, but a decrease in summer precipitation and a slight increase in autumn and winter precipitation are expected;
- a slight increase in the mean number of days with a very high amount of precipitation (R20) up to a maximum of 1.7 days in the P1 period and up to 2.1 days in the P2 period;
- increase in the maximum daily precipitation (Rx1d) up to 14.3 mm in the P1 period and up to 11.8 mm in the P2 period;
- changes in the number of consecutive dry days with precipitation less than 1 mm do not have a clear trend;
- changes in the number of consecutive rainy days with precipitation greater than or equal to 1 mm also do not show significant changes;
- changes in maximum wind speeds show a slight decrease in the future P1 period up to 0.36 m/s and a slight increase up to 0.27 m/s in the future P2 period.

Following the model of the table review from the Climate Change Adaptation Strategy of the Republic of Croatia until 2030 with an Outlook to 2050 (Official Gazette 63/21), Table 4.11 was made, providing a table review of climatological parameters for the City of Zagreb analysed in this document under the RCP8.5 scenario.

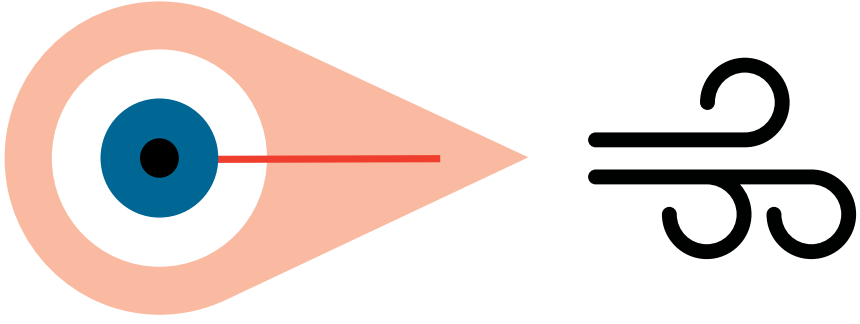


Table 4.1-1
Overview of the Climatological Parameters of the Future Climate of the City of Zagreb According to the RCP8.5 Scenario

City of Zagreb

Climatological parameter		Projections of the future climate according to the RCP8.5 scenario in relation to the period 1971-2000 obtained by climate modelling with the RegCM model	
		2011-2040	2041-2070
PRECIPITATION		**Average annual volume:** *no significant changes expected*	
		Seasons: clearly pronounced *reduction* **(10%) of precipitation in summer** with a slight decrease in winter and a weak increase in precipitation in spring and autumn	**Seasons:** clearly expressed *decrease* **in precipitation in summer and autumn** as well as clearly expressed *increase* **in precipitation in winter** and weak decrease in spring
		Increase in **maximum daily precipitation**, the number of consecutive dry days shows no clear signal, but an increase is possible; the number of consecutive rainy days does not have a clear signal, but is likely unchanged	*Increase in* **maximum daily precipitation**, the number of consecutive dry days shows no clear signal, but an increase is possible; the number of consecutive rainy days does not have a clear signal, but is likely unchanged
AIR TEMPERATURE		Mean: *rise* in range from 0.9 °C to 1.7 °C	Mean: *rise* in range from 2.1 °C to 3.4 °C
		Mean maximum: *rise* from 0.9 °C to 2.8 °C	Mean maximum: *rise* from 2.1 °C to 4.4 °C
		Mean minimum: *rise* from 1.0 °C to 1.7 °C	Mean minimum: *rise* from 1.7 °C to 3.3 °C
EXTREME WEATHER CONDITIONS	**Hot days** (number of days with Tmax ≥ +30 °C)	**11.2 to 16.2 days** *more than* the reference period (reference period: 25 – 54 days per year)	**15.2 to 39.1 days** *more than* the reference period
	Warm nights (number of days with Tmin ≥ +20 °C)	**5 to 7 days** *more than* the reference period (reference period: 3-13 days per year)	**9 to 46 days** *more than* the reference period
	Max. Max. speed at 10 m	Slight decrease	Slight increase

According to the national strategy analysis, significant climatic changes are expected in the RCP4.5 scenario for Croatia. In particular, it is envisaged to reduce snow cover, especially in mountainous areas and reduce surface runoff in the P2 period. Also, the number of cold days (with a temperature below -10 °C) will decline, while the mean wind speed in spring and summer will increase. Evapotranspirations are expected to increase throughout the year, which means that a greater amount of water will evaporate from the soil and plants, thus increasing air humidity. Consequently, increased evapotranspiration can mean a higher need for water in agriculture or higher humidity in the atmosphere, which can increase the risk of extreme weather conditions such as droughts or heavy rainfall. Solar radiation will increase in all seasons except the winter period, when there will be a decrease. These climate changes envisaged for Croatia can also be expected in Zagreb.

4.2

Climatological and Meteorological Features

According to the Köppen classification [13], the area of the City of Zagreb is dominated by a humid temperate climate with hot summers (Cfa) in which there is no dry season during the year, and precipitation is evenly distributed throughout the year [14]. The precipitation maximum occurs twice a year. The first takes place in spring (May), while the second occurs in late summer (July and August). The smallest amounts of precipitation are present in the cold part of the year. The temperature of the coldest month of the year is above 0 °C, while the mean monthly temperature of the warmest month is above 22 °C.

4.3

Climate Change

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change has pointed out that climate change is caused by human activity and has a wide impact on people and nature. There is irrefutable scientific evidence of global warming: the atmosphere and ocean have warmed, amounts of snow and ice have decreased, and sea levels have risen [15]. It is evident that climate change is ongoing and it is not possible to stop it, but to adapt to it.

4.4

Observed Climate Change

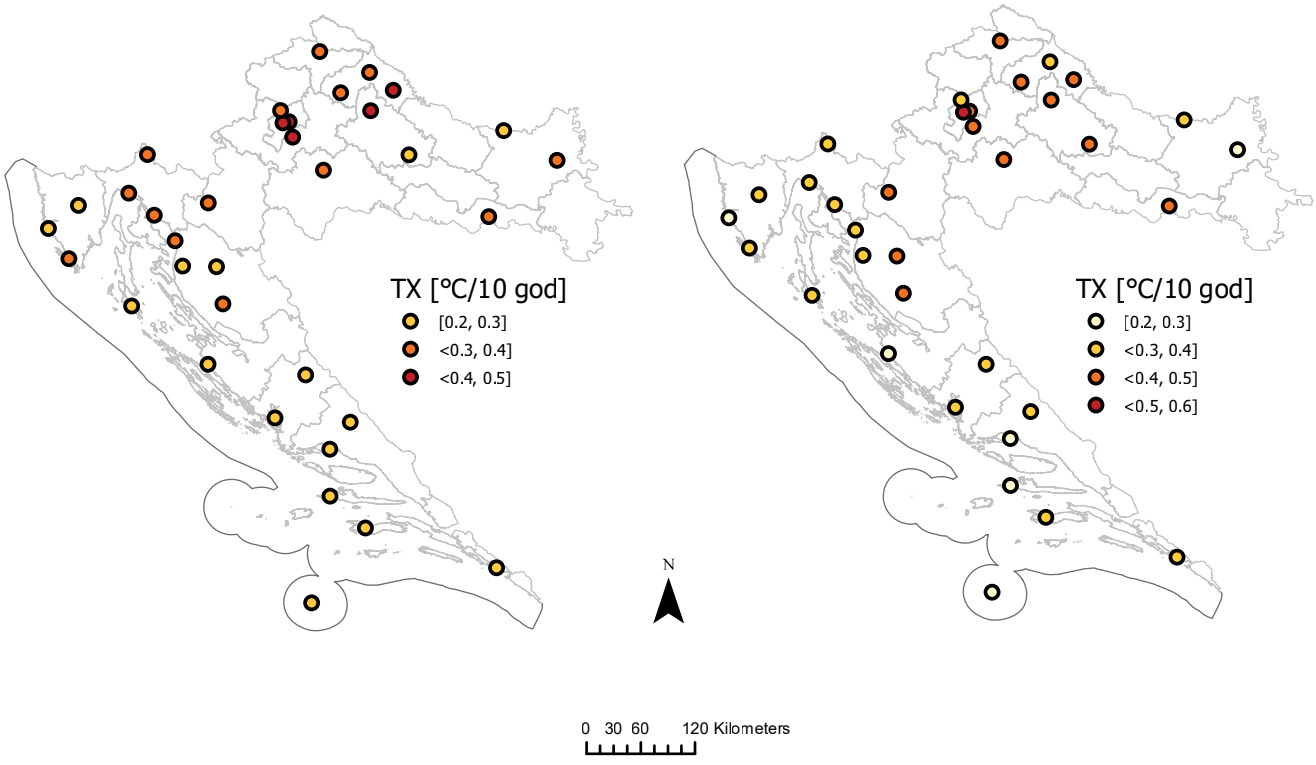
As part of the preparation of the Eighth National Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC) (hereinafter: The Eighth National Report) [16] diagnosed climatic variations and changes in air temperature and precipitation in Croatia for the period 1961-2020. The observed climate changes were analysed on the basis of measurements of mean daily and extreme air temperatures at 35 meteorological stations and daily rainfall at 143 stations of the Croatian Meteorological and Hydrological Service (hereinafter: DHMZ). Climatological seasons are defined so that the abbreviation DJF represents winter (December, January, February), MAM represents spring (March, April, May), JJA represents summer (June, July, August) and SON represents autumn (September, October, November).

Below is a summary of observed climate change in the geographic region that includes Zagreb, based on data from the Eighth National Report of the Republic of Croatia.

The most obvious indicator of climate change, i.e. global warming, is the increase in annual air temperature. This increase in mean annual air temperature is due to changes in the frequency of temperature extremes, i.e. changes in temperature indices. Temperature indices refer to days when the air temperature exceeds a certain threshold, which is defined on the basis of the probability of occurrence of these temperatures in certain return periods. Warming is expected to manifest itself by increasing the number of days for “warm temperature indices” and decreasing the days of “cold temperature indices”.

A continuous increase in temperature has been observed in Croatia since the second half of the 20th century (Figure 4.11). Trends in mean annual air temperatures range from 0.2 to 0.3°C / 10 years along the Adriatic coast, while in central Croatia an increase of 0.5 °C / 10 years has been recorded. The annual temperature rise is the result of a significant increase in air temperatures during all seasons, especially in summer (ranging from 0.3 to 0.6 °C / 10 g). A significant increase is also observed in the mean minimum and maximum air temperatures during all seasons, as well as on an annual basis. This increase in temperature is also reflected in all temperature extremes indices, positive trends of warm temperature indices (warm days and nights and duration of warm periods) and negative trends of cold temperature indices (cold days and cold nights and length of cold periods).

Figure 4.4-1
Decade trends of mean (left) and mean maximum (right) annual air temperature (°C / 10 yr) for the period 1961-2020
A statistically significant trend at each meteorological station is indicated by a bold circle. [16]

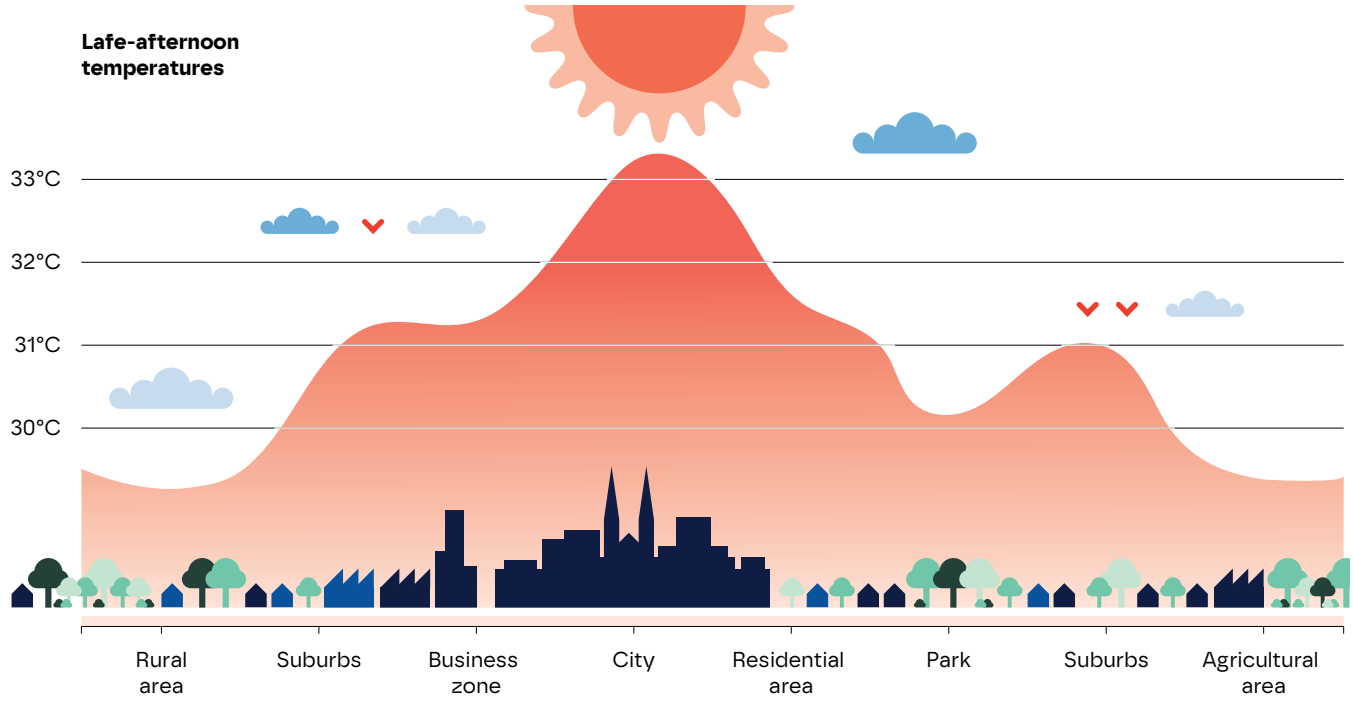


4.5

Climate Characteristics of Cities and Expected Climate Change

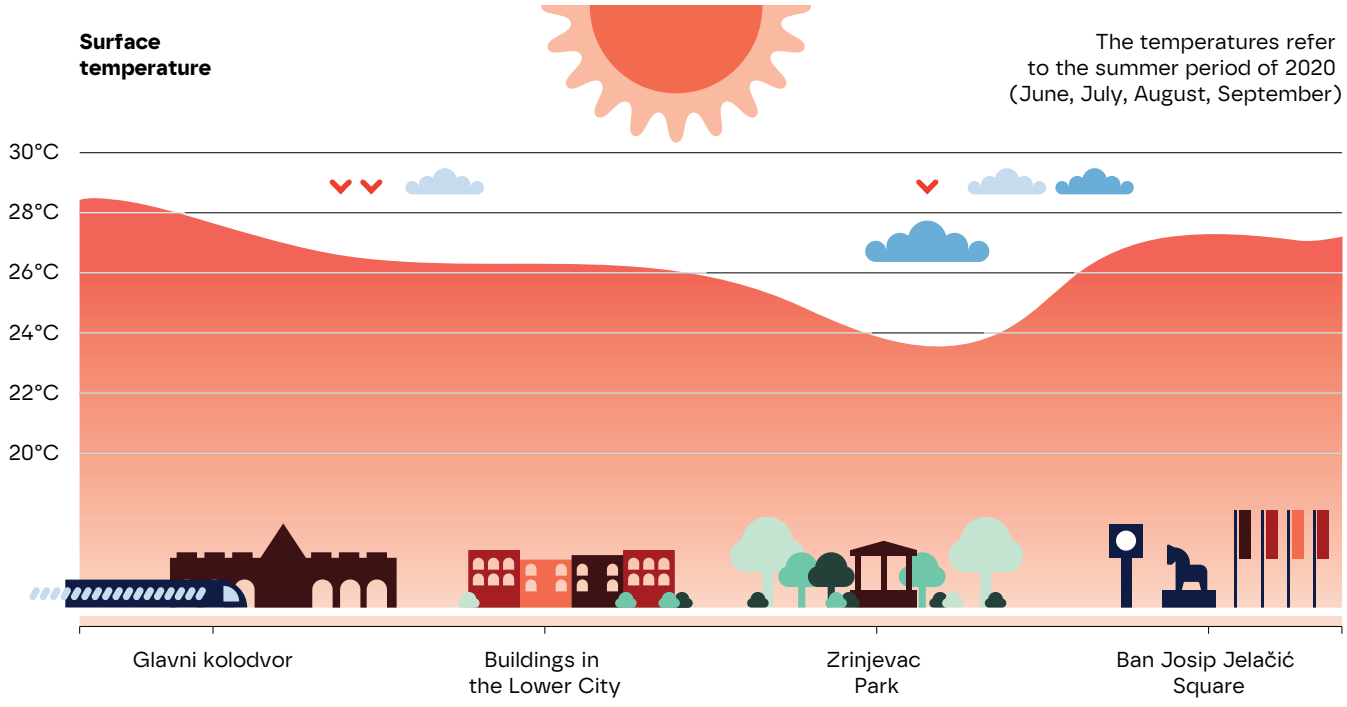
Urban development provides numerous benefits, including an increase in the standard of living of society, but it also brings adverse environmental, social and economic consequences. One of such phenomena is the creation of an urban heat island (UHI), a phenomenon characterized by a significantly higher air temperature in the built-up area compared to the surrounding rural area. The isotherms of such an area form a shape reminiscent of an island and follow the shape of an urban area surrounded by a colder zone (Figure 4.51). The heat map of the city also shows extremely warm smaller areas within the city itself. These are the so-called micro-urban heat islands that most often occur in parts of the city that are associated with large asphalt surfaces or other impermeable materials such as parking lots, shopping centers, industrial plants, etc. There are also places in the city that are cooler than the rest of the urban environment (so-called heat sinks), such as parks, green areas, open water surfaces, etc.

Figure 4.5–1
Schematic representation of air temperature above different parts of the city and its surroundings,
Source: www.healthyurbanhabitat.com.au



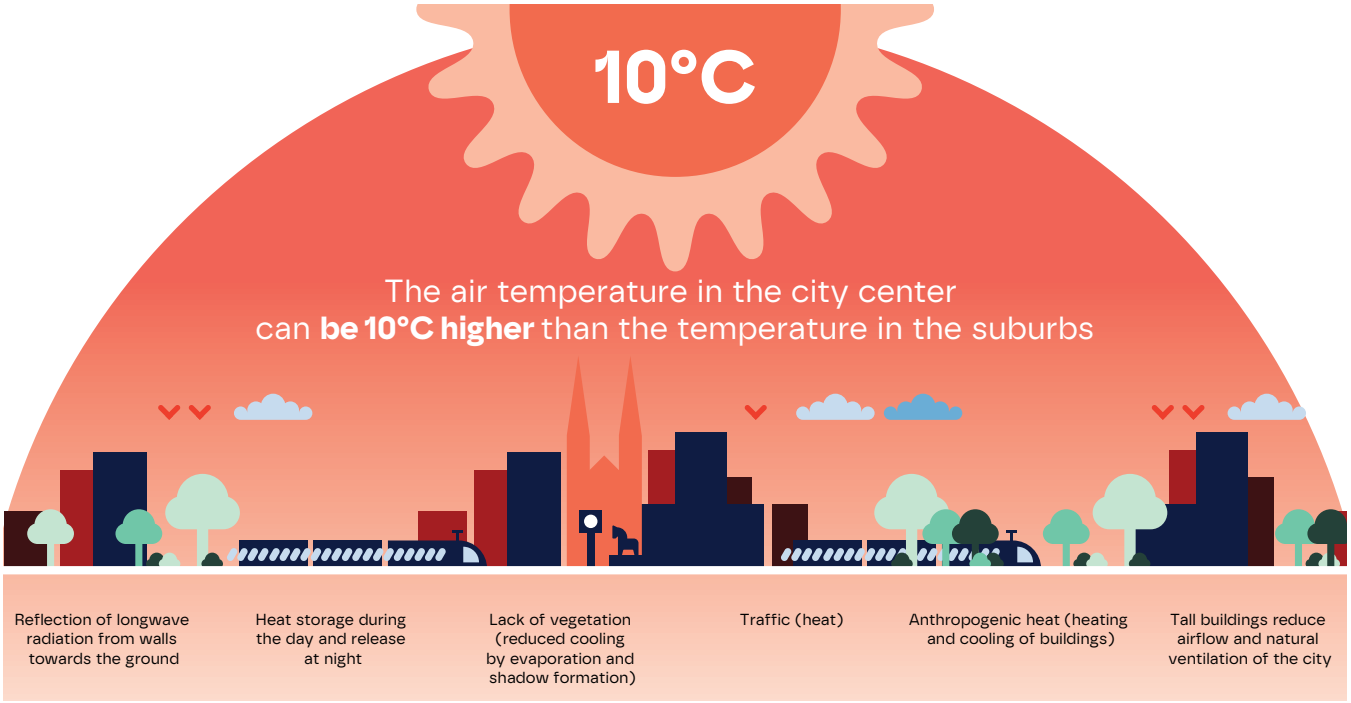
The difference between the temperature of the warmest urban zone and that of the rural area represents a measure of the intensity of the urban island. UHI intensity varies depending on the season and time of day. Cities in temperate latitudes generally have urban heat islands with the highest intensity in the summer and winter seasons, and the day cycle shows that urban heat islands are generally more pronounced at night. This is a consequence of the heat absorbed by the city during the day, which is released at night, further warming the atmosphere. This impact is especially dangerous during summer heat waves when the additional heat emitted can significantly increase the heat load in the city, as a result of which the city's climate becomes extremely unfavourable. The mean annual temperature of a city with one million inhabitants can be 1-3°C higher than that of the surrounding area, while during calm nights it can be even more intense, with temperature difference of up to 12 °C [17]. The increase in surface temperature differences caused by higher levels of urbanization and the use of materials such as concrete, asphalt or bricks, which absorb and release heat differently than soil, water or vegetation, is also visible in certain parts of Zagreb (Figure 4.5-2). The effects associated with the occurrence of a city's heat island depend, among other factors, on its size, but smaller cities and towns also develop the emergence of an urban heat island [18].

Figure 4.5-2
Surface temperatures in Zagreb during the summer period of 2020, source: Department of Geophysics, Faculty of Science, University of Zagreb



The urban heat island effect is one of the most significant environmental problems in cities because it is associated with multiple negative consequences, such as excessive heating of the substrate, exposure of citizens to adverse climatic conditions, increased health risk due to the impact of high air temperatures with weakened night cooling, increase in water needs, increased energy consumption, impact on ecosystems, etc. The causes of a significantly warmer urban environment in relation to its surroundings are diverse (Figure 4.53). In addition to the geographical location and local climatic factors (topography, wind, clouds, sea influence, etc.), anthropogenic influence is also important for the appearance of the heat island of the city: reduction of vegetative cover [19] [20] [21], greenhouse gases, use of impermeable materials such as asphalt and most building materials [22] [23] [24], thermal properties of the material, reduction of surface reflectivity, morphology of the city and its size [25] [24], and anthropogenic heating (e.g. heat emitted by vehicles, cooling devices and industrial plants).

Figure a 4.5-3
Schematic representation of the different contributions to urban heat island development



The effect of the urban heat island is interesting from a meteorological point of view, but it is also extremely important due to the significant, mostly unfavourable, impact on the urban climate and its inhabitants. The urban heat island effect is manifested in the following examples:

- Air quality: UHI contributes to the formation of smog and ozone [26], and also affects indoor air quality. Namely, increased heat promotes the development of mites, mold and bacteria. Higher temperatures increase the risk of toxic substances (e.g. formaldehyde) being released from materials used in construction and furniture manufacture. Also, the local circulation induced by the UHI promotes the transport of urban pollutants to the surrounding suburban and rural areas and thus affects the air quality of the surrounding areas [27].
- Increased water requirements: The need for drinking water is increasing due to more intensive use of water in households [28] and more abundant use of water for other purposes (cooling, swimming pools, fountains, watering of plants, etc.).
- Energy use: The UHI impact on energy consumption can be

positive in winter (due to reduced heating demand) and negative in summer (increased cooling demand which further enhances the UHI effect). In any case, the UHI has a significant impact on energy needs for cooling purposes [29] which may further increase in the coming years due to global warming. According to data cited by USEPA (2008) [25] for the US, a 1 °C increase in temperature can increase cooling energy consumption by 5-20%. Therefore, even a small increase in temperature in cities can significantly affect energy needs.

- Biological activity: UHI generally has a beneficial effect on the length of the vegetative period. However, in the summer period, due to the lack of precipitation and exceptional dryness of the soil, the effects associated with UHI are an additional burden on vegetation.
- Ice and snow: UHI impact is mostly positive as higher temperatures accelerate the melting of snow and ice on urban areas.
- Human health: High temperatures pose a significant danger to people and can cause serious consequences due to the limited ability of the human body to adapt to high temperatures. Certain groups of people are particularly vulnerable to high temperatures, for example people with chronic diseases (especially those with respiratory and cardiovascular diseases and nervous system diseases), older population, young children, outdoor workers, mental illness patients, people who cannot take care of themselves, as well as people with limited mobility. This also promotes the spread of vector diseases such as malaria, dengue fever and West Nile virus.
- Heat waves: In this way, it can promote the influence of heat waves (periods with extremely hot and often humid weather). Heat waves significantly increase energy consumption and cause serious health problems. The extremely unfavourable impact of UHI is manifested precisely during heat waves at night, when additional heat is released in the city and thus significantly increases the heat load in the city due to the disabling (or weakening) of night cooling that occurs undisturbed in the natural environment. Croatia is an area with a frequent occurrence of heat waves, and their negative effect from various aspects (environmental, social, economic, health, energy, etc.) should certainly be taken into account, and the additional heat load of cities should also be taken into account. Thus, the analysis of the impact of heat load on mortality in Croatia showed that prolonged exposure to extremely high air temperatures significantly increases mortality [30], which is highest in the first three to five days of the heat wave [31].

It is obvious that urban heat islands have a strong impact on the environment and people living in cities, and the urban microclimate is an important problem that is becoming more pronounced with the expansion of cities and urbanization.

Over the last few decades, certain measures have been developed to mitigate the UHI impact and the main categories of intervention include:

- Buildings: Changing the properties of buildings using green roofs and facades reduces the temperature not only of these surfaces, but also the temperature of the surrounding air and thus the cost of energy consumption.
- Pavement material: The use of a "cold" pavements with a higher albedo than conventional materials and the use of permeable materials significantly reduces air temperature in urban areas and excessive drying of the soil.
- Green and blue infrastructure: It includes parks, lakes, forests and smaller green areas such as green roofs, green facades, roadside plants, water storage areas, etc. Greening the city (planting trees in city streets, parks and green areas) and forming new green areas (parks, forests) enables the creation of shadows and evaporative cooling. According to the results cited by the EPA [25], during the summer season 70-90% of the solar energy reaching the ground can be reduced by shading with the help of vegetation, especially if greenery is planted in appropriate places around buildings with regard to their orientation towards the sun.
- Designing city streets: The city morphology significantly affects the UHI. Street orientation with regard to prevailing winds and solar radiation and the ratio between street width and building height significantly affect UHI creation and intensity.

4.6

Current Climate of the City of Zagreb

Climate is the average state of the atmosphere of an area determined by the mean values, extremes and fluctuations of climate elements over a long period of time (usually about 30 years). Climate elements change under the influence of climate factors, which can be natural (terrestrial and cosmic in nature) and anthropogenic (human labor and influence).

The City of Zagreb can be seen as a unique climate system that can be classified as a temperate humid climate. But it can also be seen as a set of different environments and individual ecosystems (forest, urban...) whose microclimates have different characteristics [14]. The local natural climate modifier of Zagreb is the Medvednica Mountain, which intensifies short-term heavy precipitation on the windward side and the formation of a rain shadow in the eastern part of the city, where Medvednica acts as an obstacle to northwest rainfall incursions. The Sava River also forms an obstacle, with the area south of it being modified by a maritime influence from the Mediterranean, while such influence is weaker in the northern and eastern areas [32].

The land cover and soil of the area of the City of Zagreb also have an impact on the climate, so the climate in the urban part of the city has different characteristics compared to forest areas, wetlands or other ecosystems covered with greenery. Urbanisation has a significant impact on the microclimate by changing the inflow of short-wave solar radiation and outgoing long-wave radiation, as well as the state of air flow. Buildings and roads made of concrete and asphalt, which have replaced the original green areas, absorb more solar energy, which is retained, accumulated and heats the atmosphere, resulting in an increase in mean air temperature. In addition, the release of a large amount of heat occurs due to industrial plants, a large number of vehicles and household heating, which contributes to air heating, while less heat is spent on evapotranspiration, further contributing to air heating. The buildings themselves block the wind, which also prevents cooling [33].

According to the Köppen climate classification, which takes into account the mean annual air temperature and precipitation, the climate in the City of Zagreb has up to now belonged to a temperate humid climate Cfb. It is a type of temperate rainy climate with a mean monthly temperature of the coldest month higher than -3 °C and lower than 18 °C (mark C), while the warmest month of the year has a mean temperature lower than 22 °C (mark b) and no pronounced dry season (mark f) [13]. **However, recent measurements show a change in the city: the summers have gone from temperate to hot, given that the mean monthly temperatures of the hottest month, July, have risen above 22 °C** (Figure 4.61, **Figure 4.62** and Figure 4.63) and the **Zagreb climate can now be classified as a moderately warm humid climate with hot summers (Cfa)**.

Medvednica and its forests are especially important for Zagreb's climate because they enable natural airflow, cool the city, and purify the air. However, the climate on Medvednica has also changed. Data from Puntijarka Station show that the mean monthly temperature of the coldest month (January) has risen and is no longer falling below -3 °C. **Therefore, the climate of Medvednica changed from a humid snow-forest climate (Dfb) to a humid temperate (Cfb) climate.**

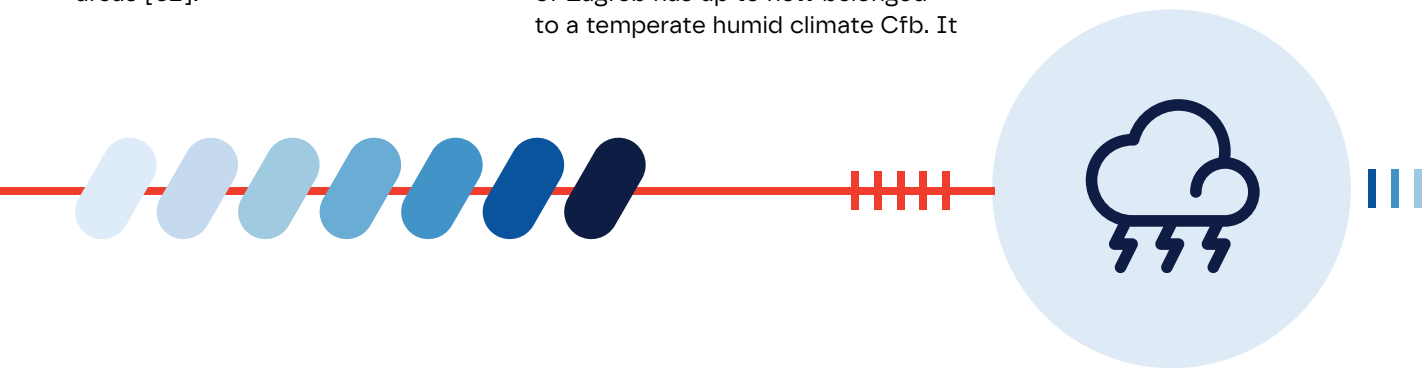
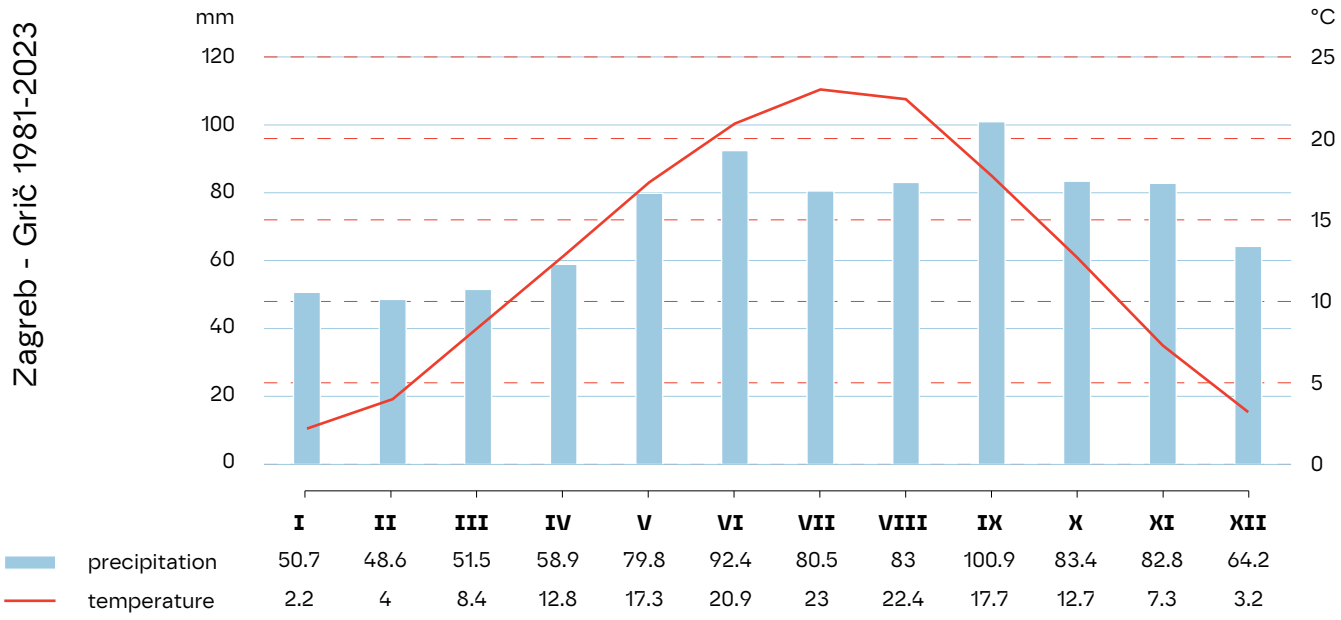
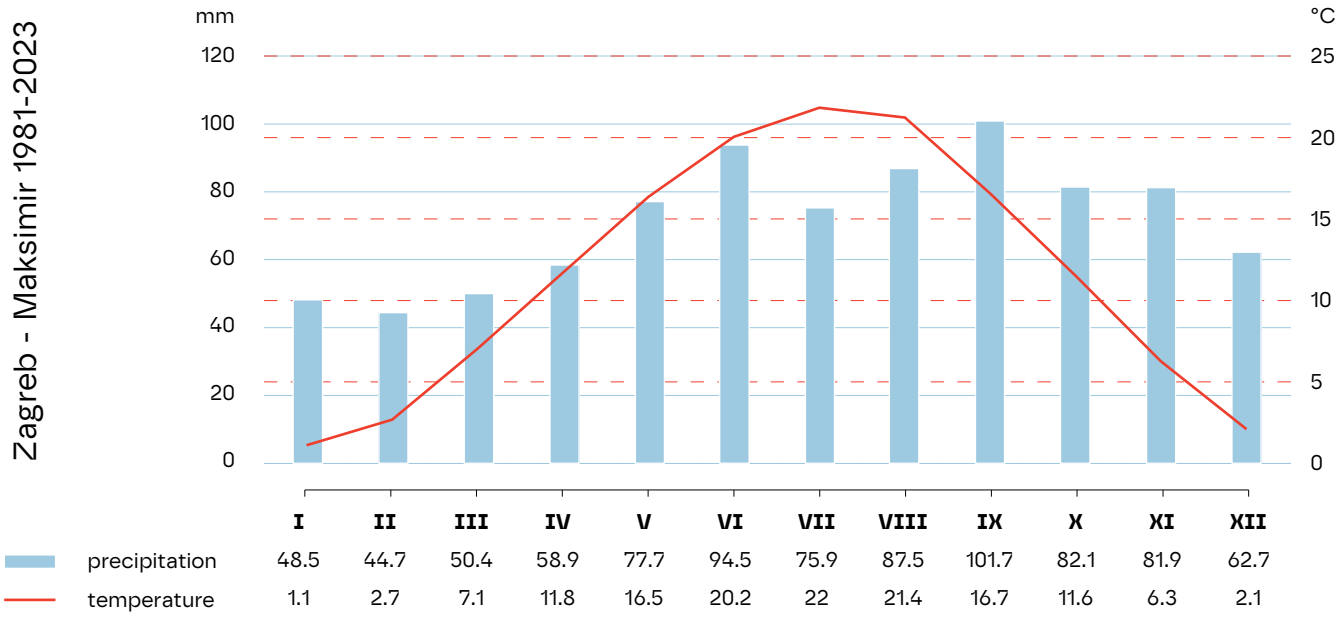


Figure 4.6-1
Climate diagram at the Zagreb-Grič meteorological station for the period 1981-2023 Source: DHMZ



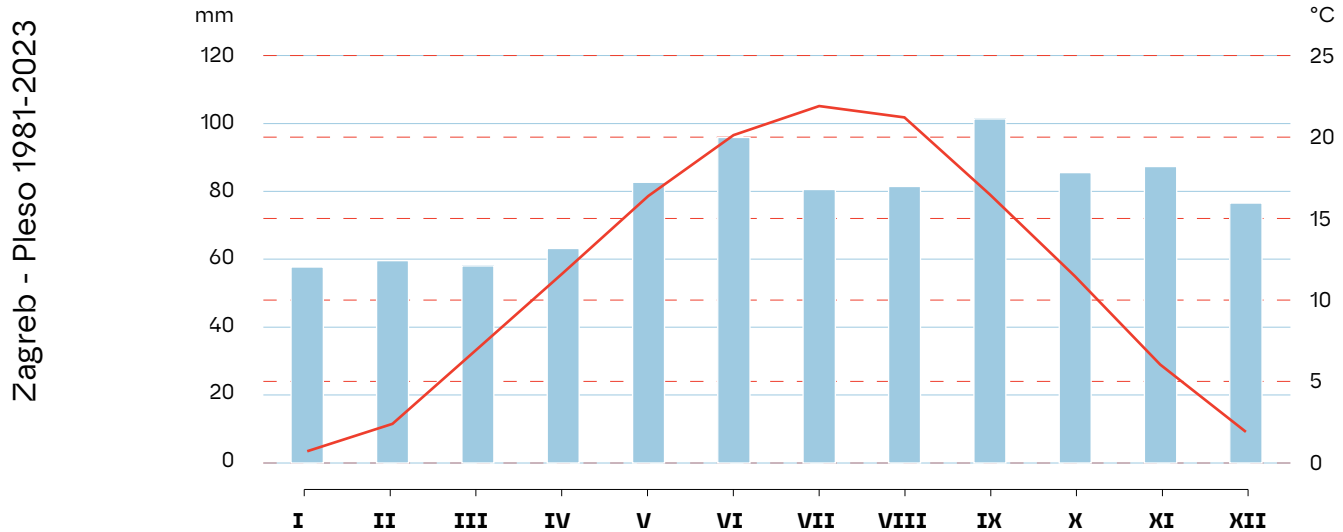
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
precipitation	50.7	48.6	51.5	58.9	79.8	92.4	80.5	83	100.9	83.4	82.8	64.2
temperature	2.2	4	8.4	12.8	17.3	20.9	23	22.4	17.7	12.7	7.3	3.2

Figure 4.6-2
Climate diagram at the Zagreb-Maksimir meteorological station for the period 1981-2023 Data source: DHMZ



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
precipitation	48.5	44.7	50.4	58.9	77.7	94.5	75.9	87.5	101.7	82.1	81.9	62.7
temperature	1.1	2.7	7.1	11.8	16.5	20.2	22	21.4	16.7	11.6	6.3	2.1

Figure 4.6-3
Climate diagram at the Zagreb-Pleso meteorological station for the period 1981-2023 Data source: DHMZ



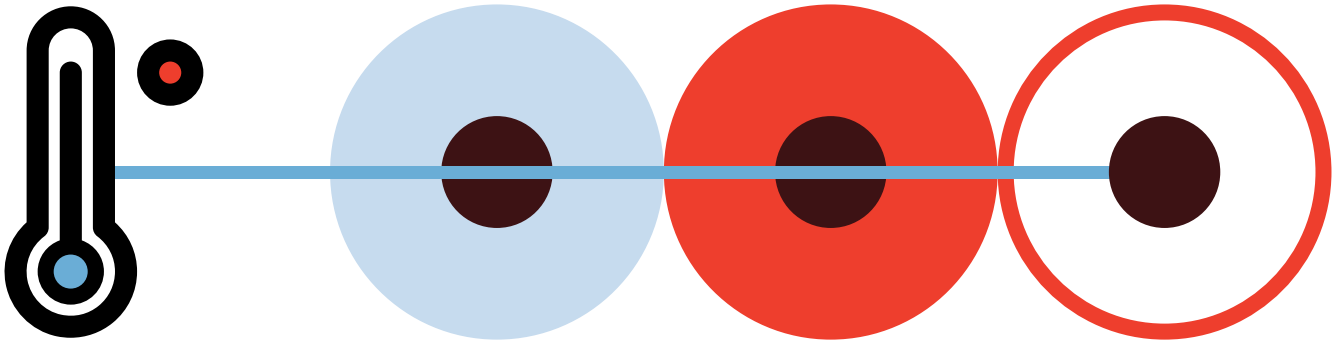
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
precipitation	58.6	60.5	59	64.2	84	97.4	81.8	82.7	102.9	86.9	88.7	77.8
temperature	0.5	2.2	6.9	11.6	16.4	20.2	22	21.3	16.5	11.4	5.9	1.7

Air temperature and precipitation data collected over the last 40 years (1981-2023) from meteorological stations in the Zagreb area provide insight into the characteristics of the most recent climate period (Figure 4.61, Figure 4.62 and Figure 4.63). The Zagreb-Grič meteorological station is located in the center of Zagreb at 157 m.a.s.l. and reflects the climate conditions in the urban area. The Zagreb-Maksimir meteorological station is located at 123 m.a.s.l., and the Zagreb-Pleso station is located at an altitude of 106 m.a.s.l. right next to the airport, located within the city, but away from urban areas and on an open grass surface [34].

Zagreb-Maksimir and Zagreb-Pleso stations have slightly lower mean monthly temperatures compared to Zagreb-Grič station, according to their location, degree of urbanization and substrate properties. The mean annual air temperature at the Zagreb-Grič station is 12.6 °C, with a standard deviation of 1 °C. In the area of Zagreb-Maksimir station, the mean annual air temperature is 11.6 °C, with a standard deviation of 1 °C. Zagreb-Pleso Station is the furthest station from the city center, located in the open area in the Sava River Valley, where cooling conditions develop, and it is the coldest station, with a mean temperature of 11.4 °C, and a standard deviation of 0.9 °C. The July summer temperature at the Zagreb-Grič station is 23 °C, giving the urban part of the city the characteristics of a temperate climate with hot summers. At the remaining two stations, the mean July temperature is exactly 22 °C, which puts them at the very threshold between a temperate climate and a temperate climate with hot summers.

In the period 1981-2023, the mean annual precipitation at the Zagreb-Grič meteorological station was 876.7 mm, at the Zagreb-Maksimir station 866.7 mm and at the Zagreb-Pleso station 945.8 mm. The annual precipitation cycle indicates a continental precipitation regime, characterised by the absence of dry periods, and most of the amount of precipitation occurring during the warmer part of the year. Secondary maximum precipitation occurs in autumn, while the least precipitation occurs in winter.

The absolute maximum and minimum air temperatures show the amplitude of change and the thermal difference of a given area. The highest absolute air temperature was 39.2 °C at Zagreb-Maksimir station, 39.1 °C at Zagreb-Grič station and 38.8 °C at Zagreb-Pleso station (Figure 4.64). The lowest absolute air temperature was



-22.6 °C at Zagreb-Maksimir station, -17.2 °C at Zagreb-Grič station and -24.1 °C at Zagreb-Pleso station (Figure 4.65). The absolute temperature range varied from 56.3 °C at the Zagreb-Grič station, to 61.4 °C at the Zagreb-Maksimir station, and 63.3 °C at the Zagreb-Maksimir station. **Higher values of absolute minimums and lower extreme amplitudes at the Zagreb-Grič station indicate a strong influence of urban structures around this station in the city center.**

Figure 4.6-4
Annual pattern of absolute maximum temperatures at the meteorological stations of the City of Zagreb for the period 1981-2023 Data source: DHMZ

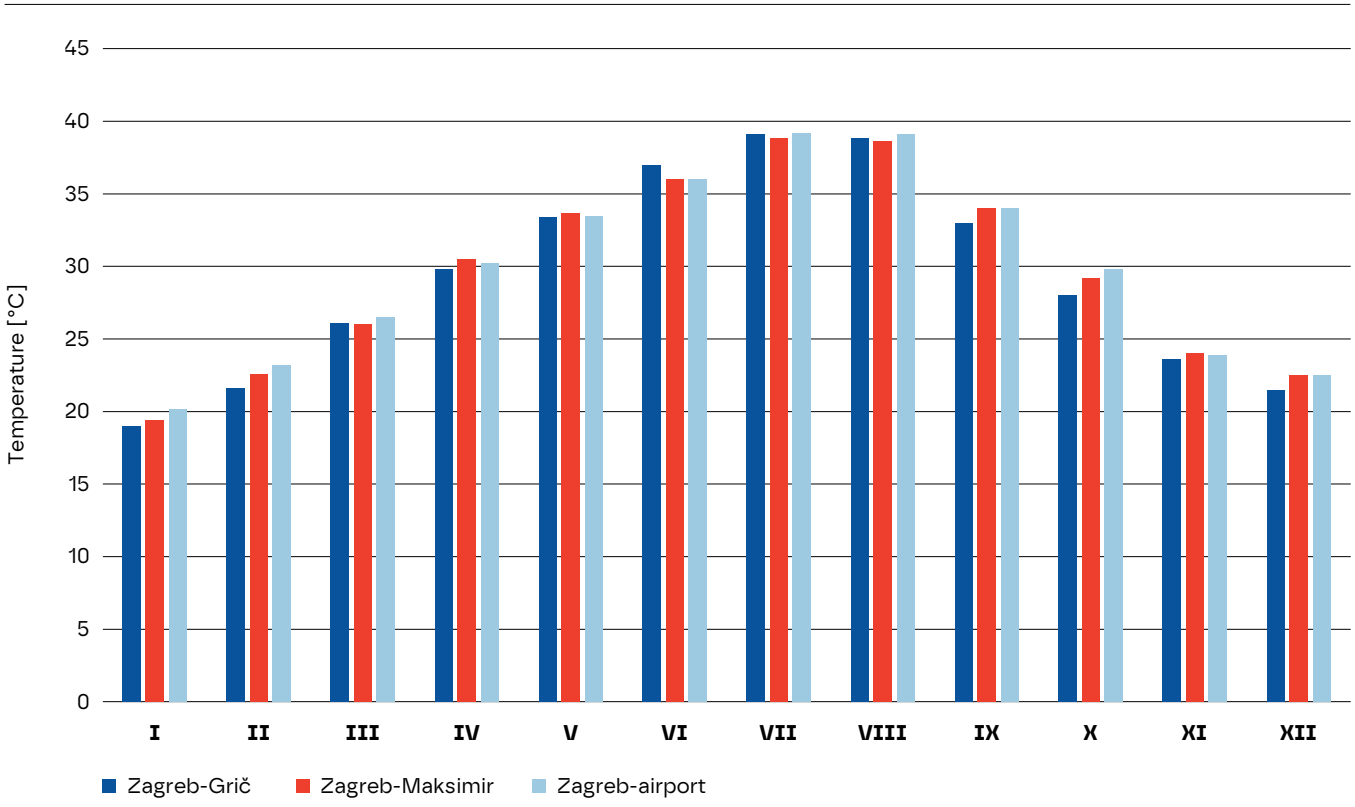
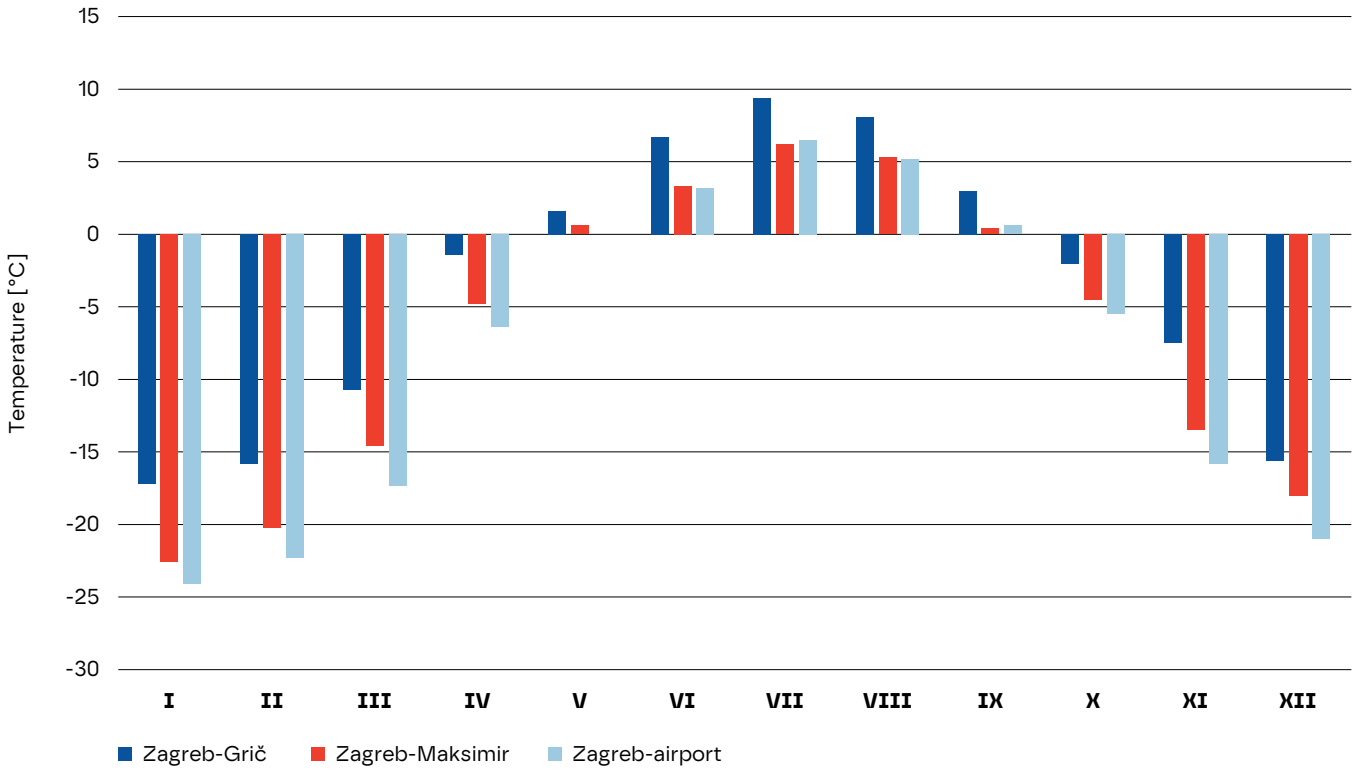


Figure 4.6-5
Annual pattern of absolute minimum temperatures at the meteorological stations of the City of Zagreb for the period 1981-2023 Data source: DHMZ



The time series of deviations of the annual mean daily air temperature from the average for the observed period (1981-2023) **for all Zagreb stations show a significant trend of increase in mean temperature** (Figure 4.66). Moreover, at all observed locations in the City, an upward, statistically significant trend of thermal indices is visible. Figure 4.67 and Figure 4.68 show a time series of the number of hot days in which the maximum daily temperature exceeded the value of 30 °C and the number of tropical nights when the minimum daily temperature exceeded the value of 20 °C. **The obtained results show worrying trends of rising temperatures and are in line with numerous studies that indicate an increase in temperatures in cities, but also more frequent, prolonged and intense heat waves.** Heat waves and rising temperatures have a negative impact on human health, and people with chronic diseases, the elderly population, children and people of lower socioeconomic status are especially at risk. **Due to the urban heat island effect, the city center of Zagreb is particularly sensitive to rising temperatures.**

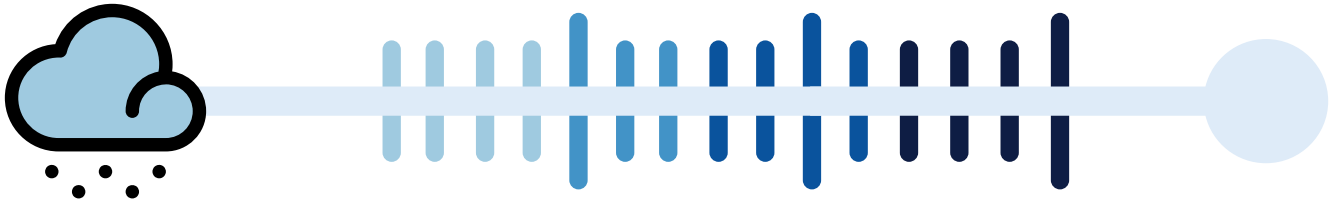


Figure 4.6-6
Deviation from the average temperature in the period 1981-2023 for Zagreb stations. Data source: DHMZ

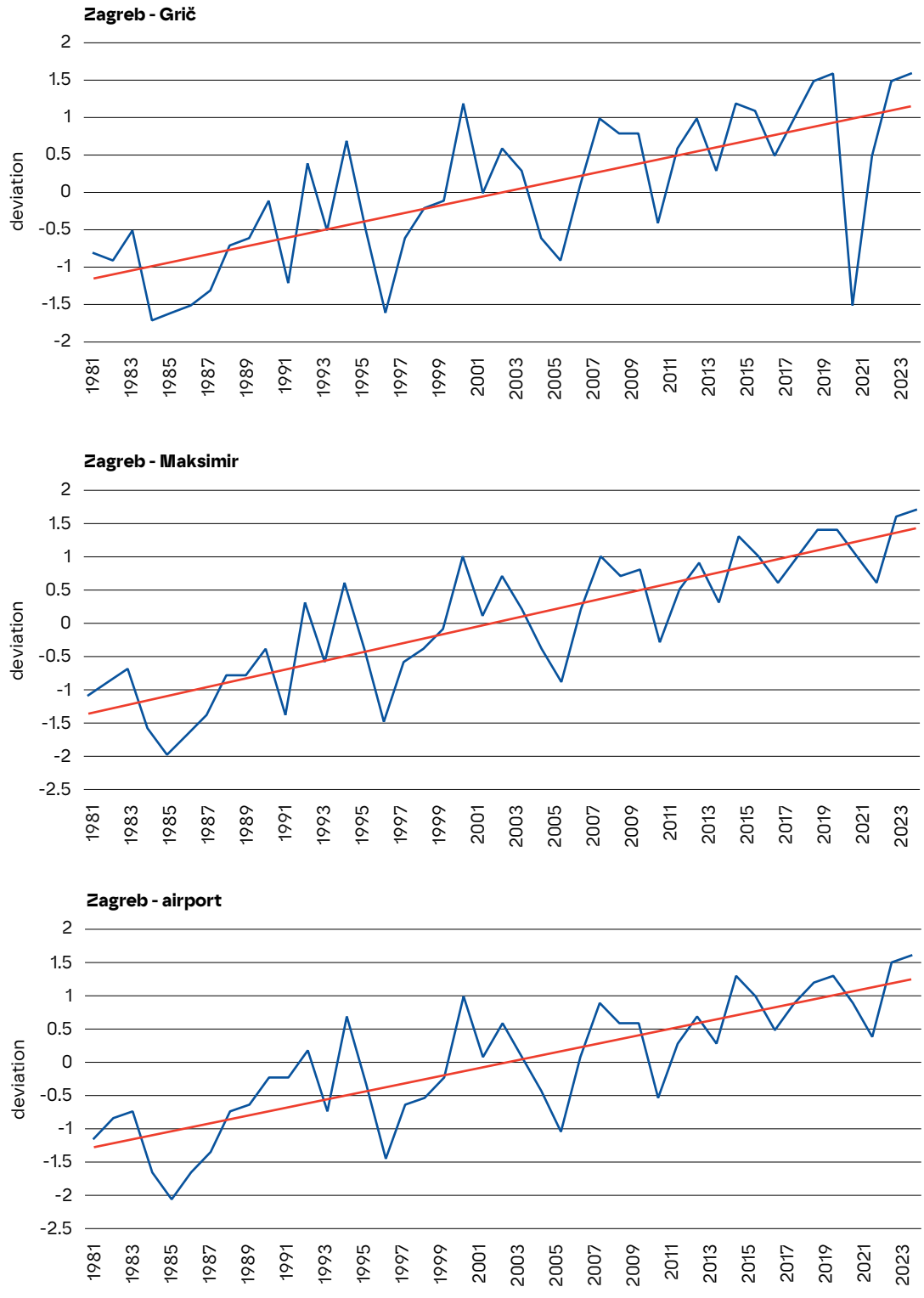


Figure 4.6–7
Time series and linear trend of the number of hot days (Tmax ≥ 30 °C) in the period from 1981 to 2023 for Zagreb stations. Data source: DHMZ

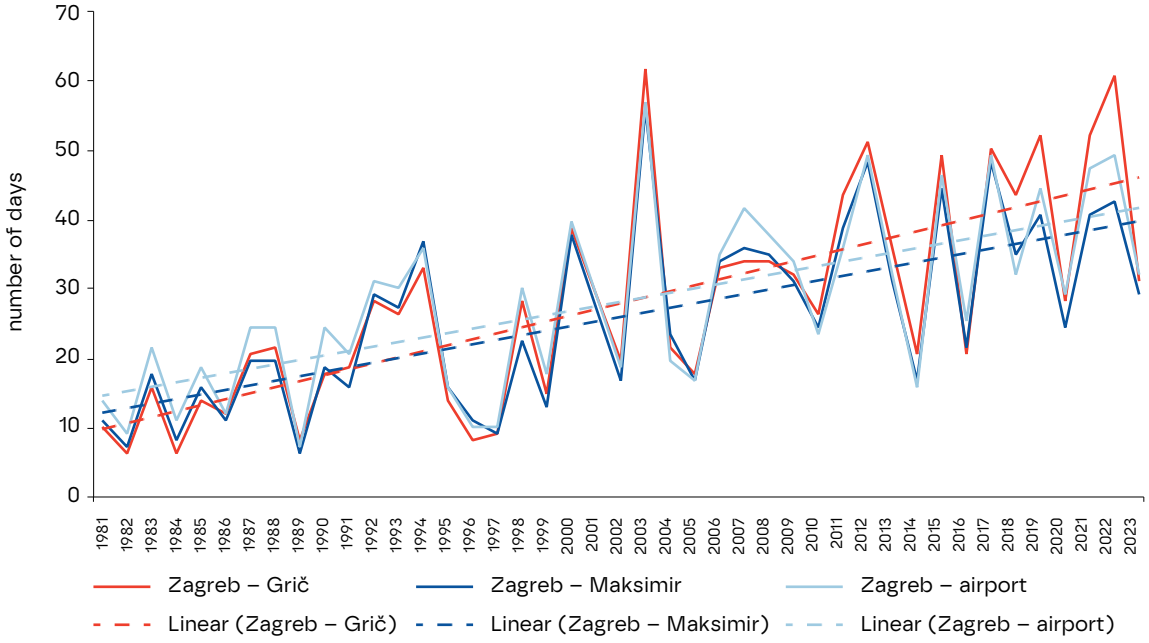
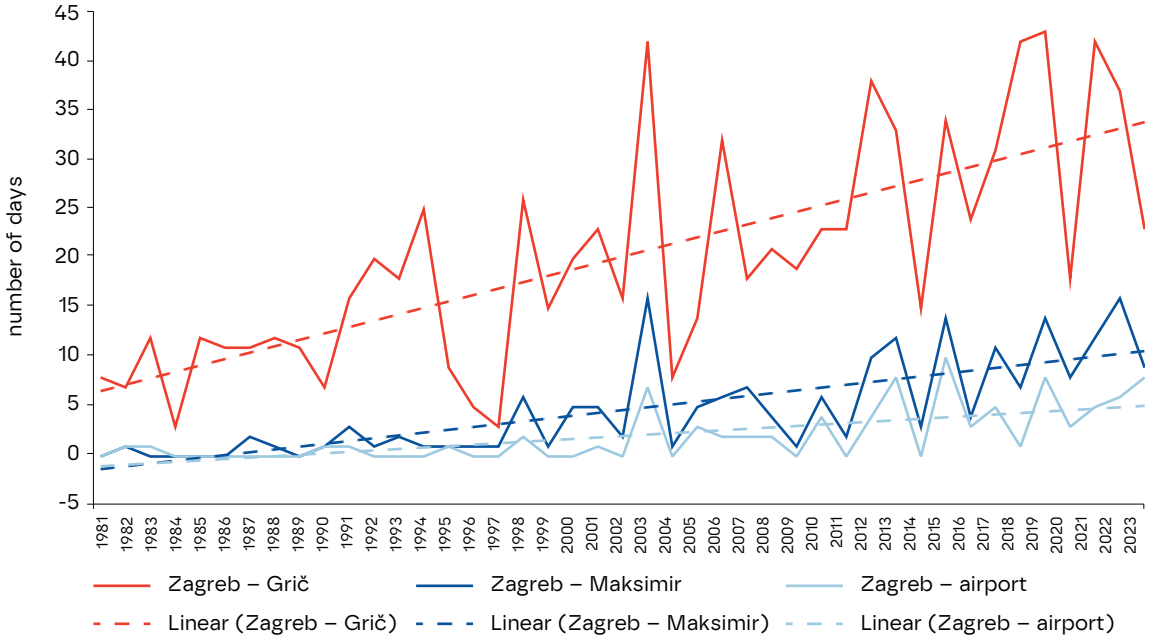


Figure 4.6–8
Time series and linear trend of the number of tropical nights (Tmin ≥ 20 °C) in the period from 1981 to 2023 for Zagreb stations. Data source: DHMZ



The spatial distribution of mean annual temperature and total annual precipitation in the City of Zagreb are shown in Figure 4.69 and Figure 4.610. The impact of topography on temperature and precipitation is evident, with mean temperatures decreasing in the higher, hilly areas of the City, and, likewise, greater amounts of precipitation occurring at higher elevations.

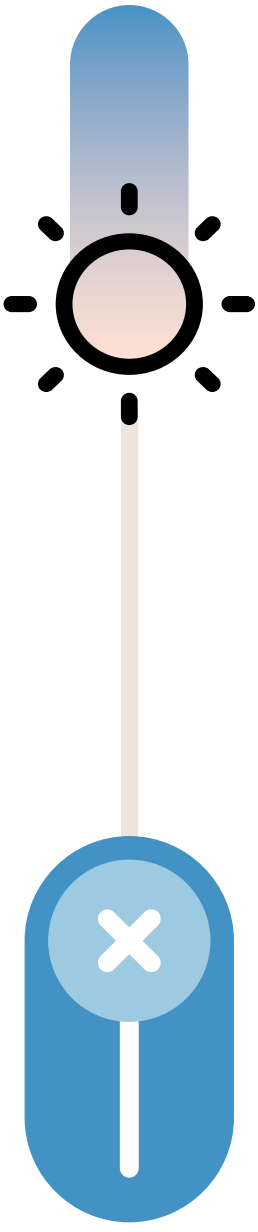


Figure 4.6-9
Spatial distribution of mean annual temperature in the area of the City of Zagreb from 1980-2000. Source: Gekom d.o.o.

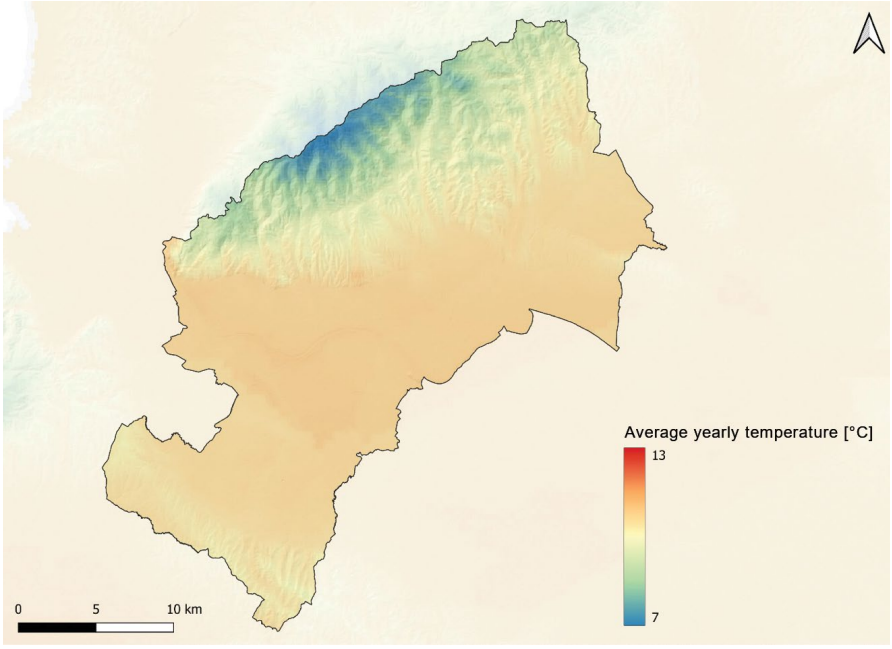
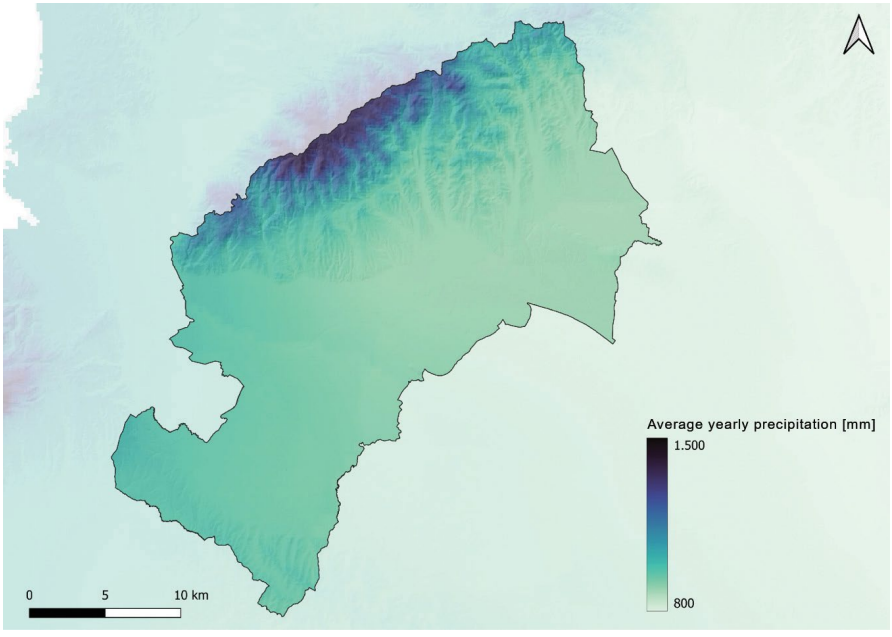


Figure 4.6-10
Spatial distribution of the total annual precipitation in the area of the City of Zagreb from the period 1980-2000. Source: Gekom d.o.o.



Recent research on temperature characteristics of the city of Zagreb [12] has confirmed an urban heat island phenomenon in Zagreb, where the measured temperatures reflect the influence of the surrounding urban structures. Thus, data from the urban meteorological stations Zagreb-Grič, Zagreb-Maksimir and Zagreb-Pleso, as well as from the nearby mountain station Puntijarka, show a similar annual temperature gait, but with different amplitudes. The warmest months are June, July, and August. Furthermore, changes in air temperature in Zagreb and its surroundings were thoroughly investigated by Nimac et al. (2021) [35].

The average air temperature at the Grič station stands out as the highest in the morning and evening, which is due to the influence of the surrounding urban structures and the dense development that further warms the surrounding air. Average temperatures for the winter season are shown in Table 4.61.

Table 4.6-1
Average air temperature at Zagreb stations in the winter season

Weather	Grič (°C)	Maksimir (°C)	Pleso (°C)	Puntijarka (°C)
7 a.m.	0.8	– 0.7	– 1.3	– 2.5
2 p.m.	4.2	4	3.7	– 0.3
9 p.m.	2.5	0.9	0.4	– 2

For example, the average winter air temperature at 7 am at the Grič station is 0.8° C, and at other stations temperatures of -0.7° C to -2.5° C occur. In the evening (9 p.m.), the temperature on Grič is still the highest, while in the afternoon (2 p.m.) there is no such obvious difference in the mean temperatures of the city stations, and Puntijarka is expected to be the coldest. These results are expected given the position of the stations. Also, the Grič station most strongly reflects the impact of dense construction on air temperature values. During the day (2 p.m.), the air temperature is predominantly determined by the received amount of solar radiation, so the air temperatures at Grič, Maksimir and Pleso stations are also equal. On the other hand, during the night air is further warmed by the release of heat absorbed during the day in the built-up parts of the city, which is why Grič, located in a densely developed area, is the warmest station. A similar situation occurs in the summer, and the average air temperatures in the summer season are shown in Table 4.62.

Table 4.6-2
Average air temperature at Zagreb stations in the summer season

Weather	Grič (°C)	Maksimir (°C)	Pleso (°C)	Puntijarka (°C)
7 a.m.	18.2	18.2	17.5	13.8
2 p.m.	24.9	25	25.3	18.2
9 p.m.	20.9	19	19.5	14.3

Thus, the mean air temperatures at urban stations at 7:00 am and 2:00 pm are almost the same, and at 9:00 pm the Grič station is again the warmest, thanks to the influence of the urban heat island. **Nimac et al. (2021) showed the persistent warming of Zagreb and its surroundings in the summer and winter seasons. The temperature increase was measured at all stations (Grič, Maksimir, Pleso, Puntijarka) at all times (7:00 h, 14:00 h and 21:00 h)**, and Nimac et al. (2021) state the values of the temperature trend for the winter and summer seasons in Tables 4.63 and 4.64.

Table 4.6-3
Average annual temperature increase by station in the winter season

Weather	Grič (°C/10 god.)	Maksimir (°C/10 god.)	Pleso (°C/10 god.)	Puntijarka (°C/10 god.)
7 a.m.	0.37	0.34	0.30	0.36
2 p.m.	0.54	0.58	0.62	0.41
9 p.m.	0.46	0.45	0.43	0.37

Table 4.6-4
Average annual temperature increase by station in the summer season

Weather	Grič (°C/10 god.)	Maksimir (°C/10 god.)	Pleso (°C/10 god.)	Puntijarka (°C/10 god.)
7 a.m.	0.47	0.62	0.59	0.41
2 p.m.	0.6	0.59	0.64	0.52
9 p.m.	0.58	0.67	0.5	0.58

Although there are some variations in temperature trends, it is important to emphasize that all meteorological stations, including the one on Puntijarka, show an increase in temperature. Puntijarka, located on Medvednica, a mountain that is not susceptible to urbanization, shows a positive temperature trend resulting from global warming. On the other hand, stations in urban areas record temperature changes caused by global warming, but also by urbanization.

Based on the research by Nimac et al. (2022) on the impact of urbanization on climate change, using the urban model MUKLIMO_3 [36], **it has been shown that the warmest parts of the city are precisely those that are densely built and have few green areas. These results match data from land surface temperature (LST) and normalized difference vegetation index (NDVI) satellite measurements.** The density of construction increases the temperature, while the vegetation and water surfaces have a cooling effect.

The highest land surface temperatures (LST) of up to 40 °C were recorded in areas with a low proportion of vegetation, while the lowest temperatures were recorded in wooded areas outside the city and in urban parks, such as Maksimir, as well as in smaller green areas, such as the Botanical Garden and Zrinjevac. On these natural or wooded areas, LST moves around 25°C, which is significantly lower than temperatures in surrounding urban areas, where LST often exceeds 30°C. In these areas, NDVI is very high, above 0.5, indicating a high proportion of green areas.

It is important to note that air temperature is not the same as land surface temperature (LST). LST is mainly the result of solar radiation and the thermal characteristics of the surface, while the air temperature depends on a number of other factors, including airflow. Although there is an association between LST and air temperature, it is very complex. However, the spatial distribution of LST is crucial for understanding the heat load of urban areas because it shows us the springs and “sinks” of heat [34]. **The largest heat sources in the city are areas of high construction and low vegetation index.** On the other hand, natural areas, and especially green areas (i.e. areas with vegetation), as well as water areas, represent cooler parts. Such areas have a mitigating effect on the heat load in the city and lower air temperature. This mitigating effect is due to the fact that such surfaces absorb less solar radiation, so they have lower LST, but also physical processes that include evaporation cooling (i.e. cooling as a result of water evaporation) and shade cooling. Due to these effects, green areas and water surfaces play a key role in maintaining a pleasant microclimate in urban areas.

4.7

Future Climate Change Assessments for the City of Zagreb

The projection of the climate in the Republic of Croatia until 2040, with an outlook towards 2070, was carried out with simulations of the "historical" climate for the period 1971-2005 (reference period) and simulations for future time periods 2011-2040 and 2041-2070. Simulations and analyses for the territory of Croatia were made on the basis of the results of numerical integration with the regional climate model (RCM) RegCM at a spatial resolution of 12.5 km. The spatial integration domain has affected a wider area of Europe (Euro-CORDEX domain) using boundary conditions from four global climate models (GCM):

1. MPI-ESM-LR/MPI-ESM-MR (http://www.mpimet.mpg.de/en/science/models/mpi-esm/)
2. EC-EARTH (http://www.ec-earth.org/about/)
3. CNRM-CM5 (http://www.umr-cnrm.fr/spip.php?article126&lang=en)
4. HadGEM2-ES (https://www.metoffice.gov.uk/research/modelling-systems/unified-model/climate-mo dels/hadgem2)

Climate change in the future has been modelled taking into account two scenarios for the development of greenhouse gas concentrations in the future (RCP4.5 and RCP8.5), as determined by the Intergovernmental Panel on Climate Change (IPCC). The RCP4.5 scenario is considered a more moderate scenario and is characterized by a medium level of greenhouse gas concentrations with relatively ambitious expectations of their reduction in the future, which would peak around 2040. The RCP8.5 scenario is considered an extreme scenario and is characterized by a continuous increase in greenhouse gas concentrations, which by 2100 would be up to three times higher than today.

This document only looks at the RCP8.5 scenario, which is now more likely than the moderate RCP4.5 scenario. The data on the basis of which the analysis was made were taken from the DHMZ Repository [37].

The main feature of all climate projections is uncertainty about the extent and magnitude of the changes. Climate is the result of a number of natural and human factors, whose future changes are difficult to predict accurately, both globally and locally. The uncertainty in the scenarios, as well as future greenhouse gas emissions and concentrations in the atmosphere and their complex impact on the climate, as a result of human behaviour, cannot be accurately predicted. In addition, the climate system has its own internal variability resulting from the nonlinearity of climate processes. This means that small changes in initial conditions can trigger a significant climate response. Imperfection of climate models is the biggest source of uncertainty. Although models are today the best tool for assessing the future state of the climate, due to the extreme complexity of the climate system, certain simplifications are introduced into the models and they cannot fully reproduce and describe all processes and interactions in the climate system.

In order to take into account the uncertainty that comes from different climate model configurations, it is desirable to repeat climate simulations with different models. Simulations of models under the same greenhouse gas emissions scenario can also be repeated multiple times with different initial conditions to take into account the internal variability of the climate system. In this way, a set of simulations is created that enables the assessment of model result variability with respect to slightly altered initial conditions, as well as the range of possible climate states that serves to assess the uncertainty of the future climate.

For the analysis of climate change in the area of the City of Zagreb, data on annual mean, minimum and maximum air temperatures and temperature extremes indices were used. Data on annual precipitation, precipitation indices, dry and rainy periods and maximum wind speeds were also analysed.

4.7.1 Air Temperature

During the reference period (1971-2005) and in future periods (until 2070), trends of medium (Figure 4.71), minimum (Figure 4.72) and maximum (Figure 4.73) air temperatures indicate warming trend in the area of the City of Zagreb. For the location of Zagreb, a temperature increase is expected by 2070 under the boundary conditions of all four

global models. Sudden year-to-year changes are characterized by common climate variability. RegCM with the boundary conditions of the global model HadGEM2 gives the highest values of temperatures (purple curve), while the model with the boundary conditions of the global model CNRM-CM5 gives the lowest values of temperatures (blue curve).

Figure 4.7-1
Time series of mean annual temperature (°C) of Zagreb for four integrations with the RegCM model. [37]

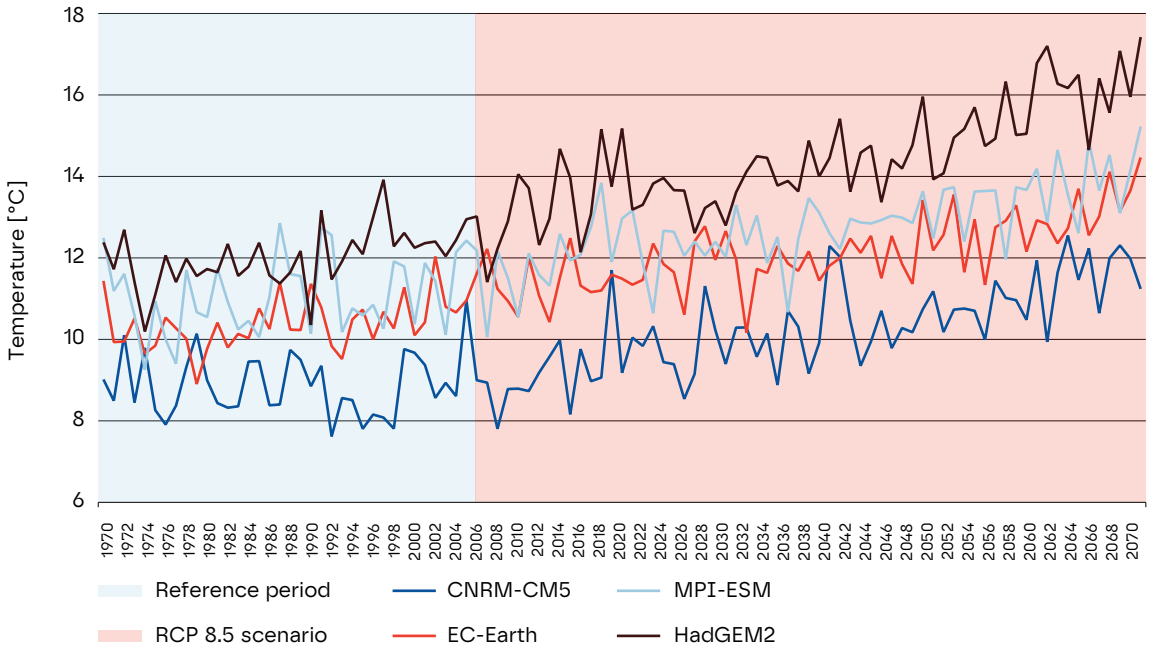


Figure 4.7-2
Time series of mean minimum annual temperature (°C) of Zagreb for four integrations with the RegCM model. [37]

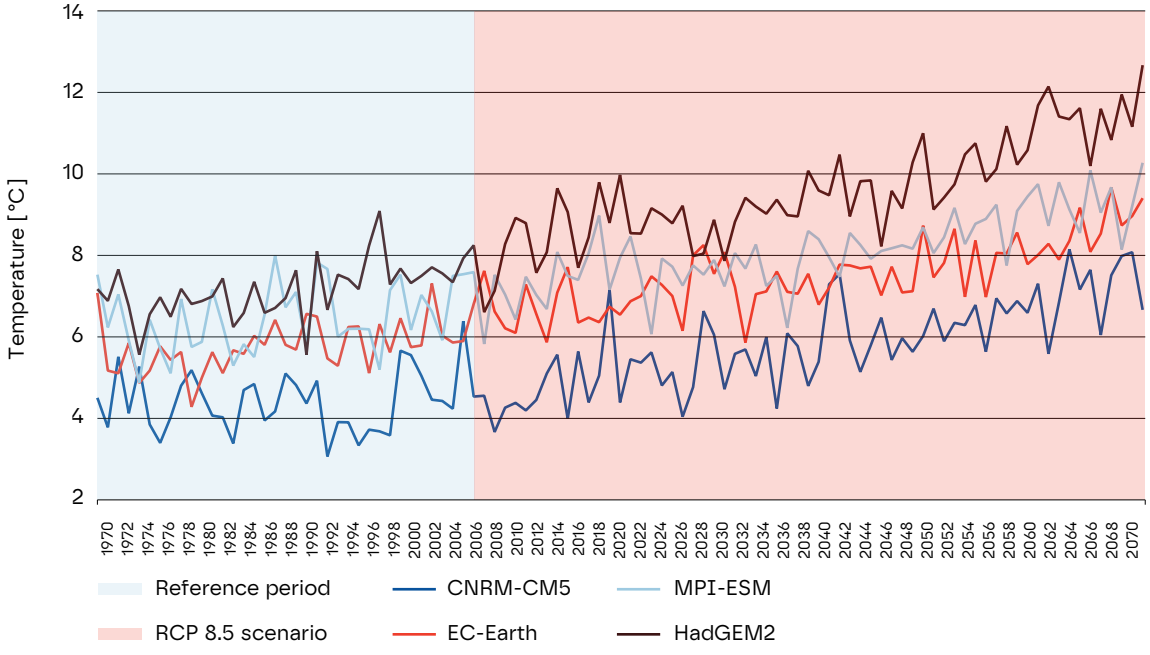
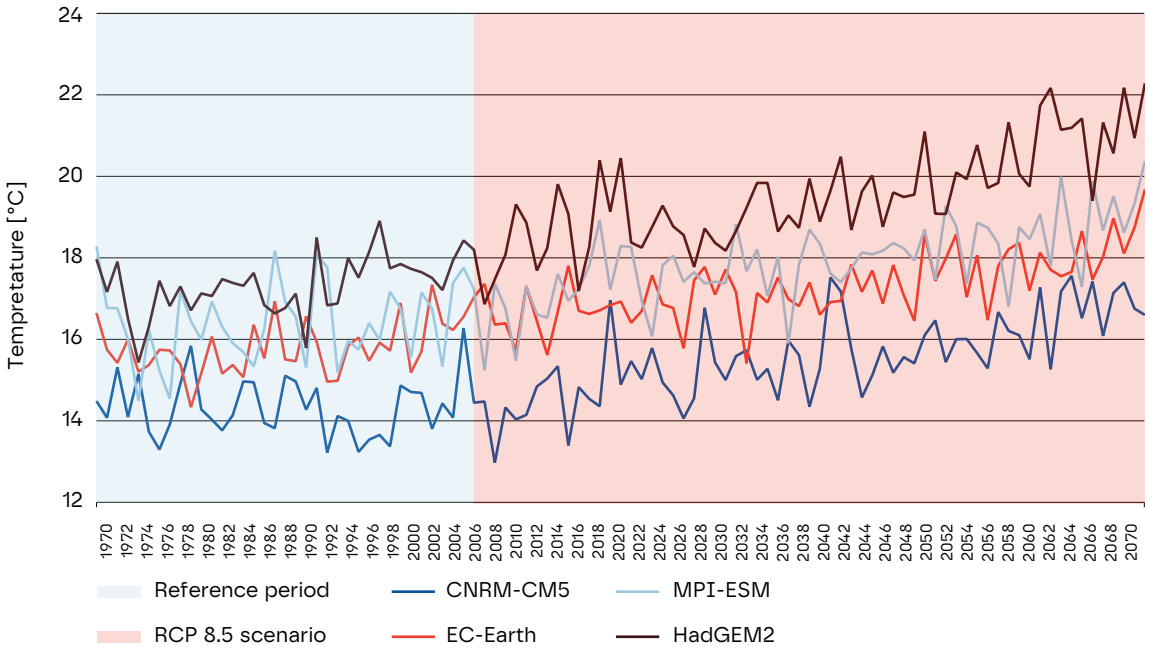


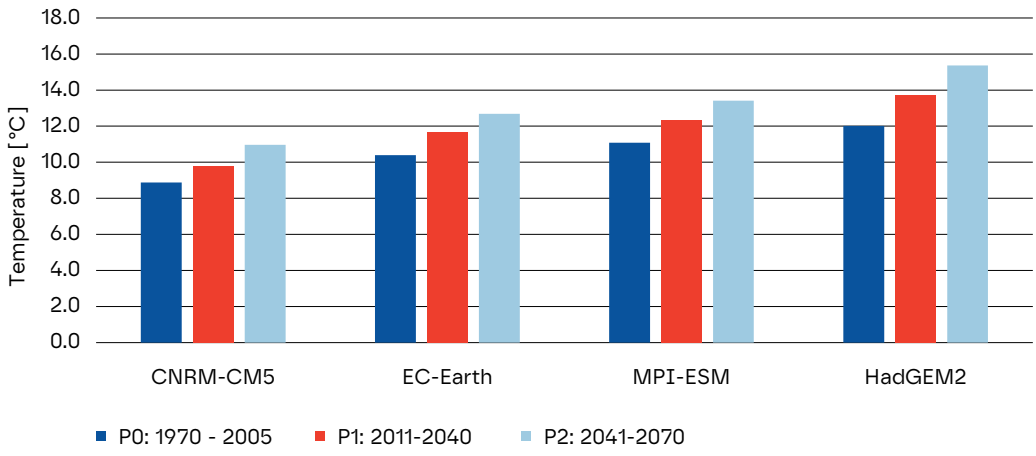
Figure 4.7-3
Time series of the mean maximum annual temperature (°C) of Zagreb for four integrations with the RegCM model. [37]



The results of climate modelling under the boundary conditions of the four observed global models indicate the following changes in the future temperature regime compared to the reference period P0:

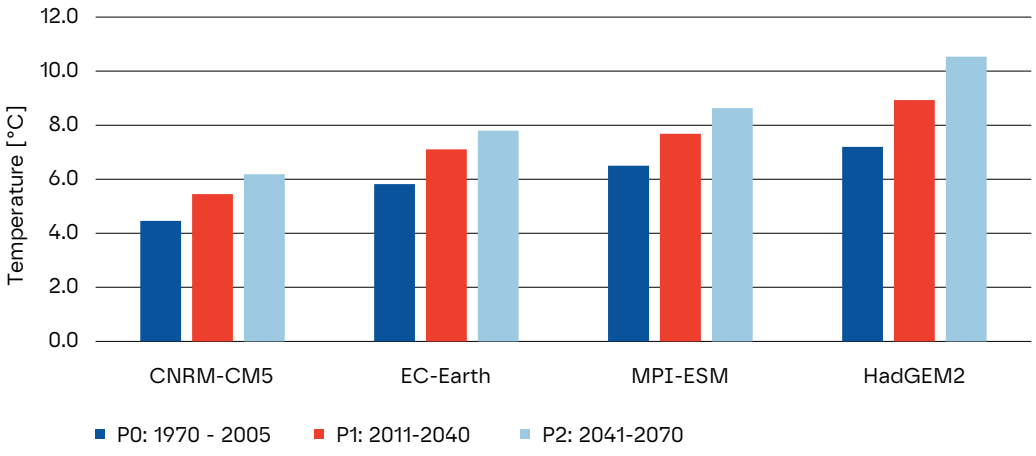
- **increase in mean annual temperature in period P1 ranging from 0.9 °C to 1.7 °C and in period P2 an increase ranging from 2.1 °C to 3.4 °C (Figure 4.74);**
- increase in mean minimum annual temperature in period P1 ranging from 1.0 C to 1.7 °C and in period P2 an increase ranging from 0.7 °C to 1.6 °C (Figure 4.75);
- increase in mean maximum annual temperature in period P1 ranging from 0.9 °C to 1.7 °C and in period P2 an increase ranging from 2.1 °C to 3.4 °C (Figure 4.76).

Figure 4.7-4
Change of the mean annual air temperature for Zagreb by four integrations with the RegCM model. [37]



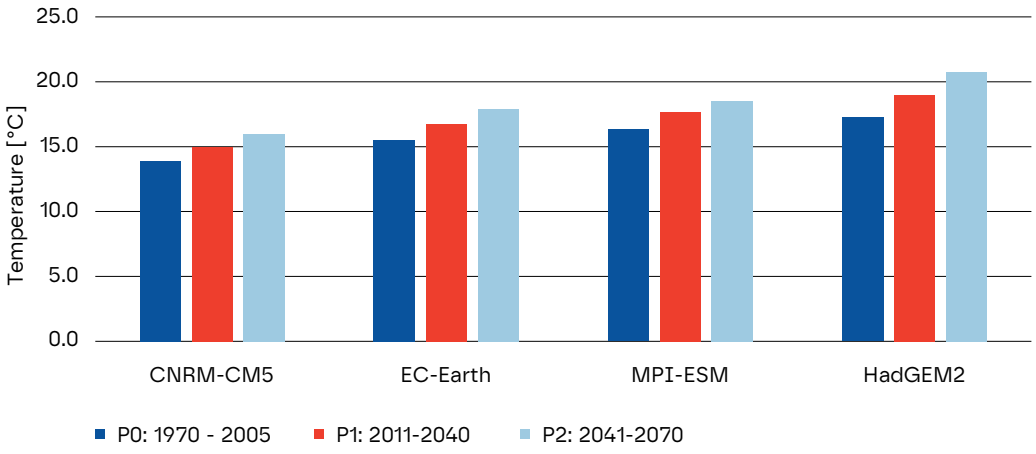
Tmean (°C)	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	8.9	9.8	11.0	0.9	2.1
EC-Earth	10.4	11.7	12.7	1.3	2.3
MPI-ESM	11.1	12.3	13.4	1.3	2.3
HadGEM2	12.0	13.7	15.4	1.7	3.4

Figure 4.7-5
Change of the mean minimum annual air temperature for Zagreb by four integrations with the RegCM model. [37]



Tmean (°C)	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	4.5	5.4	6.2	1.0	0.7
EC-Earth	5.8	7.1	7.8	1.3	0.7
MPI-ESM	6.5	7.7	8.6	1.2	0.9
HadGEM2	7.2	8.9	10.5	1.7	1.6

Figure 4.7-6
Change in the mean annual maximum air temperature for Zagreb across four integrations with the RegCM model. [37]



Tmean (°C)	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	13.9	14.8	15.9	0.9	2.1
EC-Earth	15.5	16.7	17.8	1.2	2.3
MPI-ESM	16.2	17.5	18.5	1.3	2.3
HadGEM2	17.2	19.0	20.6	1.7	3.4

4.7.2 Temperature Indices

The observed warming can be observed in the increase in the number of days with extreme temperatures, as evidenced by the increase in warm temperature indices. For the period from 1971 to 2005, as well as for future periods up to 2070, the following temperature indices were observed:

- the total annual number of tropical nights (TR20), i.e. the number of days when the minimum air temperature exceeds 20 °C (Figure 4.77);
- the total annual number of hot days (HD), i.e. the number of days when the maximum air temperature exceeds 30 °C (Figure 4.78).

For the area of Zagreb, an increase in the mentioned indices is expected by 2070 according to all global climate models. The RegCM model with boundary conditions of the HadGEM2 model predicts the highest number of tropical and hot days (purple curve), while the model with boundary conditions of the CNRM-CM5 predicts the lowest number of those days (blue curve).

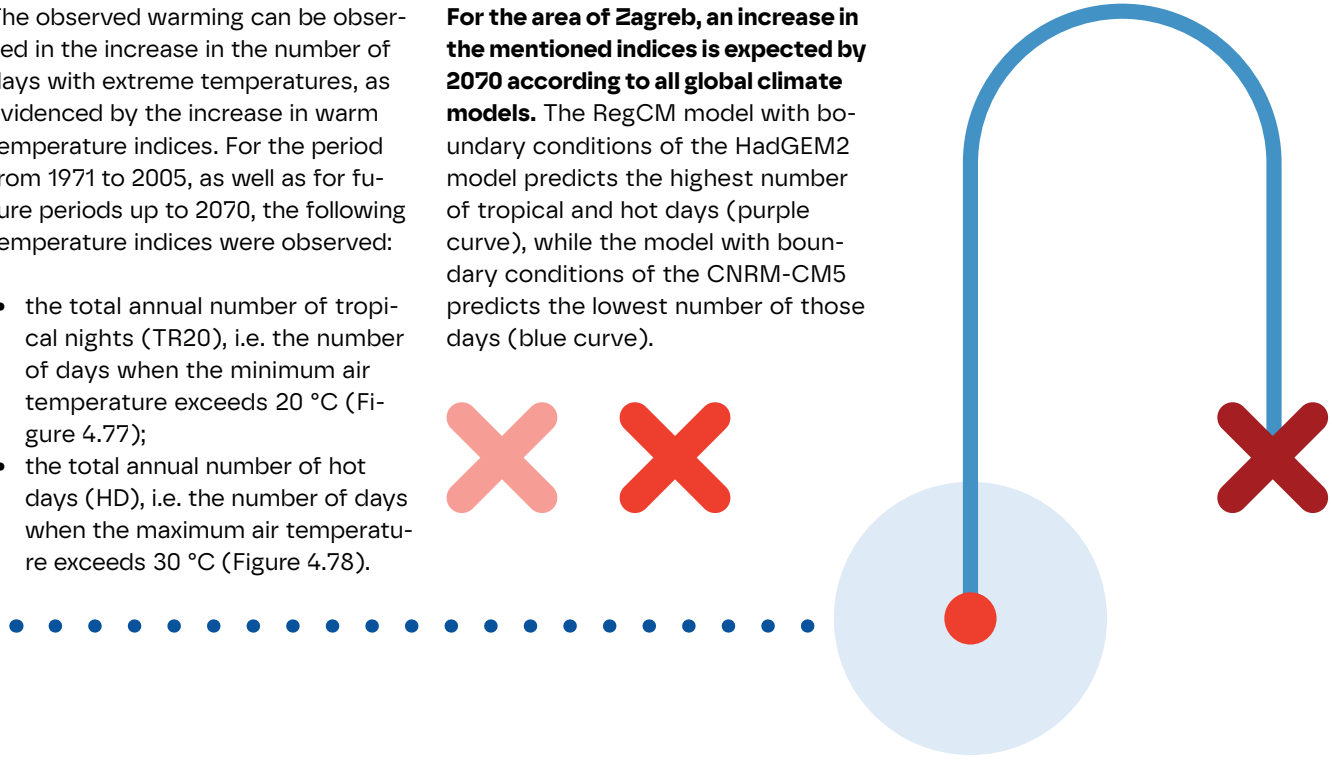


Figure 4.7-7
Time series of the number of tropical nights (Tmin ≥ 20 °C) for Zagreb for four integrations with the RegCM model. [37]

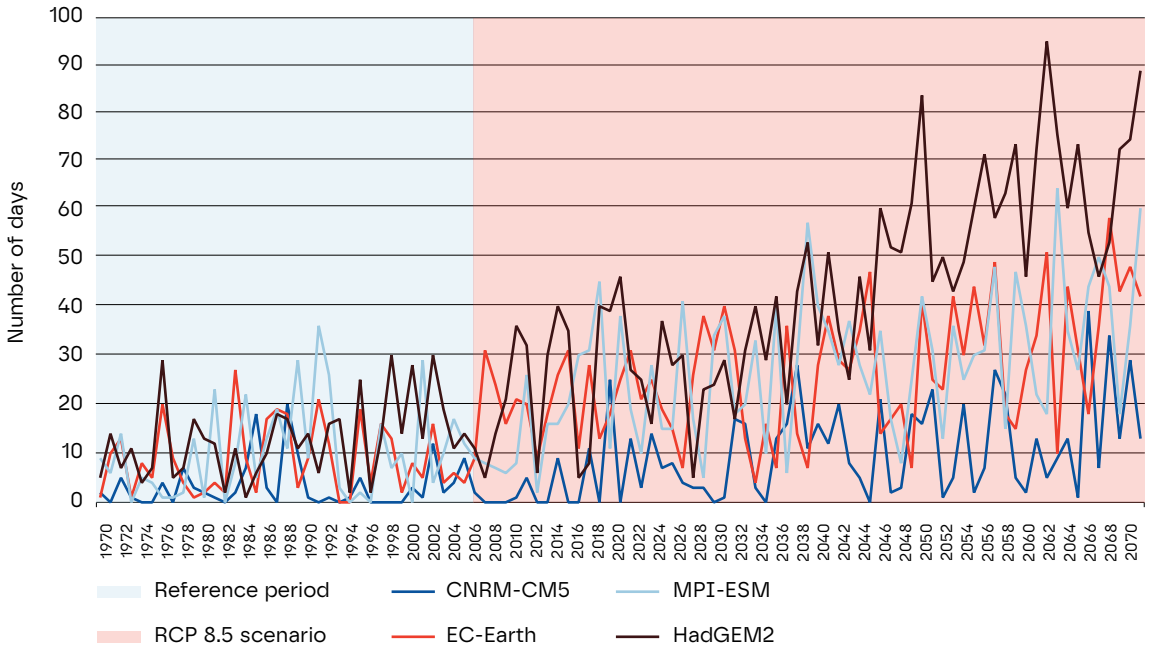
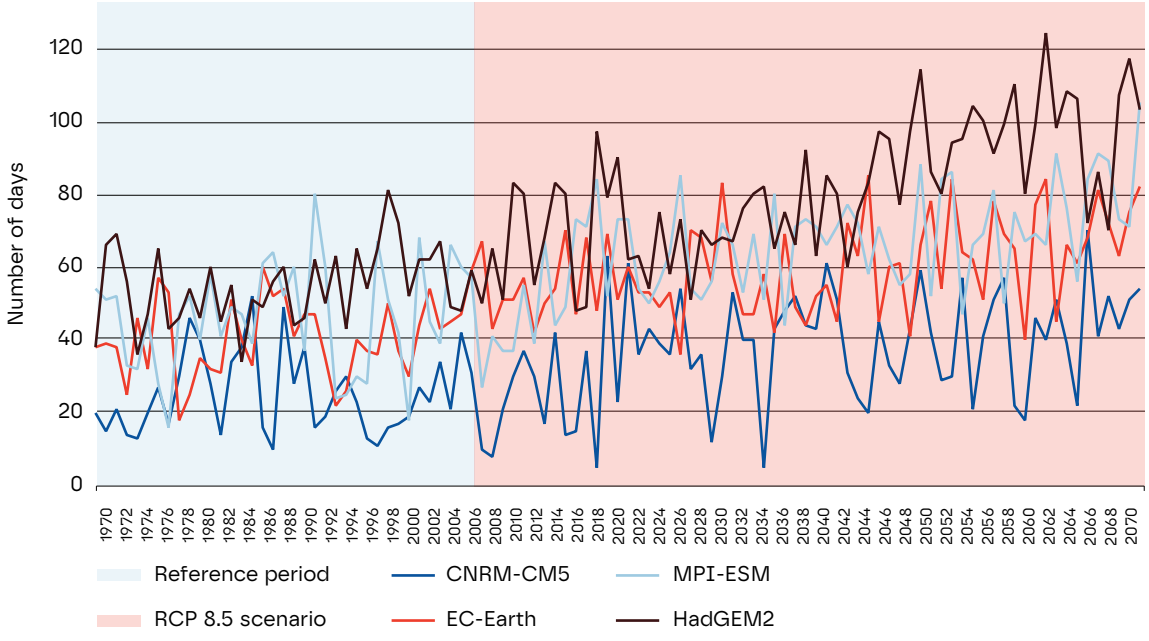


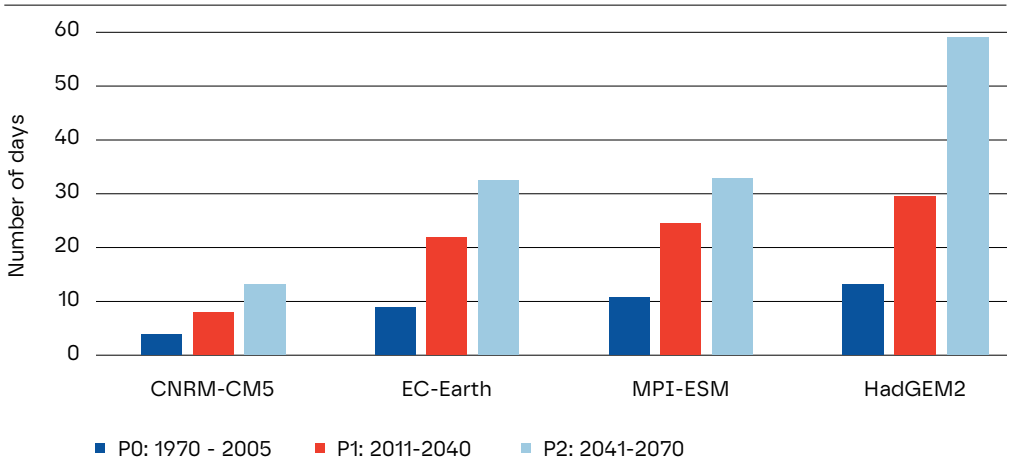
Figure 4.7-8
Time series of the number of hot days (Tmax ≥ 30 °C) for Zagreb for four integrations with the RegCM model. [37]



The results of climatological modelling with boundary conditions of the four observed global models indicate the following changes in future temperature indices compared to the reference period P0:

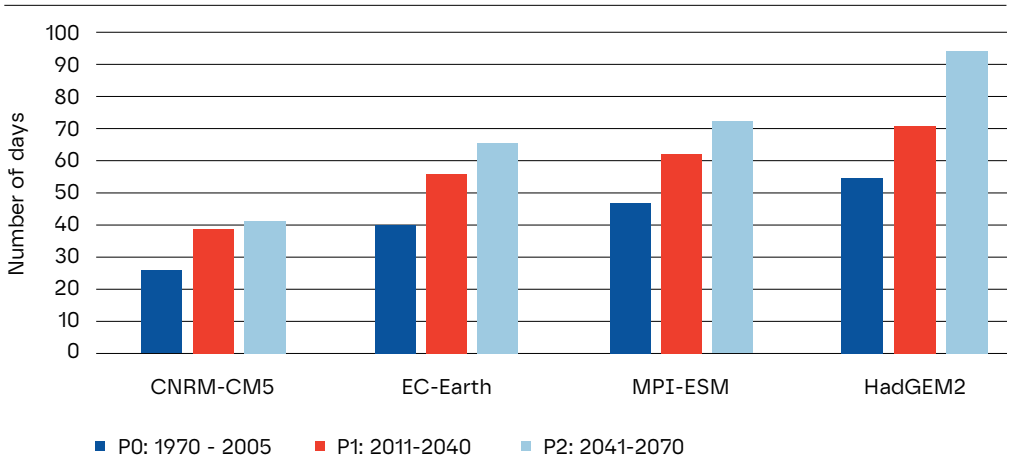
- **an increase in the mean annual number of tropical nights in period P1 ranging from 4.5 to 16.6, and in the period P2 an increase ranging from** 9.3 to 45.7 (Figure 4.79)
- an increase in the mean annual number of hot days in period P1 ranging from 11.2 to 16.2, and in the period P2 an increase ranging from 15.2 to 39.1 (Figure 4.710)

Figure 4.7-9
Change in the mean number of tropical nights (Tmin ≥ 20 °C) for Zagreb for four integrations with the RegCM model. [37]



TROPICAL NIGHTS	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	3.4	7.9	12.7	4.5	9.3
EC-Earth	8.7	21.5	32.1	12.8	23.4
MPI-ESM	10.2	24.8	32.5	14.6	22.3
HadGEM2	12.8	29.4	58.5	16.6	45.7

Figure 4.7-10
Change in the mean number of hot days (Tmax ≥ 30 °C) for Zagreb for four integrations with the RegCM model. [37]



HOT DAYS	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	25.2	36.4	40.4	11.2	15.2
EC-Earth	40.0	55.3	65.2	15.3	25.2
MPI-ESM	46.2	62.2	72.0	16.0	25.8
HadGEM2	54.5	70.7	93.6	16.2	39.1

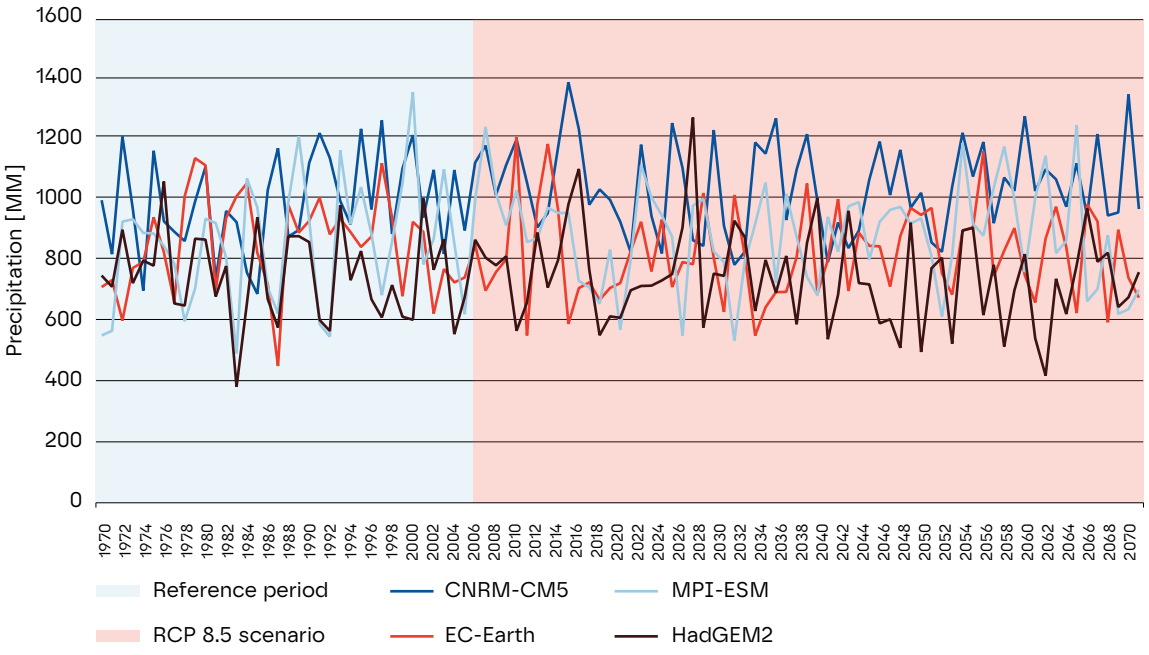
4.7.3 Precipitation

In the Zagreb area, according to RegCM models with boundary conditions from all four global models, no significant changes in average precipitation are expected by 2070. (Figure 4.711). Step changes from year to year are characterized by climatic variability, but interannual variability is small and without major differences between seasons.

If the change in the total precipitation in the seasons (DJF – winter, MAM – spring, JJA – summer, SON – autumn) in period P1 (2011 – 2040) and P2 (2041 – 2070) compared to period P0 (1971 – 2005) is observed, the results show different trends by season, depending on simulations with different boundary conditions of global models (Table 4.71).

When observing the mean score of all models, **simulations indicate a decrease in precipitation during summer, while changes in other seasons are less pronounced**. During period P1, a slight increase in precipitation is expected in the spring and autumn seasons. During period P2, **summer brings an even more pronounced decrease in precipitation, while precipitation declines in autumn,** with an increase in winter precipitation (Table 4.71).

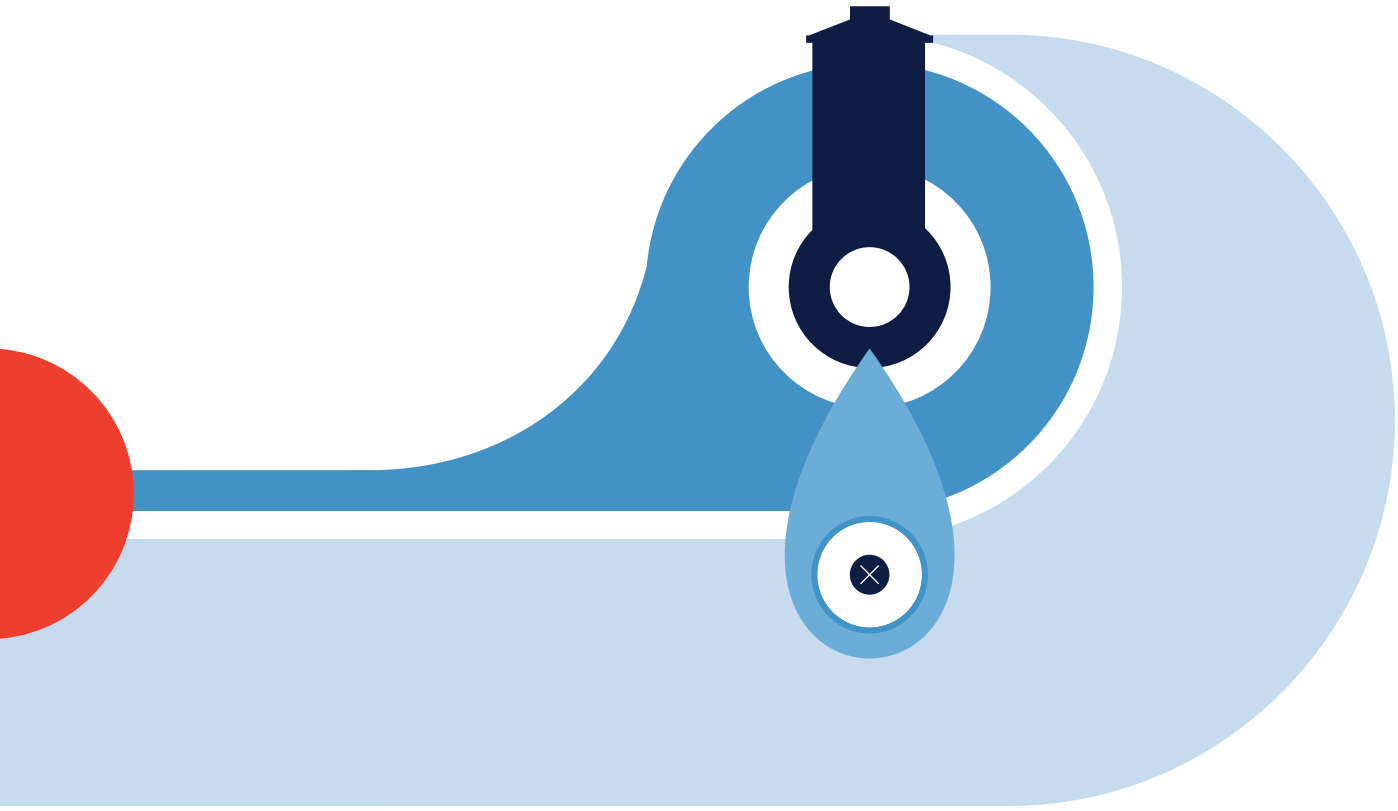
Figure 4.7-11
Figure 4.711 Time series of the total annual precipitation [mm] for Zagreb for four integrations with the RegCM model. Data source: DHMZ



Tablica 4.7-1
Relative change in the total precipitation for each of the models and in the mean of the ensemble of models used for periods P1: 2011-2040 and P2: 2041-2070 compared to the P0 reference period: 1971-2005 [37]

(P1 – P0)/P0	DJF [%]	MAM[%]	JJA[%]	SON[%]
CNRM-CM5	5.3	6.8	– 12.8	5.8
EC-Earth	– 4.7	– 14.9	– 28.9	3.6
MPI-ESM	– 6.1	– 1.1	– 16.8	4.2
HadGEM2	1.5	14.7	9.4	– 12.0
AVERAGE	– 1.0	1.4	– 12.3	0.4

(P2 – P0)/P0	DJF[%]	MAM[%]	JJA[%]	SON[%]
CNRM-CM5	18.1	– 0.1	– 2.5	– 1.0
EC-Earth	11.0	– 14.8	– 11.9	– 0.1
MPI-ESM	7.3	9.0	– 10.3	– 1.2
HadGEM2	3.5	2.2	11.7	– 24.2
AVERAGE	10.0	– 0.9	– 9.1	– 6.6



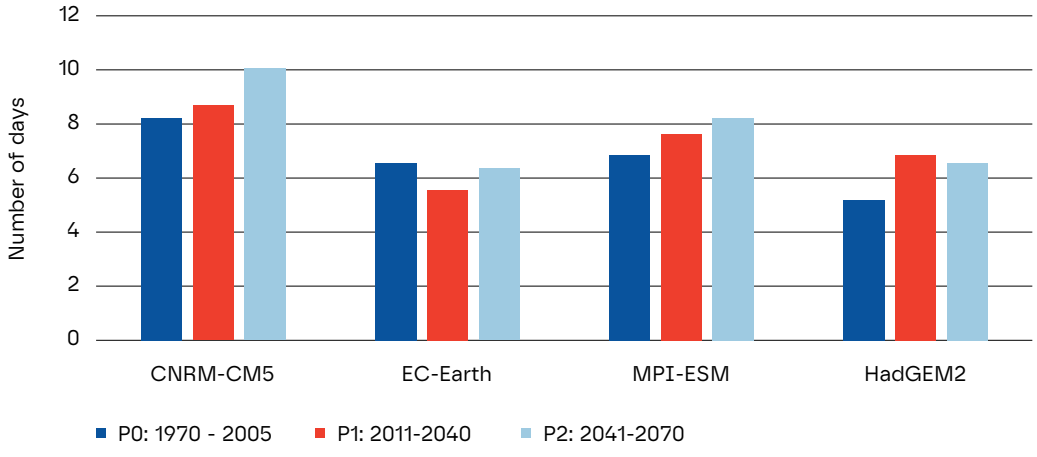
4.7.4 Precipitation Extremes

In addition to temperature extremes, the following precipitation extremes were also analysed:

- maximum daily precipitation during the year (Rx1d; mm);
- number of very wet days or number of days with daily precipitation ≥ 20 mm (R20 - heavy precipitation days);
- consecutive dry days with daily precipitation ≥ 1 mm - duration of dry periods (CDD - consecutive dry days, R ≥ 1 mm) and
- consecutive wet days with a daily precipitation of < 1 mm duration of rainy periods (CWD - consecutive wet days, R < 1 mm).

According to RegCM simulations, the number of days with very high precipitation (R20) is expected to increase (Figure 4.712). According to the analysed data, during the period P1 (2011-2040) the number of days could increase from 0.6 to 1.7, and in the period P2 (2041-2070) from 1.3 to 2.1 days, according to the boundary conditions of all three global models (CNRM-CM5, MPI-ESM, HadGEM2). Only with the boundary conditions of the EC-Earth model does the forecast show a decrease in the number of days, namely -0.8 days in the period P1 and -0.1 days period P2.

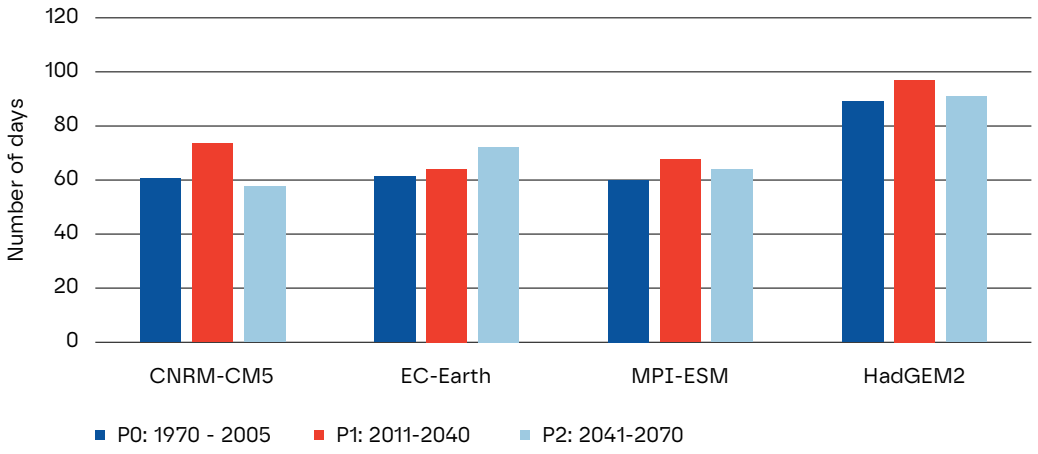
Figure 4.7-12
Change in the mean number of days with very high precipitation (R20) for Zagreb by four integrations with the RegCM model. [37]



R20	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	8.2	8.8	10.3	0.6	2.1
EC-Earth	6.6	5.8	6.5	– 0.8	– 0.1
MPI-ESM	6.9	7.9	8.4	1.0	1.5
HadGEM2	5.4	7.1	6.8	1.7	1.3

Expected changes in the maximum daily precipitation (Rx1d), according to the analysed simulations of the RegCM model, indicate a possible increase between the current climate and future climate periods, ranging from 2 to 14.3 mm in period P1 under boundary conditions from all four global models. In the period P2, only under the CNRM-CM5 model boundary conditions is there a possibility of reducing the maximum daily precipitation by -3.6 mm, while simulations with boundary conditions of other models show increases ranging from 2 to 11.8 mm (Figure 4.713).

Figure 4.7–13
Change in maximum daily precipitation (Rx1d) for Zagreb by four integrations with the RegCM model. [37]



Rx1d	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	65.0	79.3	61.5	14.3	– 3.6
EC-Earth	66.0	68.0	77.8	2.0	11.8
MPI-ESM	64.7	72.8	68.4	8.1	3.6
HadGEM2	96.0	103.9	98.0	7.9	2.0

The expected change in the mean number of consecutive dry days with precipitation of < 1 mm, according to the analysed RegCM simulations, does not indicate a consistent trend. For period P1, most models (except CNRM-CM5) indicate a possible increase, with differences between the present climate and the future climate period ranging from 2.7 to 6.6 days. For period P2, there is a possible increase of 2.9 to 8 days under boundary conditions of EC-Earth and HadGEM2 global models, and a decrease of -0.8 to -3.2 days under boundary conditions of CNRM-CM5 and MPI-ESM global models (Figure 4.714).

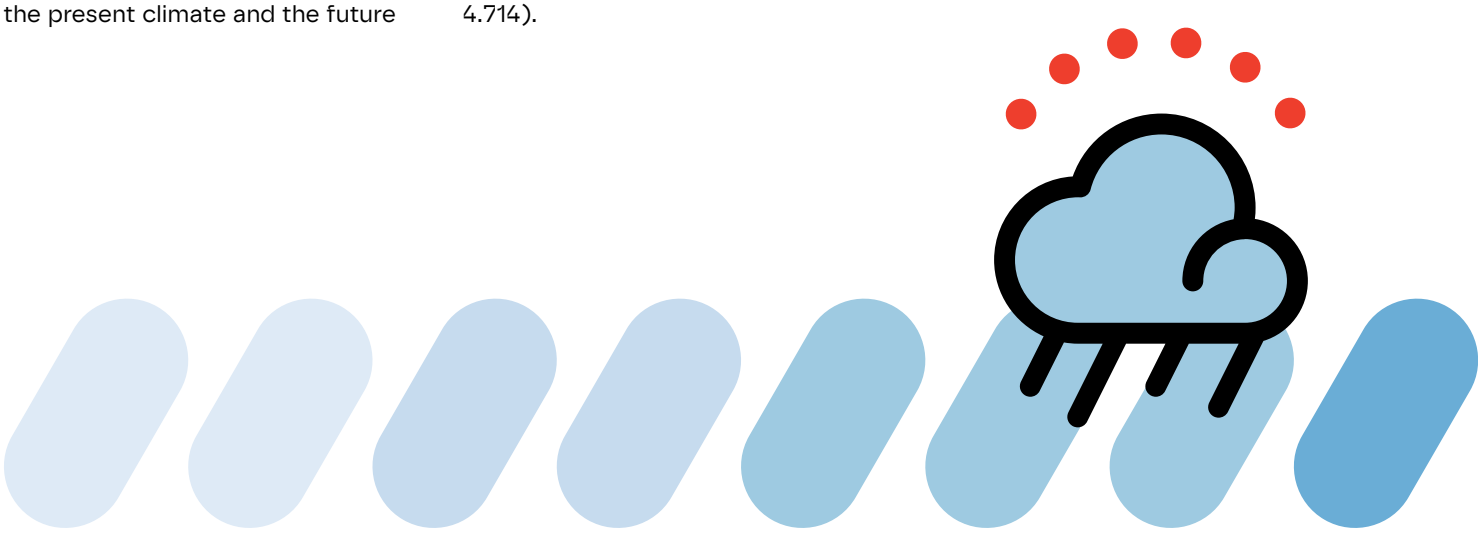
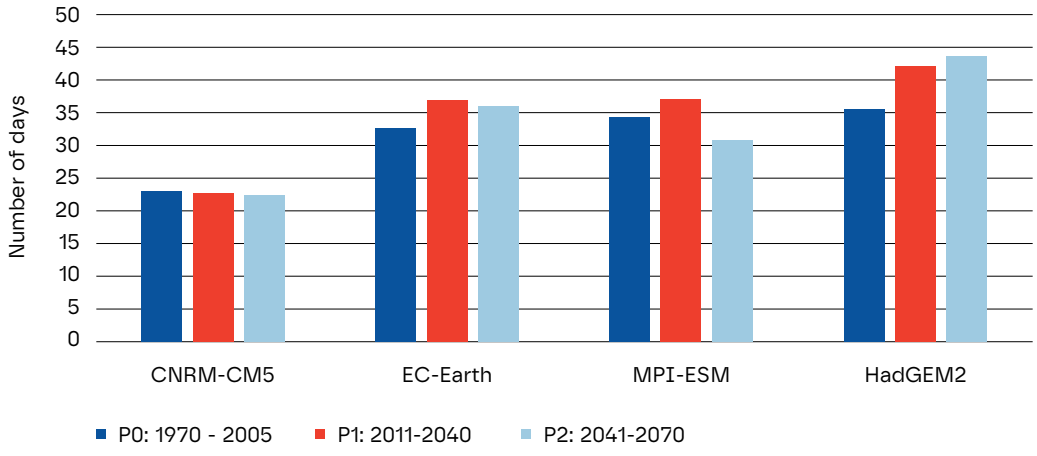


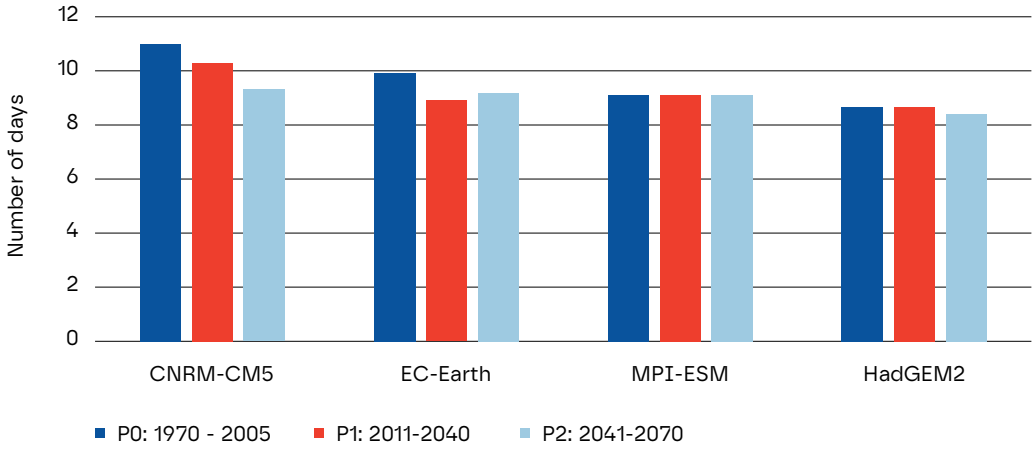
Figure 4.7-14
Change in the mean number of consecutive dry days (number of days with < 1 mm precipitation) for Zagreb by four integrations with the RegCM model. [37]



CDD	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	22.9	22.3	22.1	-0.6	– 0.8
EC-Earth	32.6	36.3	35.5	3.7	2.9
MPI-ESM	33.8	36.5	30.6	2.7	– 3.2
HadGEM2	35.4	42.0	43.5	6.6	8.0

The expected change in the mean number of consecutive rainy days with precipitation ≥ 1 mm, according to the analysed RegCM simulations, indicates that no significant shifts will occur. In period P1, two models (CNRM-CM5 and EC-Earth) indicate a possible decrease between the present climate and the future climate period ranging from -0.8 to -1.2 days, while other models do not predict a change. For period P2, most models likewise do not predict significant changes in the duration of the period with precipitation, with only the simulations under CNRM-CM5 boundary conditions, indicating a decrease of maximum – 1.1 days (Figure 4.715).

Figure 4.7–15
Change in mean number of consecutive rainy days (number of days with precipitation ≥ 1 mm for Zagreb for four integrations with the RegCM model. [37]

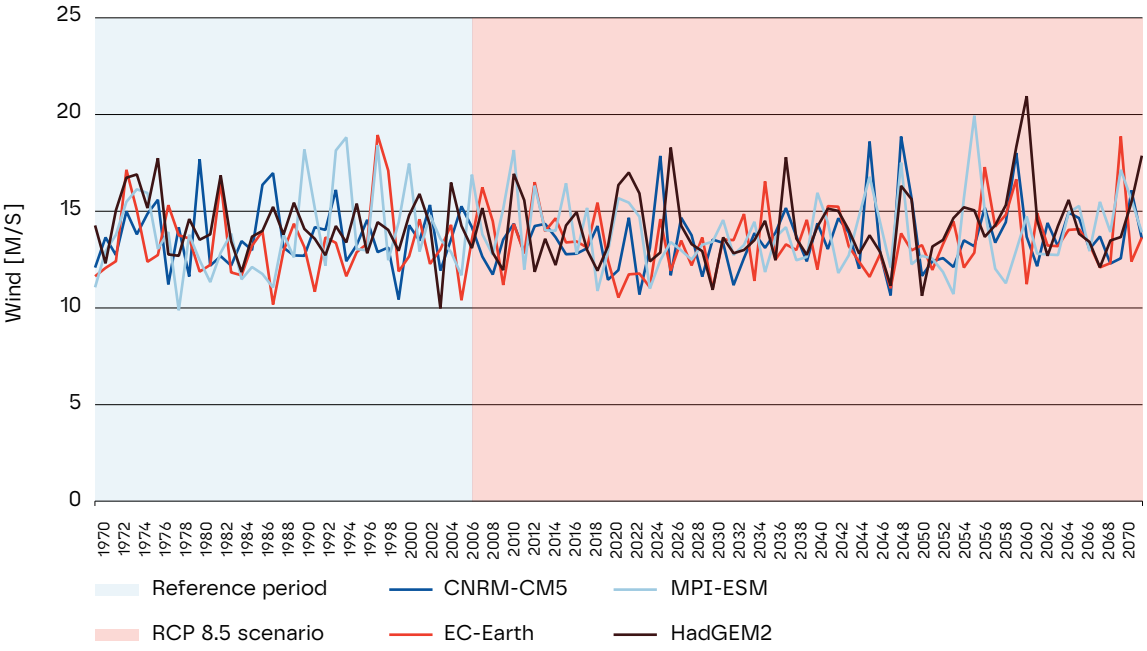


CWD	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041.– 2070	P1 – P0	P2 – P0
CNRM-CM5	11.6	10.8	9.7	-0.8	– 1.1
EC-Earth	10.4	9.2	9.6	– 1.2	0.3
MPI-ESM	9.4	9.4	9.4	0.0	0.0
HadGEM2	9.0	9.0	8.8	0.0	– 0.3

4.7.5 Maximum Wind Speed

During the reference period (1971-2005) and in future periods (up to 2070), maximum wind speed trends indicate that no significant changes in the maximum wind speeds are expected in the City of Zagreb (Figure 4.716).

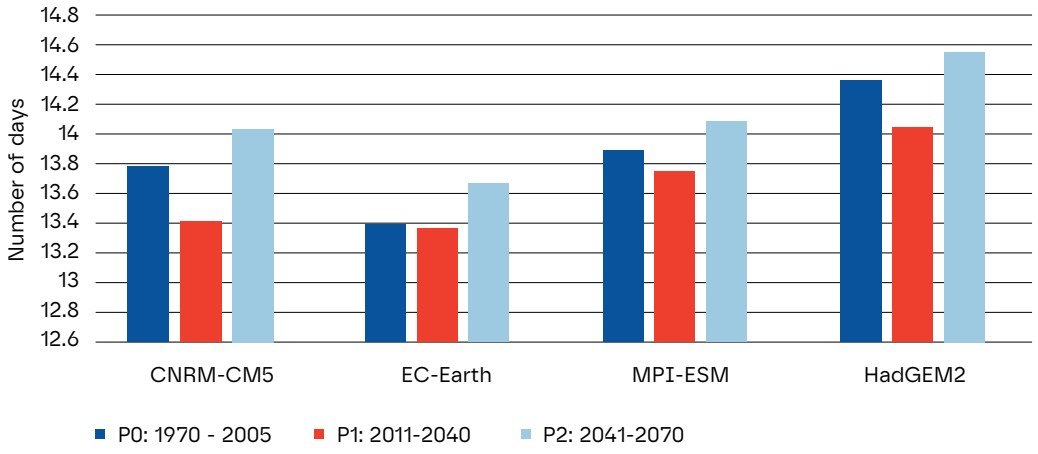
Figure 4.7-16
Time series of maximum annual wind speed (m/s) for Zagreb for four integrations with RegCM model [37]



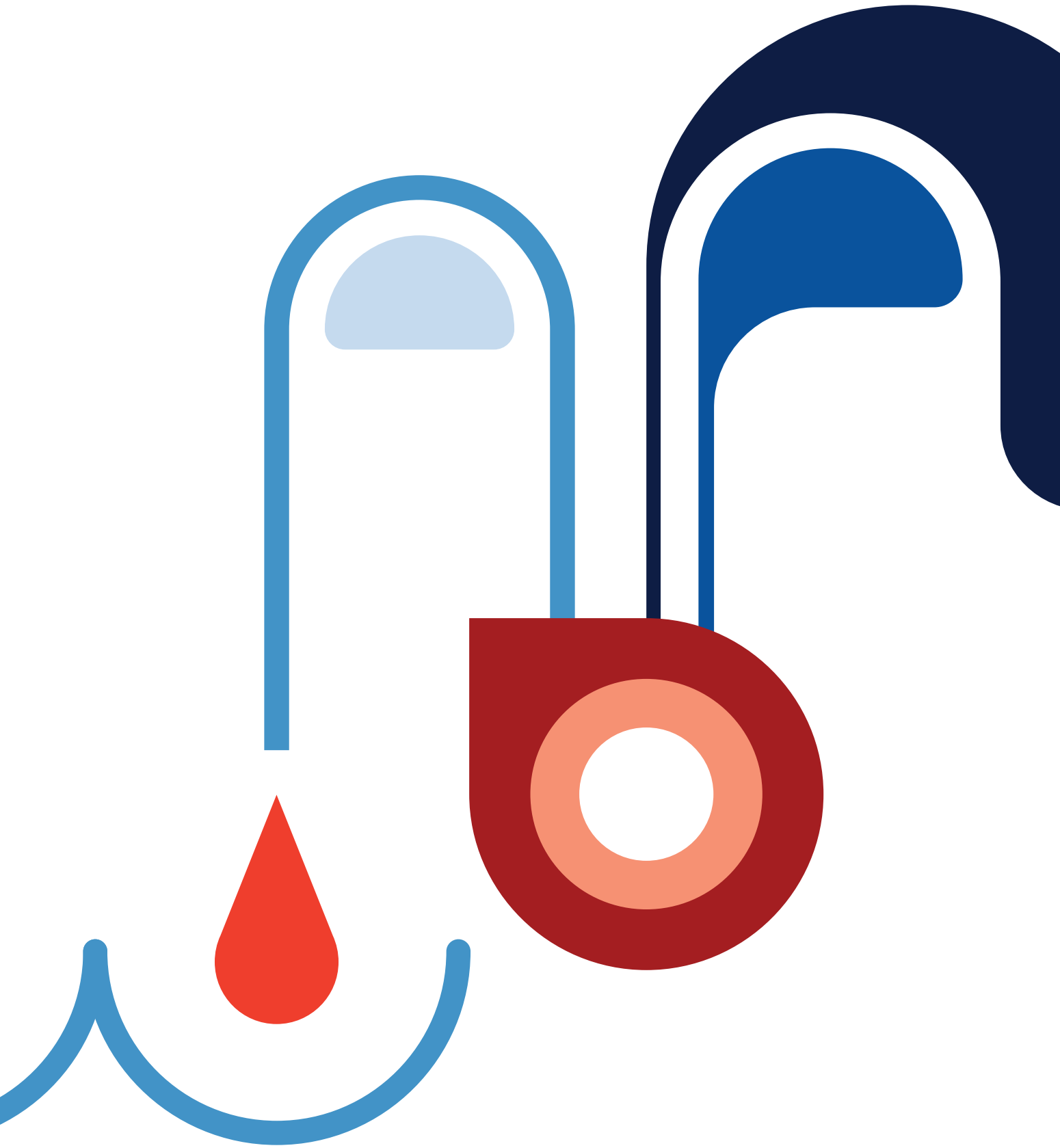
The RegCM model with the boundary conditions of the HadGEM2 model produces the highest speed values (blue curve), while the model with EC-EARTH boundary conditions produces the lowest speed values (orange curve), although the differences between the models are very small.

The expected change in the mean maximum wind speeds, according to the analysed RegCM simulations, indicates that no significant shifts will occur. During period P1, models predict a possible decrease in velocities between the current climate and the future climate period in the range of -0.03 to -0.36 m/s. Whereas in the future period P2 models predict a slight increase in maximum speeds from 0.19 to 0.27 m/s (Figure 4.717).

Figure 4.7-17
Change in the mean maximum wind speed for Zagreb for four integrations with the RegCM model [37]

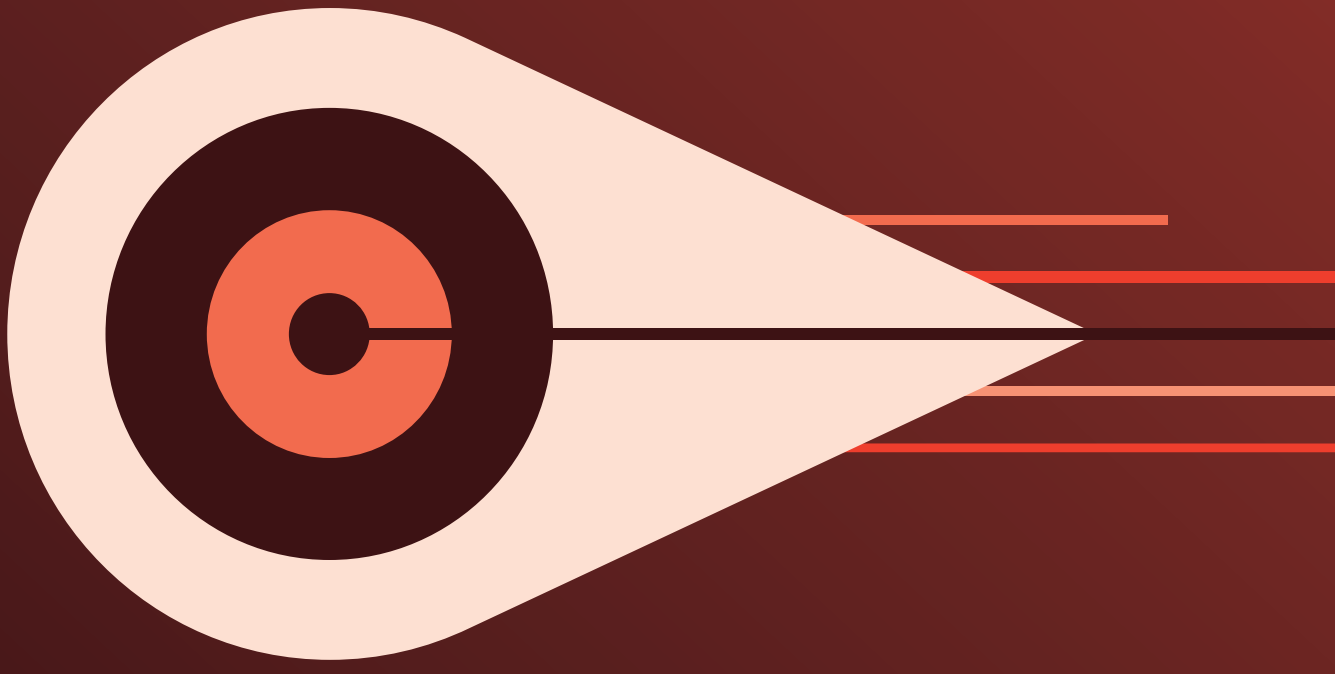


Maximum wind speed	P0: 1970 – 2005	P1: 2011 – 2040	P2: 2041 – 2070	P1 – P0	P2 – P0
CNRM-CM5	13.76	13.40	14.01	– 0.36	0.25
EC-Earth	13.38	13.35	13.65	– 0.03	0.27
MPI-ESM	13.87	13.73	14.06	– 0.14	0.19
HadGEM2	14.33	14.02	14.52	– 0.31	0.19



5

Estimation of CO_2 missions of the City of Zagreb



5.1

Calculation of CO_2 Emissions of the City of Zagreb for 2023

p. 64→

5.1

Calculation of CO_2 Emissions of the City of Zagreb for 2023

For the calculation the City of Zagreb's CO_2 emission estimates, the energy consumption by energy products was assessed, using data from the Energy Balance of the City of Zagreb for 2023 with consumption estimates for 2024 and 2025.

CO_2 emissions were calculated using an internationally recognized IPCC methodology [38]. CO_2 emissions from fuel combustion and contributions from individual energy subsectors are shown in Table 5.11.

Table 5.1 -1
CO_2 emissions in tonnes from the total energy consumption of the City of Zagreb in 2023 [39]

Energy Production and Transformation	**1,174,615.00**	**38.5 %**
Public heating plants (TE-TO and EL-TO Zagreb)	1,134,044.00	37.2 %
Other energy transformations	40,571.00	1.3 %
Industry and construction	**146,938.00**	**4.8 %**
Industry	63,480.00	2.1 %
Construction	83,458.00	2.7 %
Transport	**1,092,601.00**	**35.8 %**
Road	1,045,084.00	34.3 %
Railway	0.00	0.0 %
Public urban	47,517.00	1.6 %
Overall consumption	**635,204.00**	**20.8 %**
Households	416,795.00	13.7 %
Services	207,989.00	6.8 %
Agriculture	10,419.00	0.3 %
Total emissions (tCO_2)	**3,049,357**	**100.0 %**

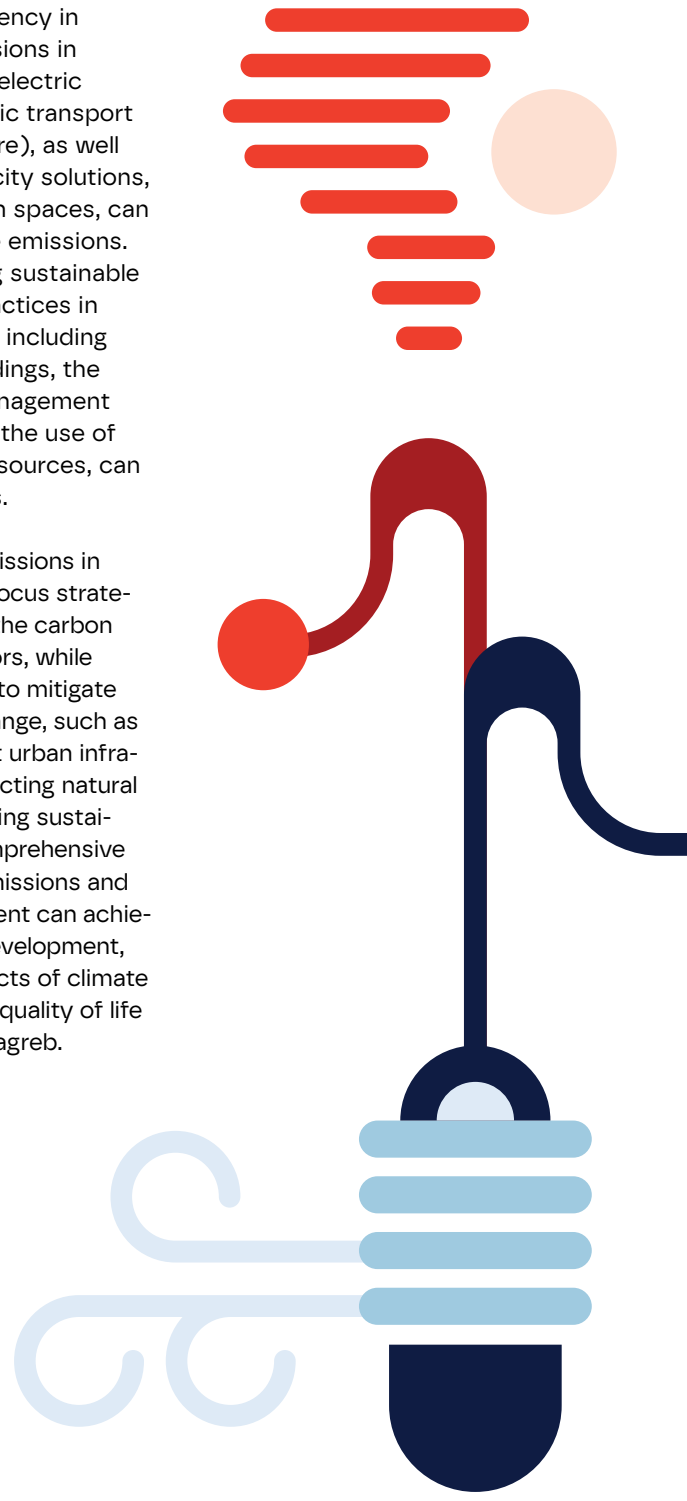
CO_2 emissions in the City of Zagreb area in 2023 show a significant distribution of emission sources: the largest share comes from energy production and transformation (1,174.62 kt, accounting for 38.5% of total emissions), followed by emissions from transport (1,092.60 kt, accounting for 35.8%). Emissions from general consumption (households, services and agriculture) amount to 635.20 kt (20.8%), while industry and construction contribute with 146.94 kt (4.8%). The total CO_2 emissions from energy sources in the City of Zagreb amounted to 3.05 million tonnes, which is 3.44% higher than in the previous year, 2022.

These data clearly indicate the main sources of greenhouse gas emissions in urban areas, particularly the challenges associated with transport and energy consumption.

Given that the largest share of emissions is linked to energy production and transport, reducing emissions from these sectors is becoming crucial for mitigating climate change. Climate change can be effectively mitigated by reducing its negative impact on the environment, primarily by reducing CO_2 and other greenhouse gas emissions. This includes switching to renewable energy sources, such as solar, and investing in more energy efficient technologies and infrastructure.

Increasing energy efficiency in industry, reducing emissions in transport (switching to electric vehicles, improving public transport and bicycle infrastructure), as well as implementing green city solutions, such as increasing green spaces, can also significantly reduce emissions. In addition, encouraging sustainable and energy-efficient practices in households and utilities, including better insulation of buildings, the use of smart energy management systems and increasing the use of energy from renewable sources, can bring long-term benefits.

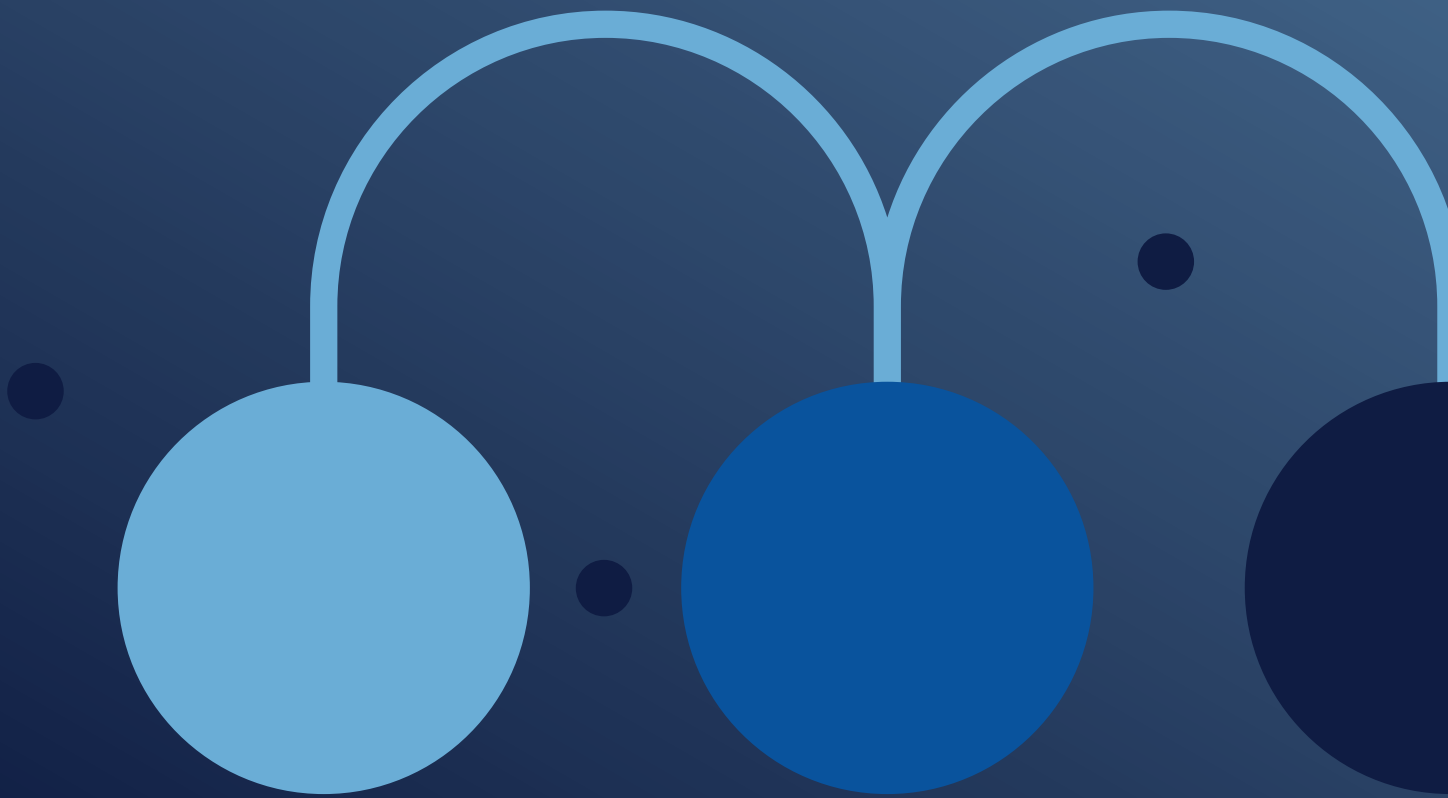
Given the increase in emissions in 2023, it is necessary to focus strategic policies on reducing the carbon footprint across all sectors, while implementing measures to mitigate and adapt to climate change, such as developing more resilient urban infrastructure systems, protecting natural ecosystems and promoting sustainable urban plans. A comprehensive approach to reducing emissions and preserving the environment can achieve a more sustainable development, reduce the negative effects of climate change and improve the quality of life in urban areas such as Zagreb.



5
Estimation of CO_2 missions of the City of Zagreb

6

Risk and Vulnerability Assessment

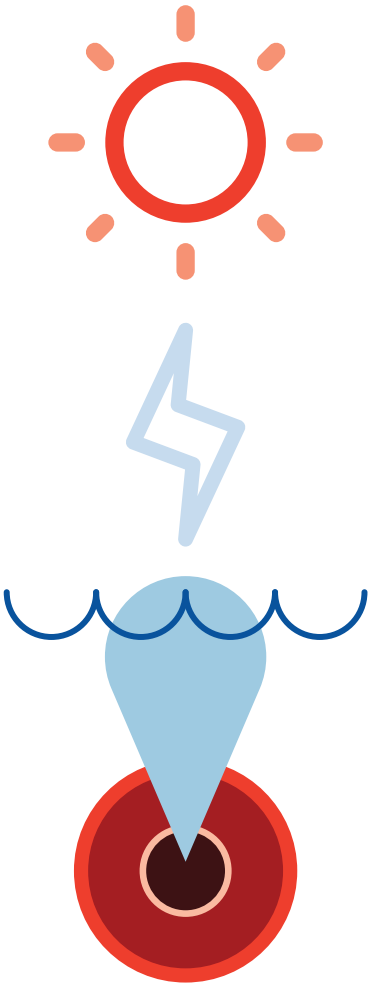


Risk assessment is a comparative analysis of natural causes and their consequences related to hazards and conditions of vulnerability in which people and property may be harmed, and livelihoods, infrastructure and services in a given area endangered. The result of risk analysis is an evaluation of the probability and level of potential losses and an understanding of why they occur and what effects they have. Climate change vulnerability serves to understand the interconnection between the causes and consequences of climate change and the impact on people, the economy, society and the ecosystem.

The effects of climate change depend on a number of parameters. According to international climate modelling results (IPCC, EEA), the Mediterranean basin has been designated as a climate "hotspot", with particularly pronounced climate change effects. The vulnerability of some economic sectors is particularly significant: building, transport, tourism, agriculture, forestry and energy; given that the success of these sectors depends largely on climate factors. Consequently, the exceptional vulnerability of the economy to the effects of climate change can also have a negative impact on overall social development, especially on vulnerable groups of society. The cost of investing in adaptation today will reduce the cost of addressing possible damages in the future, while also creating opportunities for developing new professions and value-added jobs at the local and regional level.

6.1

Climate Change Risk and Vulnerability Analysis for the City of Zagreb



Climate change brings different types of threats that significantly affect many sectors of the economy and society. While each sector has specific risks, several key threats – such as **floods** and **heat waves** – are emerging as the most critical for most sectors, increasing their vulnerability to climate change. Table 6.11 below presents the results of the risk assessment and major threats for the observed sectors in the City of Zagreb, which can be summarized as follows.

Sectors that are vulnerable to **climate change,** such as **water management**, **agriculture**, **healthcare** and **building**, require urgent adaptation to reduce the potential damage that could result from climate threats such as floods, droughts and heat waves. **Building** and **transport** are already looking for greater resilience to extreme weather conditions, while electricity and **tourism** are facing changes in energy consumption and tourism flows due to changes in climate conditions.

Ultimately, **mitigation** and **adaptation** will be crucial for reducing the negative impacts of climate change. In addition, development of early warning systems, implementing new technologies, strengthening of infrastructure, but also crisis management systems, will be necessary to mitigate the long-term consequences. Given the increasing number of extreme weather events, there is a need for **an integrated approach** involving all sectors to increase resilience to climate change and ensure sustainable development.

Table 6.1-1
Summary of risks for all analysed sectors

SECTOR	THREAT	RISK
WATER MANAGEMENT	Flooding	High
	Drought	High
AGRICULTURE	Flooding	Moderate
	Drought	Moderate
FORESTRY	Fire	Low
	Stormy weather	High
HEALTHCARE	Heat wave	Moderate
TOURISM	Heat wave	Moderate
BIODIVERSITY	Temperature increases and changes in precipitation patterns	Moderate
BUILDING	Flooding	Moderate
	Stormy weather	High
TRANSPORT	Flooding	High
ELECTRICITY	Heat wave	Moderate

The vulnerability and risks analysis of the City of Zagreb's economic sectors to the effects of climate change indicates **significant challenges the city will face in the future**. **Rising temperatures, changes in rainfall patterns and extreme weather events affect all sectors of society, from water management and agriculture to forestry and healthcare.**

Data analysis shows a significant trend of rising temperatures, hot days and tropical nights in Zagreb. The climate of Medvednica mountain has also shifted from a humid snow-forest climate to a humid temperate climate. Simulations of climate models for future periods indicate a further increase in temperature, a decrease in summer precipitation and a slight increase in autumn and winter precipitation. More frequent and intense extreme weather events such as floods, droughts, storms and heat waves are also expected.

RISK
Extremely low
Low
Moderate
High
Extremely high

6.2

Risks by sector

- **Water management:**
  High risk of floods and droughts due to the occurrence of extreme precipitation, increasing land use, high population density, and aging infrastructure. The drainage system is not adapted to future rainfall volumes and there is a need for the development of nature-based solutions and infrastructure improvements, as well as support for innovative water management solutions and technologies. Additional analyses of soil permeability and the possibility of infiltration into the soil are needed, as a basis for developing the Green Infrastructure Plan, which will also serve to mitigate flood risks, as well as an analysis of the water retention possibilities through nature-based solutions to mitigate the impacts of drought. Furthermore, the identified risks, alongside climate change, require stronger preparation and adaptation of infrastructure, as well as the development of early warning and protection systems.

- **Agriculture:**
  Moderate risk of agricultural losses due to droughts and floods. The increasingly prolonged dry periods and more extreme precipitation events indicate a high degree of threat to this sector. Adjustments are needed in tillage practice, planting adaptive crops and the use of irrigation technologies, as well as cooperation between farmers, institutions and the scientific community to strengthen the resilience of the agricultural sector of the City of Zagreb to climate change and ensure long-term food security.

- **Forestry:**
  High risk of thunderstorms, which can severely damage forest ecosystems because existing urban systems are not adapted to this threat. Although fire risks are low, rising temperatures in the future may increase this risk. It is necessary to research the impact of climate on local tree populations in Zagreb's forests, establish systematic monitoring of forest health status using remote sensing methods, prescribe minimum permissible logging areas, introduce adaptive management of urban forests, parks and green infrastructure, all in line with European forest legislation by 2030.

- **Health:**
  Moderate risk of heat waves with an upward trend in the future. Extreme temperatures can increase the number of health problems. In this context, it is essential to implement measures for reducing health risks (such as cooling systems and education). It is necessary to include green infrastructure in urban plans, improve internal and external housing conditions, develop heat protection plans and monitor the impact of heat waves on health.

- **Tourism:**
  Low risk of a decrease in the number of tourists due to heat waves and extreme weather, but with a growing trend in the summer months. It is necessary to develop a tourist offer that is resilient to climate change and promote the city as a destination for a nature-based vacation. In the summer months, it is necessary to provide sufficient green and water areas for cooling and resting (fountains, sprinklers and misting systems in urban heat island zones, installation of green canopies at bus and tram stops, free drinking water fountains). Include the aspect of climate change in tourist development strategies and plans.

- **Biodiversity:**
  Moderate risk of biodiversity loss due to changes in temperature and rainfall, which can cause species migration and habitat losses. Establishing ecological corridors, linking green spaces and protecting endangered species will be critical to preserving biodiversity. It is necessary to integrate these measures into spatial planning and to strengthen green urban areas, while connecting fragmented green spaces, creating ecological corridors to improve biodiversity, as well as selecting plant species resilient to new climatic conditions to shape plant communities in public landscapes. It is necessary to strengthen cooperation between the city administration, scientific institutions and associations for the conservation of biodiversity and maintenance of ecosystem services. The development of urban biodiversity with resilient

ecosystems is key to adapting to climate change and preserving a healthy urban environment.

- **Building:** High risk of damage during thunderstorms and moderate risk of damage to buildings due to flooding. For the building industry, this is a challenge in terms of strengthening building standards and infrastructure to ensure storm resilience. Buildings and infrastructure in the city are vulnerable to climate change due to design (poor resilience to storms) or location (areas prone to flooding, landslides, erosion). It is necessary to build resilient buildings and improve energy efficiency, adapt construction regulations in spatial plans based on previously prepared expert bases, develop a digital database of damages to public and private buildings due to natural disasters, as well as monitor land use change and changes in the condition and potential of land.
- **Transport:** High flood risk due to possible extreme weather events. The high risk is associated with inadequate rainwater drainage. It is necessary to plan and reconstruct/build flood-resilient infrastructure using technological innovations such as permeable materials and green measures. It is also important to adapt public urban transport and railways by developing a real-time traffic information system and early warning systems. It is recommended to keep records of road damages during weather disasters in order to identify critical locations and plan their adaptation.
- **Energy:** Moderate risk of increased energy demand during heat waves. High temperatures can increase cooling energy consumption, and they can also burden electricity infrastructure. For this reason, it is important to provide energy capacities that can respond to increased demand and reduce the risk of power outages during hot summer days. It is necessary to promote the use of renewable energy sources and improve energy efficiency across all sectors, especially in the building sector, with the application of green solutions.

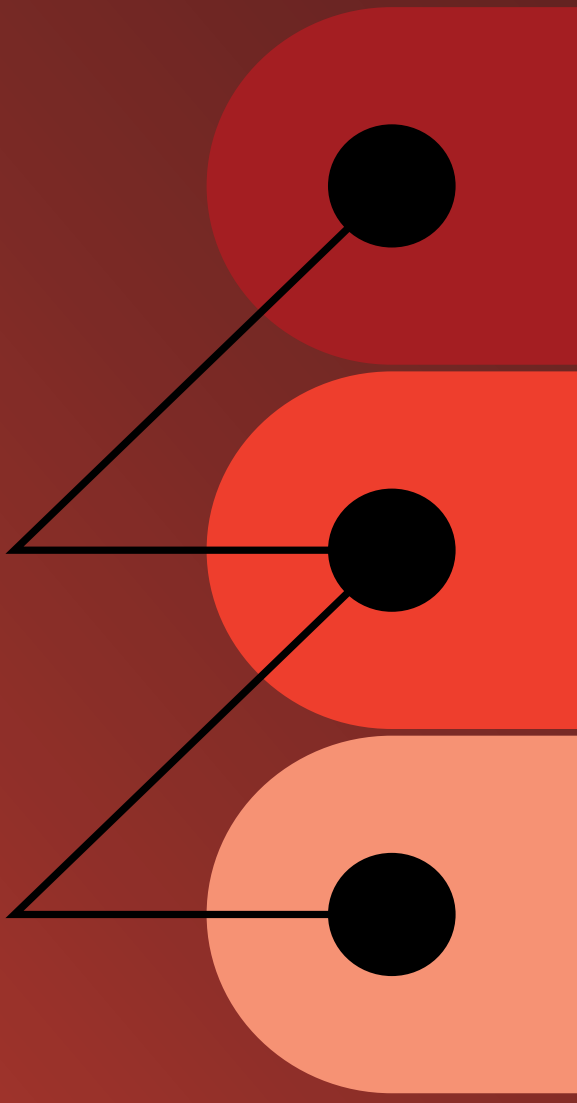
6.3

Horizontal Themes

- **Spatial planning:** The Spatial Plan of the City of Zagreb and the General Urban Plan and their provisions currently do not contain the aspect of climate change to the appropriate extent, but the City of Zagreb is making efforts in this direction. Spatial planning stands out as a key tool in the fight against climate change in Zagreb. Through strategic documents such as the Spatial Plan of the City of Zagreb and the General Urban Plan, the city can focus its development in a way that reduces vulnerability to extreme weather conditions and their negative impacts. Therefore, based on the climate change adaptation programme of measures, which will be developed on the basis of risk analysis, it is necessary to prepare guidelines for the implementation of measures in amendments to spatial plans. Spatial plans should include risk maps of climate threats, a green infrastructure plan and clearly defined implementation provisions. Greater flexibility is needed in the adoption of spatial plans for changing environmental conditions in order to reduce the city's vulnerability and improve life quality through adaptive planning methods.
- **Disaster Risk Management:** Disaster risk management in Zagreb is becoming an increasingly complex challenge due to the impact of climate change. Although the city has a low overall risk level, it is imperative to proactively prepare for heightened natural threats. The approach to risk management and climate change adaptation must be continuously refined to ensure a sustainable and secure future for the city. The City of Zagreb should focus resources on areas most vulnerable to climate change, such as heat waves, floods, storms, fires and droughts.

7

Measures for Climate Change Mitigation and Adaptation of The City of Zagreb



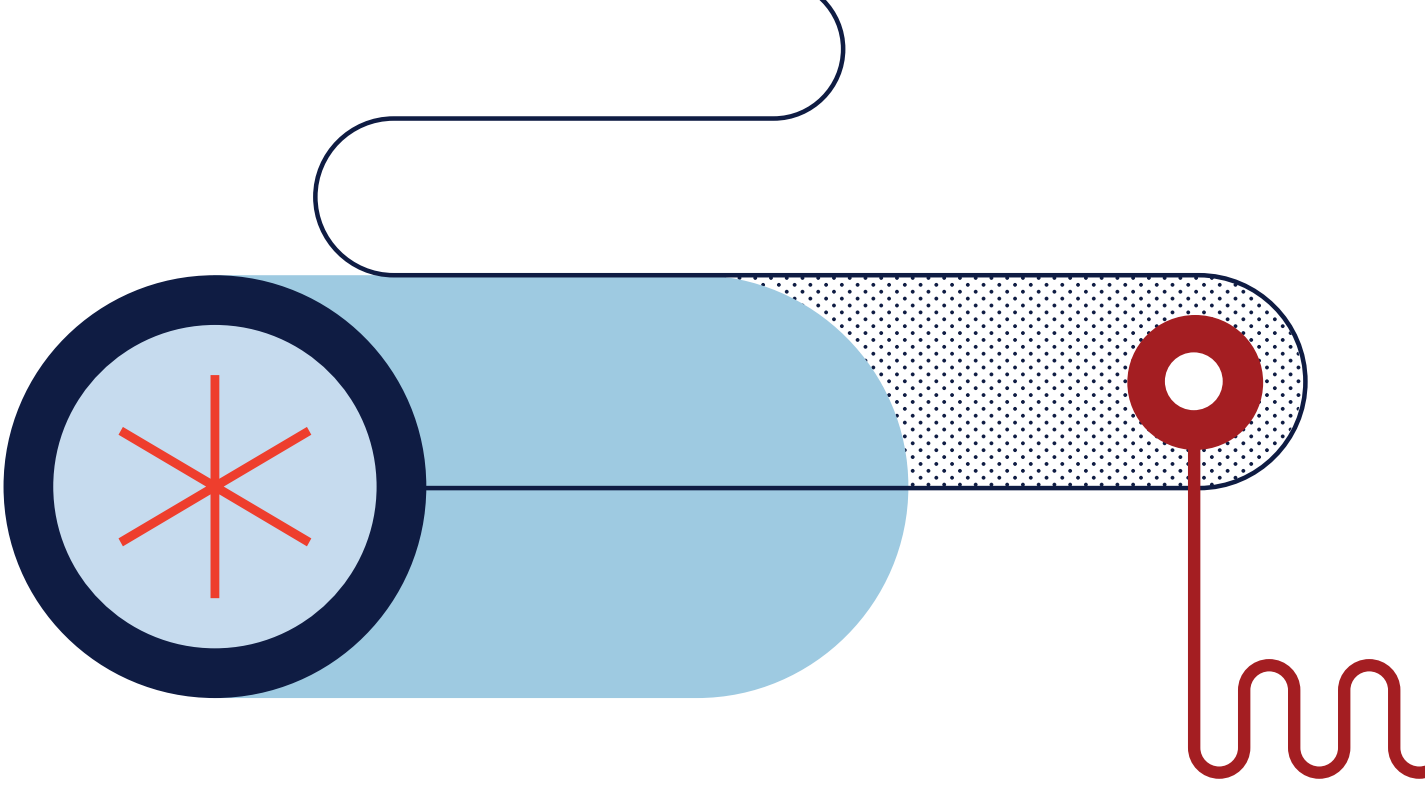
Mitigating the effects of climate change implies systematic and strategic activities aimed at reducing the impact of human activities on the environment, particularly the reduction of greenhouse gas emissions (such as CO2), which are the main drivers of global warming.

In order to reduce the atmospheric warming and mitigate negative climate impacts, it is crucial to implement measures for reducing CO2 emissions at the local level.

This includes a wide range of activities that make it possible to reduce energy consumption, increase energy efficiency and switch to sustainable energy sources. In addition, mitigation requires changes in key sectors, such as **building**, **transport** and **street lighting**, where solutions that can significantly reduce the city's carbon footprint are implemented.

The main objectives of mitigation are:

- **Increasing energy efficiency**: reducing energy consumption by modernizing buildings, applying energy-efficient technologies and improving infrastructure. This includes, among other things, improving insulation, optimizing heating and cooling, and using advanced energy management systems.
- **Greater use of renewable energy sources (RES)**: investing in solar energy, geothermal sources and other forms of green energy reduces dependence on fossil fuels and reduces greenhouse gas emissions, thus contributing to reducing global warming.
- **Sustainable transport systems**: promoting sustainable transport, including public transport, cycling and walking, and the transition to electric vehicles contribute to reduced carbon dioxide emissions and improve air quality in urban areas.
- **Sustainable public lighting**: the introduction of energy-efficient public lighting systems, such as LED lights, and the use of smart lighting control systems make it possible to reduce energy consumption and thus lower greenhouse gas emissions.



Climate change adaptation is another key component of combating climate challenges. While mitigation works to prevent further global warming, adaptation focuses on reducing the negative impacts of climate change that are already present or expected in the future. Adaptation includes assessing existing and future climate threats and implementing measures that increase community resilience to climate change.

Adaptation implies:

- **Assessment of adverse impacts of climate change**: by analysing potential threats, such as floods, droughts, heat waves and other extreme weather conditions, vulnerable areas and sectors most vulnerable to climate change are identified. This enables timely action to reduce harmful consequences.
- **Strengthening climate change resilience**: implementing measures to strengthen infrastructure, manage water resources, protect green areas, ensure the sustainability of agricultural systems and promote adaptive technological solutions that enable better adjustment to climate change.
- **Taking advantage of the possible positive effects of climate change**: in some cases, climate change can also bring certain benefits, such as a longer growing season in some areas. Identifying these opportunities can help implement strategies that will leverage positive change while minimizing negative impacts.

The City of Zagreb has defined 69 measures covering different sectors of life, from infrastructure and transport to health and biodiversity. These measures cover all key aspects of combating climate change and reducing its impacts on the local community, and are presented in detail below.

UN Sustainable Development Goals

In 2015, United Nations member states adopted the 17 UN Sustainable Development Goals (SDGs) to be achieved by 2030. The shared goals focus our global efforts towards peace and well-being of people and the planet, both today and in the future. The Sustainable Development Goals were created as an extension of the Millennium Global Goals adopted **in 2001,** which represented eight goals aimed at eradicating poverty and deprivation by 2015. The SDGs recognize that efforts to eradicate poverty and deprivation must accompany strategies that support health, education, equity, and economic development while tackling climate change and preserving oceans and terrestrial habitats. This document is aligned with the Sustainable Development Goals and each measure highlights which of the goals of the measures it contributes.

The 17 UN Sustainable Development Goals are:

Eradicating poverty everywhere and in all its forms

Eradicating hunger, achieving food security and improved nutrition, and promoting sustainable agriculture

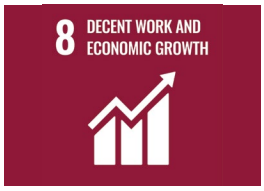
Health – ensuring healthy lives and promoting well-being for people of all generations

Ensuring inclusive and quality education and promoting lifelong learning opportunities

Achieving gender equality and empowering all women and girls

Ensuring access to drinking water for all, managing water sustainably and ensuring hygienic conditions for all

Ensuring access to reliable, sustainable and modern energy at affordable prices for all



Promoting inclusive and sustainable economic growth, full employment and decent work for all

Building scalable infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation

Reducing inequality within and between countries

Making cities and neighbourhoods inclusive, safe, resilient and sustainable

Ensuring sustainable consumption and production patterns

Taking urgent action to combat climate change and its consequences

Conserving and sustainably using the oceans, seas and marine resources for sustainable development

Protecting, establishing and promoting sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, halting soil degradation, and preventing biodiversity destruction

Promoting peaceful and inclusive societies for sustainable development, ensuring access to justice for all and building effective, accountable and inclusive institutions at all levels

Strengthening ways of implementation and strengthening the global partnership for sustainable development

7.1

Building

High energy consumption in building is one of the priorities in mitigating climate change. A significant share of consumption comes from households (family houses and multi-residential buildings), where 16.3 PJ was consumed in 2023, representing the largest share of total consumption of the City of Zagreb by sectors [39]. In order to reduce energy consumption, energy efficiency measures are implemented, primarily on public buildings, but also on private ones, in the household sector and commercial buildings. Further results may also be achieved by careful monitoring of consumption in allowing timely response to system failures and the prevention of unnecessary consumption.

Development and investment in the building sector is constantly under pressure from changing climatic conditions and associated extreme weather events. Due to the need for longevity of buildings and related infrastructure, as well as their high economic value, preparedness and resilience to future climate change impacts are of utmost importance.

The impact of climate change his particularly significant for the construction industry due to the expected lifespan of buildings and the necessity of renovating existing structures in order to cope with climate conditions that are or will be different from those at the time they were designed and built.

The main challenges for the construction sector and buildings, which require actions to be taken within a relatively short period of time, are as follows:

- extreme heat waves, leading to e.g. material fatigue and accelerated aging of materials, reduced living comfort and potential negative effects on human health, large amounts of energy required for cooling, etc.;
- extreme amounts of precipitation, causing e.g. water penetration, damage to foundations and underground parts of buildings, destruction of buildings and infrastructure, etc.;
- the risk of soil subsidence, which may increase depending on the stability of building structures and foundations;
- the risk of strong wind gusts, waterspouts and tornadoes;
- the appearance of hail;
- open space fires.

Buildings may be vulnerable to climate change due to the way they are designed (e.g. low resistance to extreme weather events such as storms) or due to the location on which they are built.

All new projects in the building sector must comply with the Technical Guidelines on Increasing the Resilience of Infrastructure to the Effects of Climate Change [40].

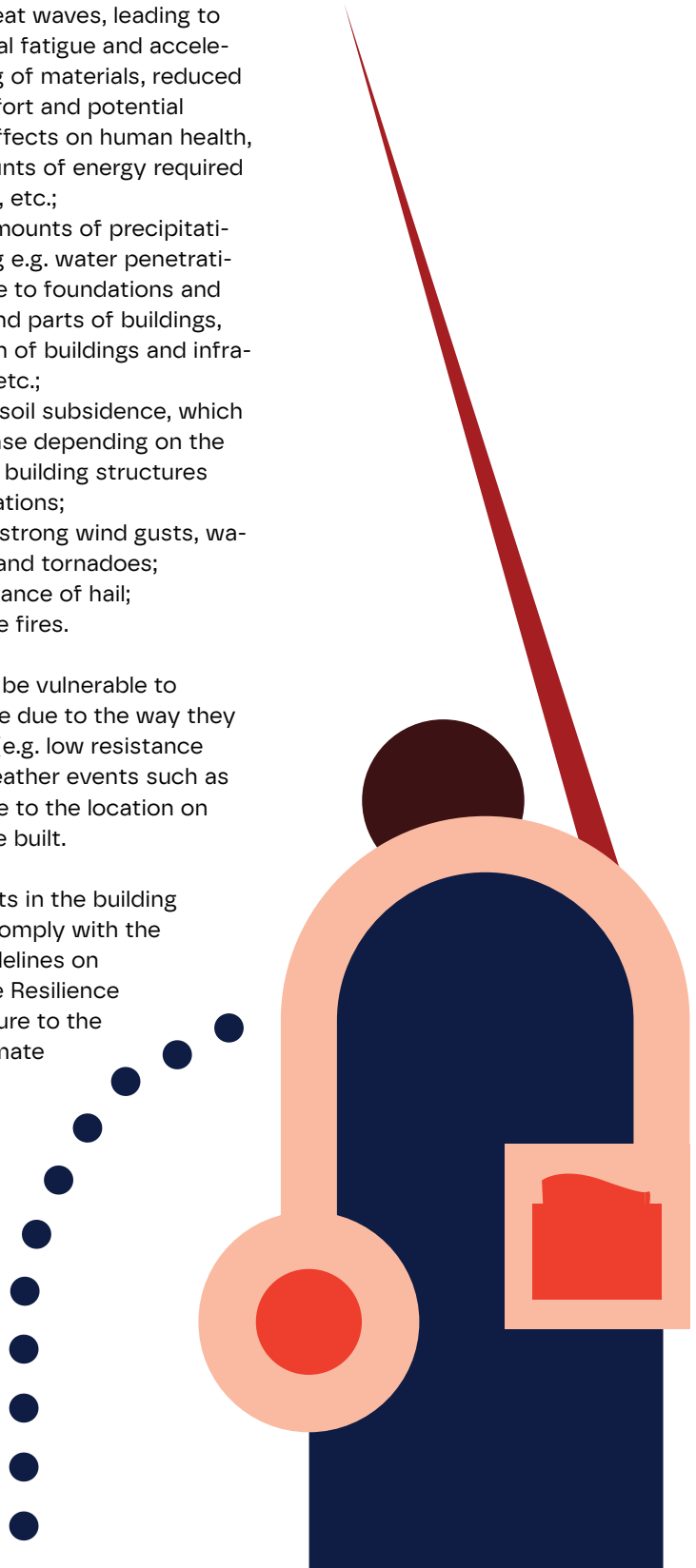


Table 7.1-1
Overview of the impacts and challenges of climate change adaptation in the field of building construction in the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• High energy consumption in the building industry with particularly pronounced losses due to inefficiencies • Poor implementation of energy renovation of residential buildings • Energy poverty • Buildings that are not adapted to climate change	• Strengthening energy independence and efficiency of the private and public buildings sector • Encouraging energy renovation and climate adaptation in the private building sector • Renovation of public buildings

Table 7.1-2
Climate change adaptation measures proposed for the building sector of the City of Zagreb

Measure code	Measure name	Key stakeholders
ZG-01	Automatic and remote monitoring of consumption in public buildings with activities to reduce consumption	GEOS; City offices/institutes or services, budget users and subsidiaries of ZGH d.o.o. responsible for the building; ViO d.o.o.; Gradska plinara Zagreb d.o.o.; HEP Toplinarstvo d.o.o.; HEP Elektra d.o.o.; REGEA
ZG-02	Energy renovation of public buildings owned by the City of Zagreb and companies owned by the City of Zagreb up to nZEB category	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services and Information System and Technical Service; City offices/institutes or services, budget users under whose jurisdiction the building is; GEOS; City Office for Finance and Public Procurement; Office for EU programmes and projects; Institute for Physical Planning of the City of Zagreb; Regea; MRDEUF; Ministry of Physical Planning, Construction and State Assets; EPEEF
ZG-03	Education, Promotion and Encouragment of Energy Efficiency and Raising Awareness of the Impacts of Climate Change for Citizens through the Zagreb Energy Center	GEOS; City offices, institutes and services; GSKG d.o.o.; ZGH d.o.o.; REGEA; civil society associations; EPEEF
ZG-04	System for Monitoring Energy Consumption and Renovation of Commercial and Residential Buildings and Family Houses	GEOS; companies operating commercial non-residential buildings (building managers); MZOZT; APN
ZG-05	Climate validation of infrastructure projects (new construction, reconstruction and upgrading)	GEOS; REGEA; city administrative bodies; city companies and institutions; designers, contractors, supervising engineers
ZG-06	Capital investments related to green infrastructure projects	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; The City Office for Local Self-Government, Civil Protection and Security; GEOS, Councils of City Districts and Local Committees; OCD
ZG-07	Air conditioning of educational institutions owned by the City of Zagreb	City Office for Education, Sports and Youth; GEOS; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Affairs; Information System and Technical Service; REGEA

Building measure

ZG-01

Measure name

Automatic and Remote Monitoring of Consumption in Public Buildings with Activities to Reduce Consumption

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	City offices/institutes or services, budget users and subsidiaries of ZGH responsible for the building	ViO d.o.o. Gradska plinara Zagreb d.o.o. HEP Toplinarstvo d.o.o. Hep Elektra d.o.o. REGEA
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2030	Budget of the City of Zagreb HBOR ESCO EPEEF	6 7 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	50,000	50,000	50,000

Indicators	Initial value (2024)	Target value (2028)
Annual Reports on Consumption Analysis	0	4
Prepared guidelines for reduced consumption	0	1
Implemented training activities for employees and building managers	0	12
Number of digital systems for remote consumption metering	122 (2023)	267

ZG-01

Short description/ comment

The revised Energy Performance of Buildings Directive (2018) introduces an indicator of the building's preparedness for smart technologies, which assesses the building's capacity to adapt to the needs of occupants and the grid, thus improving its energy efficiency and overall performance of the building. The methodology for calculating the indicator takes into account smart metering, automation and control systems, self-regulating and temperature control systems, electric vehicle battery charging stations, energy storage and the interoperability of all these systems.

The measure involves the installation of a device for remote reading of energy consumption in real time, automation of data collection and analysis, and the implementation of measures to increase energy efficiency. Systematic collection of data on electricity, heat, gas and water consumption encourages energy-efficient behaviour and opens the possibility of achieving savings of up to 5%. A number of the City of Zagreb's public-use buildings have remote reading systems in line with existing legal obligations for installing such systems once a defined annual consumption is exceeded, while in all facilities the consumption is monitored on a monthly and annual basis. Particular emphasis should be placed on the maintenance of existing remote sensing systems, strengthening of the system for automatic collection and analysis of consumption data, and on training employees and staff responsible for building management and maintenance.

Along with the remote reading of consumption system and automatic monitoring and analysis of consumption in public buildings, the measure also envisages an analysis of the implementation of low-capital activities for energy and water saving – such as staff training and systematic temperature management within the building, regular maintenance of certain heating, cooling and ventilation systems, etc., the use of more efficient taps and inspection of pipes for leaks, optimization of water heating systems, replacement of lighting with more energy-efficient alternatives, etc. To support the implementation of this activity, the issuance of guidelines and staff training is also proposed.

Key activities

- Installation and maintenance of a system for remote reading of energy and water consumption
- Automatic monitoring of energy and water consumption and preparation of annual consumption reports
- Developing guidelines for lower energy and water consumption in buildings, as well as staff and employee training
- Analysis of proposed low-capital activities for energy savings per individual buildings

Building measure

ZG-02

Measure name

Energy Renovation of Public Buildings Owned by the City of Zagreb and Companies Owned by the City of Zagreb up to nZEB Category

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services and Information System and Technical Service	City offices/institutes or services, budget users responsible for the building GEOS City Office for Finance and Public Procurement EU Programs and Projects Office Institute for Physical Planning of the City of Zagreb REGEA	MRDEUF Ministry of Physical Planning, Construction and State Assets EPEEF

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2030	Budget of the City of Zagreb State budget EU funds EFSI/PPP (ESCO) EIB/HBOR PDA (e.g. ELENA Horizon Europe (through PDA and Smart City) Commercial bank funds	4 7 9

Estimation of required funds (EUR)	2025	2026	2027	2028
	30,000,000	96,000,000	31,000,000	31,000,000

Indicators	Initial value (2024)	Target value (2028)
Number of energy-renovated public buildings to the nZEB category	82	120
Number of individual activities carried out with the aim of achieving energy efficiency	0	200

ZG-02

Short description/ comment

As buildings are the largest energy consumers and account for 36% of EU-wide CO2 emissions and approximately 31% at the level of the City of Zagreb, this measure will contribute to the European Union's goals for a sustainable, safe and decarbonized energy sector by 2050, with the scope of this document aligns with short-term targets (by 2030). The revised Energy Performance of Buildings Directive envisages a highly energy-efficient and decarbonized building sector, while this measure foresees measurable, targeted activities that will contribute to reducing energy demand for heating/ cooling. Given the fact that the revision of the said Directive introduces the obligation to develop a Building Renovation Strategy at the national level, this specific measure will, given the share of buildings owned by the City of Zagreb, significantly contribute to the achievement of the goals of the strategy. The scope of activities is broad and the measure itself is capital-intensive, making it is necessary to plan the use of financial mechanisms, support from structural funds and the involvement of financial institutions and private capital for implementation. It is therefore appropriate to develop the project as a strategic project, in cooperation with the competent state institutions and in the process of programming for the financial perspective 2021-2028.

The measure entails a cost-effective transformation of buildings to the nZEB standard by implementing the following activities:

- Energy audits and certification of buildings
- Renovation of the building envelope - improving the thermal protection of the envelope by adding, renewing or replacing parts of the building that form part of the envelope of the heated or cooled part of the building, such as windows, doors, transparent facade elements, thermal insulation of floors, walls, ceilings, flat, sloping and rounded roofs, covers and waterproofing
- Installation of a new high-efficiency heating system or improvement of an existing one
- Replacement of the existing domestic hot water system with a system that uses RES such as solar collectors
- Replacing or introducing a cooling system with a high-efficiency system or improving an existing one
- Replacement or introduction of a high-performance ventilation system or improvement of an existing one
- Replacing indoor lighting with more efficient lighting
- Installation of photovoltaic modules for the production of electricity from RES for ETC purposes
- Introduction of building automation and management system
- Design and installation of equipment for compliance with the building's smart readiness indicator that assesses the building's readiness to adapt to the needs of users and the network
- Installation of sensors and equipment for smart power management and remote reading of consumption
- Installation of heat pumps for heating and hot water preparation
- Installation of reactive energy compensators.

The implementation of energy renovation of buildings is a lengthy process given the available number of contractors on the labor market; certain energy efficiency measures should be implemented individually in order to achieve emission reductions and lower energy costs as soon as possible.

Key activities

Renovation of individual buildings
Implementation of individual energy efficiency measures

Building measure

ZG-03

Measure name

Education, Promotion and Encouragment of Energy Efficiency and Raising Awareness of the Impacts of Climate Change for Citizens through the Zagreb Energy Center

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	City offices, institutes and services GSKG d.o.o. ZGH d.o.o. REGEA City Office for Asset Management and Housing	Civil Society Associations EPEEF

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
Ongoing	Budget of the City of Zagreb EU funds	1 7 9 12 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	120,000	35,000	35,000	35,000

Indicators	Initial value (2024)	Target value (2028)
Zagreb Energy Centre established	0	1
Conducted workshops and other promotional activities related to energy renovation and efficiency	0	100
Number of co-owners' representatives who, with the support of the Zagreb Energy Center, implemented energy renovation on multi-apartment buildings and family houses	0	40
Counselling of households in energy poverty	0	400

ZG-03

Short description/ comment	This measure establishes the Zagreb Energy Center as a “one-stop-shop” with the aim of informing citizens about climate adaptation, increasing energy efficiency and encouraging the use of renewable energy sources. The communication strategy will determine how to approach citizens as key actors in reducing emissions in residential buildings, including single-family houses. The Zagreb Energy Week will be designed and implemented, while educational activities aimed at citizens and representatives of co-owners will be implemented throughout the year. The Energy Renovation Programme for multi-apartment buildings and family houses in the City of Zagreb will be developed, with the aim of supporting citizens in the energy renovation process, as well as increasing and accelerating energy renovation in the building sector through targeted measures such as counselling, co-financing, etc.
Key activities	• Establishment of the Zagreb Energy Center for energy counselling of citizens and representatives of co-owners • Development of a communication strategy • Implementation of workshops, lectures and forums on energy renovation, energy efficiency, climate adaptation, climate resilience in building, etc. • Organizing the Zagreb Energy Week • Development of the Energy Renovation Programme for multi-apartment buildings and family houses in the City of Zagreb • Development of promotional and educational materials • Counselling of households in energy poverty

Building measure

ZG-04

Measure name

System for Monitoring Energy Consumption and Renovation of Commercial and Residential Buildings and Family Houses

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
	REGEA City authorities Urban companies and institutions City Office for Asset Management and Housing	HEP ODS Energy supply companies ViO d.o.o. HEP Toplinarstvo d.o.o.

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2030	City Budget State budget EU funds	7 8 9

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	100,000	100,000	100,000

Indicators	Initial value (2024)	Target value (2028)
Number of years with data on energy consumption in the Energy Atlas for the City of Zagreb	8	14
Installed renewable energy sources (in MW) through energy cooperatives and communities	0	2

ZG-04

Short description/ comment

The building sector at the level of the City of Zagreb is responsible for approximately 31% of greenhouse gas emissions, mainly due to inefficient energy consumption. This includes family houses, multi-apartment buildings, as well as commercial buildings.

In line with the long-term goal of decarbonising Europe by 2050, it is also important to make significant investments in monitoring consumption (and consequently emissions) in the building sector, as well as in energy renovation and the introduction of energy efficiency measures in the private building sector. This measure provides for the upgrading and use of the Energy Atlas of the City of Zagreb, a previously developed platform for monitoring energy consumption to the level of the accounting point. The tool would be further developed in the direction of the planning tool, with its functionalities to include certain elements of monitoring climate parameters, while further development would focus on turning it into a decision-making tool for investments related to the energy transition and adaptation to the effects of climate change.

Based on the collected data and annual analysis, changes in energy consumption in buildings would be monitored in line with the implementation of energy renovation or similar measures that will have an impact on energy consumption. The analysis could also determine the impact of spatial interventions (e.g. greening of public areas in the immediate vicinity of the building) on overall energy consumption.

Key activities

- Update and development of the Energy Atlas of the City of Zagreb
- Analysis of energy consumption in the building sector
- Development of a system for monitoring consumption and reporting emissions of commercial buildings
- Identifying the buildings with the highest potential to achieve energy savings, reduce emissions or produce energy from renewable sources
- Encouraging and developing energy cooperatives and communities

Building measure

ZG-05

Measure name

Climate Validation of Infrastructure Projects (New Construction, Reconstruction and Upgrading)

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	REGEA City authorities Urban companies and institutions	Designers, contractors, supervising engineers

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-ongoing	Budget of the City of Zagreb EU funds EIB Promotional bank loans (EIB/HBOR/EBRD) Commercial bank loans	9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	350,000	350,000	300,000	300,000

Indicators	Initial value (2024)	Target value (2028)
Technical documentation on adaptation to the effects of climate change for infrastructure projects	40	500

ZG-05

Short description/ comment	Climate validation is a process that ensures that infrastructure is resilient to the expected impacts of climate change. The process itself is described in the Technical Guidance on Climate Proofing of Infrastructure 2021-2027 [40], and has two main components: the monetization of greenhouse gases and the adaptation of infrastructure to the expected effects of climate change. It is necessary to establish a systematic approach to climate validation so that the process takes place in a timely manner, from the preliminary design phase onwards, with the development of detailed calculations of the cost of infrastructure adaptation for each project separately.
Key activities	• Preparation of technical documentation for adaptation to the effects of climate change for all infrastructure projects • Calculation of the cost of adaptation to the effects of climate change and monetization of greenhouse gas emissions

Building measure

ZG-06

Measure name

Capital investments related to green infrastructure projects

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services City Office for Municipal Self-Government, Transport, Civil Protection and Safety	GEOS Neighbourhood Councils and Local Committees OCD Hrvatske vode	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2028	Budget of the City of Zagreb EU funds	6 8 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	395,000	50,000	50,000	1,000,000

Indicators	Initial value (2024)	Target value (2028)
Implementation of tenders or public procurement procedures for the development of public green spaces	0	12
Conducting tenders for the development of urban park areas	0	5
Implementation of landscaping or renovation of public green spaces	0	12
Construction of a new city park	0	1
Renovated existing city park	0	3
Development of a sports and recreational zone	0	2
Greening the area along watercourses and decorating promenades and living spaces	0	2

ZG-06

Short description/ comment	Development of new and renovation of existing city-level parks: • implementation of tenders in areas where their conduct is mandatory • construction of new parks • renovation of existing parks • development of sports and recreational zones • greening the area along watercourses and decorating promenades and living spaces • green transformation of major infrastructure areas Development of atlases of existing projects and bases related to the development of green infrastructure: • Identification of existing projects of varying stages • of readiness by category • List of geolocated initiatives - citizens • List of Municipal Action Plan initiatives • List of city district council and local committee initiatives The implementation of these activities should be planned and coordinated with recognized areas that are specifically highlighted as urban heat islands or at risk of torrential floods and the like, in order to address these hazards as well. Also, it is important to take into account the continuity of green infrastructure in order to achieve the greatest possible benefits.
Key activities	• Development of project documentation and new elements of green infrastructure • Identification of areas suitable for stream renaturation

Building measure

ZG-07

Measure name

Air Conditioning of Educational Institutions Owned by the City of Zagreb

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Education, Sport and Youth	GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services Information System and Technical Service REGEA	Educational institutions owned by the City of Zagreb

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb State budget EU funds	3 4 9 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	250,000	600,000	600,000	350,000

Indicators	Initial value (2024)	Target value (2028)
Prepared analysis of the current state of air conditioning in educational institutions owned by the City of Zagreb and the need for additional air conditioning	0	1
Prepared activity plan for the introduction of air conditioning system in educational institutions owned by the City of Zagreb has been developed	0	1
Share of educational institution facilities owned by the City of Zagreb that have an adequate level of air conditioning	To be determined after the analysis	90

ZG-07

Short description/ comment

This measure is aimed at ensuring uninterrupted educational process in educational institutions (preschool, primary and secondary school) founded by the City of Zagreb during periods of extreme heat.

Taking into account the continuous increase in temperature during all seasons, especially in summer, the increasing occurrence of temperature extremes with positive trends in warm temperature indices (number of warm days and nights and duration of warm periods), as well as increasingly prolonged heat waves, it is necessary to ensure adequate thermal protection in accordance with the prescribed conditions of the National Pedagogical Standard for Preschool Education (Official Gazette 63/2008), the National Pedagogical Standard for the Primary Education System (Official Gazette 63/2008) and the National Pedagogical Standard for the Secondary Education System (Official Gazette 63/2008).

Of the 435 facilities of educational institutions, a total of 327 facilities are fully or partially air-conditioned. The most vulnerable areas for all-day stay are all non-conditioned areas where children and employees of educational institutions spend extended periods of time. The aim is to ensure optimal temperature conditions by air conditioning of non-conditioned and partially air-conditioned facilities of educational institutions owned by the City of Zagreb or by implementing energy renovation measures for buildings.

When it comes to preventing the occurrence of heat islands, it is necessary to plan the design of appropriate air conditioning systems for new kindergartens, primary and secondary schools, as well as the implementation of air conditioning systems in the energy renovation of educational buildings owned by the City of Zagreb.

Key activities

- Preparation of an analysis of the current state of air conditioning of educational institutions owned by the City of Zagreb
- Development of a plan of activities on the introduction of air conditioning systems in educational institutions owned by the City of Zagreb
- Development of project documentation for the introduction of air conditioning systems in educational institutions owned by the City of Zagreb (based on the developed activity plan)
- Commencement of works in accordance with the prepared project documentation

7.2

Energy

The energy sector of the City of Zagreb contributes significantly to greenhouse gas emissions, primarily by heating with natural gas by producing hot water and steam, but also by using electricity, both in households and business premises. Therefore, significant savings in greenhouse gas emissions can be achieved in this sector through the use of renewable energy sources, the development of geothermal energy potential, and the development of a decarbonization plan for heating and cooling systems. In this context, measures are being implemented to increase the share of renewable energy sources in the City of Zagreb.

The main expected impact of climate change on the energy sector of the City of Zagreb will be a decrease in the reliability and availability of energy supply from the national grid due to extreme precipitation, floods and droughts, as well as an increase in consumption during the summer period due to cooling. The increase in temperatures in the winter period will also reduce gas demands, while frequent disruptions in the gas market can also be expected. The deterioration of gas and heating pipelines further increases the risk of extreme events. Given the importance of energy for critical infrastructure such as water supply, it is necessary to ensure energy self-sufficiency from different and decentralized energy sources.

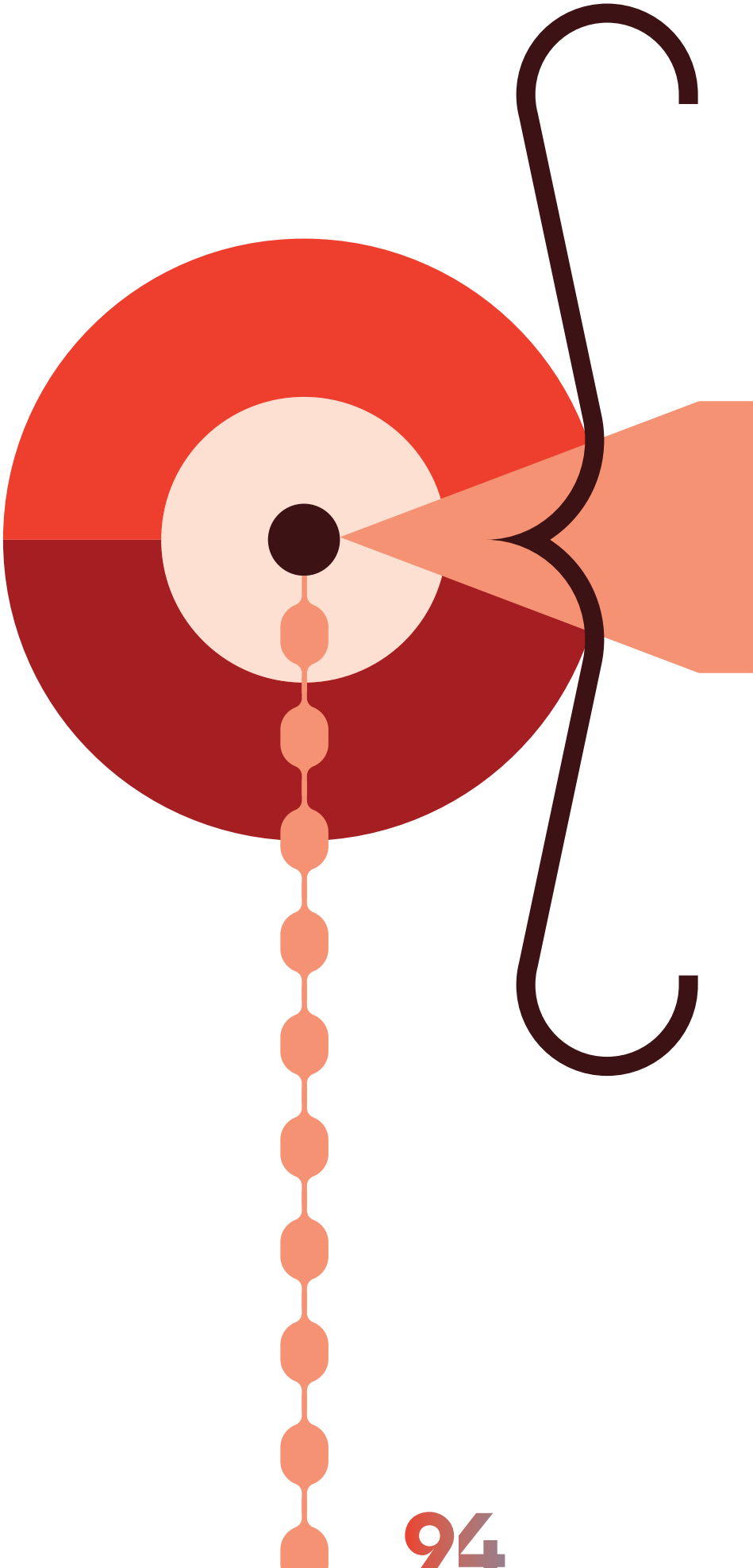


Table 7.2-1
Overview of the impacts and challenges of climate change adaptation in the field of energy in the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• Reduced energy availability due to natural disasters, network overload, market disturbances, etc. • Temperature rise in winter and disturbances in the gas market • Durability of energy distribution infrastructure	• Investment in decentralized production of energy from renewable sources • Better use of existing energy resources • Timely maintenance and monitoring of the state of the energy distribution network

Table 7.2-2
Climate change adaptation measures proposed for the energy sector of the City of Zagreb

Measure code	Measure name	Key stakeholders
EN-01	Development of Local RES Energy Production from RES on Public Buildings in Combination with the Application of Green Infrastructure Elements	GEOS; REGEA; ZSK; City offices, institutes and services that manage buildings in their portfolio; HEP ODS; HEP Toplinarstvo d.o.o.
EN-02	Exploration of geothermal energy potential by evaluating existing and developing new geothermal wells	GEOS; FZOEU; HEP Toplinarstvo d.o.o.; REGEA; EIHP
EN-03	Monitoring of Emissions in the Energy Sector and Development of a Decarbonisation Strategy of Heating and Cooling Systems	GEOS; REGEA; EIHP; Gradska plinara Zagreb; Hep ODS; Hep Toplinarstvo; Hep Proizvodnja
EN-04	Exploitation of landfill gas for thermal energy production	GEOS; Environmental Protection and Energy Efficiency Fund; HEP Toplinarstvo d.o.o.; Čistoća d.o.o.; ZGH d.o.o.; EIHP
EN-05	Implementation of the Program for Combating Energy Poverty	City Office for Social Protection, Health, Veterans and Persons with Disabilities; GEOS; Social Welfare Center of the City of Zagreb; HEP d.d.; building managers

Energy measure

EN-01

Measure name

Development of Local RES Energy Production from RES on Public Buildings in Combination with the Application of Green Infrastructure Elements

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	REGEA ZSK City offices, institutes and services that manage buildings in their portfolio	HEP ODS HEP Toplinarstvo d.o.o.

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-ongoing	Budget of building owners/managers Budget of the City of Zagreb EU funds EPEEF	7 8 9

Estimation of required funds (EUR)	2025	2026	2027	2028
	5,000,000	5,000,000	5,000,000	5,000,000

Indicators	Initial value (2024)	Target value (2028)
Installed power of the renewable energy production system on public buildings	3 MW	17 MW
Installed MW of solar power plants in parking lots	0	2
Feasibility studies on the use of RES	0	200
Pilot solution for RES generation with elements of green infrastructure – GI	0	1

EN-01

Short description/ comment	Climate change could affect the amount of electricity, as well as the heat consumed and the time of energy use, which can adversely affect production and distribution systems due to increasingly frequent extreme weather events. Local energy production has a number of advantages, and in the event of damage to distribution systems or insufficient production due to the unavailability of energy sources for production or water for plant cooling, local production becomes the only option. In the case of combining local energy production from a solar power plant with elements of green infrastructure – GI (bio-solar roof), the effect of one element on the other is synergistic, increasing the efficiency of both systems. The City of Zagreb encourages such technologies in its spatial plans. The assessment of the possibility of applying these technologies is made at the stage of the preliminary design or the process of preparation of the main design.
Key activities	• Installation of solar power plants on public buildings • Installation of solar power plants on existing parking lots and in other areas • Preparation of feasibility studies on the use of RES • Installation of solar collectors or other individual solutions for RES production on public buildings • Development of a pilot solution for RES production from with green infrastructure

Energy measure

EN-02

Measure name

Exploration of Geothermal Energy Potential by Evaluating Existing and Developing New Geothermal Wells

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	EPEEF HEP Toplinarstvo d.o.o. REGEA	AZU Scientific institutions such as the Faculty of Mining, Geology and Petroleum Engineering, Energy Institute Hrvoje Požar

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2030	Budget of the City of Zagreb Concession holder assets Horizon Europe PPP EIB	7 8 9

Estimation of required funds (EUR)	2025	2026	2027	2028
	73,000	65,000	300,000	300,000

Funds are allocated for the preparation of preliminary studies and reports. Exploration and drilling costs will depend on site preparation, well depth, drilling service costs, tools and equipment installed in the well, type and power of the drilling rig, as well as issues that may arise during drilling (e.g. loss of mud circulation, tool jam, instrumentation), etc.

Indicators	Initial value (2024)	Target value (2028)
Locating new exploration wells	0	4
Well sampling	0	8

EN-02

Short description/ comment	The research is focused on determining the size and flow characteristics of geothermal reservoirs and the temperature gradient that meets the conditions for exploiting energy from geothermal sources. As part of the measure, it is necessary to make an assessment of the possibilities for supplying users with geothermal energy, i.e. the number and size of potential consumers, the distance of consumers from the geothermal field and production wells, and the complexity of the implementation of the technological system (direct or indirect system, cascading exploitation of geothermal energy, etc.). For efficient heating systems, the temperature of the geothermal water should be between 70 °C and 90 °C. Innovative achievements in the world allow the use of geothermal energy in central heating systems with starting temperatures of only 60°C. The implementation of the research should be based on a multidisciplinary expert analysis using all available data, as well as previously conducted analyses and research.
Key activities	Data required to estimate geothermal potential: • determining the locations of new exploration wells based on geological maps, forecast geological columns, tectonic data, seismic profiles, urban and spatial plans • geophysical surveys (logging measurements, electromagnetic methods, geoelectric, gravimetric, seismic methods) • analysis of data and sampling from existing (reference) wells and correlation of data with exploration wells • determination of characteristics of reservoir rocks (average values of thermal conductivity and thermal capacity, possibility of existence of aquifers with geothermal water, determination of associated hydrodynamic units) • drilling of directional and horizontal wells in order to capture reservoirs with the best collector properties.

Energy measure

EN-03

Measure name

Monitoring of Emissions in the Energy Sector and Development of a Decarbonisation Strategy of Heating and Cooling Systems

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	REGEA Gradska plinara Zagreb HEP ODS HEP Toplinarstvo HEP Proizvodnja HEP ODS	Building managers Academic community (Faculty of Electrical Engineering and Computing, Faculty of Mechanical Engineering and Naval Architecture) NGOs and civil society representatives
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-ongoing	HEP ODS HEP Proizvodnja d.o.o. ZSK d.o.o. Budget of the City of Zagreb EU funds Promotional bank loans (EIB/HBOR/EBRD) Commercial bank loans	7 8 9 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	70,000	200,000	300,000	70,000

Indicators	Initial value (2024.)	Target value (2028.)
Heating and cooling system decarbonisation plan developed	0	1

EN-03

Short description/ comment	A Heating and Cooling System Decarbonisation Plan will be developed in accordance with the obligation provided for in the latest version of the Energy Efficiency Directive, which obliges all cities with more than 45,000 inhabitants to develop heating and cooling plans. This plan will contain at a minimum a baseline emission inventory, decarbonisation scenarios that will include district heating options, as well as individual and smaller centralized systems options, implementation mechanisms and an analysis of the resources required, as well as potential sources and financing mechanisms for these scenarios. The plan will also contain qualitative and quantitative objectives, as well as measures to monitor the effectiveness of implementation. For the purposes of developing the Plan, the City of Zagreb Energy Atlas will be used and all key stakeholders, including HEP Toplinarstvo, Gradska plinara Zagreb and Building Managers, will be involved in the process from the beginning.
Key activities	• Updating the energy model of the City of Zagreb and further elaboration of scenarios for achieving climate neutrality • Development of the Decarbonization Plan for the Heating and Cooling System of the City of Zagreb • Update of the City of Zagreb Greenhouse Gas Emissions Inventory with data for 2023 and 2024 • Development of an interactive platform containing historical data from the energy balance and inventory of the City of Zagreb and estimates of future production and consumption up to 2050. • Regular obtaining of meteorological data from DHMZ

Energy measure

EN-04

Measure name

Exploitation of Landfill Gas for Thermal Energy Production

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	EPEEF HEP Toplinarstvo d.o.o. Čistoća d.o.o. ZGH d.o.o.	-

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2027	Concession holder assets Horizon Europe Public-private partnership EIB	7 8 9

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	250,000	250,000	250,000

Indicators	Initial value (2024.)	Target value (2028.)
Construction of a heating pipeline	0 m	550 m
Delivery of thermal energy of the gas plant to the HEP Toplinarstvo system	0	2.5 MW_t
Construction of the heat exchanger on the generator plant 3	0	1

EN-04

Short description/ comment	The Prudinec-Jakuševec landfill managed by Čistoća requires continuous degassing in order to control the amount of landfill gas and the concentration of methane and other gases in the landfill. By combustion in gas engines, landfill gas is used to generate electricity in four generator systems. During the process of gas combustion in engines, thermal energy is released, which is not utilized within the existing system and thus represents a potential for use within the district heating network of HEP Toplinarstvo in the Jakuševec area. The use of local heat sources is in line with the goal of strengthening energy independence.
Key activities	• In order to distribute thermal energy, the cooling system of the third generator plant must be upgraded with a water-to-water heat exchanger that will be carried out within the existing generator in such a way that the equipment is installed inside and on the roof of the existing container. • The heat exchanger through which the generator's cooling water heat will be delivered to the central heating system of HEP Toplinarstvo must be built as a separate system. • To connect the plant to the district heating system of HEP Toplinarstvo, it is necessary to build a heating pipeline approximately 550 m in length. • Plan the installation of a heat pump that will cover the peak load in the winter period.

Energy measure

EN-05

Measure name

Implementation of the Program for Combating Energy Poverty

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	City Office for Social Protection, Health, War Veterans and People with Disabilities Croatian Institute for Social Work HEP d.d. building managers	Civil Society Associations EPEEF

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
Ongoing	Budget of the City of Zagreb EU funds	1 3 7 10 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	300,000	300,000	300,000	300,000

Indicators	Initial value (2024)	Target value (2028)
Distributed energy packages	0	4000
Replaced household furnaces and appliances	0	1000
Co-financed energy renovation of apartments and family houses	0	3000
Number of applied RES for energy-poor households	0	8000

EN-05

Short description/ comment

The City of Zagreb has adopted the Energy Poverty Reduction Programme for its area by 2030. Energy poverty is described as the inability of households to ensure socially adequate living conditions by using the necessary amounts of electricity and thermal energy to achieve the required level of temperature, humidity and illumination of living spaces.

The main causes of energy poverty are as follows: poor energy efficiency of buildings, heating and cooling systems and household appliances, relatively high energy costs in relation to income, lack of access to basic energy services, inability to manage consumption and measure energy consumption, and low energy literacy.

According to key indicators of energy poverty, in 2021 in the Republic of Croatia, almost 16.6% of households were late with paying their energy bills, and just under 5.7% were unable to keep their home adequately warm. In the absence of indicators measured specifically for the area of the City of Zagreb, until their determination, taking into account the lower unemployment rate and higher average income in relation to the population of the Republic of Croatia, it can be conservatively assumed that at least 5% of the population in the area of the City of Zagreb is affected by energy poverty.

The Energy Poverty Programme envisages the development of a system for the collection and monitoring of data on energy poverty, co-financing of energy consulting, energy packages, replacement of home furnaces and household appliances with more efficient ones; co-financing of renewable energy sources and energy renovation of multi-apartment buildings and family houses for families affected by energy poverty.

Key activities

- Determining the definition of energy poverty
- Establishment of an energy poverty data monitoring system
- Distribution of the energy package, i.e. the package for energy-poor consumers
- Encouraging the replacement of household furnaces and appliances with more efficient ones
- Co-financing the use of RES
- Co-financing energy renovation

7.3

Transport

Motor transport is one of the major sources of greenhouse gas emissions, with the main share of emissions stemming from the passenger vehicle sector. This is why mitigation measures are extremely important here, primarily aimed at reducing greenhouse gas emissions from passenger vehicles, which is achievable by placing strong emphasis on public transport and sustainable mobility.

In the context of transport and climate change adaptation, a significant risk for the transport sector arises from the susceptibility to urban floods, as well as heat waves, especially for public urban transport infrastructure, as well as emergency services transport. The high level of road infrastructure development and a large share of asphalt surfaces increase the risk of flooding and intensify the effect of heat islands. The lack of developed infrastructure for sustainable mobility conditions dependence on the car, creating a feedback loop with high emissions from motor transport and air quality. An additional risk also arises due to the high dependence on road infrastructure, since in the event of an extreme event there are no alternative routes (e.g. unobstructed cycling tracks or pedestrian corridors) available for emergency services.

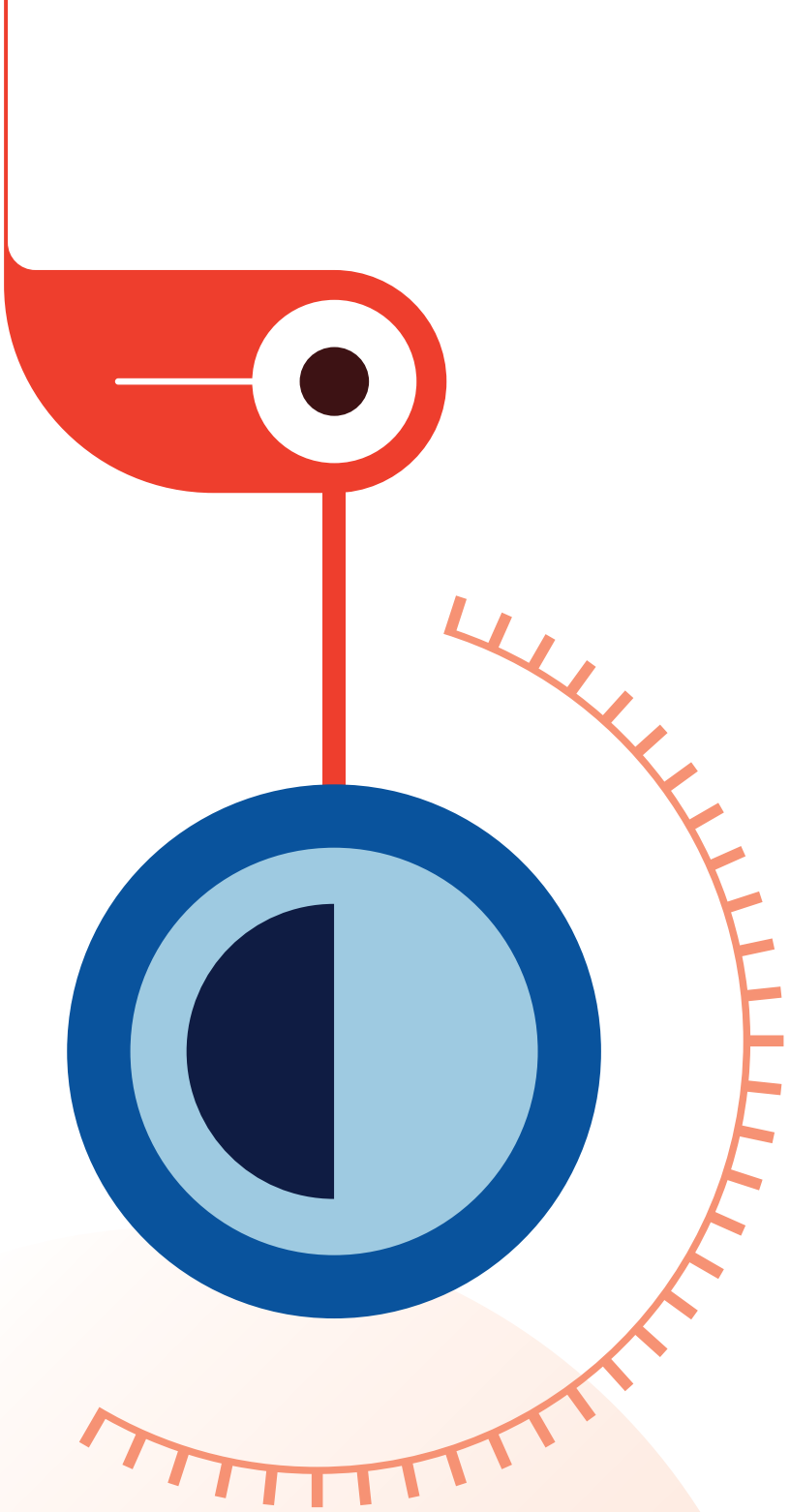


Table 7.3-1
Overview of the impacts and challenges of climate change adaptation in the field of transport in the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• High rate of greenhouse gas emissions from motor vehicles • Significant vulnerability to flooding and the intensified impact of heat islands from paved surfaces • Lack of safe infrastructure for the use of sustainable mobility • Traffic congestion without developed alternatives	• Development of public urban transport infrastructure • Development of sustainable mobility infrastructure • Reducing dependence on motor vehicles • Expanding the network of pedestrian areas and developing facilities

Table 7.3-2
Climate change adaptation measures proposed in the transport sector of the City of Zagreb

Measure code	Measure name	Key stakeholders
PR-01	Increasing the frequency and reliability of public transport	City Office for Local Self-Government, Civil Protection and Security; GEOS; Zagrebačke ceste; Ministry of the Interior of the Republic of Croatia (MUP); IPZP
PR-02	Development of the Public City Bicycle System	City Office for Municipal Self-Government, Transport, Civil Protection and Safety
PR-03	Improvement of the Tram Electric Power System in Order to Improve the Public Service	ZET d.o.o.; City Office for Local Self-Government, Civil Protection and Security; GEOS; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services
PR-04	Development of an integrated passenger transport system in the City of Zagreb, Zagreb County and Krapina-Zagorje County	PZP d.o.o.; GEOS; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; City Office for Reconstruction, Development, Physical Planning, Construction, Utility Services and Transport; ZET d.o.o.; HŽ Infrastruktura d.o.o.; HŽ Putnički prijevoz d.o.o.; Transport service providers on request (taxis); Car sharing service providers
PR-05	Development of a network of pedestrian and cycling corridors and zones, together with accompanying infrastructure	City Office for Municipal Self-Government, Transport, Civil Protection and Safety; GEOS; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; Zrinjevac; Ministry of the Interior
PR-06	Establishment of a single system for smart management of automotive traffic and public transport	City Office for Municipal Self-Government, Transport, Civil Protection and Safety; GEOS; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; Zrinjevac; Ministry of the Interior
PR-07	Greening grey infrastructure	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; ZGH; Zagrebačke ceste; Zrinjevac; City Institute for the Conservation of Cultural and Natural Heritage

Transport measure

PR-01

Measure name

Increasing the Frequency and Reliability of Public Transport

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
ZET d.o.o.	City Office for Municipal Self-Government, Transport, Civil Protection and Safety GEOS Zagrebačke ceste Ministry of the Interior of the Republic of Croatia (MUP) IPZP d.o.o.	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	City Budget State budget EU funds ZET d.o.o.	3 7 9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	62,500,000	103,300,000	107,650,000	90,850,000

Indicators	Initial value (2024)	Target value (2028)
Number of transported passengers	163,000,000 (2023)	180,000,000
Number of vehicles (buses and trams)	783 (2023)	900
Number of bus and tram departures on selected lines	Bus - 9565 (with night lines) Tram - 3607 (with night lines)	Bus - 10184 (with night lines) Tram - 3681 (with night lines)

PR-01

Short description/ comment

In the transport sector, a large part of emissions come from personal motor vehicles. According to the National Institute of Statistics data, personal vehicles are frequently used for trips averaging up to 5 km, which means that a large number of car trips cover distances considerably shorter than 5 km. These trips have the greatest potential to be replaced by public urban transport, as well as other forms of active mobility, with the main obstacle being the excessive unreliability of public urban transport and the low frequency of bus services. If the shift from private vehicles to public transport is to be encouraged, it is necessary to strengthen the competitiveness of public transport in relation to passenger cars. This can be achieved by separating public urban transport from car traffic by yellow lanes in order to enhance the timetable reliability, along with the control of yellow lanes. Furthermore, a rapid increase of the frequency of departures on the routes is required, which can only be achieved by investing in the number of vehicles and drivers, all with the aim of making public urban transport more attractive for shorter distances. In the short term, these goals can be achieved through significant investments in the existing type of public transport vehicles for which infrastructure is already in place, while reductions in emissions can be achieved by reducing the use of personal vehicles. In the long term, it is necessary to carry out an analysis of the possibilities for using innovative propulsion systems in public urban transport (electric batteries and hydrogen) and to expand the tram line in order to enable access to public transport system for as many citizens as possible.

Key activities

- Developing a plan for expanding the yellow lane network
- Developing a procurement plan for used and new public transport vehicles
- Developing a scholarship programme for bus and tram drivers
- Establishing a yellow lanes control programme
- Developing a plan for the expansion of the tram line and bus network
- Analysing the possibility of using public urban transport propulsion systems without reduced emissions
- Strengthening the capacity of traffic wardens and the service responsible for the removal of illegally parked vehicles

Transport measure

PR-02

Measure name

Development of the Public City Bicycle System

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety	GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services Zrinjevac MUP ZET HŽ	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-ongoing	City Budget	3 8 9 11 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	2,500,000	2,500,000	2,500,000	2,500,000

Indicators	Initial value (2024)	Target value (2028)
Number of stations of the public city bicycle system	0	180
Number of public city bicycles	0	3000
Promotional campaigns for the use of the public bicycle system	0	3

PR-02

Short description/ comment	The bicycle is becoming an increasingly important means of urban transport, regardless of meteorological conditions and the season, requiring little urban space and bringing numerous benefits to both individuals and society as a whole, from financial to health-related. Therefore, in order to reduce traffic congestion, delays in reaching the desired destination, peak-hour traffic jams, living costs and harmful gas emissions, the bicycle has been recognized as an attractive and desirable form of transport. Many European cities already have a developed public bicycle system, either as a commercial activity or as a form of public-private partnership. In Zagreb, an increasing number of people use bicycles for commuting and other activities, which is especially noticeable in parts of the city where cycling infrastructure enables the opportunity to quickly pass through urban traffic. The development of a public bicycle system would significantly contribute reducing emissions from motor traffic and represents a key step in the development of sustainable mobility.
Key activities	• Preparation of technical documentation for public bicycle system stations • Preparation of a development plan for the public bicycle system network • Promoting the system and integration with other forms of transport

Transport measure

PR-03

Measure name

Improvement of the Tram Electric Power System in Order to Improve the Public Service

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
ZET d.o.o.	City Office for Municipal Self-Government, Transport, Civil Protection and Safety GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2027	City Budget State budget EU funds EPEEF	9 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	3,775,000	8,700,000	2,500,000	1,900,000

Indicators	Initial value (2024)	Target value (2028)
Procurement of a mobile rectifier station	0	3
Renovation of existing rectifier stations	2	10

PR-03

Short description/ comment

Efficient tram traffic requires sufficient energy. In order to continue the long-standing tradition of high-quality tram transport services in the City of Zagreb, it is necessary to improve the electricity system. The analysis has determined that it is necessary to improve the following parts of the system:

- rectifier and transformer stations with associated equipment;
- networks of power supply (+) and return (-) power cables;
- tramway overhead contact networks (tram contact network sectors, associated poles and consoles of the overhead contact network, cathodic surge arresters and connection points, suspension equipment, disconnectors and switches signaling on the network);
- tramway cross ties (devices for automatic control of cross ties, cross tie set-up devices with drives, devices for regulating the heating of cross ties and cross tie heaters, signal devices and announcement of the arrival of tram vehicles on the overhead contact line).

In addition to system improvements, it is necessary to implement an energy monitoring and management system.

The implementation of the measure will achieve the following positive effects:

- reduction of energy consumption and reduction of CO_2 emissions;
- increase in traffic capacity and average speed of trams;
- reduction of costs related to traction energy and reduction of maintenance costs;
- increase in the attractiveness of tram traffic and increasing the number of passengers transported per km.

Key activities

- Procurement of a mobile rectifier station
- Upgrading and renovation of existing rectification stations

Transport measure

PR-04

Measure nama

Development of an Integrated Passenger Transport System in the City of Zagreb, Zagreb County and Krapina-Zagorje County

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
IPZP d.o.o.	GEOS City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services ZET d.o.o. HŽ Infrastruktura d.o.o. HŽ Putnički prijevoz d.o.o. On-demand transportation providers (*taxis*) Car sharing providers	Ministry of the Sea, Transport and Infrastructure (MMPI) Krapina-Zagorje County Zagreb County

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2030	City Budget State budget EU funds Budget of ZET d.o.o. HŽ Infrastruktura d.o.o. HŽ Putnički prijevoz d.o.o. On-demand transportation providers (*taxis*) Car sharing providers EIB/EBRD/HBOR Commercial banks	8 9 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	10,000,000	10,000,000	10,000,000	10,000,000

Indicators	Initial value (2024)	Target value (2028)
Establishment of a passenger information system by phases (a total of 4 phases within 48 months)	0	3
Establishment of a single ticket billing and control system (project phases in 4 phases, 48 months)	0	3
Optimizing the existing network of lines	1	3

PR-04

Short description/ comment	For longer-distance trips between Zagreb County, Krapina-Zagorje County and the City of Zagreb, the use of personal vehicles with a low occupancy rate remains frequent, leading to high greenhouse gas emissions. Therefore, it is necessary to strengthen the interconnection of major urban centers, which also entails the integration of several different forms of public transport. Activities need to be undertaken to enable easier travel planning with several forms of public transport (rail, tram, bus, public cycling system) through a unified common ticketing system with a single ticket, all based on harmonized timetables. This significantly increases the quality of public transport services, leading to an increase in the number of users and a decrease in the use of personal vehicles, ultimately resulting in a decrease in CO_2 emissions and a greater safety of all traffic participants
Key activities	• Introducing a single timetable • Introducing a unified passenger information system • Introducing a unified tariff policy • Establishing a single ticketing system

Transport measure

PR-05

Measure name

Development of a Network of Pedestrian and Bicycle Corridors and Zones with Supporting Infrastructure

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety	GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services Zrinjevac MUP	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-ongoing	City Budget EU funds	3 8 9 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	8,000,000	8,000,000	8,000,000	8,000,000

Indicators	Initial value (2024)	Target value (2028)
Length of pedestrian zones	5	10
Length of cycling routes	1700	1800
Number of pedestrians and cyclists harmed in traffic (MO)	384 P + 190 B (2023)	300 P + 150 B
Number of bicycle parking lots (stands)	1700	3000

PR-05

Short description/ comment	As part of the development of the transport system, it is necessary to develop cycling and pedestrian infrastructure in order to increase the share of cycling and walking in traffic, which results in a reduction in greenhouse gas emissions, i.e. mitigation of climate change. For this reason, it is necessary to plan the development of pedestrian zones and zones of reduced intensity of motor traffic in residential zones, together with the connection of major urban centers with cycling infrastructure, in such a way that space predominantly intended for motor traffic is redistributed to provide an equal share for sustainable modes of transport. As part of the repurposing of space, it is necessary to provide for green infrastructure to make this space more pleasant and to mitigate the impact of heat islands, whereby green infrastructure can also be used to slow down motor traffic where necessary. The analysis should designate urban centers of special interest as pedestrian zones, plan the development of infrastructure for sustainable transport that will connect the selected centers, and include the renewal of centres with green solutions and infrastructure. An important factor is the safety of traffic participants who rely on sustainable mobility. Therefore, pedestrian and cycling corridors, urban centers, exclusively residential areas or spaces next to schools and kindergartens should be regulated as speed reduction zones for motor vehicles (30 km/h limit) with the implementation of such rules in cooperation with the Ministry of the Interior.
Key activities	• Preparation and implementation of a plan for expanding the cycling lane network • Preparation of guidelines for the development and arrangement of pedestrian zones and the plan for the expansion of the pedestrian zone • Updating cycling infrastructure databases • Introduction of 30 km/h restriction zones

Transport measure

PR-06

Measure name

Establishment of a Unified System for Smart Management of Automotive Traffic and Public Transport

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety	GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services Zrinjevac MUP	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-ongoing	City Budget	3 8 9 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	15,800,000	25,800,000	30,800,000	15,800,000

Indicators	Initial value (2024)	Target value (2028)
Number of corridors with public transport prioritization	0	5
Installing traffic count sensors	5	150
Connecting key stakeholders into a single Automatic Traffic Management system	2	10
Pollution reduction (CO_2, noise, NO_x) on smartly managed routes	–	– 5%

PR-06

Short description/ comment	The unified system for smart management of road traffic and public urban transport is the central place of integration of all data and the place of coordination of all traffic actions. It defines functionalities and technologies, as well as methods of connecting with existing sectoral sub-centers, as well as the hierarchy, availability and modification of data. It consists of the following elements: main traffic center, traffic light subsystem, traffic demand service, variable traffic signs service, video surveillance service, public traffic management service, VIP route service, parking management service, referral parking system service, meteorological system service, travel and pre-trip information service and electronic payment service. In addition, a mobile air quality control and monitoring station would enable traffic management with the aim of reducing pollutants.
Key activities	• Prioritizing public transport corridors • Sensor Traffic Counting • Establishment of a smart traffic management system • Establishment of a mobile station for air quality control and monitoring

Transport measure

PR-07

Measure name

Greening grey infrastructure

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; City Office for Municipal Self-Government, Transport, Civil Protection and Safety	ZGH Zagrebačke ceste Zrinjevac	City Institute for the Conservation of Cultural and Natural Heritage Public institutions
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2028	Budget of the City of Zagreb EU funds	3 9 11 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	500,000	500,000	500,000	500,000

Indicators	Initial value (2024)	Target value (2028)
Development and implementation of the project of greening city streets (km)	0	4
Development and implementation of the project of reconstruction of a street block and expansion of the pedestrian zone (km)	0	1
Development and implementation of the project for the reconstruction of an existing parking lot of larger dimensions (m^2)	0	2
Development and implementation of a roundabout reconstruction project	0	5
Development and implementation of green roof and facade design (m^2)	0	1

PR-07

Short description/ comment	The aim of the measure is to reduce the heat island effect by greening gray infrastructure and other biotechnical solutions and addressing identified areas susceptible to the heat island effect by developing green infrastructure. Climate change mitigation measures (planting, nature-based solutions, etc.) will be applied in priority areas - such as downtown blocks without vegetation. Plans include greening the facades and roofs of public buildings, especially those facing the street, greening streets (interpolation of greenery into existing streets and improvement and expansion of green corridors), greening and reconstruction of entire street blocks with the expansion of the pedestrian zone, greening of parking lots by introduction of vegetation and changing the way rainwater is managed and greening of roundabouts.
Key activities	• Development and implementation of the project for greening city streets • Development and implementation of the project of reconstruction of street blocks and expansion of pedestrian zones and calming of car traffic • Development and implementation of projects for the reconstruction of existing parking lots of larger dimensions • Development and implementation of roundabout reconstruction projects • Development and implementation of the project of installing green roofs and facades • Activities may include the construction of new transport solutions through a more substantial integration of green infrastructure elements.

7.4

Waste Management

In the context of climate change mitigation, the waste management sector can contribute to reducing emissions by reducing the amount of waste generated, but also by optimizing the waste collection process by using larger capacity containers and adjusting vehicle routes in order to increase efficiency and reduce energy consumption.

To achieve sustainable resource and waste management, raising public awareness and understanding is crucial. Helping people understand what the transition from a linear to a circular economy means, how it will be implemented, and what financial frameworks support establishing the circular economy principle. Educational and media campaigns, as well as programmes at all levels increase public awareness of waste management. A combination of training, infrastructure and legal measures can ensure long-term changes in the way the society manages waste and uses products, thus reducing pollution and protecting the environment.

Encouraging and strengthening cooperation with representatives at the national level contributes to ensuring and adopting effective legislation and policies that encourage the reduction of plastic waste and promote sustainable waste management, e.g. by banning the use of single-use plastic packaging, especially single-use plastics, as well as the use of recycled materials in the plastics industry.

Waste prevention has great potential for protecting the environment and combating climate change, since products and materials do not have to end up as waste, but can instead be designed to support a longer lifespan and enable reuse and repair. Such a development can significantly contribute to economic efficiency and a positive impact on the environment. One of the key waste prevention activities is the reuse of items and products that have not been classified as waste and have not entered the waste management system, namely through the establishment of a system of reuse centers. The environmental benefits of extending the life of products or their parts by preparing for re-use are significant and present great potential for reducing greenhouse gas emissions, in particular CO2 emissions.

In order to establish a sustainable and green waste management system, it is necessary to ensure a high level of waste recovery, taking into account the highest environmental protection standards, by building a waste management center where mechanical and biological treatment of waste and/or energy recovery, including permanent waste management. The establishment of a waste management center using the best available technologies significantly contributes to reducing and minimizing the impact on climate change.

Food waste, as an integral part of biodegradable waste and its prevention/reduction, represents one of the biggest challenges in combating climate change, given that its decomposition creates methane gas, which is the second most common greenhouse gas causing global warming. Therefore, it is necessary to actively encourage the prevention of waste generation, i.e. the reduction of the amount of waste that is disposed of, with an emphasis on the pre-treatment of waste that must be disposed of at landfills and ultimately the complete cessation of the disposal of biodegradable waste. In this sense, schools, kindergartens and neighbourhood communities must be involved in recycling projects in order to encourage awareness of citizens, and most of all children, with the aim of acquiring positive habits from an early age.

Equipping existing and construction of new civic amenity sites and underground/semi-underground tanks with a separate waste collection system reduce greenhouse gas emissions, improve recycling and minimize environmental pollution. With their construction and capacity, underground/semi-underground tanks enable a more economical service of municipal waste collection as well as efficient waste sorting. In this sense, they can receive larger quantities of waste, and they are less susceptible to overfilling, which prevents waste from dissipating and emitting into the soil and air (unpleasant odors, leakage of liquid waste, evaporation and decomposition of waste in the environment). In addition, their construction and use, or proper sorting of waste, reduces the number of necessary waste removal on a weekly/monthly basis. This cuts down on the necessary resources and energy for the transport of waste, and in this regard, the emission of exhaust gases from vehicles into the air is also reduced. Exhaust gases from vehicles are a major source of air pollution due to their chemical composition, which mostly contains carbon dioxide, the main greenhouse gas.

Removing environmental waste by volunteer initiatives can be an extremely effective and positive method for cleaning natural spaces, raising awareness of the importance of preserving the environment, raising community awareness of the impor-

tance of sustainable lifestyles and collective responsibility for nature protection, and have a long-term positive impact on human behaviour and waste reduction in natural and urban environments.

Table 7.41
Overview of the impacts and challenges of climate change adaptation in the field of waste management in the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• Landslide activation due to landfill instability • Explosions of accumulated methane due to biowaste degradation • Increased amounts of plastic ending up in the environment and endangering biodiversity • Increase in waste generation and greenhouse gas emissions	• Reduced share of biodegradable waste in mixed municipal waste • Reducting waste generation • Reducing food waste • Locating smaller biodegradable waste treatment plants

Table 7.4–2
Climate change adaptation measures in the field of waste Management in the City of Zagreb

Measure code	Measure name	Key stakeholders
GO-01	Improvement of infrastructure for separate collection of municipal waste	GEOS; ity Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; City Office for Asset Management and Housing
GO-02	Optimization of Driving Routes of Čistoća Waste Management trucks During Waste Collection Service	Information System and Technical Service
GO-03	Raising awareness, informing and educating on waste and product management	GEOS; ZGH d.o.o., Čistoća and Zrinjevac branches; other city offices; external associates; legal and/or natural persons - craft enterprises authorized for waste management; volunteers; civil society associations; educational and scientific institutions; citizens
GO-04	Establishment of re-use centres	GEOS; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; City Office for Asset Management and Housing
GO-05	Bio-waste reduction	GEOS; City Office for Education, Sport and Youth; City Office for Social Protection, Health, War Veterans and People with Disabilities; ZGH d.o.o. Zrinjevac Branch
GO-06	Waste Management Center and Civic Amenity Site for Construction Waste	GEOS; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; ZCGO d.o.o.; ZGH d.o.o. Čistoća Branch; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; City Office for Asset Management and Housing
GO-07	Environmental waste removal	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; ZGH d.o.o. Čistoća Branch; civil society associations; volunteers; citizens

Waste Management measure

GO-01

Measure name

Improvement of Infrastructure for Separate Collection of Municipal Waste

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Office for Asset Management and Housing	ZGH d.o.o., Čistoća Branch	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EPEEF EU funds	8 9 11 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	9,500,000	5,300,000	4,500,000	0

Indicators	Initial value (2024)	Target value (2028)
Number of civic amenity sites built	11	13
Number of equipped existing civic amenity sites	4	7
Number of installed sets of underground tanks	39	80
Number of installed sets of semi-underground tanks	2	753
Number of built-in enclosures for residential buildings	81	500
Reduced amount of collected biowaste from the HOReCa industry	Not currently measured	-15% compared to 2025
Reduced amount of plastic collected at events in public areas and facilities owned by the City of Zagreb	Not currently measured	-15% compared to 2025

GO-01

Short description/ comment

At the end of 2022, the City of Zagreb introduced a new model of collection and collection of municipal waste based on the "polluter pays" principle. The main feature of the model is that, in addition to the fixed price of the service, users also pay a variable price by using ZG bags in which they are obliged to dispose of mixed municipal waste. The results of this model that stimulates waste separation were visible in 2023, when the share of separately collected waste in the city area increased by more than 50% compared to the previous year. Consequently, the amount of mixed municipal waste disposed of at the Jakuševac landfill was reduced by 17%.

In addition to these moves aimed at changing citizens' behaviour and reducing the generation of mixed municipal waste, efforts are continuing to be made to improve waste management infrastructure in order to reduce the share of biodegradable municipal waste in mixed municipal waste and increase the amount of separately collected recyclable waste.

So far, 149 new underground tanks have been installed in Zagreb at 39 locations in the city center, which has enabled the removal of thousands of tanks from public areas that prevented citizens from passing and visually damaged the city. A decision was also made to expand the coverage of the zone of underground tanks, which are primarily intended for the disposal of mixed municipal waste in ZG bags, waste plastics, paper and bio-waste.

Also, a map of the locations of semi-underground tanks was created, which will be installed throughout the city at the expense of the city budget, which includes the installation of semi-underground tanks at approximately 750 locations, i.e. the installation of more than 2200 semi-underground tanks for the disposal of dry recyclable waste fractions for citizens of multi-residential buildings. The system of semi-underground tanks will consist of 3 individual semi-underground tanks intended for the disposal of recycled materials (paper, plastic, glass) and their installation is planned by the end of 2027.

As part of this measure, it is also planned to additionally equip the existing and build new civic amenity sites.

The overall measure aims to establish an integrated system of separate collection of all waste fractions, thus reducing greenhouse gas emissions, increasing efficiency in recycling and minimizing environmental pollution.

In addition, in order to improve the current model of waste collection and disposal, the City of Zagreb will continue to co-finance the costs of construction of enclosures and waste storage in multi-residential buildings. For this purpose, more than 600 requests for reimbursement were received during 2024, namely for the construction of enclosures for separate waste containers, closing existing ones or adaptation of the waste room doors for code locks or installing a master key system or electronic lock on enclosures and waste rooms.

Key activities

- Construction of new civic amenity sites and equipping of existing ones
- Installation of underground and semi-underground tanks
- Construction of enclosures to accommodate containers
- Reduction of waste at events on the public area and in facilities owned by the City of Zagreb

Waste Management measure

GO-02

Measure name

Optimization of Driving Routes of Čistoća Waste Management trucks During Waste Collection Service

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
Information System and Technical Service	GEOS ZGH d.o.o., Čistoća and Zrinjevac branches External associates	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EU funds	7 8 9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	100,000	100,000	100,000	100,000

Indicators	Initial value (2024)	Target value (2028)
Developed software solution for route optimization	0	1
Achieved fuel savings	0	5%

GO-02

Short description/ comment	The need to dispose of different types of waste, the limited number of means of transport and drivers, and the vastness of the area where the waste collection service is performed make the management of the waste collection and transport system extremely challenging. Route optimization software offers considerable potential to improve operations with special savings in fuel consumption, which is directly reflected in the reduction of greenhouse gas emissions, i.e. in the reduction of the environmental impact of the waste management system. The truck route can be optimized by choosing the vehicle route with the aim of, for example, maximizing vehicle occupancy before leaving for disembarkation, minimizing time spent in crowds or encompassing as many service users as possible with as few routes as possible, etc. Such optimization results in human and material resource savings.
Key activities	• Assessing ways to improve Čistoća vehicle routes. • Creating a prototype of a software system for optimizing vehicle routes • Implementation of the vehicle route optimization system in regular operations

Waste Management measure

GO-03

Measure name

Raising Awareness, Informing and Educating on Waste and Product Management

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	ZGH d.o.o., Čistoća and Zrinjevac branches Other city offices External associates	Legal and/or natural persons - craft enterprises authorized for waste management Volunteers Civil Society Associations Educational and scientific institutions Citizens
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2028	Budget of the City of Zagreb EPEEF EU funds	3 8 11 12 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	76,000	76,000	76,000	76,000

Indicators	Initial value (2024)	Target value (2028)
Number of conducted trainings	15	55
Number of persons who completed the training	5,400	15,000
Number of distributed educational and informative materials (leaflets, brochures, posters, etc.)	220	660

GO-03

Short description/ comment	To achieve sustainable resource and waste management, raising public awareness and understanding is crucial. Helping people understand what the transition from a linear to a circular economy means, how it will be implemented, and what financial frameworks support establishing the circular economy principle. Educational and media campaigns, as well as programmes at all levels increase public awareness of waste management. A combination of education, infrastructure and legal measures can ensure long-term changes in the way the society manages waste and uses products, thus reducing pollution and protecting the environment.
Key activities	• Educating citizens about waste prevention • Educating citizens on waste separation at the point of generation • Educating citizens on the proper separation of biodegradable waste • Educating citizens on the proper way of composting and the harmfulness of burning plant waste and weeds • Campaigns to reduce food waste • Developing educational and informative materials

Waste Management measure

GO-04

Measure name

Establishment of re-use centres

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Office for Asset Management and Housing	ZGH d.o.o., Čistoća Branch ZCGO d.o.o.	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EPEEF EU funds	8 9 11 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	200,000			

Indicators	Initial value (2024)	Target value (2028)
Number of established Re-Use Centers	0	1

GO-04

Short description/ comment	One of the important waste prevention activities is the reuse of objects and products that have not been declared waste and have not entered the waste management system, i.e. the establishment of re-use centers. The establishment of a Re-use Center greatly contributes to the improvement of the ecological waste management system and the prevention of waste generation, and encourages the achievement of a circular economy. The Center will collect various discarded items directly from the owner, which after repair and restoration are returned to the market as used products / products.
Key activities	• Location determination and documentation preparation • Constructing re-use centres • Equipping re-use centres

Waste Management measure

GO-05

Measure name

Bio-waste reductions

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Office for Education, Sport and Youth City Office for Social Protection, Health, War Veterans and People with Disabilities	ZGH d.o.o., Zrinjevac and Tržnice Zagreb branches	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EPEEF EU funds	8 9 11 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	662,200			

Indicators	Initial value (2024)	Target value (2028)
Number of digesters (schools, kindergartens, homes for the elderly and infirm, marketplaces and hospitality establishments, etc.)	9	100

GO-05

Short description/ comment	Biowaste can also be processed by aerobic digestion, which breaks down food and other biowaste residues by converting them into water. An anaerobic digestion device operates by inserting food residues into the waste processor, where special mixtures of microorganisms are added that convert bio-waste into wastewater during processing, thus reducing the need for storage, transport and disposal of bio-waste. The intended users of the devices are elementary schools, kindergartens, homes for the elderly and disabled, and marketplaces, as well as hospitality establishments.
Key activities	• Assessing users' need for digesters • Market testing and selection of digesters according to identified needs • Digester distribution

Waste Management measure

GO-06

Measure name

Waste Management Center and Civic Amenity Site for Construction Waste

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services ZCGO d.o.o.	ZGH d.o.o., Čistoća Branch	City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Office for Asset Management and Housing

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EPEEF EU funds	8 9 11 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	900,000	1,500,000	50,000,000	90,000,000

Indicators	Initial value (2024)	Target value (2028)
Built WMC	0	1
Civic amenity site for construction waste established	0	1

GO-06

Short description/ comment	In January 2024, The City Assembly of the City of Zagreb adopted a summary of the amended Feasibility Study for the construction of a comprehensive waste management system of he City of Zagreb and Zagreb County and endorsed the construction of the Zagreb Waste Management Center at the Resnik site. The feasibility study considers existing technologies that can achieve circular economy objectives in waste management, i.e. the application of circular economy principles and the preservation of the environment and natural resources. Given the provisions of the Waste Framework Directive, it is necessary to increase the share of separately collected waste for recycling, which implies the collection of recyclable "dry" fractions: primarily plastics, paper and cardboard, glass, metals, but also other smaller recyclable fractions. Therefore, it is planned to combine the treatment of separately collected dry recyclable materials at Zagreb Waste Management Center as part of a single mechanical treatment plant. Study and project documentation is currently being prepared, while construction works are scheduled for the end of 2026, with a trial operation of Zagreb Waste Management Center planned in October 2028. At Zagreb Waste Management Center, a total of about 362,000 t of waste is planned to be treated annually, which includes: 135,000 tonnes of mixed municipal waste, 45,000 tonnes of plastic, 80,000 tonnes of paper and cardboard, 55,000 tonnes of bio-waste and 47,000 tonnes of bulky waste. This measure plans to achieve a high level of waste recovery and directly contribute to the achievement of goals of reducing the landfilling of biodegradable municipal waste, total municipal waste and construction waste, thus reducing the negative environment impact of landfilling. Therefore, in addition to Zagreb Waste Management Center, the establishment of a civic amenity site for construction waste is planned at the Resnik site by the end of 2025.
Key activities	• Construction of the Waste Management Center (WMC Zagreb) • Waste Management Center and Civic Amenity Site for Construction Waste

Waste Management measure

GO-07

Measure name

Environmental waste removal

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services	GEOS City Office for Municipal Self-Government, Transport, Civil Protection and Safety ZGH d.o.o., Čistoća Branch Civil Society Associations	Volunteers Citizens

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EPEEF EU funds	3 11 12 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	100,000			

Indicators	Initial value (2024)	Target value (2028)
Number of locations of illegally disposed waste	40	0
Number of locations with installed surveillance cameras	10	30

GO-07

Short description/ comment

The establishment of the e-Redar system enabled citizens to report the locations of illegally disposed waste in the environment outside designated waste management sites. Municipal wardens carry out regular monitoring, issue orders for the removal of waste from a polluted location and intensify monitoring of locations where frequent illegal waste dumping has been established.

Furthermore, the removal of environmental waste through voluntary actions can be a very effective and positive method for cleaning natural areas, raising awareness of the importance of preserving the environment, strengthening community consciousness of the importance of sustainable lifestyles and collective responsibility for nature protection, and producing long-term positive impact on human behaviour and waste reduction in natural and urban environments.

In 2023, through administrative procedures, municipal wardens issued orders to landowners at 34 locations to remove waste. As in previous years, the largest number of such procedures concerned the outskirts of the city, the eastern and western entrances to the city, undeveloped open land, and the Sava riverbank areas. Among these administrative procedures, the largest pollution cases (greater than 50 m3 of waste) were recorded in the city districts of Novi Zagreb – East, Novi Zagreb – West and Brezovica, as well as in Peščenica – Žitnjak, Dubrava and Sesvete, while the remaining procedures in other city districts were mostly related for minor pollution cases (less than 50 m3 of waste).

The largest instances pollution / illegal landfills occur, as in previous years, in the area of the City District of Novi Zagreb – West, namely in the area of Ježdovec forrest and Blato, stretching from the University Hospital site in the east to the flood-relief canal in the west and the Sava riverbed in the north, as well as in the area of the City District of Peščenica – Žitnjak, particularly in area III. Struga, Ivanjorečka and Resnik according to GOK. The entire contaminated area is mostly uncultivated and neglected land marked “arable land”, but in practice consisting of forests, thickets, gravel roads and the like, which are largely unfit for purpose and without owner supervision, more difficult to access by personal vehicles and relatively less visible from public spaces.

At these locations, the area has been polluted for many years by bringing in various bulky and mixed construction waste.

With the establishment of the Waste Management Center (WMC Zagreb) by the end of 2028, and especially the civic amenity site for construction waste by the end of 2025, it is planned to significantly reduce the occurrence and stop the trend of waste disposal in the environment.

Key activities

- Recording locations of illegally disposed waste
- Removing illegally disposed waste at recorded locations
- Installing physical barriers and surveillance cameras at locations with frequent illegal waste disposal
- Amending the existing legislation and improving the existing reporting and evidence system, which will enable easier and more efficient penalization of illegal waste disposal
- Removing illegally disposed waste in other natural areas (watercourses, protected areas)

7.5

Water Resources

Climate change poses a challenge to the management of natural resources, as it affects their availability, while simultaneously emphasizing the increased demand from both the population and the economy, thus threatening the sustainable development of society.

Water management poses a particular challenge to adapt to climate change given the high sensitivity of water security and availability to climate impacts. Climate change is reflected in altered precipitation patterns, an increase in the frequency and intensity of extreme weather events, and affects the water balance. Reduced precipitation and increased evapotranspiration decreases the average annual surface run-off, which is important for the nutrition of watercourses and the underground aquifer, that serves as the basic water supply resource. On the other hand, changes in the annual distribution of precipitation also lead to an intensification of the difference between dry and extremely wet periods. Due to extremely wet periods, the risk of torrential watercourses that threaten the safety of the population, property and infrastructure increases.

The main expected impacts that may lead to a high degree of vulnerability in the water resources sector in the City of Zagreb are the following: reduction of underground water supplies and lowering of groundwater levels, decrease in water volume in watercourses, increase in the frequency and intensity of torrents caused by mountain waters from the southern slopes of Medvednica and increase in the frequency and intensity of floods from rainwater in urban areas.

The problem of vulnerability of the water sector due to climate change is also recognized in one of the basic planning documents of the water management - the River Basin District Management Plan. (Official Gazette 84/23). According to the document, the risk of flooding is expected to increase due to changes in the duration, intensity and frequency of extreme precipitation, combined with changes in the way land is used. Also, the question arises whether these changes will require a change in the current approach to flood risk management.

Only integrated water management can provide sufficient quantities of water of adequate quality for the water supply of the population and other needs, ensure the protection of human life and material goods from the harmful effects of water, achieve and/or preserve good water status and protect water and water-dependent ecosystems.

Table 7.5-1
Overview of the impacts and challenges of climate change adaptation in the field of hydrology and water resources in the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• Reducing underground water supplies and lowering groundwater levels • Reducing the amount of water in watercourses • Increasing the frequency and intensity of torrents caused by mountain waters from the southern slopes of Medvednica • Increasing the frequency and intensity of precipitation flooding in urban areas	• Enhanced protection of spring inflow areas and strengthening of research and management capacities • Conservation of available natural resources in their most original form • Application of an integrated approach to water resources and systems management, interdisciplinary approach to finding optimal solutions, intensification of cross-sectoral cooperation • Construction of new and reconstruction of existing water protection systems using green hydrotechnical solutions

Table 7.5–2
Overview of climate change adaptation measures in the field of hydrology and water resources in the City of Zagreb

Measure code	Measure name	Key stakeholders
VR-01	Protection of Water Source Inflow Areas	GEOS; ViO d.o.o.; Ministry of Environmental Protection and Green Transition; Hrvatske vode; Institute for Physical Planning of the City of Zagreb; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; City Institute for the Conservation of Cultural and Natural Heritage; scientific institutions; ZGH d.o.o., Čistoća Branch
VR-02	Water Supply System Improvement and Reduction of Water Losses in the Water Supply Network of the City of Zagreb	ViO d.o.o.; ZGH d.o.o.; GEOS; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; City Institute for the Conservation of Cultural and Natural Heritage; Hrvatske vode
VR-03	Water consumption rationalization	GEOS; City Office for Social Protection, Health, Veterans and Persons with Disabilities; City Office for Education, Sports and Youth; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; ViO d.o.o.; Hrvatske vode; Management of Sports Facilities; ZGH d.o.o., Zrinjevac Branch; ZGH d.o.o., Čistoća Branch; Institute for Physical Planning of the City of Zagreb; local committees; public institutions
VR-04	Improvement of the Stormwater Drainage System	ViO d.o.o.; Hrvatske vode; Institute for Physical Planning of the City of Zagreb; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; GEOS; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; educational and scientific institutions
VR-05	City water tap network development	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; ViO d.o.o.; GEOS; City Office for Social Protection, Health, Veterans and Persons with Disabilities; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; educational and scientific institutions; Teaching Institute for Public Health "Dr. Andrija Štampar"; Institute for Physical Planning of the City of Zagreb
VR-06	Strengthening capacity and raising awareness of effective management and rational use of water and the impact of climate change on water as an environmental component	GEOS; City Office for Education, Sports and Youth; Teaching Institute for Public Health "Dr. Andrija Štampar"; ViO d.o.o.; Hrvatske vode; local self-government; public institutions; associations in the field of environmental protection; scientific and educational institutions; HKIG; HKA
VR-07	Identification of flood-sensitive social groups and critical assets	Hrvatske vode; Ministry of the Interior, Civil Protection Directorate; Institute for Physical Planning of the City of Zagreb; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; GEOS; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; City Institute for the Conservation of Cultural and Natural Heritage; Teaching Institute for Public Health "Dr. Andrija Štampar"
VR-08	Ensuring Sufficient Capacity of Water Sources for Safe Water Supply	ViO d.o.o.; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; GEOS; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; Institute for Physical Planning of the City of Zagreb; Hrvatske vode
VR-09	Improvement of the Wastewater Treatment System	ViO d.o.o.; Hrvatske vode; Institute for Physical Planning of the City of Zagreb; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; GEOS; City Office for Municipal Self-Government, Transport, Civil Protection and Safety
VR-10	Improvement of the Wastewater Drainage System	ViO d.o.o.; Hrvatske vode; Institute for Physical Planning of the City of Zagreb; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; GEOS; City Office for Municipal Self-Government, Transport, Civil Protection and Safety

Water Resources measure

VR-01

Measure name

Protection of Water Source Inflow Areas

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	ViO d.o.o. Ministry of Environmental Protection and Green Transition Hrvatske vode	Institute for Physical Planning of the City of Zagreb City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Institute for the Conservation of Cultural and Natural Heritage Scientific institutions ZGH Čistoća Branch
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2028	ViO d.o.o. Budget of the City of Zagreb EU funds Hrvatske vode	3 6 9 11 12 13 14 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	366,000	600,000	600,000	349,260

Indicators	Initial value (2024)	Target value (2028)
Prepared amended decision on water source protection	0	1
Remediation measures programme within sanitary protection zones for existing buildings and existing activities prepared	0	1
Cadastre of collection and septic pits prepared	0	1
Functional system for monitoring detected contaminated sites and tracking remediation efforts within water source sanitary protection zones established	0	1
Number of piezometric fields built	0	20
Analysis of the effectiveness of groundwater protection in the inflow areas of the water source	0	1
Developed/amended study on sanitary protection zones	0	1

VR-01

Short description/ comment

The aim of the measure is to protect groundwater in the inflow areas of Zagreb water sources, to alleviate and/or eliminate the pressures of existing buildings and activities on water sources and to remediate existing pollution in order to ensure safe water supply of the City of Zagreb.

The measure consists of an analytical part and a part that implies the implementation of specific remedial interventions. In the study-analytical-research part, it is necessary to initiate the activities of modification of sanitary protection zones, i.e. an analysis of the effectiveness of groundwater protection in inflow areas of the wellfield, in conditions of increasingly pronounced impacts of climate change, and to elaborate the application of integrated instruments and groundwater protection measures in inflow areas of the wellfield and cost-benefit analysis.

Part of the measure with adaptive effect implies the identification and provision of all administrative, legal and technical bases for the implementation of the necessary remedial interventions of contaminated parts of the aquifer system within the inflow areas of the wellfield by priority.

Key activities

- Preparation of the draft document for the amendment of the Decision on Sanitary Protection Zones of water sources
- Development of a Resolution measures scheme within sanitary protection zones for existing buildings and existing activities
- Identification of contaminants in water source inflow areas
- Determination of the required specific remedial interventions
- Elaboration of the mandatory content of the cadastre of collecting and septic tanks or individual drainage systems and establishment of a register at ViO d.o.o.
- Establishment of surveillance and monitoring of contaminated sites in sanitary protection zones of water sources for priority remediation
- Implementation of water exploration works at water sources
- Analysis of the effectiveness of groundwater protection at the water source inflow areas
- Amendment of sanitary protection zones of water sources according to future climate and hydrological changes

Water Resources measure

VR-02

Measure name

Water Supply System Improvement and Reduction of Water Losses in the Water Supply Network of the City of Zagreb

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
ViO d.o.o.	ZGH d.o.o. GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Institute for the Conservation of Cultural and Natural Heritage	Hrvatske vode

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2028	ViO d.o.o. Budget of the City of Zagreb EU funds	6 9 11 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	17,300,000	32,690,000	44,083,000	47,537,000

Indicators	Initial value (2024)	Target value (2028)
Number of implemented public procurements	29	107
Number of concluded contracts (for construction works)	4	107
Length of reconstructed pipelines	0	100
Establishment of a zero zone	0	1
Šalata water reservoir construction	0	1
Construction of the transport pipeline to the Šalata water reservoir	0	1
Establishment of DMA zones	16	40
Blaguša water reservoir construction	0	1
Length of built pipelines	0	3900

VR-02

Short description/ comment	Large losses of drinking water in the water supply system require more water to be pumped than delivered, which in synergy with climate change can lead to a violation of the quantitative status of the water body of the Zagreb aquifer. Unnecessary abstraction of large volumes of water in the long term can alter the natural biological and hydrological balance, but also reduce the capacity of the water source and thus endanger the water supply in the long run. The objective of this measure is to enable a more efficient water supply system from the aspect of reducing losses and increasing security of supply through a comprehensive reconstruction of the water supply network, thus implementing compliance with the Water Framework Directive (2000/60/EC) and the Directive on the quality of water intended for human consumption (2020/2184EC) in order to ensure sufficient quantities of safe water for human consumption. The specific activities to be carried out include the preparation of study and project documentation, as well as the implementation of physical interventions of upgrading, reconstruction and installation of equipment for smart monitoring of the water supply system.
Key activities	Priority interventions that would achieve the effects of improving the water supply system and reducing water losses in the water supply network of the City of Zagreb in the future include: • establishment of a zero zone, • detection and repair of ruptures and malfunctions, • establishment of DMA zones and monitoring and control system, • reconstruction of pipelines and • expansion of the water supply system.

Water Resources measure

VR-03

Measure name

Water consumption rationalization

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	City Office for Social Protection, Health, War Veterans and People with Disabilities City Office for Education, Sport and Youth City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services ViO d.o.o. Hrvatske vode	Sports Facilities Management ZGH d.o.o., Zrinjevac Branch ZGH d.o.o. Čistoća Branch Institute for Physical Planning of the City of Zagreb Local committees Public institutions

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2028	Budget of the City of Zagreb ViO d.o.o. EU funds	6 7 9 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	230,000	400,000	500,000	400,000

Indicators	Initial value (2024)	Target value (2028)
Optimization of water consumption in institutions owned by the City of Zagreb	22	46
Analysis of the application of lower-quality water supply systems for secondary water use	0	1
Number of mapped water sources outside the public water supply system	0	50
Study of mapping water sources outside the public water supply system	0	1
Analysis and basis for identifying suitable locations for the construction of the water reservoir system prepared	0	1
Number of developed project proposals for sustainable use of rainwater	0	4
Broj pilot-projekata održivog korištenja oborinskih voda	0	1

VR-03

Short description/ comment	The groundwater of the Zagreb aquifer supplies almost a quarter of the population of the Republic of Croatia, which therefore represents a strategic water reserve. Water is one of the most sensitive resources to the effects of climate change, given its availability and quality. Therefore, it is necessary to continuously undertake activities to rationalize its use. The City of Zagreb should implement measures to rationalize and reduce water consumption, review the realistic possibilities of reducing the use of water for human consumption for other designated uses and examine the possibilities of retaining and utilizing rainwater. The measure consists of an analytical part and a part that involves the preparation of project documentation and the implementation of specific interventions.
Key activities	• Optimization of water consumption in institutions owned by the City of Zagreb • Analysis of the application of lower-quality water supply systems for secondary water use • Mapping of water sources outside the public water supply system, analysis of possibilities and proposal of dedicated water use • Preparation of analysis and bases for determining suitable locations for the construction of water accumulation systems • Development and preparation of project proposals and project documentation and implementation of pilot projects in the field of sustainable use of rainwater

Water Resources measure

VR-04

Measure name

Improvement of the Stormwater Drainage System

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
ViO d.o.o.	Hrvatske vode Institute for Physical Planning of the City of Zagreb City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services GEOS City Office for Municipal Self-Government, Transport, Civil Protection and Safety	Educational and scientific institutions

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2028 (ongoing)	Proračun Grada Zagreba ViO d.o.o. Hrvatske vode Fondovim EU	6 9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	925,000	3,336,000	8,954,000	4,225,000

Indicators	Initial value (2024)	Target value (2028)
Urban stormwater drainage cadastre prepared	0	1
Central information system for urban rainwater drainage management of the City of Zagreb established	0	1
A comprehensive study of urban flood risk management in the City of Zagreb prepared	0	1
Hydraulic model developed with the definition and realization of measuring points	0	1
Number of measuring points for measuring the intensity of precipitation	2	4
Number of designed rain overflows	1	3
Number of built overflows	8	11
Number of realized urban stormwater drainage construction projects	0	3

VR-04

Short description/ comment

The drainage system of the City of Zagreb is mostly constructed as a mixed system, whereby the sewage network drains domestic wastewater, precipitation water from the urban part of the City and drainage water from most Medvednica streams.

Combined collection of wastewater and stormwater and their joint drainage towards the Central Wastewater Treatment Plant of the City of Zagreb leads to the mixing of relatively clean stormwater with polluted wastewater and prevents their natural function, at the same time additionally burdening the wastewater treatment plant with the amount of water. Such a system design also increases the risk of flooding because its capacity for stormwater drainage is reduced at key moments of maximum load. Likewise, most streams from Medvednica flow into the underground drainage collectors by approaching the urbanized area, further burdening the sewage system. The existing single-purpose grey rainwater infrastructure consisting of conventional drainage and water treatment pipeline systems is designed to drain rainwater from the built environment as quickly as possible, while the application of nature-based solutions would reduce the negative impact of rainwater already at its source, while bringing environmental, social and financial benefits.

The issue of urban stormwater drainage is one of the major challenges facing the City of Zagreb and needs to be observed through several segments:

- impact of streams and impact on streams, as well as catchment waters from the slopes of Medvednica
- lack of “rain overflows”, i.e. relief mechanisms for the combined drainage system
- construction of an urban stormwater drainage system in areas where the construction of a distribution drainage system is envisaged.

It is necessary to review the existing drainage system and, in addition to conventional measures, implement nature-based solutions in the spirit of retaining rainwater as close as possible to the point of their origin.

Key activities

- Development of project proposals and project documentation with the aim of increasing the areas, green roofs and green public transport stops, as well as retention to protect against the harmful effects of stream water and the arrangement of torrential streams within the systematic improvement of water management
- Pluvial flood hazard analysis in the area of the City of Zagreb
- Implementation of the Framework Programme of Activities for Improving Flood Risk Management in the Urban Area of the City of Zagreb through Climate Change Adaptation Measures
- Development of a hydraulic-hydrological model of catchment areas with the proposal of measuring points
- Realization of measuring points for measuring the intensity of precipitation
- Design and construction of rain overflows or relief structures in the combined drainage system, aimed at reducing flood risk
- Preparation of project documentation of the precipitation drainage system
- Construction of urban rainwater drainage for the Škorpikova underpass with the aim of preventing flooding
- Construction of urban rainwater drainage of southern Zagreb in the part of the distribution system in accordance with the design solutions
- Maintenance and monitoring of the functionality of rainwater drainage facilities, including rain overflows
- Correction of input parameters based on monitoring results in terms of performance improvement and flood risk reduction

Water Resources measure

VR-05

Measure name

City Water Tap Network Development

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services	ViO d.o.o. GEOS City Office for Social Protection, Health, War Veterans and People with Disabilities City Office for Municipal Self-Government, Transport, Civil Protection and Safety Teaching Institute for Public Health "Dr. Andrija Štampar"	Institute for Physical Planning of the City of Zagreb

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2028 (ongoing)	Budget of the City of Zagreb ViO d.o.o. EU funds	3 6 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	120,000	120,000	120,000	120,000

Indicators	Initial value (2024)	Target value (2028)
Total number of water taps in use	130	170
Development of a modern public water tap model	0	1
Decision on public watertaps drafted	0	1

VR-05

Short description/ comment	Publicly available free water for human consumption is a communal, public health and civilization standard and part of Zagreb's urban tradition. In order to promote a culture of free drinking water availability in the public space, it is necessary to reverse the negative trends of non-maintenance and removal of existing public water taps in locations where they are needed. All major public spaces should have access to free drinking water via public water taps as part of standard urban utility equipment. Also, public water taps, wells and pumps provide access to all those who do not have access to water through the public water supply system, and at the same time the population is encouraged to use tap water instead of plastic packaging, which should contribute to reducing the use of plastics and the generation of plastic waste, thus achieving a positive impact on climate change mitigation and the environment as a whole.
Key activities	• Protection of existing public water taps as part of Zagreb's identity • Development of a modern public water tap model that meets standards that include easy consumption, easy access for all age groups, the ability to easily pour water into bottles and separate access to water for animals • Balanced development of a network of modern city taps across all city districts, at high-frequency locations (schools, parks, kindergartens, recreational and sports fields) • Monitoring the health safety of water on public water taps • Drafting a decision on public water taps

Water Resources measure

VR-06

Measure name

Strengthening Capacities and Raising Awareness of Effective Water Management and Rational Use and the Impact of Climate Change on Water as an Environmental Component

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	City Office for Education, Sport and Youth Teaching Institute for Public Health "Dr. Andrija Štampar" ViO d.o.o. Hrvatske vode Local self-government Public institutions	Environmental associations Scientific and educational institutions HKIG HKA
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2028 (ongoing)	Budget of the City of Zagreb State budget EPEEF EU funds	6 7 11 12 13 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	30,000	30,000	30,000	30,000

Indicators	Initial value (2024.)	Target value (2028.)
Number of informative and educational activities carried out for the public	0	8
Number of implemented vocational trainings	0	4

VR-06

Short description/ comment	Water is one of the resources most sensitive to the effects of climate change, given its availability and quality. Any activity aimed at raising awareness of rational use and how climate change affects water is highly desirable and necessary. Educational projects enable the development of society as a whole. This measure should involve as many stakeholders as possible, while using existing communication channels, systems and infrastructure, and developing new ones.
Key activities	The measure includes **educating the public about the importance and ways of effective water management**. Also, in order to strengthen capacities o, the measure implies the **education of staff and spatial planners and water infrastructure designers on topics in the field of management of urban water phenomena and urban water infrastructure, as well as the possibilities of reusing treated wastewater and stormwater**.

Water Resources measure

VR-07

Measure name

Identification of Flood-Sensitive Social Groups and Critical Assets

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
Hrvatske vode	Ministry of the Interior, Civil Protection Directorate Institute for Physical Planning of the City of Zagreb City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services GEOS City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Institute for the Conservation of Cultural and Natural Heritage	Teaching Institute for Public Health "Dr. Andrija Štampar"
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2026	Hrvatske vode Budget of the City of Zagreb EU funds	6 10 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
		N/A		

Indicators	Initial value (2024)	Target value (2028)
Sites and most vulnerable areas identified	0	1

VR-76

Short description/ comment	The aim of the measure is to mitigate human and material losses in populated and economic areas of the City of Zagreb where there is a high risk of flooding. In doing so, a faster and more prepared response of the local community and institutions responsible for flood damage repair is crucial, through identifying priority social groups whose needs will be quickly identified and whose areas will be evacuated first, and whose property will be protected. It is necessary to identify those settlements, houses and dwellings located in the most sensitive areas with regard to water surfaces in the immediate vicinity and with regard to the available infrastructure and the existence of adequately built embankments. It is necessary to analyse in detail the main activities engaged in by the local population potentially affected by flooding. Meteorological and climate data should assist in identifying the areas most likely to experience flood events within the annual cycle (important for agriculture), with more precise identification of the locations and characteristics of the most vulnerable and sensitive social groups, which will increase the effectiveness of flood risk assessment and rescue intervention in case of floods. In case of unacceptable flood risks based on the prior identification of vulnerable groups, the competent institutions should organize educational programmes to inform the part of the population potentially most affected by floods and organize a response for the protection of households against flooding. The materials should also address the recommended type of construction and/or adaptation of infrastructure in households and on agricultural and industrial areas in the event of flooding.
Key activities	

Water Resources measure

VR-08

Measure name

Ensuring Sufficient Capacity of Water Sources for Safe Water Supply

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
ViO d.o.o.	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services GEOS City Office for Municipal Self-Government, Transport, Civil Protection and Safety Institute for Physical Planning of the City of Zagreb Hrvatske vode	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2028	ViO d.o.o. Budget of the City of Zagreb EU funds Hrvatske vode	

Estimation of required funds (EUR)	2025	2026	2027	2028
	4,648,000	4,648,000	4,648,000	4,648,000

Indicators	Initial value (2024.)	Target value (2028.)
Number of replacement wells put into operation	0	28
Number of closed old wells	0	10

VR-08

Short description/ comment	The aim of the measure is to ensure a sufficient amount of water for the public water supply needs of the City of Zagreb in all conditions, including the hydrological droughts. Pumping quantities above the optimal level leads to an accelerated deterioration of the wells and significantly increases the operating costs. In order to revitalize the existing or build new replacement wells at active sources, it is necessary to initiate additional water investigation works in order to optimize the pumping quantities and operating costs.
Key activities	• Implementation of water investigation works • Preparation of project documentation and obtaining permits • Announcement of public procurement for works • Construction of wells • Commissioning and connection • Closing old wells

Water Resources measure

VR-09

Measure name

Improvement of the Wastewater Treatment System

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
ViO d.o.o.	Hrvatske vode Institute for Physical Planning of the City of Zagreb City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services GEOS City Office for Municipal Self-Government, Transport, Civil Protection and Safety	Hrvatske vode
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2028	ViO d.o.o. Budget of the City of Zagreb EU funds	6 9 11 12 14 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	8,400,000	39,000,000	31,600,000	21,000,000

Indicators	Initial value (2024)	Target value (2028)
Upgrading the Central Wastewater Treatment Plant of the City of Zagreb to stage III purification	0	1
Upgrading the sludge line on the Central Wastewater Treatment Plant of the City of Zagreb	0	2

VR-09

Short description/ comment	Pursuant to the regulations of the European Union Urban Waste Water Treatment (Directive – 91/271/ EEC) transposed into the Croatian legal framework, the Implementation Plan of the Water Utility Directives of the Government of the Republic of Croatia from December 2010, as well as the Ordinance on Limit Values of Wastewater Emissions (Official Gazette 26/2020), there is an obligation for the Central Wastewater Treatment Plant of the City of Zagreb to increase the level of treatment from stage II to stage III. The third (III) stage of treatment represents a stricter municipal wastewater treatment by a process that, in addition to the second stage of treatment, achieves additional requirements, primarily concerning nitrogen and phosphorus. In relation to the Central Wastewater Treatment Plant of the City of Zagreb, it is primarily necessary to achieve a limit value for total phosphorus ≤ 1 mg P/L (with a minimum percentage reduction in pollution of 80%) and total nitrogen ≤ 10 mg/L (with a minimum percentage reduction in pollution of 70%). At the Central Wastewater Treatment Plant of the City of Zagreb, which is currently operating with the second stage of purification, approximately 50 to 55g of ST/ES sludge is generated daily. It is estimated that after upgrading the Central Wastewater Treatment Plant of the City of Zagreb with the third stage of purification, sludge will be generated with a unit value of 50 g DS/PE d, noting that with the implementation of the Zagreb Project, there will be an increase in the load of the Central wastewater treatment plant of the City of Zagreb measured by the number of PE. It should be pointed out that the wastewater treatment plant construction projects that include a final sludge disposal solution are considered complete, among other things, because they include related technological solutions and costs.
Key activities	It is necessary to include activities related to increasing the level of wastewater treatment to Stage III and investments to reduce the amount of sludge and additional mud treatment.

Water Resources measure

VR-10

Measure name

Improvement of the Wastewater Drainage System

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
VIO d.o.o.	Hrvatske vode Institute for Physical Planning of the City of Zagreb City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services GEOS City Office for Municipal Self-Government, Transport, Civil Protection and Safety	Educational and scientific institutions
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2028 (ongoing)	Budget of the City of Zagreb ViO d.o.o. Hrvatske vode EU funds	

Estimation of required funds (EUR)	2025	2026	2027	2028
		50,100,000	56,400,000	28,500,000

Indicators	Initial value (2024)	Target value (2028)
Construction of gravity sewers	0	156,700
Reconstruction of gravity sewers	0	56,000
Construction of pressure pipelines	0	7700
Construction of pumping stations	0	28
Construction of retention basins	0	8

VR-10

Short description/ comment	The results of hydraulic modelling of the drainage system indicate high pressures and surface water occurrence, especially in the western and eastern part of the city on the left bank, as well as in the central part of Novi Zagreb, which continues to indicate the need for the construction of interventions planned by POKS and confirmed by the Strategy, in order to ensure the functionality and safety of drainage, as well as to reduce the sensitivity of the system to the impact of extreme precipitation. In order to bring the drainage system into a fully functional state, it is necessary to reconstruct or repair a significant part of the network. A particular problem is the area of Sesvete, which must be integrated into the drainage system of the City of Zagreb.
Key activities	Priority interventions that would achieve the effects of improving the wastewater drainage system in the following period are: • expansion of the drainage network and connection to the Central Wastewater Treatment Plant of the City of Zagreb and • optimization of the existing mixed drainage system.

7.6

Agriculture

The agriculture sector is directly exposed to weather conditions and climate changes that amplify the tendency to reduce crop yields with increased production costs. The intensity of physical and (bio)chemical processes, which take place in soil, plants and domestic animals, is largely determined by soil moisture/water and air temperature. Agriculture will continue to face the greatest risks by the increase in the frequency and intensity of warm temperature extremes and droughts, as well as the occurrence of stormy weather and frost.

Temperature is considered one of the most important factors influencing the distribution patterns and abundance of plant crops. This is a factor that limits the geographical areas where different crops can be grown, as well as a factor that affects the development, growth and yield of crops. Prolonged hot and dry periods and temperature extremes can have adverse effects on crop development, growth and yield, and thus have a negative impact on the quantity and quality of agricultural yields. Agricultural crops have the basic requirements of temperature values for each individual phenophase, as well as the entire life cycle. The moment of occurrence of extreme events is crucial because they can happen at sensitive stages of the life cycle of agricultural crops, especially during more sensitive phenophases such as flowering. The rise in temperature also increases the need for water, which can lead to water stress and subsequently contribute to a decrease in yield. There is also a growing need for technological solutions that can improve the management of water resources, such as the development of various sensor technologies with the purpose of optimizing water use, reducing its consumption and controlling and mitigating water stress. The introduction of advanced technologies such as fine misting as a method for controlling plant temperature stress, especially in critical phenophases, ensures a more stable yield and reduces the risk of damage caused by thermal stress.

In addition to agricultural crops, temperature is the most important environmental factor influencing the dynamics of harmful populations, and global warming is expected to stimulate the expansion of their geographical range. There may also be and increase in the proportion of overwintered individuals, increase the number of generations, a higher risk of introducing invasive pests and vector plant diseases, as well as possible changes in their interaction with host plants and natural enemies.

Climate change is likely to change precipitation patterns, the proportion of stored soil moisture, evapotranspiration, and runoff. It is estimated that more than 80% of the world's total crop production is supplied by precipitation. Therefore, oscillations in total seasonal precipitation and changes in precipitation patterns are very important. Changes in precipitation patterns are often more important for plant cultivation than changes in temperature, especially in regions where dry seasons can be a limiting factor. In soils lacking sufficient levels of humus and high water retention capacity, or in soils without irrigation potential, frequent droughts and yield losses will occur. It is necessary to preserve and increase organic matter in the soil, which is a key element of the soil strategy until 2030, through the use of compost, biochar, the integration of forest and agricultural crops (agroforestry) and the development of models for different climate scenarios and manuals for farmers that will help in the management of organic matter in the soil. Prolonged droughts and a decrease in the availability of water for agricultural crops cause a decrease in yields and physical damage to plants, and create favourable conditions for the emergence and spread of vegetation fires, which, in addition to forests, also destroy agricultural areas and thus cause great economic losses.

The main expected impacts of climate change that cause high vulnerability in the agricultural sector are: shortening the growing season of agricultural crops with lower yields, higher water demand, and lower yields or destruction of agricultural potential due to storm and frost damage.

Without increased investments, it will not be possible to achieve a satisfactory percentage of areas under irrigation and indoor production, as well as to significantly raise the level of organic matter in the soil, which will result in a decrease in agricultural production compared to the current situation.

Table 7.6-1
Overview of the impacts and challenges of climate change adaptation in the field of agriculture in the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• Change in the duration/length of the growing season of agricultural crops and lower yields • Increased irrigation water demand due to frequent droughts • Surface water stagnation • Lower yields or destruction of agricultural potential due to frequent occurrence of storm storms or frost	• Increasing the areas where urban farming and edible landscapes activities take place • Encouraging organic and precision agriculture • Application of digital technologies for agricultural management - use of remote sensing and IoT sensors to monitor soil condition, humidity and climate conditions • Encouraging the construction of a system of protection against natural disasters • Strengthening resilience to climate change by water reservoir systems • Utilization of treated wastewater for irrigation • Application of agrometeorological and climate data • Crop rotation and polyculture • Implementation of agroforestry • Digitalization and innovation (use of smart technologies and digital solutions for precise agricultural management, which enables better monitoring and adaptation to climate conditions) • Education and information of farmers and other stakeholders

Table 7.6-2
Overview of climate change adaptation measures in the agricultural sector of the City of Zagreb

Measure code	Measure name	Key stakeholders
PO-01	Increasing the areas where urban farming and edible landscapes activities take place	GEOS; City Office for Asset Management and Housing; City Office for Cadastre and Geodetic Activities; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; Faculty of Agriculture of the University of Zagreb; ZGH d.o.o., Zrinjevac Branch; civil society associations; citizens
PO-02	Encouraging organic and precision agriculture	GEOS; Faculty of Agriculture, University of Zagreb; agricultural holdings
PO-03	Encouraging the construction of a system of protection against natural disasters	GEOS; Faculty of Agriculture, University of Zagreb; agricultural holdings

Agriculture measure

PO-01

Measure name

Increasing the areas where urban farming and edible landscapes activities take place

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS: Agriculture, Forestry and Hunting Sector	City Office for Asset Management and Housing City Office for Cadastre and Geodetic Works City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services GEOS: Sector for Strategic Information and Research	Faculty of Agriculture, University of Zagreb ZGH d.o.o., Zrinjevac Branch Civil Society Associations Citizens

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb State budget EU funds	2 3 9 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	250,000	500,000	500,000	500,000

Indicators	Initial value (2024)	Target value (2028)
Area of landscaped and equipped arable land for urban gardens in ha	23.55	30
Number of garden plot users	2022	2800
Number of associations/institutions using the therapeutic garden	3	6
Surface of landscaped urban orchards	5012 m^2	20,000 m^2
Surface of roof and vertical gardens	/	1000 m^2
Number of parameters (physico-chemical and biological impurities)	22	44
Number of samples	60	120

PO-01

Short description/ comment	When the areas used for urban gardening are compared to concrete and asphalt surfaces, they have a highly positive effect on adaptation to the effects of climate change. Increasing the presence of vegetation will increase the capacity of water infiltration, reducing the load on sewage systems and the risk of flooding, which is especially important for areas with limited areas for rainwater absorption, which in turn leads to better adaptation to future needs in terms of rainwater runoff for storms. Plants in urban gardens absorb CO2 from the atmosphere and produce oxygen, thus contributing to reducing the concentration of greenhouse gases that contribute to climate change. Urban agriculture attracts different animal species and thus increases local biodiversity. Moreover, gardens are used as a place for socializing, education and recreation, improving the ecological qualities of urban areas. The aim of the measure is to integrate food production into urban landscapes and public spaces, making the city more resilient to climate change by increasing local food security and availability, improving urban biodiversity and creating green spaces that can help mitigate the urban heat island effect. By implementing the measure, certain unused spaces in the city would be transformed into urban orchards and food production areas (such as urban gardens) and orchard parks would be integrated. Activities would be enhanced by information and communication functionalities for monitoring, aimed at improving communication with users and key stakeholders, as well as better assessing the impacts of expected climate change on urban gardens.
Key activities	• Development and digitization of dynamic monitoring based on risk assessment and development of new areas and existing urban and therapeutic gardens • Equipping and arranging city orchards • Arranging and equipping roof and vertical gardens

Agriculture measure

PO-02

Measure name

Encouraging Organic and Precision Agriculture

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS: Agriculture, Forestry and Hunting Sector	Faculty of Agriculture, University of Zagreb	Agricultural holdings

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb	2 8 9 11 12 13 14

Estimation of required funds (EUR)	2025	2026	2027	2028
	250,000	250,000	250,000	250,000

Indicators	Initial value (2024)	Target value (2028)
Share of agricultural holdings in the organic production system	4.01%	10%
Area under organic agricultural production in ha	162.83	200
Number of agricultural holdings that procured precision agriculture equipment with support	0	15
Amount of funding allocated to organic and precision agriculture	0	EUR 1,000,000
Number of agricultural holdings that participated in trainings on organic and precision agriculture	0	200

PO-02

Short description/ comment	The aim of the measure is to increase the area under organic agricultural production by giving organic farmers an advantage in exercising the right to aid and a higher intensity of support because it plays a key role in the preservation of natural habitats and the development of a sustainable food production system, and its impact on the environment and biodiversity is significantly lower compared to conventional agriculture. The aim of the measure is also to encourage the introduction of innovative and smart solutions that contribute to the digitization of agriculture and other social activities and environmental goals through mitigation and adaptation to climate change. Smart agriculture enables better resource management, which reduces the need to use fossil fuels and reduces CO2 emissions. Precision farming reduces the need for pesticides and herbicides, thus preserving the environment and the living world and enabling better soil management, therefore reducing soil erosion and degradation. In addition to encouraging organic agriculture, the measure would also grant support to agricultural holdings for the procurement of equipment in the field of precision and digital agriculture such as agrometeorological stations, sensors, crop analysis drones, spraying drones, pest control and traps, etc.
Key activities	• Aid for organic agricultural production • Aid for the procurement of precision farming equipment • Organization of training on the topic of ecological and precision agriculture

Agriculture measure

PO-03

Measure name

Encouraging the Construction of a System of Protection against Natural Disasters

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS: Agriculture, Forestry and Hunting Sector	Faculty of Agriculture, University of Zagreb	Agricultural holdings

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb	2 3 9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	125,000	125,000	125,000	125,000

Indicators	Initial value (2024)	Target value (2028)
Number of agricultural holdings that applied for subsidies for the construction of natural disaster protection systems	0	15
Number of courses held on the topic of building natural disaster protection systems	0	2

PO-03

Short description/ comment	The aim of the measure is encouraging the construction of a system of protection against natural disasters on agricultural holdings by granting support to agricultural holdings for the construction of a system of protection against natural disasters in order to preserve agricultural production, ensure the survival of agricultural holdings and minimize damage from natural disasters that are increasingly common in the City of Zagreb. This measure would ensure faster adaptation and increase the resilience of the agricultural sector to the effects of climate change with the aim of preserving agricultural production.
Key activities	• Subsidies for the construction of natural disaster protection systems • Organization of training for farmers on natural disaster protection systems

7.7

Forestry

Utjecaj klimatskih promjena na šume i šumarstvo složeThe impact of climate change on forests and forestry is complex and manifests itself:

- in changes in temperature and precipitation that affect the growth and development of forest stands and the production of wood and non-wood products and services, which will affect economic revenues and the availability of wood as an energy source for the wider population, as well as indirect existential consequences for all stakeholders in the forestry sector;
- in the occurrence of temperature extremes and the alternation of cold and warm periods, which cause physiological stress for forests;
- in changes in the spatial distribution of forest vegetation that can be manifested in the representation of current forest communities, the possible disappearance of existing or the emergence of new communities, the change in the distribution of certain types of trees, the productivity of forest ecosystems, etc.;
- in dry periods without precipitation or longer periods of unfavourable ratio of precipitation and potential evapotranspiration (which is a direct function of rising temperature), which can lead to a decrease in soil water supplies, increasing the risk of physiological stress, and ultimately to drying of forests;
- in dry periods and absence of precipitation, which also increases the risk of forest fires;
- in the increased risk of spread and harmful impact of foreign invasive species in forest ecosystems, as well as other tree diseases and pests;
- in a higher frequency of extreme weather events, such as storms, increasing the likelihood of degradation of forest habitats (e.g. windfalls and windbreaks), often with a drastic reduction in the value of wood assortments and an overall loss of forest utility functions for a longer period.

Therefore, it can be assumed that climate change will inevitably affect all segments of sustainable forest management: restoration, care, thinning, timber harvesting, forest management, forest protection, forest infrastructure and transport, nursery production, management and forestry policy.

In the forestry sector, there are several main expected impacts that cause high vulnerability. The current trend in the number of forest fires shows that they were significantly more frequent in dry years, particularly in the Mediterranean area, while projections show that the risk of forest fires in the future will be higher across the Republic of Croatia. Furthermore, the phenological phases of tree development are expected to shift, such as earlier onset of vegetation and extension of the growing season depending on species and habitats. Changes in habitat conditions could also lead to the migration of species and pests, including invasive alien species. The productivity of some forest ecosystems, such as pedunculate oak forests, could be reduced, although it should be emphasized that it depends not only on atmospheric changes, but also on management and other abiotic influences. Due to the increased frequency of forest fires and the occurrence of windbreaks, icebreaks, pest outbreaks, etc., greater damage to forest ecosystems is expected, such as a decrease in the value of wood assortments and the loss of forest functions. Trees in urban areas that are part of urban green infrastructure already live under challenging conditions that are aggravated by the impact of climate change.

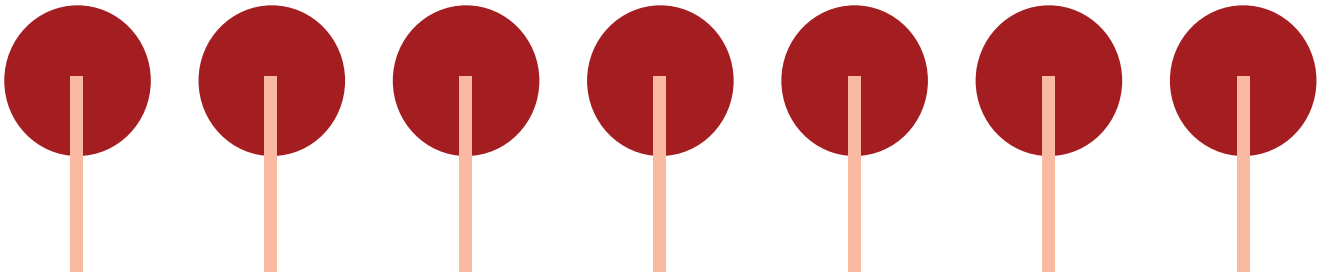


Table 7.7–1
Overview of the impacts and challenges of climate change adaptation in forestry in the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• Decrease in productivity of some forest ecosystems • Migration of harmful organisms • Shifts in phenological stages of forest tree species development • Damage to forest ecosystems due to the frequency of extreme weather events • Reduced value of widely useful forest functions • High proportion of private forests not actively managed	• Forest regeneration to strengthen resilience to climate change • Education and exchange of knowledge and experience in the field of forestry and forest adaptation to climate change • Implementation of green infrastructure models with the aim of strengthening climate resilience in urban areas • Continuous monitoring of the state of forest ecosystems and urban green infrastructure • Encouraging private forest owners to actively manage their forests or managing on their behalf with compensation • Strengthening the capacity of key stakeholders to respond to the consequences of extreme weather events (e.g. windbreaks, wind waves) • Evaluate and preferably include in the green infrastructure areas that have trees in their composition, but are not forests by definition (e.g. smaller groups of trees on an area of less than 0.1 ha) • Adaptation of fire protection plans to the effects of climate change

Table 7.7–2
Overview of climate change adaptation measures in the agricultural sector in the City of Zagreb

Measure code	Measure name	Key stakeholders
ŠU-01	Forest restoration, i.e. conversion in order to strengthen resilience to climate change	GEOS; Hrvatske šume d.o.o.; private forest owners; Faculty of Forestry and Wood Technology, University of Zagreb; Croatian Forestry Institute; civil society associations; citizens
ŠU-02	Education and exchange of knowledge and experience in the field of forestry and forest adaptation to climate change	GEOS; City Office for Education, Sports and Youth; state and local administration from neighboring countries / EU; Hrvatske šume d.o.o.; private forest owners; Faculty of Forestry and Wood Technology of the University of Zagreb; Croatian Forestry Institute; PI Medvednica; PI Priroda; OCD
ŠU-03	Implementation of green infrastructure models with the aim of strengthening climate resilience in urban areas	GEOS; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; Institute for Physical Planning of the City of Zagreb; Hrvatske šume d.o.o.; private forest owners; Faculty of Forestry and Wood Technology, University of Zagreb; Croatian Forestry Institute; civil society associations; citizens
ŠU-04	Valorization and inclusion of areas smaller than 0.1 ha overgrown with smaller groups of trees owned by the City or the Republic of Croatia in green infrastructure	GEOS: Agriculture, Forestry and Hunting Sector; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services Sector for Utilities and Public Areas, Department for Utilities and Greenery; City Office for Municipal Self-Government, Transport, Civil Protection and Safety; ZGH d.o.o., Zrinjevac Branch; Hrvatske šume d.o.o.; DORH; Croatian Forestry Institute; Faculty of Forestry and Wood Technology, University of Zagreb; city district councils and local boards; private forest owners
ŠU-05	Strengthening the capacity of key stakeholders to respond to the consequences of extreme weather events such as windbreaks and wind-waves in forests	GEOS: Sector for Agriculture, Forestry and Hunting; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; The City Office for Local Self-Government, Civil Protection and Security; ZGH d.o.o.; Hrvatske šume d.o.o.; Croatian Forestry Institute Faculty of Forestry and Wood Technology, University of Zagreb; Councils of City Quarters and Local Committees; Private Forest Owners

Forestry measure

ŠU-01

Measure name

Forest Regeneration to Strengthen Resilience to Climate Change

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS: Agriculture, Forestry and Hunting Sector	Hrvatske šume Faculty of Forestry, University of Zagreb Croatian Forest Research Institute Civil Society Associations Citizens	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb	8 11 12 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	3,891,500	3,891,500	3,891,500	3,891,500

Indicators	Initial value (2024)	Target value (2028)
Established economic unit of urban forests and developed management programme	0	1
Uniform management of state-owned, city-owned and private park forests	395	600

ŠU-01

Short description/ comment	The forestry sector is highly exposed to risks due to climate change and the natural structure of forest communities is being disturbed. The aim of the measure is to restore forests with suitable species that are more resilient and better adapted to the impacts of climate change. Within the framework of this measure, it is necessary to conduct research on the climate sensitivity of species, identify those that are best adapted to the impact of climate change, as well as develop and carry out a restoration plan with appropriate tree species.
Key activities	• Establishment of a special economic unit for forest parks owned by the City of Zagreb • Development of a forest management plan for urban forest parks in accordance with the protection measures established by management programmes and GUP • Financial support for the implementation of the forest management plan Management basis for the economic unit “Park-forests of the City of Zagreb” in the park-forests of the City of Zagreb owned by the Republic of Croatia • Implementation of the forest management plan for park-forests owned by the City of Zagreb for the newly established economic unit • Development of an implementing act to grant financial support for the implementation of forest management plans in private forests, in particular for larger forest holders

Forestry measure

ŠU-02

Measure name

Education and Exchange of Knowledge and Experience in the Field of Forestry and Forest Adaptation to Climate Change

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS: Agriculture, Forestry and Hunting Sector	Hrvatske šume State and local government from neighboring countries / EU Faculty of Forestry, University of Zagreb Croatian Forest Research Institute International forestry and other organizations	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EU funds	9 11 12 13 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	0	50,000	0	50,000

Indicators	Initial value (2024)	Target value (2028)
Number of participants in conferences in the field of forestry and forest adaptation to climate change	0	100

ŠU-02

Short description/ comment	Climate change poses significant potential risks to forests and challenges for forest managers. Adaptation to climate change involves monitoring and predicting change and taking action to avoid negative consequences and take advantage of the potential benefits of these changes. The aim of this measure is to bring together relevant experts dealing with climate change in forestry once a year at a conference, providing a platform for presenting recent findings on the impacts of climate change on forest species and communities and possible adaptation measures that are already being implemented or tested, as well as management options for climate change adaptation. Key topics for researchers and forest managers would be identified and very specific topics within which knowledge and experiences would be shared.
Key activities	• Organization of a conference in the field of forestry and forest adaptation to climate change

Forestry measure

ŠU-03

Measure name

Provođenje modela zelene infrastrukture s ciljem jačanja otpornosti na klimatske promjene u urbanim sredinama

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS: Agriculture, Forestry and Hunting Sector City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services Institute for Physical Planning of the City of Zagreb	Hrvatske šume Faculty of Forestry, University of Zagreb Croatian Forest Research Institute Civil Society Associations Citizens	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb State budget funds EU funds EPEEF	12 15

Estimation of required funds (EUR)	2025	2026	2027	2028
		500,000	500,000	

Indicators	Initial value (2024)	Target value (2028)
Established forest valuation methodology	0	100%
Share of the established ownership structure	0	70%

ŠU-03

Short description/ comment	The activity will include the inventory and validation of forest areas within the construction areas of the City of Zagreb and Sesvete, with the aim of determining in detail the ownership structure of forests. This process will analyse the types and condition of forest communities and then apply a forest valuation methodology. The valorization will assess the economic, environmental and social value of forest areas, thus ensuring a better management strategy, with an emphasis on the conservation of biodiversity and the functional connectivity of forest ecosystems within the urban area.
Key activities	• Implementation of the project of inventory, validation and then valorization of Zagreb forests within the construction areas of the settlements of Zagreb and Sesvete with the establishment of a detailed ownership structure and a methodology of forest value assessment

Forestry measure

ŠU-04

Measure name

Valorization and Inclusion of Areas Smaller than 0.1 ha Overgrown with Smaller Groups of Trees Owned by the City or the Republic of Croatia in Green Infrastructure

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS: Agriculture, Forestry and Hunting Sector	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; Department of Utilities and Public Areas, Department of Utilities and Greenery City Office for Municipal Self-Government, Transport, Civil Protection and Safety ZGH d.o.o., Zrinjevac Branch Hrvatske šume State Attorney's Office Croatian Forest Research Institute	Faculty of Forestry and Wood Technology, University of Zagreb Neighbourhood councils and local committees Private forest owners
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2028	Budget of the City of Zagreb	11 12 15

Estimation of required funds (EUR)	2025	2026	2027	2028
		300,000	300,000	400,000

Indicators	Initial value (2024)	Target value (2028)
Valorized percentage of areas overgrown with woody vegetation smaller than 0.1 ha	0	100%

ŠU-04

Short description/ comment	Currently, there are areas in urban or state ownership of less than 0.1 ha overgrown with woody vegetation that have the potential to be included in the existing urban green infrastructure management system. Isolated groups of forest trees covering an area of up to 0.1 ha are not considered to constitute a forest, and therefore these areas cannot be included in the existing forest management plans. Nevertheless, they can have significant ecological and cultural value as part of urban green infrastructure.
Key activities	• Development of a digital solution for areas with forest vegetation smaller than the minimum area of 0.1 ha (by forest definition), including the calculation of vegetation valorization

Forestry measure

ŠU-05

Measure name

Strengthening the Capacity of Key Stakeholders to Respond to the Consequences of Extreme Weather Events such as Windbreaks and Wind Waves in Forests

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS: Agriculture, Forestry and Hunting Sector	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services City Office for Municipal Self-Government, Transport, Civil Protection and Safety ZGH d.o.o. Hrvatske šume d.o.o Croatian Forest Research Institute Faculty of Forestry and Wood Technology, University of Zagreb Neighbourhood councils and local committees Private forest owners	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb	11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
		10,000		10,000

Indicators	Initial value (2024)	Target value (2028)
Number of training participants	0	100

ŠU-05

Short description/ comment	The forestry sector is highly exposed to risks due to climate change and the natural structure of forest communities is being disturbed. Windbreaks and wind waves are the result of the interaction of adverse and extreme abiotic factors, most often large amounts of wet snow, severe weather accompanied by stormy winds and similar adverse weather conditions in a particular area. Winds of insignificant to moderate intensity are a useful environmental factor during the growth, fertilization and distribution of forest trees, but under certain conditions they can adversely affect the soil and forest atmosphere and cause direct physiological and mechanical damage to forest trees. In addition, excessive and catastrophic phenomena in forests can have an impact on humans and the environment and can lead to permanent consequences that can pose a threat to human, animal and plant life. For this reason, it is necessary to strengthen the capacities of key stakeholders.
Key activities	• Education of key stakeholders to respond to the consequences of extreme weather phenomena in forestry

7.8

Healthcare

Research and development of measures to increase resilience to the expected impacts of climate change on health is one of the public healthcare priorities in Croatia. Field and laboratory measurements and analyses of the monitoring of the incidence and clustering of acute infectious and chronic non-communicable diseases, related to environmental safety indicators, such as air quality, water and food safety, and environmental and work safety, are key preventive and adaptation measures.

The negative impacts of expected climate change on health primarily include an increase in mortality, changes in the epidemiology of chronic non-infectious diseases (e.g. cardiovascular, pulmonary, renal) and in the epidemiology of acute infectious diseases. Indirect negative consequences for the health system are an increase in the burden due to a larger number of admissions, the need for a larger scope of diagnostic and therapeutic procedures, the number of days of hospitalizations, days of sick leave, drug consumption, etc. Wide range and types of health effects – direct (e.g. heart failure) or indirect (e.g. increase in drug consumption for chronic cardiovascular or respiratory diseases), acute (e.g. dehydration, acute cardiovascular and neurological symptoms) or chronic (e.g. blood pressure fluctuations), general (e.g. increased exposure to lower quality air) or specific (e.g. exposure to a heat wave) presents a particular challenge due to the complexity, low level of digital data integration and the need for permanent, spatial-temporal and comprehensive monitoring using selected indicators from databases of different sectors (e.g. water resources, agriculture, forestry, biodiversity, energy, tourism).

One of the most important priorities is the increasing risk of spreading diseases transmitted to humans through invasive animal species due to the impact of climate change on their spread. Particular attention is paid to the monitoring and activities associated with the presence and expected mosquito-borne viral diseases (malaria, dengue, yellow fever, West Nile virus, Zika viruses) or tick-borne diseases (Lyme disease, tick-borne encephalitis). The exposure of the population to low quality outdoor and indoor air is expected to increase due to extremely high and low temperatures, disturbances of microclimate conditions in the living and working environment, and the spread of invasive aeroallergenic plant species. In addition to the negative impact on the occurrence of acute irritations of the mucous membranes of the eye, nose, mouth or the development of acute and worsening chronic symptoms, e.g. respiratory and other systems, it is important to monitor delayed health outcomes, such as the development of autoimmune diseases, intestinal and malignant diseases due to the impact on the DNA methylation process, inflammatory and cellular immunity processes, and protein expression in the lungs. Changes in the amount of precipitation can lead to frequent and prolonged periods of unavailability of safe water for human consumption and generally to an increase in the level of pollutants in the environment and indirectly in the soil and in food. Given the increased displacement of the population due to climate change, the risk posed by the urban environment and the expected changes in the age structure of the population, a significant negative impact of climate change on mental health, quality of life, increased mortality and injuries is expected, especially among vulnerable subgroups such as emergency workers in various sectors (health, firefighting, social activity, civil protection, etc.) and the elderly, who represent a significant share of the population in the city of Zagreb. According to the World Health Organization, mental health is inseparable from physical health and is a priority in preventive medicine.

Possible responses and adaptation measures to anticipated climate change challenges that increase community resilience include strengthening health system competencies for spatio-temporal monitoring, impact recognition and effective response to climate change. In doing so, the digitalization of the healthcare system and its integration with databases from other sectors is extremely important. This enables systematic monitoring of health and environmental indicators related to climate change and timely treatment.

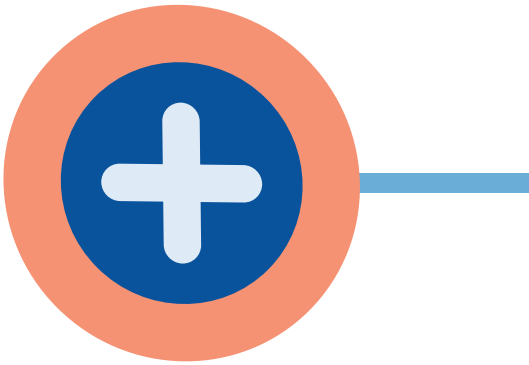


Table 7.8-1
Overview of the impacts and challenges of climate change adaptation in the health sector

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• Increased population mortality • Changes in the epidemiology of acute and chronic non-communicable diseases associated with climatological factors • Decreased quality of outdoor and indoor air due to extremely high and low temperatures and precipitation • More frequent and prolonged periods of unavailability of safe food and water for human consumption • Increase in the level of physico-chemical and biological pollutants in the environment	• Strengthening information and communication competences of health system stakeholders regarding monitoring of environmental and health indicators and impacts of climate change on health and possible responses to expected impacts (intra-sectoral and inter-sectoral plan and implementation of corrective and preventive measures) • Extension of the system for monitoring health and environmental indicators related to climate change, health impact and risk assessment systems and responses (corrective and preventive measures)

Table 7.8-2
Climate change adaptation measures proposed in the health sector

Measure code	Measure name	Key stakeholders
ZD-01	Development of advanced ICT functionalities for monitoring environmental and health indicators and the impact of air quality on the population and health indicators, presented in a spatio-temporal information and communication display	GEOS; City Office for Social Protection, Health, Veterans and Persons with Disabilities; NZJZ "Dr. Andrija Štampar"; HZJZ; DHM; IMI
ZD-02	Preparation and implementation of public education on the safety and availability of water and food during expected climate changes (extreme weather conditions, etc.)	City Office for Social Protection, Health, Veterans and Persons with Disabilities; NZJZ „Dr. Andrija Štampar"; HAPIH

Healthcare measure

ZD-01

Measure name

Development of Advanced Information and Communication Functionalities for Monitoring the Impact of Air Quality on the Population and on Health Indicators in the Spatial and Temporal Information and Communication Display

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Social Protection, Health, War Veterans and People with Disabilities GEOS Information System and Technical Service	Teaching Institute for Public Health "Dr. Andrija Štampar"	Croatian Institute of Public Health (HZJZ) DHMZ IMI

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	EU funds Budget of the City of Zagreb	3 6 11 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	260,000	500,000	500,000	250,000

Indicators	Initial value (2024.)	Target value (2028.)
Number of advanced functionalities for environmental health impact assessments	1 (2023)	4 (2027)
Number of deaths from infectious and parasitic (ICD A00-B99), digestive (ICD K00-K93), respiratory (ICD J00-J99), cardiovascular diseases (I00-I99) and neoplasms (ICD C00-D48)	6,812 (2023)	6,000 (2027)
Identified diseases and conditions during the provision of emergency medical care for selected diagnoses: infectious and parasitic (ICD A00-B99), digestive (ICD K00-K93), respiratory (ICD J00-J99), cardio-vascular diseases (I00-I99) and neoplasms (ICD C00-D48)	19,156 (2023)	18,500 (2027)
Annual number of reports of infectious diseases	27,389 (2023)	27,389 (2027)
Number of areas with planted invasive and/or allergenic plant species	40% (2023)	30% (2027)
Number of acquired invasive and/or allergenic plant species for greening	20% (2023)	<5% (2027)

ZD-01

Indicators	Initial value (2024.)	Target value (2028.)
Number of identified sites with mapped invasive and/or vector animal species of public health importance	100% (2023)	90% (2027)
Annual number of non-compliant food samples	15% (2023)	<8% (2027)
Annual number of non-compliant water for human consumption samples	10% (2023)	<5% (2027)
Annual number of inquiries from the public (citizens and media) about environmental impacts on health	365 (2023)	100 (2027)

Short description/ comment

Integration of databases of environmental indicators related to expected climate change and health indicators of selected diseases from the ICD (International Classification of Diseases). Integrating environmental and health indicators into the ICT system for key health stakeholders and decision-makers in the City of Zagreb would enable monitoring of the impact of environmental factors on the health of the population and vulnerable population subgroups. Digitalization of the process of collecting, raising the level of safe data exchange and monitoring indicators at the population level across time and space will enable the prevention of negative impacts on mortality and incidence of environmental diseases, reduce the number of sick days and absences from work and education, increase the effectiveness of responses of key stakeholders to citizens and the public, which will result in increasing the level of citizens' trust in the environmental risk monitoring system in the city of Zagreb. Informatizing the process of monitoring the impact of the urban environment on health simultaneously raises the level of efficiency and cross-sectoral approach in the management of climate change adaptation processes.

Key activities

- Establishment of a database registry
- Forming a list of environmental and health indicators
- Establishment of the base of key stakeholders
- Conclusion of multi-institutional agreements on data exchange
- Collecting bids to upgrade the ICT functionality of existing tools for monitoring exposure to environmental factors from air, water and soil
- Establishment of a system for reporting environmental health impacts for citizens
- Establishment of automated notifications on expected environmental impacts for target population subgroups (elderly, chronic sufferers, pregnant women, healthcare professionals and other emergency responders)
- Procurement of services
- Validation of purchased functionalities
- Training key stakeholders to use the tool
- Communication to key stakeholders
- Communication campaign towards the public

Healthcare measure

ZD-02

Measure name

Preparation and Implementation of Public Education on the Safety and Availability of Water and Food During Expected Climate Changes (Extreme Weather Conditions, etc.)

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Social Protection, Health, War Veterans and People with Disabilities	Teaching Institute for Public Health "Dr. Andrija Štampar"	City Office for Social Protection, Health, War Veterans and People with Disabilities Teaching Institute for Public Health "Dr. Andrija Štampar"HAPIH
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2028	EU funds Budget of the City of Zagreb	1 2 3 6 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	50,000	50,000	50,000

Indicators	Initial value (2024.)	Target value (2028.)
Number of deaths from infectious and parasitic (ICD A00-B99), digestive (ICD K00-K93), respiratory (ICD J00-J99), cardiovascular diseases (I00-I99) and neoplasms (ICD C00-D48)	6812 (2023)	6000 (2027)
Identified diseases and conditions during the provision of emergency medical care for selected diagnoses: infectious and parasitic (ICD A00-B99), digestive (ICD K00-K93), respiratory (ICD J00-J99), cardio-vascular diseases (I00-I99) and neoplasms (ICD C00-D48)	19,156 (2023)	18,500 (2027)
Annual number of reports of infectious diseases	27,389 (2023)	27,389 (2027)
Annual number of inquiries from the public (citizens and media) about food safety, digestive diseases, poisoning and food handling	365 (2023)	100 (2027)
Annual number of non-compliant food samples	15% (2023)	<8% (2027)
Annual number of non-compliant water for human consumption samples	10% (2023)	<5% (2027)

ZD-02

Short description/ comment	Informiranje javnosti o utjecajima očekivanih klimatskih promjena i prirodnih katastrofa (poplava i ekstremnih vrućina i hladnoća) na zdravlje stanovništva i najosjetljivijih populacijskih podskupina ključno je planirati pravovremeno, međusektorski i provoditi trajno, posebno za prioritetne objekte kojima je osnivač ili upravitelj Grad Zagreb, u skladu s obvezama Zakona o zdravstvenoj zaštiti. Proaktivna komunikacija s ključnim dionicima i javnošću osigurava podizanje razine svijesti, podizanje razine otpornosti zajednice i razine prilagodbe očekivanim klimatskim promjenama u redovnim i izvanrednim okolnostima.
Key activities	• Appointing a working group • Procuring public campaign services • Preparing campaign materials and educating the public • Procuring services for the production of animation, infographics and educational videos • Presenting to the public through the media

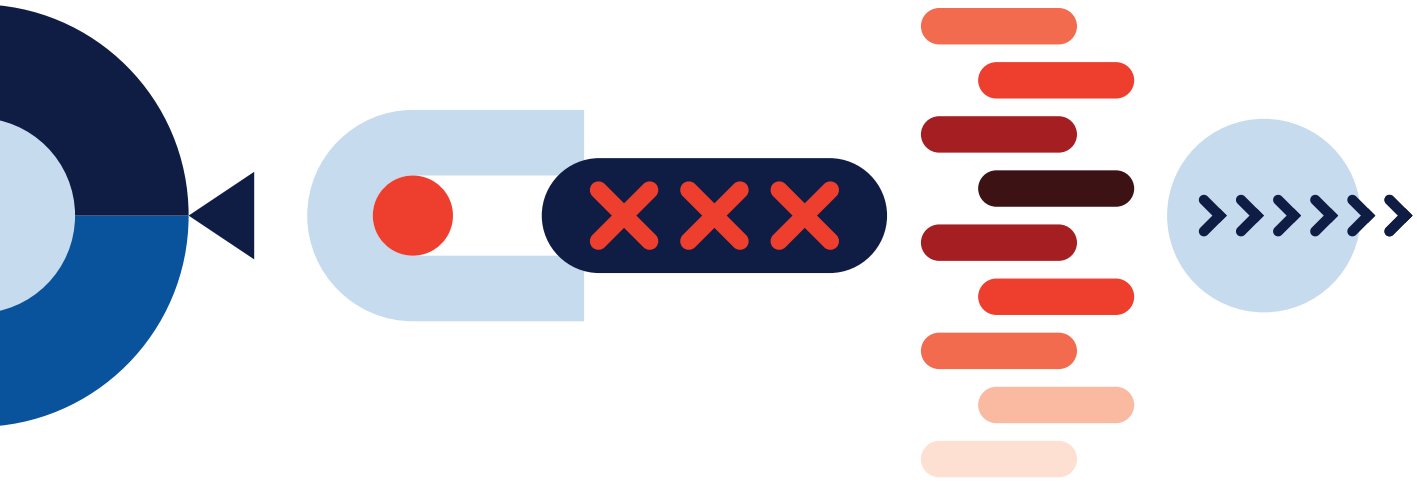
7.9

Spatial Planning

Spatial planning is an ongoing process that includes identification, verification and assessment of the possibilities of use, protection and development of space, development and adoption of spatial plans and monitoring the implementation of spatial plans and the condition of the space. Based on needs, new disciplines and knowledge have been developed outside and within spatial planning, which seeks to prevent the negative impact of climate change on all aspects of society, development and quality, and safety of life of humans and animals. Spatial planning has emerged as a key tool for the implementation and application of climate change mitigation and adaptation measures, as it has an integrative cross-sectoral function in planning sustainable and resilient spatial development. The basis of spatial planning is a multisectoral, interdisciplinary approach that considers, harmonizes and regulates the space needs of all other sectors. The same approach applies to planning climate change adaptation measures. Spatial planning is becoming a link between multiple sectoral policies focused on the adaptive capacities of urban systems. Responsibility for the integration of climate change adaptation measures into spatial plans lies with all sectors involved in the preparation of bases. Integration of all necessary climate change adaptation measures is ensured by spatial planners directly, through planning solutions and indirectly, through sectoral requirements and data.

The City of Zagreb and the Institute for Physical Planning of the City of Zagreb recognized the need to introduce a new planning paradigm, i.e. the inactivity of the current way of planning in terms of adapting to new standards and requirements, interdisciplinary approach to planning, the role of population participation, etc. Spatial planning s faced with the challenge of finding answers to complex issues, especially in cities that are more vulnerable to the negative impacts of climate change than other areas. Nature-based solutions (NBS), as well as the inclusion of green infrastructure in spatial planning, have proved particularly important for reducing risks and increasing resilience and adaptation to climate change and preserving biological and landscape diversity. In addition to ensuring a better quality of life for people, green infrastructure contributes to reducing spatial fragmentation, supports biodiversity, maintains and enhances ecosystems and their benefits, and protects against climate change and environmental disasters.

The challenge from the position of the need to adapt to climate change is the systematic integration of ecosystem-based solutions into spatial planning policies in order to promote the resilience of space to various threats within the given scope. Alongside modern systematic and long-term indirect solutions that need to be embedded in the frameworks of spatial plans and various urban development strategies, spatial planning can directly participate in creating climate change impacts by through land-use management (e.g. conversion from agricultural



or forest to construction or conversion of forest to agricultural land) and thus have a positive or negative impact on greenhouse gas emissions. Knowledge of spatial morphology, the impact of wind or relief on the environment, the impact of built space on the microclimate, the recognition of modern urban solutions and their contribution to the quality of the environment, knowledge of modern technologies and traditional solutions are key tools of spatial planners with knowledge of the basic elements of other scientific disciplines (from engineering, ecological, sociological to economic).

In conditions of various climatic disasters, spatial planning should be placed in a new context that requires the strategic inclusion of a new dimension of risk (from climate disasters) in the planning perspective.

In the area of the City of Zagreb, the adverse impact of climate change on the vulnerability of the urban environment includes:

- floods as a result of the frequency and increased intensity of extreme weather events characterized by large amounts of precipitation in a short period;
- the occurrence of heat islands due to the influence of extreme temperatures, in particular the increase in the number of hot days and days with a temperature above 35 oC;
- storms and strong winds;
- drought;
- instability and/or subsidence as a result of extreme rainfall and torrential sediments in the context of reduced soil absorption.

The spatial plan of the City of Zagreb and the general urban plans of Zagreb and Sesvete do not currently contain an aspect of climate change in their provisions to an appropriate extent that would ensure the possibility of their implementation, but the City of Zagreb is making efforts in this direction. With the help of spatial plans, the City of Zagreb can focus its development in a way to reduce vulnerability to extreme weather conditions and their negative consequences. Therefore, the programme of measures for adaptation to climate change, developed on the basis of risk analysis, provides guidelines for the implementation of measures in amendments or new spatial plans. Spatial plans need to incorporate hazard and risk maps for various threats of climate change (e.g. floods, landslides, etc.), a green infrastructure plan and the establishment of clear provisions for implementation. The inclusion of risk maps is one of the adaptive planning methods.

In 2023, the Strategy for Green Urban Renewal of the City of Zagreb was developed as a strategic-planning basis of importance for the City of Zagreb, which strategically plans and directs the development of green infrastructure and circular management of space and buildings in order to ensure green transition and future sustainable development of space and contribute to achieving climate neutrality and overall resilience to natural and anthropological risks.

The inclusion of green infrastructure in spatial planning is particularly important in urban areas where natural processes are interrupted or disrupted by construction and activities. By adopting the Green Urban Renewal Strategy of the City of Zagreb, the City of Zagreb has established the basis for the development of urban green infrastructure as a system of quality green and water surfaces that achieve numerous benefits for the population, while at the same time providing habitat for plants and animals.

Possible responses to reduce the impact of climate change on the area of the City of Zagreb in the field of spatial planning are primarily related to the adaptation and upgrading of spatial standards and conditions for construction in the direction of strengthening the resilience of new and built structures to the effects of climate change and finding models for raising the resilience of existing structures to risks. For example: prescribing special construction conditions in areas of increased risk - from selecting the least risky areas for construction to prescribing the distance and level of the entrance floors of buildings in areas of increased flood exposure, planning green roofs and walls, considering natural ventilation of residential areas and appropriate infrastructure capacity, forming accumulation areas with a dual use regime (e.g. planning recreational areas that are activated as flood retention areas), etc.

Activities related to climate change adaptation include settlement and housing development, communal economy, spatial and urban planning, protection and improvement of the natural environment, and fire and civil protection. For more effective climate change adaptation, it is necessary to significantly strengthen competencies and capacities at the City level, at the strategic level, by preparing development and spatial plans that include adaptation to climate change, and at the technical level, by training officials and experts in specific areas of adaptation.

It is also necessary to include modern information technologies in the planning of space and to take advantage of the prevalence of smart mobile devices and satellites,

and to continuously collect different categories and types of data that will be the basis for a comprehensive multidata base, i.e. a map of risks and climate threats necessary for the development of new generation spatial plans.

When considering the future and the development of spatial planning, the fact that the climate is changing much faster than spatial plans must not be forgotten, and when planning it is necessary to envisage provisions that will enable adaptive planning methods related to mitigation and adaptation to climate change and incorporate them into the plans.

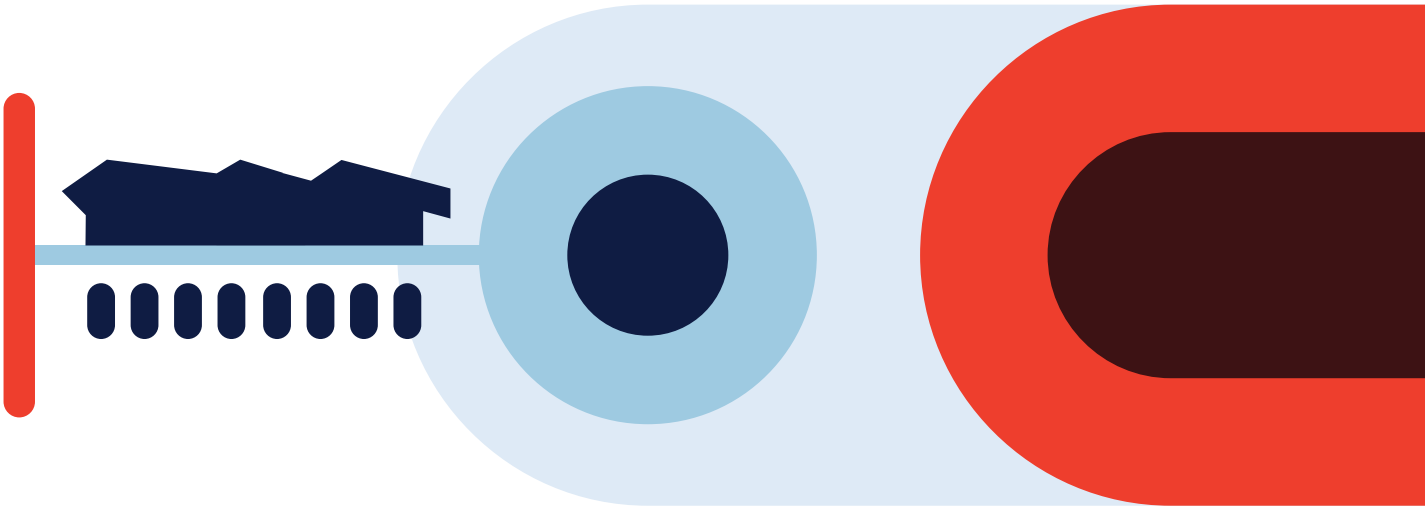
In its opinion submitted to the City of Zagreb, the Ministry of the Interior proposed the need to plan the development of expert bases for climate change adaptation and climate change mitigation by individual sectoral topics in order to implement the results during the next amendments or new Spatial Plan of the City of Zagreb. For the most part, topics have been identified and incorporated into the sectoral measures of this programme, monitoring of indicators by sectors has been prescribed, and the implementation of results in spatial plans is planned. For topics that have not been identified sectorally and topics for which it will be necessary to develop expert bases on the manner of their implementation in spatial plans in accordance with laws and special regulations, it is planned to develop expert bases for climate change adaptation and climate change mitigation within the spatial planning topic. These are, for example, the development of an expert basis for spatial plans for the agricultural landscape of the City of Zagreb, green infrastructure and nature-based solutions, the development of an expert basis for the spatial possibilities of using renewable energy sources, then an expert basis for the implementation of the Flood Risk Management Plan in the Spatial Plan of the City of Zagreb, the Landscape Basis of the City of Zagreb, which are for this reason included in the activities for the period until 2028.

Table 7.9–1
Overview of the impacts and challenges of climate change adaptation in the area of spatial planning of the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• Landslides and soil erosion in parts of the City of Zagreb • Construction on unstable slopes and potential activation of landslides • Lack of a complete landslide register that would be continuously updated, which would facilitate the issuance of various permits and space planning • Flooding due to insufficient capacity of the drainage system and clogging of the drainage system • Climate change further increases variability in the water cycle and results in extreme weather phenomena • Lack of building database (unknown characteristics of housing stock, lack of classification of structures according to earthquake resistance) • Lack of knowledge to plan climate change adaptation measures in all sectors • Heat islands in settlements due to an increase in mean temperature in the summer months • Disappearance of rural settlements • Endangering the landscape and green infrastructure through unplanned construction and urbanization • Lack of integrated spatial planning due to lack of standards for integrated spatial planning focused on climate change impact and adaptation • Lack of spatial standards and conditions for construction in the direction of strengthening the resilience of new and built structures to the consequences of climate change and lack of models for raising the resilience of existing structures to risks • Insufficient participation of residents due to insufficient information • Insufficient use of modern information technologies for the purpose of collecting different categories and types of data as a basis for a comprehensive multidata base, i.e. a map of risks and climate threats required for the development of next-generation spatial plans	• Development of spatial standards and conditions for construction within the spatial planning system with the aim of integrating climate change adaptation measures into spatial planning • Determination of zones and guidelines of climate-neutral and climate-positive parts of the City • Integration of climate change adaptation measures and construction conditions into the spatial plan system • Implementation of the green infrastructure system • Use of nature-based solutions (NBS) • Ensuring the maintenance or achievement of a favourable conservation status of target species and habitat types, as well as the integrity of the ecological network area, by selecting sites and solutions that will not lead to a significant negative impact (independent or cumulative) on the integrity and conservation objectives of the ecological network area • Improving the information base as a basis for making rational decisions regarding the planning of climate change adaptation measures • Continuous education of citizens, raising public awareness and decision makers on the importance of climate change adaptation measures • Systematic investments in people, instruments, research and databases related to natural risks • Plan gray and green uses and implementation measures through spatial plans

Table 7.9-2
Climate change adaptation measures proposed in the spatial planning sector

Measure code	Measure name	Key stakeholders
PP-01	Development of Expert Bases for Spatial Plans of the City of Zagreb in the Function of Climate Change Adaptation	Institute for Physical Planning of the City of Zagreb
PP-02	Integration of climate change adaptation measures and conditions for implementation into spatial plans of the City of Zagreb	Institute for Physical Planning of the City of Zagreb
PP-03	Development of various IT databases / catalogues	City Office for Economy, Environmental Sustainability and Strategic Planning; various economic operators who thus market and promote their products
PP-04	Strengthening competencies and raising awareness of space planning opportunities with the aim of mitigating and adapting to climate change	Institute for Physical Planning of the City of Zagreb



Spatial Planning measure

PP-01

Measure name

Development of Expert Bases for Spatial Plans of the City of Zagreb in the Function of Climate Change Adaptation

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	Institute for Physical Planning of the City of Zagreb	REGEA Hrvatske vode ViO d.o.o. - ZGH d.o.o. City Office for Municipal Self-Government, Transport, Civil Protection and Safety
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
Ongoing	Budget of the City of Zagreb	2 6 7 9 11 12 13 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	200,000	200,000	200,000	200,000

Indicators	Initial value (2024)	Target value (2028)
Number of expert bases prepared	1	4

PP-01

Short description/ comment	Spatial planning stands out as a key tool in the fight against climate change in the City of Zagreb. With the help of spatial plans, the City of Zagreb can focus its development to reduce vulnerability to extreme weather conditions and their negative consequences. For this purpose, it is necessary to develop expert bases that will propose appropriate solutions and develop standards and conditions for construction within the spatial planning system with the aim of integrating climate change adaptation measures into spatial planning.
Key activities	• Development of an expert basis for the Spatial Plans, agricultural landscape of the City of Zagreb, green infrastructure and nature-based solutions • Development of an expert basis on spatial possibilities of using renewable energy sources (RES) • Development of an expert basis for the implementation of the River Basin District Management Plan and the Flood Risk Management Plan in the Spatial Plan of the City of Zagreb • Development of the Landscape Basis of the City of Zagreb

Spatial Planning measure

PP-02

Measure name

Integration of Climate Change Adaptation Measures and Conditions for Implementation into Spatial Plans of the City of Zagreb

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	Institute for Physical Planning of the City of Zagreb REGEA	Professional and other interested public All public law bodies involved in the process of drafting and adopting spatial plans

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
Ongoing	Budget of the City of Zagreb State budget	9 11 13 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	180,000.00	200,000.00	200,000.00	200,000.00

Indicators	Initial value (2024.)	Target value (2028.)
Number of professional/public meetings/workshops held	3	10
Number of spatial plans adopted with integrated additional/ improved climate change adaptation measures	4	10

PP-02

Short description/ comment	Integration of climate change adaptation measures and construction conditions into the spatial plan system. Spatial plans should plan gray and green purposes and implementation measures (e.g. in the case of extreme rainfall, it implies technical and infrastructure solutions that will be able to sufficiently mitigate the negative consequences (floods, etc.), dimensioning of infrastructure lines to extreme precipitation and other climate changes, as well as the formation of absorbent areas, e.g. green areas in settlements, public parks, etc.)
Key activities	• Early participation of the professional and other interested public in the process of preparation of spatial plans • Procedures for developing and adopting spatial plans on all levels

Spatial Planning measure

PP-03

Measure name

Development of Various IT Databases/Catalogues

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	Various economic operators who market and promote their products in this way EPEEF City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services ZGH d.o.o., Zrinjevac Branch ZGH d.o.o., Zagrebačke ceste branch	Scientific and professional organizations Civil Society Associations Citizens

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
Ongoing	Budget of the City of Zagreb EU funds	8 9 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	20,000	22,000	24,000	26,000

Indicators	Initial value (2024)	Target value (2028)
Database/catalog created	0	1
Establishment of a data collection and database management platform	0	1
Number of articles in public media / on the *web* / social media	0	8

PP-03

Short description/ comment	Seeking answers to complex questions in the preparation and implementation of projects, especially in cities that are more vulnerable to the negative impacts of climate change than other areas, can be addressed through an innovative approach, both by developing new technologies and applying nature-based solutions (NBS). It is necessary to create IT databases or catalogues for free use: • modern materials that increase the permeability of the substrate • open urban shading systems • Solutions based on RES sources and methods of installation and use • green facade and roof systems • materials that are fully recyclable and the like The database / catalog offers concrete and currently available technical solutions that users will be able to easily select and include in the planning and implementation of the project.
Key activities	• Data collection • App design and database formation • Webpost • Promotional activities • Updating apps

Spatial Planning measure

PP-04

Measure name

Strengthening Competencies and Raising Awareness of Space Planning Opportunities with the Aim of Mitigating and Adapting to Climate Change

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	Institute for Physical Planning of the City of Zagreb	City offices/institutes/services of the City of Zagreb General and professional public
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
Ongoing	Budget of the City of Zagreb EU funds	11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	20,000	22,000	24,000	26,000

Indicators	Initial value (2024)	Target value (2028)
Number of conducted trainings	0	10
Number of persons involved in education	0	200
Number of study trips	0	6
Number of persons involved in study trips	0	12

PP-04

Short description/ comment	By training officials and experts in specific areas of climate change adaptation, their competencies and capacities need to be significantly strengthened through the exchange of knowledge and experience with other cities, at the strategic level (by developing regional development and spatial plans that include climate change adaptation) and at the technical level; involving citizens in education to raise awareness of local communities about spatial planning processes that contribute to climate change mitigation and adaptation.
Key activities	• Organizing training sessions and study trips for employees and stakeholders involved in spatial planning • Exchange of best practices and experiences • Educating citizens through a web platform and workshops, both online and in local communities

7.10

Biodiversity and Environment

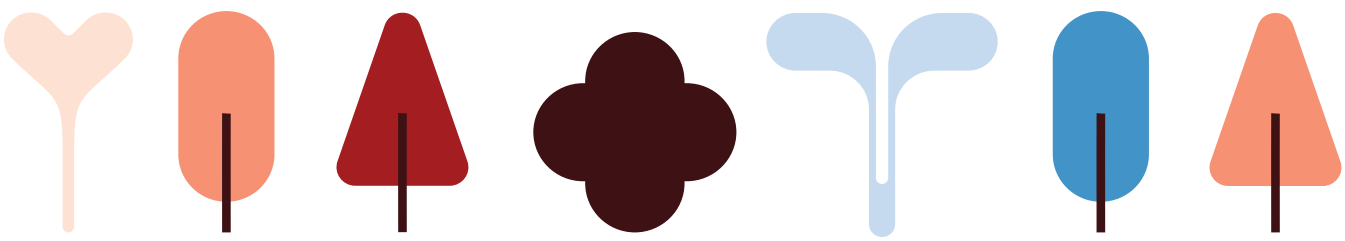
Among the most important impacts and challenges that can be observed due to the impact of climate change in the environment are the increase in the share of invasive species, the disappearance/extinction of indigenous plant and animal species, as well as the disappearance of certain habitat types and changes in their ratios.

Natural ecosystems and species (biodiversity) are currently most threatened by habitat loss (conversion of natural and subnatural areas into areas of intensive agriculture and construction of various purposes, the regulation and reconstruction of watercourses and the drainage of small stagnant and wetland areas, etc.) and unsustainable exploitation of natural resources. Foreign invasive species and pollution also have a very negative impact, and the effects of all these pressures are further exacerbated by climate change and the climate extremes they bring. In the context of changes caused by climate extremes, an increase in the number of wildlife in urban areas is also noticeable. In addition, the trend of human population growth quite understandably leads to the consequent expansion of human settlements pushing further into wildlife habitats, while reducing their living space. Human presence in wildlife habitats is not limited to settlements, but also to numerous recreational and other activities by which people are getting deeper into nature and thus disturbing the peace of wildlife.

The most important climate impacts in this sector are the following: changes in average air temperatures, reduction in quantities and changes in the spatial distribution of precipitation, the occurrence of climate extremes, mild winters and reduction in quantities of water in watercourses and springs.

As a consequence, at the habitat level, the following are expected: drainage of wetland habitats, expansion of arid areas, increased consumption of water from nature for irrigation in food production, increased frequency and intensity of floods from rainwater in urban areas, reduction, alteration and disappearance of some habitats and species, with a decline in biodiversity and the occurrence and spread of some invasive species, animal suffering in extreme climatic events, increased change of natural habitats in the name of climate change adaptation measures (additional gray infrastructure and regulation of watercourses for flood protection, increased forest management, etc.), more frequent occurrence of wildlife in urban areas, migration and animal loss.

The consequences of climate change are particularly visible on migratory species of wild animals. For example, during the winter, so-called wintering migratory birds come to Croatia from northern Eurasia (Scandinavia and Siberia), such as the Eurasian woodcock (*Scolopax rusticola*), the common snipe (*Gallinago gallinago*), the bean goose (*Anser fabalis*), the greater white-fronted goose (*Anser albifrons*), and with the predicted changes in climate, it can be assumed that species will increasingly rarely stay with us because there will be no need for their longer migrations, whereby migrations over longer distances may even be absent. Likewise, there are cases such as in the case of the common quail (*Coturnix coturnix*), which is on the list of game, and comes to us in the summer, and unlike the previous species (wintering migratory bird), its stay is related to the period of reproduction, i.e. it is very likely that over time there is a decline in the number of nesting populations of this species. Therefore, it is necessary to investigate the impact of climate



change on the migration patterns of these species. In order to ensure the monitoring of migratory game bird patterns, it is necessary to introduce a cull analysis, i.e. an assessment of the age and sex structure of the cull birds, by submitting wing samples for analysis.

Game protection programmes, including activities such as migration monitoring and wildlife coexistence education, can make a significant contribution to reducing conflicts between humans and wildlife.

In the future, the agricultural landscape will be particularly exposed to the process of adaptation to climate change. This includes changing agro-technical interventions, changing agricultural crops, or changing varieties of common agricultural crops. The changes will be reflected in the cultivation of crops and varieties of increasingly shorter phenological cycles , which no longer coincide with the phenological cycles of field game species, such as the common quail, the grey partridge (*Perdix perdix*), the European hare (*Lepus europaeus*), leading to an even greater decline in the population of this endangered group of animals.

Therefore, the question arises about the need to establish game refuges in order to provide space for breeding, nesting and rearing the young, but also the space in which they will reside in the future. The establishment of small game refuges will need to be carried out as part of subsidies to hunting right holders. So far, it has been noticed that more and more watercourses remain without water in the riverbed during the summer. This causes the waterfowl to lose their nesting area and raise their young.

The main expected impacts that cause high vulnerability at the species level are the following: interruption of flowering of plant cryophilic and stenothermic species with shortening of vegetation and reduction of vigour, expansion of the thermophilic species range due to an increase in average air temperature, reduction of turgor and vigour, drying and extinction of hygrophilic species due to a decrease in the amount and change in the distribution of precipitation, expansion of the xerophile species range due to a decrease in the amount and change in the distribution of precipitation, reduction of populations of species associated with natural watercourses and small stagnant areas, reduction of forest species populations due to an increase in average air temperature and a decrease in the amount of precipitation, a greater number of invasive species and their spread and suppression of indigenous and increased number of wildlife and wildlife in urban areas of more intelligent and adaptable species (wild boars and crows), which show morphological changes that indicate favourable living conditions in cities.

Although part of the animal, plant and fungal species shows the ability to adapt to climate change, many species will not be able to survive these changes, as an entire species or in a particular area, without human help. It will be necessary to implement strategies to help wildlife species adapt to the consequences of climate change and to enable more connected populations that can improve the genetic diversity required for phenotypic plasticity primarily by preserving and/or restoring their natural habitats. Given all these challenges, it is clear that with human assistance and strategic approaches, it will be possible to preserve biodiversity and natural ecosystems in the context of climate change and enable not only the adaptation of existing ecosystems, but also their restoration and strengthening in the future.

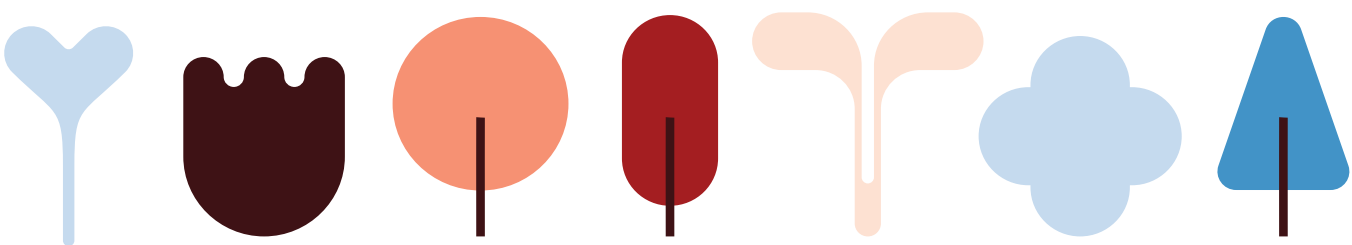


Table 7.10-1
Overview of the impacts and challenges of climate change adaptation in biodiversity in the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• Interruption of flowering of plant cryophilic and stenothermic species with shortening of vegetation and reducing vigour • Expanding the range of thermophilic species (both positive and negative) due to an increase in average air temperature • Reduction of turgor and vigour, drying and extinction of hygrophilic species due to reduced quantities and changes in precipitation distribution • Expansion of the range of xerophilic species (both positive and negative) due to reduced quantities and changes in precipitation distribution • Decrease in forest species populations due to increase in average air temperature and decrease in rainfall • Migration of wildlife due to the impact of climate change • Reduction of populations of species related to natural watercourses and small stagnant streams • Emergence of invasive species in urban areas • Disappearance of pollinators • Bird collisions with artificial objects • Loss of vulnerable species populations due to climate change • Reducing the amount of water in watercourses	• Preservation of the remaining natural and semi-natural habitats - forests, thickets, grasslands, natural watercourses, larger and smaller stagnant areas as habitats for wild species, with the simultaneous function of carbon sinks and absorbent surfaces for precipitation and areas of mitigation of temperature islands • Ecological restoration of aquatic and wetland habitats - replacement of gray with green infrastructure, deregulation of urban streams, restoration of parts of former floodplains, Sava effluents where possible • Changing the way urban greenery is managed to reduce maintenance intensity, planting drought-resistant species, and planting biodiversity-enhancing species • Raising awareness of the importance of natural ecosystem services and the impact on all aspects of life and the economy • Defining the most vulnerable habitats and species to climate change • Conservation of populations of species sensitive to climate change • Defining the zero state and establishing monitoring for the most vulnerable habitats and biodiversity • Defining measures to reduce the spreading and restrict populations of invasive species • Reduction of anthropogenic impact on natural ecosystems, primarily through sustainable development measures • Strengthening the capacity of research institutions and competent authorities to manage natural ecosystems and biodiversity • Encouraging legislative changes in the development of hunting management plans with realistic determination of the economic and social capacity of the area where the plans are implemented • Defining specific measures for the management of wildlife in urban areas • Educating and raising public awareness of the role of natural ecosystems in climate change mitigation and adaptation

Table 7.10-2
Overview of climate change adaptation measures in biodiversity in the City of Zagreb

Measure code	Measure name	Key stakeholders
BO-01	Conservation of the remaining natural and subnatural habitats of the City of Zagreb	ity Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; Public Institution for Management of Natural Values of the City of Zagreb - Nature of the City of Zagreb; Institute for Physical Planning of the City of Zagreb; Zagrebačke ceste; Zrinjevac; City Institute for the Conservation of Cultural and Natural Heritage; GEOS: Agriculture, Forestry and Hunting Sector
BO-02	Ecological restoration of aquatic and wetland habitats of the City of Zagreb	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Affairs; Hrvatske vode; Institute for Physical Planning of the City of Zagreb; Zagrebačke ceste; Zrinjevac; City Institute for the Conservation of Cultural and Natural Heritage; Public Institution for Management of Natural Values of the City of Zagreb - Nature of the City of Zagreb
BO-03	Adaptation of urban green space management and tree planting	GEOS; ZDH d.o.o. Zrinjevac Branch; City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services; Zagrebačke ceste; Zrinjevac; City Institute for the Conservation of Cultural and Natural Heritage; Public Institution for Management of Natural Values of the City of Zagreb - Nature of the City of Zagreb
BO-04	Improving sustainable wildlife management in urban and suburban areas	GEOS; ZOO Institution; Civil Society Associations
BO-05	Educating and raising public awareness of the role of natural ecosystems in climate change mitigation and adaptation	Zagreb ZOO Institution; GEOS; Public Institution “Nature of the City of Zagreb”; educational institutions; local communities; nature protection associations; educational institutions; environmental protection associations
BO-06	Improving the Capacity of the City Branch Zrinjevac for the Production of Planting Material and the Arrangement and Maintenance of Green Areas	ZGH d.o.o., Zrinjevac Branch

Biodiversity and Environment measure

BO-01

Measure name

Conservation of the Remaining Natural and Subnatural Habitats of the City of Zagreb

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS Public Institution for Management of Natural Values of the City of Zagreb - Nature of the City of Zagreb	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services Institute for Physical Planning of the City of Zagreb City Institute for the Conservation of Cultural and Natural Heritage	Department of Biology, Faculty of Science, University of Zagreb Faculty of Forestry and Wood Technology, University of Zagreb Faculty of Agriculture, University of Zagreb Other research institutions and organizations Civil Society Associations

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EU funds EPEEF	11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
		150,000	100,000	150,000

Indicators	Initial value (2024)	Target value (2028)
Number of neighbourhoods for which inventory and mapping of natural and semi-natural habitats has been performed	0	17
Share of natural and semi-natural habitats of the City of Zagreb for which an assessment of ecological status has been carried out (%)	0	100
Number of planning and strategic documents of the City of Zagreb analysed in terms of eliminating conflicts with biodiversity conservation	0	15
Established bird collision monitoring system (yes/no)	No	Yes
Number of research papers and reports on reintroduction and species protection	0	2

BO-01

Short description/ comment

The most pronounced cause of biodiversity decline both globally and in Croatia is habitat loss by changing the way land is used. The conversion of natural and semi-natural habitats (forests, thickets, grasslands, natural watercourses, larger and smaller stagnant areas) into agricultural areas, landscaped park areas and/or their repurposing for the construction of facilities/infrastructure, has direct negative affects on wildlife populations and overall biodiversity, but also their capacity to absorb and retain precipitation, their carbon sink function and their role in alleviating heat island effects. With the loss of habitats, the species themselves become more vulnerable to the weather extremes caused by climate change and the effect of reducing populations and extinction is intensified. In such a situation, wild animals often come into increased contact with residents in the urban core and conflict events potentially occur.

The aim of the measure is to inventory and assess the current state of forests, thickets, grasslands and aquatic habitats in the City, and to ensure the long-term conservation of these habitats in the City through spatial planning documentation and other legal mechanisms.

Also, the establishment and implementation of various breeding and protection programmes, as well as the reintroduction of endangered species by breeding in e.g. a zoo and their return to natural habitats when possible, would achieve the conservation of the genetic diversity of endangered species. The measure includes research of European species and their habitats with the aim of understanding and preserving biodiversity. Research will include analysis of urban and rural ecosystems, biology of endangered species, migration patterns, ecological interactions, and climate change impacts. Also, the aim of this measure is to control and reduce the number of invasive species. The measure also aims to reduce the incidence of bird collisions with artificial objects, such as glass buildings, power lines and public lighting, which has become a growing problem due to climate change and changes in bird migration routes. The tendency is also to preserve habitats suitable for pollinators in urban areas by creating flower beds, green oases and planting indigenous plants. One of the objectives of the measure is developing a nature protection system through the functioning and improvement of the work of wildlife recovery centers, which enables the care of native wild species that are injured, sick or in danger. The goal is to rehabilitate animals and, when possible, return them to nature.

The advantages of implementing this measure are as follows:

- Preserving the current surface area of wildlife habitats will also preserve their populations and reduce the risk of conflicts with wildlife in urban areas.
- Ensuring the survival of habitats for wild pollinators directly contributes to the productivity of agriculture in the surrounding area.
- Considering that natural and semi-natural habitats are currently the only efficient carbon sinks, their preservation will maintain the current level of the City of Zagreb's carbon storage potential.
- The natural substrate and its associated vegetation represent a significant (only) absorbent surface for precipitation, and their preservation also safeguards the retention capacity of the City area, mitigates the effects of increasingly frequent extreme precipitation and reduces the risk of urban flooding, which ultimately reduces the funds that would otherwise be spent on flood protection measures and/or damage repair.
- Natural and semi-natural habitats have a noticeable effect on mitigating temperature extremes. For urban areas, they are extremely important in mitigating heat islands, reducing energy consumption for cooling and preserving the quality of life of citizens.
- Control and reduction of the number of invasive species.
- Conservation of pollinator-friendly habitats in urban areas.
- Development of the nature protection system through the functioning and improvement of the work of the wildlife recovery centre.

Key activities

- Inventory and mapping (GIS) of the remaining natural and semi-natural habitats in the City of Zagreb - forests, thickets, extensive grasslands, wetlands, small and large stagnant areas in the natural or semi-natural state and streams
- Assessment of the ecological status of natural and semi-natural habitats of the City of Zagreb with the identification of significant associated species, evaluation and identification of any necessary management measures
- Comparative analysis of strategic and planning documents of the City of Zagreb with the aim of identifying conflicting projects and providing recommendations for revision.
- Incorporation of the collected data and analysis results into the relevant spatial planning documentation (or revision of spatial planning documentation) with the aim of preserving urban biodiversity and preserving the City of Zagreb's resilience to climate change
- Reduction of bird collisions with artificial objects in urban areas.

Biodiversity and Environment measure

BO-02

Measure name

Ecological Restoration and Revitalization of Aquatic and Wetland Habitats of the City of Zagreb

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS Public Institution for Management of Natural Values of the City of Zagreb - Nature of the City of Zagreb Zagreb Zoo Institution	Hrvatske vode Institute for Physical Planning of the City of Zagreb City Institute for the Conservation of Cultural and Natural Heritage City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services	Research institutions and organizations related to geomorphology and hydrology of watercourses and biodiversity of freshwater habitats, i.e. ecological restoration Civil Society Associations

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EU funds EPEEF	6 11 14 15

Estimation of required funds (EUR)	2025	2026	2027	2028
		50,000		50,000

Indicators	Initial value (2024)	Target value (2028)
Number of city districts for which the opportunities and priorities for the restoration of aquatic and wetland habitats have been identified	0	17
Number of project proposals applied for restoration of freshwater and wetland habitats	0	6

BO-02

Short description/ comment

For over 200 years, freshwater and associated wetland habitats have been under pressure due to continuous drainage, regulation, concreting, partitioning and arching. This pressure is very pronounced in urban areas, including the City of Zagreb. It resulted in a significant loss of the surface of these habitats and related species, but also a significant decline in the capacity of watercourses (and lakes) for water wave retention and water purification, a large burial of watercourses and the consequent drop in groundwater of the surrounding area. In addition to the loss of biodiversity, this condition causes increased sensitivity of urban and periurban areas to extreme rainfall, overloading of the urban drainage system and reduced availability of drinking water. In addition, it requires a significant increase in costs for flood defence, damage repair, water treatment, drilling of new and deeper wells for water supply, etc. Today, freshwater and wetland habitats have the status of the most endangered habitat type at the national level and are a priority for ecological restoration. In addition to restoring biodiversity, the restoration of these habitats represents one of the significant adaptations to climate change and strengthens the resilience of urban environments to several types of climate extremes. The aim of the measure is to identify opportunities and priorities for ecological restoration and revitalization of urban and peri-urban streams, stagnant streams and parts of wetland areas of the City of Zagreb.

The advantages of implementing this measure are as follows:

- strengthening wildlife populations associated with freshwater and wetland habitats and strengthening their resilience to climate change by increasing the availability of natural habitats through ecological restoration
- by increasing the areas of natural and semi-natural aquatic and wetland habitats, their restoration can significantly relieve the drainage system and increase the retention capacity of the City area in extreme precipitation, while saving financial and human capacities needed for flood protection
- habitat restoration also restores the auto-purification capacity of aquatic and wetland ecosystems and reduces the pressure to purify water.
- the increased area of such habitats will also have a significant effect of mitigating temperature extremes (heat islands)
- restoration of freshwater and wetland habitats would strengthen the green infrastructure of the City
- water revitalisation contributes to meeting the environmental objectives defined under the Water Framework Directive in the River Basin District Management Plan.

Key activities

- Identification of the ecological status of waters in accordance with the Water Framework Directive
- Identification of the necessary activities to achieve good water status according to the Water Framework Directive
- Interdisciplinary identification of opportunities and priorities for the restoration of aquatic and wetland habitats in the urban and periurban areas of the City of Zagreb
- Inclusion of the obtained results in the planning and strategic documents of the City of Zagreb

Biodiversity and Environment measure

BO-03

Measure name

Adaptation of Urban Green Space Management and Tree Planting

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services City Office for Municipal Self-Government, Transport, Civil Protection and Safety ZGH d.o.o., Zrinjevac Branch	City Institute for the Conservation of Cultural and Natural Heritage Public Institution for Management of Natural Values of the City of Zagreb - Nature of the City of Zagreb GEOS	Faculty of Agriculture, University of Zagreb Department of Biology, Faculty of Science, University of Zagreb Other research institutions and organizations Civil Society Associations

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb EU funds EPEEF	3 9 11 13 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	3,500,000	175,000	175,000	175,000

Indicators	Initial value (2024)	Target value (2028)
Number of city districts for which opportunities to increase environmental and financial sustainability have been identified	0	17
Number of project proposals applied for the implementation of measures to increase the environmental and financial sustainability of green area management	0	6
Number of sites with applied measures of environmental and financial sustainability of green area management	0	3
Share of green areas managed with environmental sustainability measures	<1	10
Developed guidelines for maintaining green spaces in line with expected climate risks and vulnerabilities	0	1
Construction of retention systems on existing public green spaces	0	3
Conducted tender for the development of public green spaces	0	5
Realization of new park areas	0	2

BO-03

Short description/ comment

The way in which urban green spaces are managed greatly affects the presence of certain wild species in city centres. The current intensive mowing and the trend of the absence of shrubs, as well as planting relatively isolated/solitary tall trees strongly suppresses some important groups such as pollinators and smaller birds, and strongly encourages populations of some species that are conflicted in such an environment (crows). In addition, due to faster and stronger warming, low and intensively mown urban lawns are highly susceptible to drought and contribute to the intensity of local heat islands. The lack of shade due to rare and/or very tall trees and the lack of shrubs has the same effect. Furthermore, the selection of species for flower beds significantly affects the population of wild pollinators, and makes a big difference in the need for irrigation/watering.

The aim of the measure is to assess current practice and identify opportunities and priorities to raise the environmental and financial sustainability of managing green areas of the City of Zagreb

The advantages of implementing this measure are as follows:

- Adapting the maintenance of green areas through the selection of nectariferous species for flower beds and the introduction of areas with delayed mowing will significantly strengthen food availability for the population of wild pollinators and, consequently, the population of other insects, as well as small birds that feed on them. Delayed mowing areas due to lower heating will have a positive effect on the mitigation of heat islands and will further reduce the attractiveness of these areas for crows, mitigating current conflicts with these species.
- Denser planting of trees and shrubs of different sizes will provide habitat for many species (e.g. smaller birds and insects), increase the drought resistance of individual trees, reduce area heating through shading and decrease the attractiveness of such an area for conflict species (crows).
- Choosing drought-resistant species in flower beds, but also when planting trees and shrubs, should significantly reduce the need for watering/irrigation of new plantations.
- These advantages will relieve the human, financial and environmental (water) resources currently spent on the maintenance of green spaces.

Increasing drought resistance of trees in urban conditions:
Tree planting is an existing activity carried out by the City of Zagreb with the aim of reducing the heat island effect and carbon sequestration. In recent years, the city administration has decided on a significant, almost fourfold increase in the number of planted trees, with a tendency to increase this figure. Previous planting primarily involved planting on existing, already established green areas. This trend can be continued, noting that it is also necessary to increase the share of green areas where this planting will be possible. However, tree planting needs to be carried out in already developed areas, especially in densely urbanized areas of the city. The aim of the measure is to reconstruct existing streets, squares, parking lots and other areas of low absorbency by interpolating trees and other vegetation into cassettes at locations where infrastructure allows it.

In addition to the selection of adequate resistant species, the design of the space needs to be adapted. In order to effectively adapt physical planning to measures aimed at protecting trees from water regime extremes, stormwater management through terrain design represents a key solution for increasing drought resistance of trees. This applies to existing and future green spaces, and in order to achieve optimal results, the following is required:

- construction of retention systems on public green areas of the City of Zagreb and development of technical and biotechnical solutions for rainwater retention
- changing the design of public open green areas of the City of Zagreb and the execution of earthworks with the aim of retaining rainwater in the area (water surfaces, rain gardens...)
- construction of underground rainwater tanks with a purification system
- systematic replacement of the existing plant stock and planting of species more resistant to drought and extreme conditions in all public areas
- construction of water surfaces and other absorbent surfaces as a mandatory component of public green areas.

Furthermore, in order to reduce the arbitrary selection of the location of trees, it is proposed to develop the concept of developing green infrastructure for smaller areas, such as local committee benchmarks or city districts, as a pilot project, so that decision makers have at their disposal a catalogue of possible solutions for implementation, which are then implemented in accordance with the plan, i.e. as phases.

BO-03

Indicators	Initial value (2024.)	Target value (2028.)
Replaced trees with drought-resistant species	0	1000
Development of landscape design projects for public green spaces	0	40
Implementation of landscape design projects for public green spaces	0	40
Development of planting plans in existing public and green areas and other locations	120	200
Number of trees planted in public green spaces	8000	25,000
Development of “grey zone” reconstruction projects (street complexes, parking lots, squares) involving high and low vegetation interpolation	0	10
Number of trees planted within the existing “grey zones”	0	500
Developed small-scale green infrastructure plan	0	2

BO-03

Key activities

Analysis of current green space maintenance practices with identification of opportunities to increase environmental and financial sustainability
Development of project proposals for the implementation of measures to increase environmental and financial sustainability at certain sites or groups of sites, including the development of capacities of responsible institutions (individual capacities, capacities of nurseries, equipment, etc.)
Implementation of projects for the implementation of measures to increase environmental and financial sustainability at certain sites or groups of sites
Development of guidelines for maintaining green spaces in line with expected climate risks and vulnerability

Increasing drought resistance of trees in urban conditions:

- Development and implementation of landscape architecture projects for park and other public green areas
- Implementation of tenders for the development of parks and other public green areas
- Systematic replacement of the existing plant stock with drought-resistant species and new approaches to tree planting (e.g. denser assemblies)

Activities may include the construction of new landscape solutions by significantly integrating elements of green infrastructure and nature-based solutions.

Planting trees and shrubs:

- development and realization of landscape architecture projects for the development of public green spaces
- development and realization of plans for planting trees and shrubs
- development and realization of reconstruction projects for existing infrastructure assemblies and other paved areas
- development of a pilot project - a small-scale green infrastructure plan for the area of the city district, local committee or other area of coverage.

Biodiversity and Environment measure

BO-04

Measure name

Improving Sustainable Wildlife Management in Urban and Suburban Areas

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	Zagreb Zoo Institution Hunting Association of the City of Zagreb	Faculty of Forestry and Wood Technology Veterinary Medicine Faculty Authorised hunters Civil Society Associations Local community VHS Agroproteinka

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2028	Budget of the City of Zagreb	11

Estimation of required funds (EUR)	2025	2026	2027	2028
	489,000	525,000	475,000	475,000

Indicators	Initial value (2024)	Target value (2028)
Number of crow nesting sites	0	3
Number of safe shelters created for wildlife	0	3
Game migration monitoring system in place (yes/no)	Ne	Da
New game protection programme	0	1
Number of people involved in educational activities	N/A	1000

BO-04

Short description/ comment

Hunting management plans that define the treatment of game in areas where it is not possible or not allowed to establish a hunting ground are called game protection programmes. The fact is that climate change, and especially mild winters, contribute to the increased number of game individuals in the urban area, so in terms of excretion or relocation, efforts are being made to establish a system for which the implementers of the game protection programme are in charge.

The aim of the measure is establishing a system for monitoring wildlife migration and defining natural migration corridors to prevent wildlife pressure on urban areas due to climate change. The programme will include the development of strategies to maintain optimal conditions in the natural habitats of safe wildlife refuges, thereby fostering safety and reducing the risk of conflict between humans and wildlife in urban areas.

A further objective of this measure is to develop specific wildlife management programmes within the Zoo, as well as in urban areas affected by wildlife migration due to climate change. The programmes will include education on coexistence with wild animals, reducing the negative impact of wildlife on urban areas, and cooperation with hunting societies to preserve wildlife populations.

Key activities

- Control of wild boar populations in the City of Zagreb and Medvednica Nature Park
- Creation of a nesting sites for crows outside urban settlements
- Management of wildlife migration in urban areas
- Identifying and conserving key wildlife migration corridors
- Creating and maintaining safe shelters in surrounding natural habitats for migrating wildlife
- Establishment of a system for monitoring wildlife migration through GPS technology and cooperation with research institutions
- Developing natural habitat management strategies to ensure the availability of wildlife resources
- Education and cooperation with local communities and hunting societies to reduce conflicts with wildlife
- Development of a new programme to monitor wildlife migration and its impact on urban areas
- Educating visitors about the importance of coexistence with wildlife through exhibitions, workshops and lectures
- Collaborate with local authorities and hunting societies to manage wildlife populations
- Organization of joint projects and research with biological institutes and hunting associations
- Development of campaigns to raise awareness of coexistence with wildlife

Biodiversity and Environment measure

BO-05

Measure name

Educating and Raising Public Awareness of the Role of Natural Ecosystems in Climate Change Mitigation and Adaptation

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
Zagreb Zoo Institution Public Institution for Management of Natural Values of the City of Zagreb - Nature of the City of Zagreb	GEOS	Educational institutions Local communities OCD

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2024-2028	Budget of the City of Zagreb EU funds	3 11 12 13 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	60,000	60,000	60,000	60,000

Indicators	Initial value (2024)	Target value (2028)
Number of new or customized educational programmes	0	5
Number of participants included in educational programmes	0	1600
Number of organized workshops and activities	0	40

BO-05

Short description/ comment

Understanding the role of natural and semi-natural ecosystems and their services in mitigating the effects of climate change and strengthening the city's resilience to extreme weather events is necessary to create citizen support for public policies aimed at nature conservation. Therefore, it is necessary to develop a spectrum of educational and communication activities aimed at different target groups.

The aim of this measure is to raise public awareness of the importance of preserved ecosystems and urban biodiversity in climate change mitigation and adaptation.

The advantages of implementing this measure are as follows:

- By developing and implementing educational activities on the role of ecosystems in climate change mitigation, several important environmental topics are simultaneously operating and creating support for a range of environmental public policies.
- Adapting and upgrading the existing capacities of institutions that already implement educational programmes of related content enables faster implementation and reach of target groups.
- The measure enables involvement and cooperation with a number of institutions and civil society organizations.

Key activities

- Development and/or adaptation of educational programmes for children on the conservation of ecosystems and/or individual taxonomic groups and their role in climate change mitigation
- Implementation of thematic educational programmes

Biodiversity and Environment measure

BO-06

Measure name

Improving the Capacity of the City Branch Zrinjevac for the Production of Planting Material and the Arrangement and Maintenance of Green Areas

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
ZGH d.o.o., Zrinjevac Branch	GEOS	Republic of Croatia
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2028	Budget of the City of Zagreb EU funds	8 9 15

Estimation of required funds (EUR)	2025	2026	2027	2028
	395,000	50,000	50,000	1,000,000

Indicators	Initial value (2024.)	Target value (2028.)
Development of a new strategy and plan for the production of planting material with the aim of increasing the quality and number of seedlings produced	0	1
Establishment of a new nursery	0	1
Procurement of the necessary machinery	60	140

BO-06

Short description/ comment	The aim of the measure is increasing the capacity of nursery production, developing a new strategy and planning for the production of planting material with the aim of increasing the quality and number of produced seedlings, increasing the capacity for its own closed cycle of seedling production, technological improvement (purchasing machinery, irrigation, nutrition), increasing the spatial capacity for production, increasing the capacity for landscaping and maintenance of public green areas, planting - improvement of planting technology and education, space designing: improvement of the way of space designing in accordance with the needs of adapting to climate change (sustainable management of rainwater) and increasing the communal level of existing parks, changing the paradigm of greening space, diversification of planting methods - denser planting assemblies (spacing 3 meters between trees, creating a hedge effect, planting bushes), maintenance - regular maintenance, improvement of maintenance methods (irrigation system), adequate and timely pruning of trees, adequate nutrition, adequate provision of water supply (irrigation and proper design of park areas), education of employees (pruning methods, mowing...), preparation of the Plan of maintenance, preservation and improvement of existing green areas and monitoring – keeping records of improving the state of application for the availability of citizens.
Key activities	• Development of a new strategy and plan for the production of planting material with the aim of increasing the quality and number of seedlings produced • Establishment of a new nursery with adequate production capacities • Procurement of the necessary machinery for production, landscaping and maintenance

7.11

Tourism

The climate is one of the important factors in the development of tourism with a strong impact on tourism trends, which affects the length of the tourist season, the quality of the tourist offer, and thus the tourist demand itself. Considering the above and the fact that tourists highly value destinations with favourable climatic conditions, tourism is globally singled out as one of the sectors that is extremely sensitive to climate change. As a result of climate change, the tourism sector will face new requirements in order to maintain the level of quality.

The consequences of climate change in the tourism sector are already noticeable in many global and European destinations, and predictions point out that, consequently, areas of northern Europe could become more attractive for holidays during the summer months, and the Mediterranean and the Republic of Croatia, including the City of Zagreb, could be more attractive to tourists in the rest of the year.

The vulnerabilities of the tourism sector in the City of Zagreb in relation to the impact of climate change are increasingly frequent heat waves and the appearance of urban heat islands, as well as the increasingly frequent occurrence of storms. The consequences of this are reduced tourism demand, damage to tourism infrastructure and the destruction of biosystem attractiveness and biodiversity as elements of attractiveness in tourism. Despite the above, the risk in the tourism sector of the City of Zagreb is assessed as moderate.

In order to achieve the desired impact on climate change adaptation and mitigation in the tourism sector, horizontal measures to be implemented in other sectors will indirectly contribute to climate change adaptation and mitigation in the tourism sector as well. In addition to horizontal measures to be implemented, it is necessary to adapt the tourist destination to climate change, educate, inform and stimulate hoteliers, restaurant owners and caterers to the use of new technologies and sustainable tourism practices, adapt tourism infrastructure to climate change with the aim of mitigating the impact of heat islands and educate citizens, tourists and other stakeholders in the tourism sector.

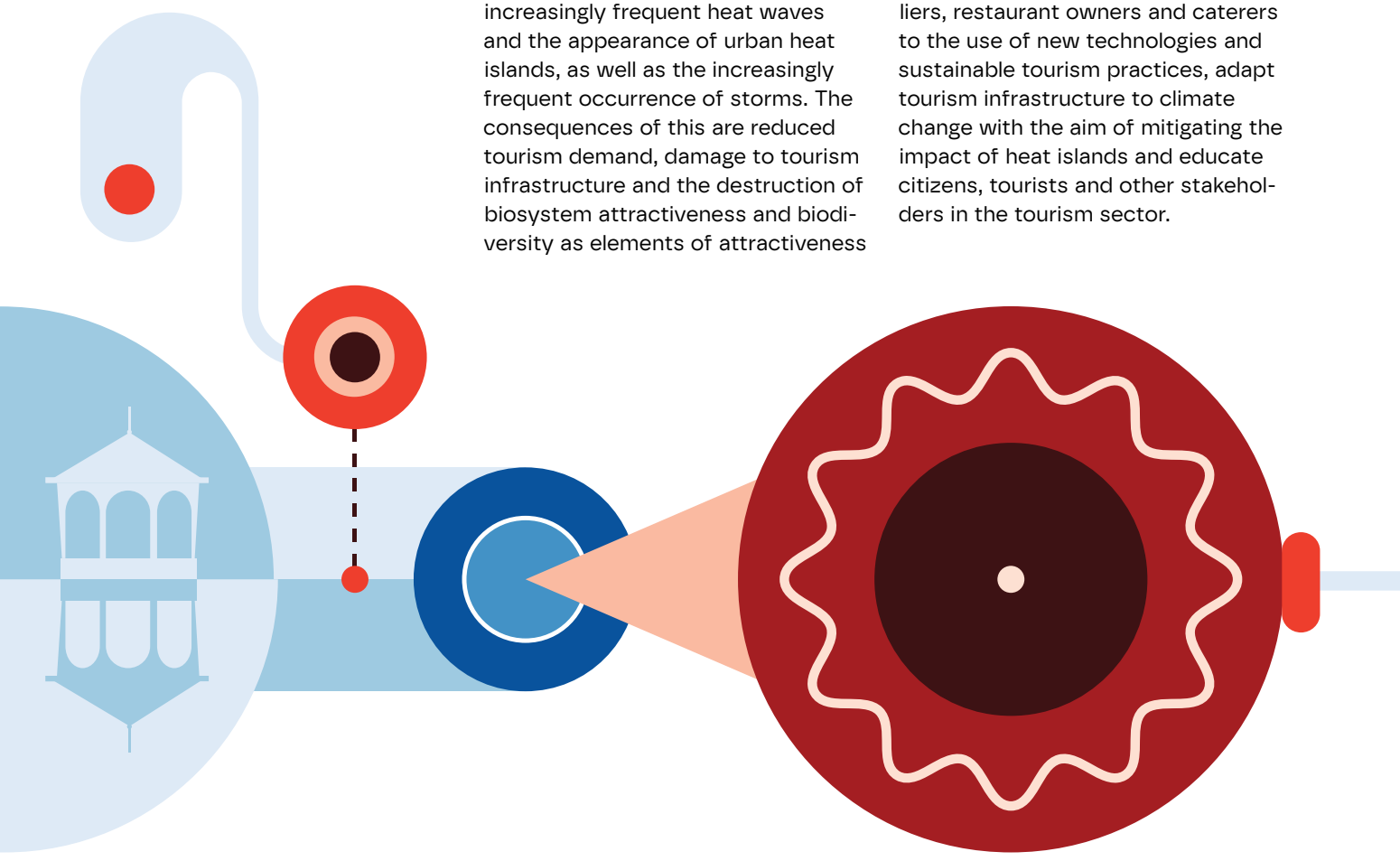


Table 7.11-1
Overview of the impacts and challenges of climate change adaptation in the tourism sector of the City of Zagreb

Impacts and challenges that cause high vulnerability	Possible responses to reduce high vulnerability
• The tourist offer is not adapted to the projected climate change • Deterioration of ecosystem and biodiversity status due to indirect effects of climate change • Occurrence of damage and/or reduced functionality of tourism infrastructure • Insufficient education of tourism sector stakeholders on the impacts of climate change	• Alignment of tourism activities with the forecasted climate change • Adaptation of the tourism sector to changed business conditions due to the impact of climate change • Investing in new tourism infrastructure or adapting the existing one • Strengthening the competence on climate change adaptation of all persons connected with the tourism sector

Table 7.11-2
Climate change adaptation measures proposed in the tourism sector

Measure code	Measure name	Key stakeholders
TU-01	Tourist destination adaptation to climate change	City of Zagreb; Zagreb Tourist Board
TU-02	Implementation of measures to encourage the use of new technologies and sustainable tourism practices to adapt and mitigate climate change	City of Zagreb; ZGH; ZICER
TU-03	Tourism infrastructure adaptation to climate change	City of Zagreb; ZGH
TU-04	Implementation of promotional activities and education for citizens, tourists and the tourism sector	City of Zagreb; Zagreb Tourist Board; ZICER

Tourism measure

TU-01

Measure name

Adapting a Tourist Destination to Potential Climate Change

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	Tourist Board of the City of Zagreb	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb	8 9 12 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	200,000	220,000	250,000	270,000

Indicators	Initial value (2024)	Target value (2028)
Map of tourist movements created	0	1
Number of events held in areas that are less visited by tourists	0	10
A platform that offers tourists an insight into the tourist offer in the entire area of the City of Zagreb	0	1

TU-01

Short description/ comment	In order to respond well to the challenges arising from climate change in the field of tourism, the City of Zagreb must analyse the extent to which it is climate resilient as a tourist destination and define measures for adaptation and mitigation of climate change. Following the above, as a first step, it is necessary to make a quality analysis of tourist movement in order to detect the most visited locations and the most common routes, after which the development or adaptation of tourist products aimed at dispersing tourists to less visited and tourist valorized areas would be initiated.
Key activities	• Creating a map of the movements and routes of tourists within the destination, along with the calculation of the reception capacity and a Management Plan • Encouraging the creation of new and adaptation of existing tourism products • Development of the tourist offer using digital tools

Tourism measure

TU-02

Measure name

Implementation of Measures to Encourage the Use of New Technologies and Sustainable Tourism Practices to Adapt and Mitigate Climate Change

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	Mayor's Office City Office for Education, Sport and Youth City Office for Culture and Civil Society City Office for Social Protection, Health, War Veterans and People with Disabilities City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services City Office for Municipal Self-Government, Transport, Civil Protection and Safety	ZGH ZICER Event planners Hoteliers Restaurants Restaurateurs

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb	8 9 12

Estimation of required funds (EUR)	2025	2026	2027	2028
	1,000,000	1,000,000	1,000,000	1,000,000

Indicators	Initial value (2024)	Target value (2028)
Number of entrepreneurs covered by incentives	4	40
Number of biowaste treatment plants procured	0	25
Number of awarded ECO certificates (EU Ecolabel, ISO, EMAS, etc.)	0	15

TU-02

Short description/ comment	During the event, large amounts of plastic and biowaste are generated in the City of Zagreb, which further impede efforts to combat climate change. In order for the events to become more environmentally sustainable, it is necessary to open a dialogue with the organizers with the aim of encouraging the reduction of the use of disposable plastics and promoting reusable and biodegradable packaging when holding events in the City of Zagreb, as well as the procurement of devices that process bio-waste in such a way that it can be safely discharged into the sewage system. Furthermore, a step forward in adapting to climate change can also be made by encouraging hotels and private accommodation providers to introduce green certificates and standards (use of energy-efficient heating, cooling and lighting systems and renewable energy sources, local foods in food preparation, procurement of furniture made from local raw materials, etc.). This would further profile local hotels and private accommodation providers in a tourism market that increasingly values those turning to sustainable business.
Key activities	• Implementation of measures to encourage the use of new technologies and sustainable tourism practices to adapt and mitigate climate change • Encouraging other tourism industries to use new technologies and sustainable tourism practices

Tourism measure

TU-03

Measure name

Tourism Infrastructure Adaptation to Climate Change

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	City Office for Municipal Self-Government, Transport, Civil Protection and Safety City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services ZGH d.o.o.	

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb Zagreb Holding Budget	3 8 9 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	100,000	120,000	150,000	170,000

Indicators	Initial value (2024)	Target value (2028)
Number of green canopies of public transport	0	20
Number of oases/areas	0	8
Number of products created	0	15

TU-03

Short description/ comment	During summer months, daily movement around the city due to the numerous concrete surfaces is an increasing challenge for citizens and tourists. In order to mitigate the negative effects of climate change, it is necessary to invest effort in activities that will provide thermal oases in extreme temperature conditions that will contribute to easier endurance of extreme conditions.
Key activities	• Creating green oases/areas in the most visited tourist locations and between the most visited tourist locations • Encouraging tourism products in challenging temperature periods

Tourism measure

TU-04

Measure name

Implementation of Promotional Activities and Education for Citizens, Tourists and the Tourism Sector

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	Tourist Board of the City of Zagreb ZICER	Mayor's Office

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb	8 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	100,000	70,000	50,000	50,000

Indicators	Initial value (2024)	Target value (2028)
Number of training sessions aimed at raising awareness among tourism stakeholders on climate change mitigation and adaptation	0	4
Number of educational and information materials (leaflets, brochures, etc.)	0	500

TU-04

Short description/ comment	The impact of the climate on the desirability of the destination will require appropriate education of citizens, tourists and the HoReCa industry (hoteliers, restaurants and caterers) in order to adapt the destination to the negative effects of climate change or mitigate them.
Key activities	• Educating citizens, tourists and the tourism sector about the challenges of climate change, adaptation and mitigation opportunities • Developing educational and informative materials

7.12

Risk Management

In the context of the Climate Change Adaptation and Ozone Protection Programme of the City of Zagreb for the period 2024-2028, risk management is becoming one of the key components for ensuring the sustainability and resilience of the City of Zagreb. Climate change brings a number of challenges that affect sectors that are recognized as most vulnerable to climate change, such as hydrology and water resources, agriculture, forestry, waste management, energy (including buildings), transport, tourism and health. In order to effectively respond to the identified challenges, it is necessary to identify the most important horizontal risks that jointly affect all these sectors and to take preventive measures and planning activities with the aim of reducing vulnerabilities and mitigating the negative effects of risks from natural disasters and disasters caused by climate change.

Among the most important risks identified in the most vulnerable sectors are extreme weather events, such as floods and droughts, which can cause serious consequences in water supply, infrastructure and citizens' health. Also, urbanization and unplanned development lead to the loss of natural resources and an increase in the vulnerability of the system. Climate change also affects biodiversity, which can have long-term consequences for agriculture, forestry and tourism. In addition, the risks associated with infrastructure and technical obsolescence, as well as the lack of financial resources to adapt them, pose significant challenges. Incorporating risk management into all identified vulnerable sectors will be critical to developing a resilient city that can effectively respond to climate challenges.

The City of Zagreb shall prepare a Major Accident Risk Assessment for the City of Zagreb (Official Gazette of the City of Zagreb 38/2022) for the purpose of reducing the risks and mitigating the consequences of major accidents for the health and lives of people, material goods and the environment. The plan of action of the City of Zagreb in the field of natural disasters is adopted annually and includes measures aimed at granting aid for mitigation and partial removal of damage from natural disasters, as well as measures aimed at granting urgent aid for the purpose of partial repair of damage from natural disasters. Regular coordination of adaptation measures, information and targeted education of key stakeholders are essential for an effective risk management system in the City of Zagreb when implementing climate change adaptation measures. The aim of measures that contribute to building resilience in the field of risk management is to ensure the long-term sustainability and quality of life of citizens of Zagreb.

One of the most important prerequisites for informed and adequate decision-making is a functional geoinformation system based on up-to-date and interoperable data. In addition to providing a basis for informed decision-making on disaster risks, it is necessary to mobilize available resources and ensure effective cross-sectoral cooperation. Increasing preparedness for an effective disaster response is crucial from the point of view of the need for a prompt, efficient and organized response, based on making quick decisions that must be in line with planning documents and changes on the ground. It is necessary to modernize the management of response to natural disasters and disasters by applying new knowledge and lessons learned from previous experience, as well as to ensure readiness to respond to similar future events.

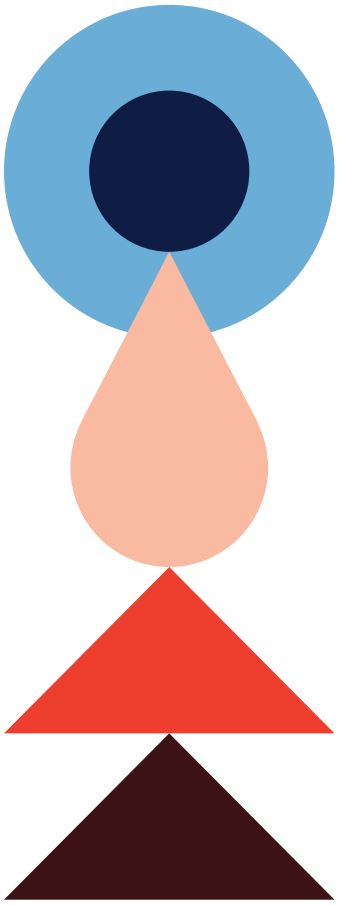


Table 7.12-1
Outline of key risks and possible mitigation measures to be taken in consideration for the effective implementation of the Climate Change Adaptation Programme

Key risks	Possible risk mitigation measures
• Inadequate preparation for climate change in existing systems, which increases the risk of negative consequences of climate change • Overload of resources and infrastructure due to an increase in the frequency of extreme weather events • Inadequate coordination when implementing preventive measures, resulting in unpreparedness to climate challenges and inadequate response to disasters • Dependence on centralized supply systems (energy, water, transport), which reduces resistance to interruptions in crisis situations • Insufficient awareness and education of key stakeholders on possible ways of preventive actions and subsequent actions • Lack of systematic periodic evaluation of preventive actions and follow-up actions in order to mitigate the consequences and gain knowledge on their more effective implementation • Lack of criteria to transparently prioritize different segments of interest	• Strengthening the competencies of key stakeholders to assess hazards and responses during disasters, major accidents, emergencies or climate-related incidents/crises • Improvement of coordination and crisis management systems in all sectors • Examining the impact of climate change on increasing the risk of living in the urban zone of Zagreb • Adaptation of urban utility infrastructure to the increasingly frequent occurrence of urban torrential floods • Development of criteria that would transparently determine priorities in different segments of interest (e.g. what are the investment priorities in infrastructure given the severity/ gravity of the consequences that may occur) • Development of infrastructure to be used in case of long-term heat waves • Development of a model for predicting landslide hazards based on precipitation forecasts and existing landslide maps

Table 7.12-2
Overview of the impacts and challenges of climate change adaptation in the area of risk management of the City of Zagreb

Measure code	Measure name	Key stakeholders
UR-01	Improvement of coordination and crisis management systems in all sectors	The City of Zagreb; public institutions and services responsible for implementing measures within their competences; non-governmental organizations and civil society; citizens; experts and research institutions
UR-02	Strengthening the Capacity of Key Stakeholders to Assess Hazards and Responses During Disasters, Major Accidents, Emergencies or Climate-Related Incidents/Crises	The City of Zagreb; public institutions and services responsible for implementing measures within their competences; non-governmental organizations and civil society; citizens; experts and research institutions
UR-03	Examining the impact of climate change on increasing the risk of living in the urban zone of Zagreb (launching initiatives, participating in projects, organizing conferences)	The City of Zagreb; public institutions and services responsible for implementing measures within their competences; non-governmental organizations and civil society; citizens; experts and research institutions
UR-04	Adaptation of urban utility infrastructure to the increasingly frequent occurrence of urban torrential floods	The City of Zagreb; public institutions and services responsible for implementing measures within their competences; non-governmental organizations and civil society; citizens; experts and research institutions
UR-05	Defining critical points and prioritization	City of Zagreb; public institutions and services responsible for implementing measures within their competences; experts and research institutions
UR-06	Development of infrastructure to be used in case of long-term heat waves	The City of Zagreb; public institutions and services responsible for implementing measures within their competences; non-governmental organizations and civil society; citizens; experts and research institutions
UR-07	Development of a model for predicting landslide hazards based on precipitation forecasts and existing landslide maps	The City of Zagreb; public institutions and services responsible for implementing measures within their competences; non-governmental organizations and civil society; citizens; experts and research institutions

Risk Management measure

UR-01

Measure name

Improvement of Coordination and Crisis Management Systems in All Sectors

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety	All city administrations	Civil Protection Directorate, Ministry of the Interior Citizens' associations DHMZ

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb European Structural and Investment Funds	3 6 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	50,000	30,000	30,000

Indicators	Initial value (2024)	Target value (2028)
Operational coordination plan developed	0	1
Number of training sessions held	0	15
Number of exercises held	0	3
Number of digital crisis coordination and early warning platforms developed and implemented	0	1
Number of established intersectoral teams	0	3

UR-01

Short description/ comment	The measure is aimed at improving the coordination and operational readiness of all sectors in the City of Zagreb to enable a quick and effective response to crisis situations, especially those caused by climate change. The measure includes the establishment of integrated protocols and digital platforms for cooperation among stakeholders, the implementation of early warning systems and regular training and exercises for crisis management.
Key activities	• Development and implementation of an operational coordination plan • Development and maintenance of digital crisis coordination platforms • Education and strengthening of crisis management capacities • Establishment of intersectoral crisis management teams • Implementation of an early warning system

Risk Management measure

UR-02

Measure name

Strengthening the Capacity of Key Stakeholders to Assess Hazards and Responses During Disasters, Major Accidents, Emergencies or Climate-Related Incidents/Crises

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety	All city administrations	Civil Protection Directorate, Ministry of the Interior Citizens' associations DHMZ

Start/end of implementation (years)	Source of funds for implementation	Contributions to UN goals
2025-2028	Budget of the City of Zagreb European Structural and Investment Funds	3 6 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	70,000	50,000	50,000	50,000

Indicators	Initial value (2024.)	Target value (2028.)
Number of training sessions held	0	15
Number of exercises held	0	3
Number of digital crisis coordination and communication platforms developed and implemented	0	1
Developed system for monitoring and evaluation of system participants' responses	0	1

UR-02

Short description/ comment	Strengthening the capacity of key stakeholders to assess hazards and respond in crisis situations involves the development of knowledge, resources and operational capabilities of stakeholders operating in different sectors in the City of Zagreb. The measure includes education, specialized training and the provision of the necessary tools to assess risks and organize responses during disasters, major accidents and other crises caused by climate change. The aim is to increase the readiness and efficiency of stakeholders in the rapid identification of threats and to ensure an optimal response in the protection of citizens and key infrastructure systems.
Key activities	• Development of training and education programmes • Implementation of simulation exercises and crisis scenarios • Improvement of digital and communication tools • Establishment of a system for monitoring and evaluating the effectiveness of responses

Risk Management measure

UR-03

Measure name

Examining the Impact of Climate Change on Increasing the Risk of Living in the Urban Zone of Zagreb (Launching Initiatives, Participating in Projects, Organizing Conferences)

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety	GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services	Teaching Institute for Public Health "Dr. Andrija Štampar" DHMZ University of Zagreb Citizens' associations
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2028	Budget of the City of Zagreb State budget European Structural and Investment Funds	7 9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	50,000	50,000	50,000

Indicators	Initial value (2024)	Target value (2028)
Number of initiatives launched	0	1
Number of conferences held	0	3
Number of projects held	0	1

UR-03

Short description/ comment

In the next period, it will be necessary to investigate more thoroughly the various ways in which climate change will affect the increase in the risk of living in the urban zone of Zagreb, especially the impact of the occurrence of heat islands and the intensification of torrential floods, as well as the growing risk of landslides in the Podsljeme zone. The City of Zagreb will therefore initiate conferences on this topic and be interested in participating in projects and initiatives aimed at increasing resilience in view of trends that cause climate change. Some of these trends are in line with the Climate Change Adaptation Strategy in the Republic of Croatia for the period until 2040 with an outlook to 2070 (Official Gazette 46/20):

- reduced amount of water in watercourses and springs; reduced water supplies in the underground and lowering groundwater levels
- increased frequency and intensity of floods in endangered areas; increased frequency and intensity of torrents; increased frequency and intensity of floods from rainwater in urban areas
- heat islands in settlements due to an increase in mean temperature in the summer months.

Flooding in settlements due to extremely high precipitation (urban flooding).

Climate change can trigger environmental degradation (e.g. activation of landslides due to heavy rainfall), dysfunction of critical infrastructure (e.g. drought – electricity and water supply; torrential flood – drainage) and endanger health, especially of vulnerable population groups due to heat waves.

In the area of the City of Zagreb, climate change contributes to:

- increasingly frequent occurrence of long-term heat waves
- increasingly frequent occurrence of high-intensity urban torrential floods
- occurrence of long-term droughts.

With regard to the activities of designing and organizing conferences on the topic of climate change, a special focus will be placed on:

- preventing new landslides and remediation of existing landslides (Faculty of Mining, Geology and Petroleum Engineering, Faculty of Civil Engineering, city offices)
- preventing the consequences of urban floods (DHMZ, ViO d.o.o., operational forces of the civil protection system, (especially firefighters)
- encouraging the development of infrastructure intended to mitigate the effects of climate change (Faculty of Civil Engineering, urban planners, builders, designers, etc.).

Key activities

- Launching the “Responsible Today for a Safer Tomorrow” initiative. The initiative will educate citizens about the impact of climate change on life in the City of Zagreb and the measures through which everyone can contribute to reducing this danger (education on green infrastructure and the application of new materials).
- Organizing the conference “Impact of climate change on the occurrence of new landslides”
- Organizing a conference on urban flooding
- Organizing a conference on the topic of the development of infrastructure intended to mitigate the effects of climate change (Faculty of Civil Engineering, urban planners, builders, designers, etc.).

Risk Management measure

UR-04

Measure name

Adaptation of Urban Utility Infrastructure to the Increasingly Frequent Occurrence of Urban Torrential Floods

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety ZGH d.o.o.	GEOS City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services Hrvatske vode	DHMZ University of Zagreb Citizens' associations
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2028	Budget of the City of Zagreb ViO d.o.o. European Structural and Investment Funds	6 9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	50,000	50,000	50,000

Indicators	Initial value (2024.)	Target value (2028.)
Number of analyses performed	0	2
Utility Infrastructure Adaptation Plan developed	0	1
Number of detected necessary interventions/upgrades	0	20
Number of implemented/built systems/modifications on utility infrastructure with the aim of reducing the consequences of torrential floods	0	10

UR-04

Short description/ comment

The traditional way of thinking about the risk of flooding, which takes into account only the proximity of watercourses due to climate change, is no longer sufficient to ensure an acceptable level of risk. This is due to increasing meteorological extremes, such as unusually large amounts of precipitation that fall on a small area in a short time, which is why even the best designed rainwater drainage systems cannot function normally.

In the event of urban torrential floods of high intensity, all infrastructure that does not function or does not function optimally due to torrential floods contributes to the additional threat to the population, e.g. transport infrastructure (underpasses in which water accumulates during each heavy rainfall), then the rainwater drainage network owned by Vodoopskrba i odvodnja, etc.

For this reason, the risk is not only posed by construction in inundation areas, but also increasingly by construction on low-lying lands situated around larger hills, slopes, etc. and zones in which the construction has intensified runoff and/or reduced natural infiltration. Such low-lying soils can also be found in the middle of urban areas (cities).

The consequences of climate change on the flood defence system are as follows:

- less and less time to prepare (flooding due to extreme weather conditions is torrential and flooding occurs very suddenly - fatalities due to this type of flooding are increasingly common)
- increasing spatial uncertainty of the possible flooding zone (the occurrence and spatial coverage of storms with the accompanying high intensity of precipitation can hardly be predicted)
- a necessary change in the flood risk assessment paradigm (so far, the source of the threat has been exclusively watercourses and occasional torrential watercourses in mountainous areas, but other anthropological-geographical factors that do not depend exclusively on the existence of permanent or temporary watercourses, but also on:
- the condition and degree of construction of the sewerage network and rainwater drainage
- geographical indicators (spatial reality of the Earth's surface, e.g. low-lying zone within urban areas, runoff intensification zone, natural infiltration reduction zone)
- degree of construction and type of constructed facilities (e.g. underground garages, underpasses prone to flooding, etc.).

The growing importance of experiential factors in torrential flooding in urban areas in assessing the consequences is a crucial experiential factor because, based on previous experience, bottlenecks or areas with the highest risk of flooding can best be identified and preventive actions can be taken to reduce threats.

Climate change also requires the adaptation of civil protection systems. The existing solutions must be complemented by new risk assessments that take into account some new factors, but also plans that emphasize the preventive approach and are developed with the plans of Hrvatske vode associated with the overspill of watercourses, increasingly due to the impact of heavy rainfall on the infrastructure of a densely populated urban area.

The new factors include: anthropological-geographical and experiential factors. Regarding anthropological-geographical factors, the analysis of the state and degree of construction of the sewage network and rainwater drainage is taken into account, as well as the analysis of types of constructed facilities prone to flooding, including geographical indicators (low-lying zones within urban areas, zones of intensification of runoff, zones of reduced natural infiltration as areas of increased risk). Experiencing factors refer to statistical indicators of the most problematic areas (most often flooded) due to storms with high intensity of precipitation in the area of a particular city.

Key activities

- Analysis of the condition and degree of construction of the sewage network and rainwater drainage with regard to the unprojected amount of precipitation (or the amount of precipitation exceeded by calculations during the construction of infrastructure)
- Revitalization of utility infrastructure in accordance with the Adaptation Plan

Risk Management measure

UR-05

Measure name

Defining Critical Points and Prioritization

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety ZGH d.o.o.	All city administrations Hrvatske vode	DHMZ University of Zagreb Citizens' associations
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2028	Budget of the City of Zagreb State budget European Structural and Investment Funds	9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	50,000	50,000	50,000

Indicators	Initial value (2024)	Target value (2028)
Number of segments of interest	0	10
Number of defined possible negative impacts and ranking criteria	0	10
Number of critical points	0	50
Number of ranked critical points	0	30
Number of elements in the vulnerability database	0	50
Number of priority revisions performed	0	1

UR-05

Short description/ comment

A major challenge in urban risk management is:
a) the absence of the necessary databases or the existence of databases with incomplete information of interest for urban risk management
b) the absence of criteria that would transparently prioritize different segments of interest (e.g. what are the infrastructure investment priorities given the severity/gravity of the consequences that may occur).

Planning is one of the more pronounced problems of risk management. For example, investments are often made in individual infrastructure facilities without planning and without taking into account priorities related to the impact of insufficient or lacking maintenance on citizens' safety, i.e. the impact of climate change on infrastructure.

In order to overcome this problem, first the segments of interest will be defined, followed by the critical points on the infrastructure in cooperation with the operators/city/state authorities. This may relate to the state of utility infrastructure, as well as the state of security of the population in general, exposure to risks, etc. The goal is to get a concrete picture of the situation in the space, in accordance with which specific measures would be taken.

Such an approach, which defines the vulnerability of infrastructure and population, i.e. lists critical points on the basis of defined criteria, establishes a database from which it is evident at all times what are the priorities in all segments of interest (including infrastructure or society). This is a solid foundation for attracting money from EU funds and directing investments to the most critical segments of risk management. With established criteria, ranking is possible not only among the same types of infrastructure, but also across different types of infrastructure and other social segments of safety interest. Since no systematic overview of the situation exists, it is difficult to allocate priorities, and properly selected priorities in a situation when there are insufficient financial resources, represent success in implementing the climate change adaptation strategy, as they ensure that the most severe problems with the most serious consequences are addressed first.

Key activities

- Defining segments of interest
- Defining possible negative impacts and ranking criteria
- Defining critical points based on criteria
- Mutual ranking of critical points according to consequences
- Creating a vulnerability database
- Prioritization
- Revision of priorities

Risk Management measure

UR-06

Measure name

Development of Infrastructure to be Used in Case of Long-Term Heat Waves

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety ZGH d.o.o.	All city administrations Hrvatske vode	DHMZ University of Zagreb Citizens' associations
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2028	Budget of the City of Zagreb State budget European Structural and Investment Funds	3 6 9 11 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	50,000	50,000	50,000	50,000

Indicators	Initial value (2024)	Target value (2028)
Number of air-conditioned hospitals / public institutions in the City of Zagreb		100
Number of air-conditioned retirement homes owned by the City of Zagreb	-	5
Number of public wells	-	50
Number of procured/installed sprinklers in public places	0	50
Number of training sessions for at-risk groups of the population on how to behave during the occurrence of heat waves	0	40
Prepared decision on the use of fountains and public wells in the event of long-term heat waves	0	1

UR-06

Short description/ comment

In the event of long-term heat waves, the most vulnerable areas to stay in are all areas without air conditioning where vulnerable groups of people (elderly population and chronic patients) live for a long time. Therefore, it is necessary to air condition all hospitals and retirement homes, i.e. institutions where at-risk groups of people gather.

Short-term measures (before the heat wave) consist of:
1. Education of the population (taking enough fluids, avoiding going outside, staying in air-conditioned areas)
2. Moving at-risk population groups to air-conditioned facilities
   Prerequisite: List of air-conditioned facilities that can accommodate a large number of people
3 Organizing the transport of risk groups of the population to a more climate-friendly area (Sljeme).

In terms of long-term measures, the following actions are necessary:
1. Using fountains and public wells for the purpose of refreshing the population (define the circumstances under which they may be temporarily used, the manner of use, and the necessary monitoring measures, taking into account health-epidemiological conditions)
2. Procuring and installing cooling sprinklers in public areas
3 Expanding the network of public wells
4 Implementing air condition in all hospitals and retirement homes, i.e. institutions where high-risk groups of people gather.

When it comes to preventing the occurrence of heat islands, it is necessary to work on increasing green infrastructure at critical points and encourage the implementation of special measures in the building sector with the aim of increasing urban resilience, e.g. green roof and green facade technology. In this way, it is necessary to plan the design of new kindergartens, schools or retirement homes, as well as to apply green technology in the energy renovation of buildings owned by the City of Zagreb. The City of Zagreb will support local initiatives and projects aimed at the implementation of green roof and green facade technologies.

Key activities

- Air conditioning of hospitals / public places in the City of Zagreb
- Air conditioning of retirement homes owned by the City of Zagreb
- Expansion of the network of public wells
- Procurement and installation of sprinklers for cooling the population in public areas
- Education of high-risk population groups
- Making a decision on how to use fountains and public wells in case of long-term heat waves

Risk Management measure

UR-07

Measure name

Development of a Model for Predicting Landslide Hazards Based on Precipitation Forecasts and Existing Landslide Maps

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
City Office for Municipal Self-Government, Transport, Civil Protection and Safety	City Office for Reconstruction, Development, Physical Planning, Construction and Utility Services	DHMZ University of Zagreb
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2028	Budget of the City of Zagreb State budget European structural and investment Funds	11 12 13

Estimation of required funds (EUR)	2025	2026	2027	2028
	100,000	100,000	100,000	100,000

Indicators	Initial value (2024)	Target value (2028)
Number of meetings held	0	10
Number of realized phases	0	4

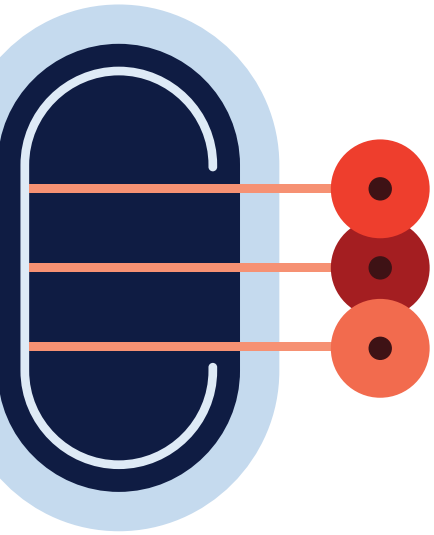
UR-07

Short description/ comment	The aim of the measure is to develop a system for modelling the probability of landslides on the basis of static and dynamic input data. Static data imply cartographic representations of landslide susceptibility and critical precipitation limit values. Dynamic data imply precipitation predictions in real time, based on an appropriate meteorological model, with the display of data in GIS. The landslide probability forecasting model should also result in a cartographic representation of temporal probability in GIS at an appropriate resolution. It is planned to develop a model that will allow updating the data several times a day to obtain a forecast of the landslide probability for 24 hours in advance, in the form of a qualitative description of the danger of slipping, e.g. “very low”, “low”, “medium”, “high” and “very high” with data visualization via a web module of the app, with the possibility of upgrading the early warning system. The goal is to create a dynamic slip hazard forecast for 24 hours in advance, with daily data updates, available online through the portal and the “Moj Zagreb” app for the hilly and mountainous area of the City of Zagreb.
Key activities	• Development of the model by phases

7.13

Other Measures

Other measures include projects and activities that are not sectoral in nature and cannot be classified into previously addressed areas. The most important is the development of a digital information platform that will enable better management and planning of the response to climate change, based on the availability of information from official sources, real-time data, GIS data and other relevant data sources. Also, it is planned to develop two-way information links with the national system in the field of climate change, two-way communication with citizens, development of visualization and simulation models and tools, and dissemination of machine-readable data on climate change. The digital information platform should be developed and harmonized with the existing systems of the City of Zagreb: Energy Atlas, EIC, GIS of the City of Zagreb, 3D model of the City of Zagreb, digital twin of the City of Zagreb, Zagreb Smart City, Statistics of the City of Zagreb, etc.



Other measures

OM-01

Measure name

Development of a Digital Information Platform for Climate Change in the City of Zagreb

Measure rightholder	Partners in the implementation of the measure	Other stakeholders involved
GEOS	City authorities Urban companies and institutions REGEA	Government administrations Academic sector Private sector Civil society and citizens DHMZ
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2025-2030	Budget of the City of Zagreb State budget EU programmes	3 11

Estimation of required funds (EUR)	2025	2026	2027	2028
	100,000	100,000	100,000	100,000

Indicators	Initial value (2024)	Target value (2028)
Created digital platform	0	1
Functionality of connection to official databases	0	1
Functionality of use of real-time data	0	1
Urban heat island monitoring functionality	0	1
Visualization, analytics and simulation functionality	0	1
Functionality of monitoring key indicators on climate change	0	1
Dissemination functionality of machine-readable data	0	1
Functionality of presentation and two-way communication with citizens	0	1

OM-01

Short description/ comment

The measure plans to develop a digital platform for the collection, integration, analysis and dissemination of data and information on climate change in the City of Zagreb and the Zagreb metropolitan area.

The goal of the development of the digital platform is to enable all relevant stakeholders to access and use all relevant data of the City of Zagreb with the help of visualization, analytical and simulation tools.

The following activities and characteristics of the digital platform are planned:
- two-way communication with the national climate change information system
- access to European Commission climate and climate change data
- access to GIS layers at local, national and international level
- access to statistics layers at local, national and international level
- integration of climate-related real-time sensor data
- preparation of a map and monitoring of urban heat islands as a basis for making decisions on measures necessary to mitigate them
- 3D visualization / VR / AR climate and climate change data
- analytical review of climate change data through thematic virtual dashboards
- simulation models of climate change
- machine-readable climate data dissemination
- data dissemination and two-way communication with citizens.

The digital platform will be developed using the infrastructure of the existing systems of the City of Zagreb such as; GIS of the City of Zagreb, Energy Atlas, 3D model of the City of Zagreb, digital twin of the City of Zagreb, Zagreb Smart City, Statistics of the City of Zagreb, etc.

Key activities

- Establishment of an initial digital platform (web) with basic information on climate change
- The process of integrating foreigners into society is important at the local, national and European level.
- Connecting with the digital twin of the City of Zagreb
- Use of real-time data (sensors)
- Development of visualization, analytical and simulation tools
- Monitoring of key indicators on climate change
- Machine-readable climate data dissemination
- Presentation and two-way communication with citizens

8

Ozone Layer Protection

8.1

Ozone Layer Protection Measures and Activities

p. 247→

Ozone is a natural gas composed of three oxygen atoms (O_3) and is an integral part of the Earth's atmosphere. Ozone is located in the atmosphere in two layers. About 90% of the total ozone is in the stratosphere, a layer of atmosphere that extends from 10 to 50 km above the ground. The remaining part, about 10% of the total ozone in the atmosphere, is located in the troposphere, i.e. within 10 km above the ground. Ozone in the troposphere (ground-level ozone) is a pollutant in the air and is subject to regulations governing air protection.

The majority of ozone in the stratosphere is located in a layer between 15 and 35 km above the ground, called the ozone layer. The ozone layer is essential for life on Earth. It absorbs harmful solar ultraviolet radiation and the amount of harmful radiation that will reach the surface of the Earth directly depends on the concentration of ozone in the stratosphere. By absorbing ultraviolet radiation, ozone is a source of heat in the stratosphere, thus playing an important role in the temperature structure of the atmosphere itself.

Ozone is naturally produced in the stratosphere by photochemical reactions. Ultraviolet solar radiation breaks down oxygen molecules (O_2) into atoms, some of which bind with other oxygen molecules, creating ozone (O_3). The ozone molecule is unstable, so the formation of ozone is accompanied by its simultaneous photochemical decomposition into oxygen molecules. Other gases in the atmosphere also participate in the formation and degradation reactions of ozone. The dynamic balance between the natural processes of ozone production and degradation maintains a consistent concentration of ozone in the stratosphere. However, human activity disturbs the natural balance, since the introduction of artificially created organohalogen compounds, as well as other gases into the atmosphere, promoting the degradation of stratospheric ozone and the reduction of its concentration in the stratosphere, thus increasing the penetration of ultraviolet radiation to the surface of the Earth, which has an adverse effect on human health and ecosystems.

Changes in the ozone layer, primarily over the Earth's poles, were observed in the mid-1970s. The ozone layer was found to be endangered by the accumulation of gases containing halogen elements (chlorine and bromine)1 in the atmosphere. The first ozone hole (an area of extremely low ozone concentration in the stratosphere) was observed in the mid-1980s over Antarctica.

As it has been scientifically established that the ozone layer will gradually restore itself when the consumption of ozone-depleting substances is eliminated and the concentration of chlorine and bromine in the atmosphere is reduced, the response at the global level was the adoption of the Vienna Convention for the Protection of the Ozone Layer in 1985 and the accompanying Montreal Protocol on Substances that Deplete the Ozone Layer in 1987. The Montreal Protocol set out concrete measures: the dynamics of phasing out the production and consumption of ozone-depleting substances, uniform control mechanisms (reporting and labelling) and ways of cooperating at the global level in monitoring the implementation of the Montreal Protocol, which further amendments (Kingali, 2016) to mitigate climate change also included certain fluorinated greenhouse gases that began to be used as substitutes for certain ozone-depleting substances.

In September 2019, theozone hole over Antarctica was the smallest since measurements began. The last major ozone layer damage over the Arctic was in spring 2011 and spring 2020.

1 Ozone degradation is accelerated by the presence of catalysts, free radicals of nitrogen oxides, chlorine, bromine and hydroxyl radicals. Although there are natural sources for these radicals, concentrations of chlorine and bromine in the atmosphere are primarily due to the introduction of large amounts of artificially created organohalogen compounds into the atmosphere, especially chlorofluorocarbons (CFCs) and bromofluorocarbons (halons). These compounds are stable (insoluble in water, resistant to physical, chemical and biological influences) and reach the stratosphere from the lower layers of the atmosphere. In the stratosphere, they are exposed to strong solar ultraviolet radiation under which they decompose into reactive atoms (radicals) of chlorine and bromine, and each radical of chlorine and bromine can freely initiate and catalyze (accelerate) a chain reaction that can degrade more than 100,000 ozone molecules.

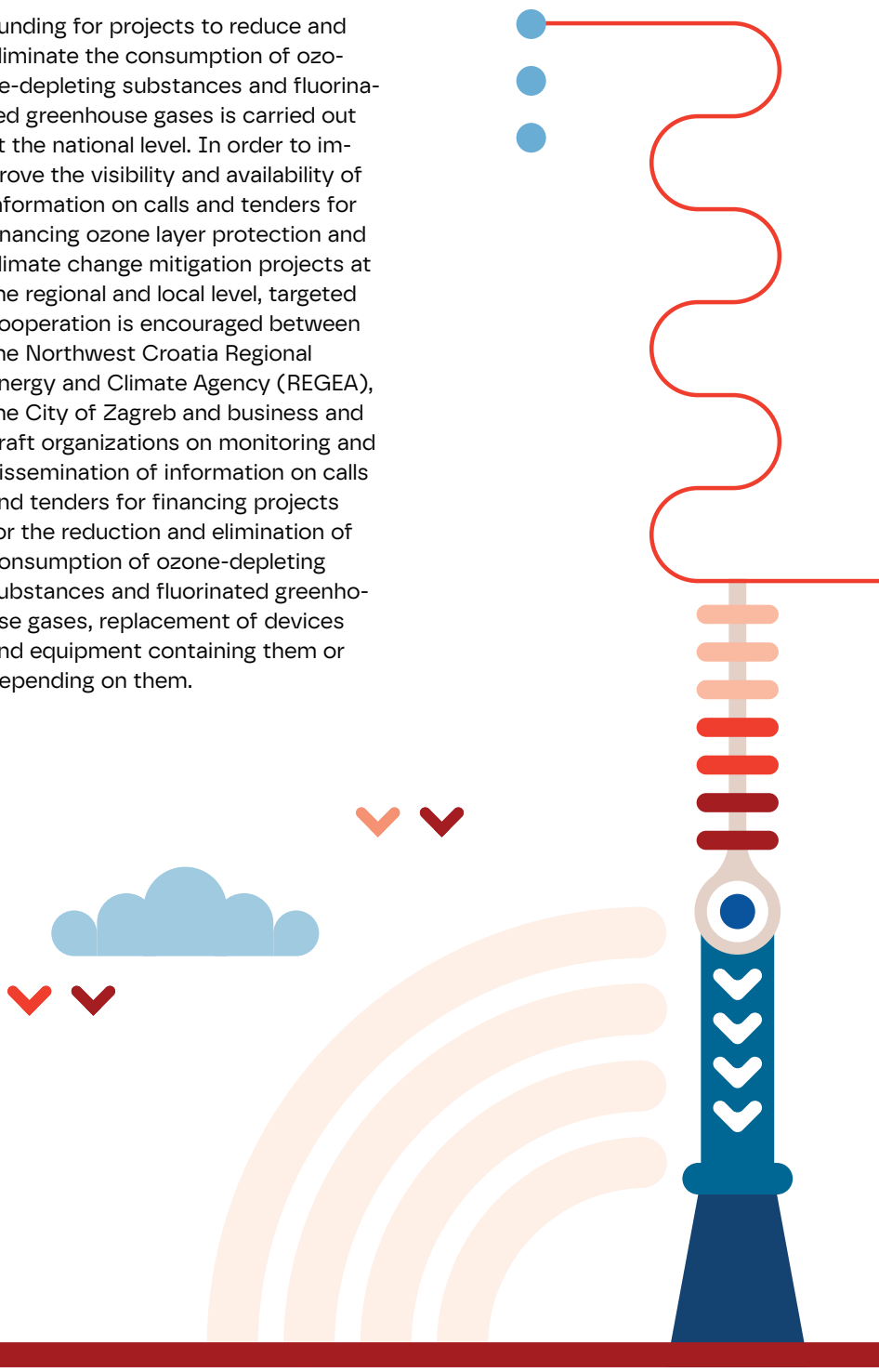
8.1

Ozone Layer Protection Measures and Activities

The ozone layer is protected by preventing the release of ozone-depleting substances into the atmosphere. Fluorinated greenhouse gases are used as a substitute for ozone-depleting substances. However, as some of the fluorinated greenhouse gases have a high greenhouse potential, their use is limited globally to mitigate climate change. The dynamics of reducing and eliminating the production and consumption of ozone-depleting substances and fluorinated greenhouse gases is determined at the global level by international agreements, to which the Republic of Croatia is a signatory.

The regulations governing the protection of the ozone layer determine the treatment of substances that deplete the ozone layer, as well as fluorinated greenhouse gases and devices and equipment containing them or depending on them, in such a way as to prevent the release of these substances into the environment as much as possible. The regulations also establish control and reporting mechanisms for the treatment of ozone-depleting substances and fluorinated greenhouse gases, and devices and equipment containing or relying on them. Additional measures at the level of regional (regional) and local self-government to reduce or prevent the release of ozone-depleting substances and fluorinated greenhouse gases are not necessary.

Funding for projects to reduce and eliminate the consumption of ozone-depleting substances and fluorinated greenhouse gases is carried out at the national level. In order to improve the visibility and availability of information on calls and tenders for financing ozone layer protection and climate change mitigation projects at the regional and local level, targeted cooperation is encouraged between the Northwest Croatia Regional Energy and Climate Agency (REGEA), the City of Zagreb and business and craft organizations on monitoring and dissemination of information on calls and tenders for financing projects for the reduction and elimination of consumption of ozone-depleting substances and fluorinated greenhouse gases, replacement of devices and equipment containing them or depending on them.



Measure order number

ZO-01

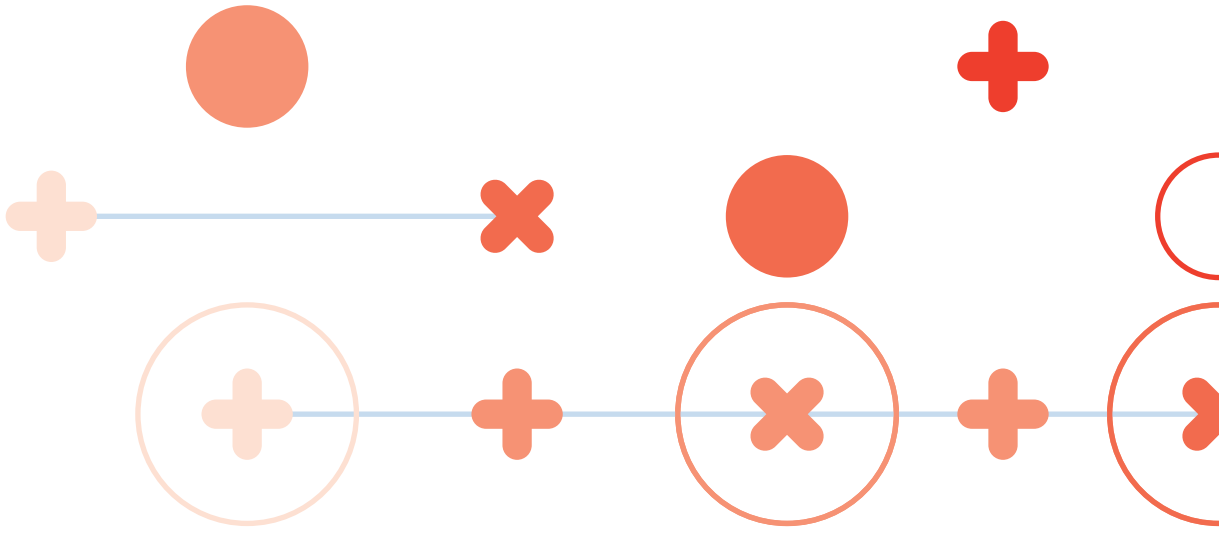
Measure name

Increasing the Visibility of Information on Calls and Tenders for Financing Projects for the Reduction and Elimination of Consumption of Ozone-Depleting Substances and Fluorinated Greenhouse Gases

Measure rightholder	Partners in the implementation of the measure	Other inclusive stakeholders
City of Zagreb	Croatian Chamber of Economy - Chamber of Zagreb Croatian Chamber of Trades and Crafts - Chamber of Zagreb REGEA	EPEEF Business community Institutions (co-)owned by the City of Zagreb
Start/end of implementation (years)	**Source of funds for implementation**	**Contributions to UN goals**
2024-2030 (ongoing)	Budget of the City of Zagreb	8 9 11 12

Short description/ comment

The aim of the measure is to monitor calls and tenders at the national level for financing projects for the reduction and elimination of consumption of ozone-depleting substances and fluorinated greenhouse gases by replacing devices and equipment containing them or depending on them, replacing these substances, introducing new technologies, etc. In cooperation with partners, activities of forwarding information on calls and tenders to beneficiaries of funds envisaged by calls and tenders are carried out. If necessary, support shall be provided in the application of projects for the reduction and elimination of consumption of ozone-depleting substances and fluorinated greenhouse gases to calls and tenders.



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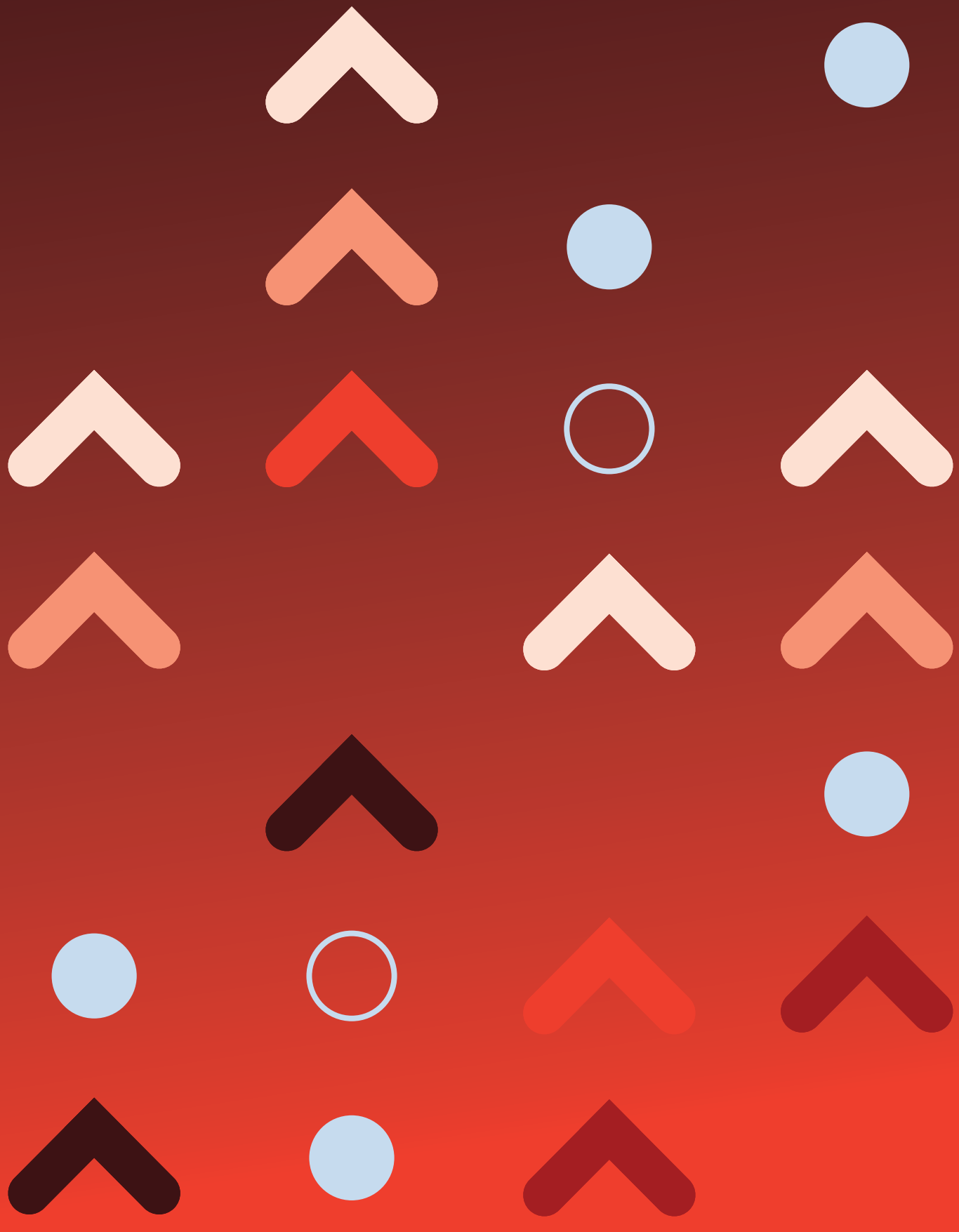
Total Amount of Planned Investments



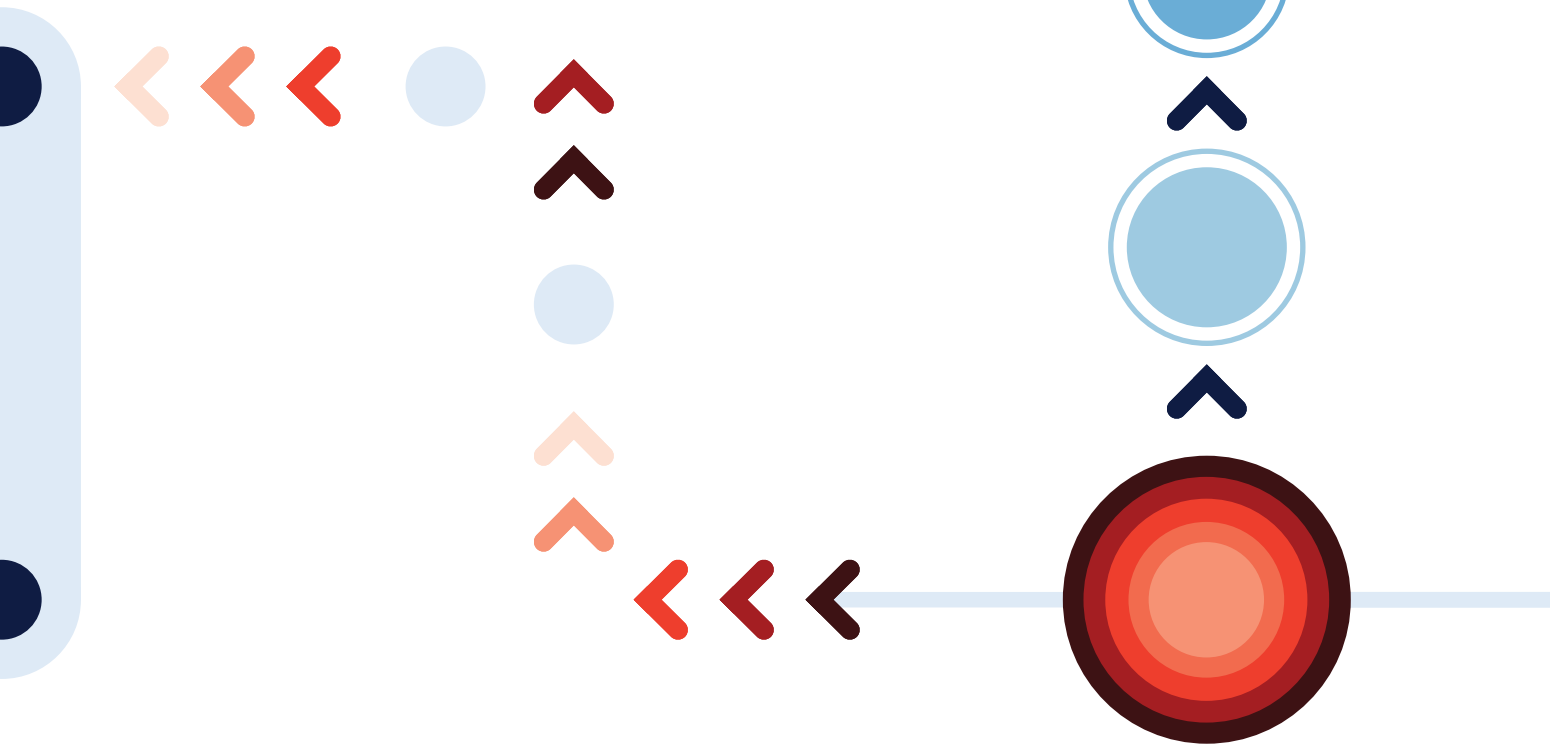
Total Amount of Planned Investments

In the period from 2025 to 2028, this Program envisages an investment in the amount of EUR 1.4 billion. By comparison, the budget of the City of Zagreb in 2025 is EUR 2.8 billion.

The largest investments will be made in the transport sector, where it is planned to increase the frequency and reliability of public urban transport through the procurement of new vehicles, the improvement of the existing electricity network, but also the development of the public bicycle system. Together, this will contribute to greater use of public urban transport, i.e. reduction of emissions from automotive transport.

In the area of water resources, it is planned to improve the water supply network through the reconstruction of pipelines with the aim of reducing losses in the network, as well as the construction of Stage III wastewater treatment plants. This will contribute to reducing the emissions required to deliver water but also reduce the use of water and ensure environmental protection from pollution.

Among other major measures, investments in a waste management center should be highlighted, which will contribute to the reduction of emissions through more rational use of waste as a resource, more advanced technology for waste treatment, but also the reuse of certain materials. In addition, part of the emissions will be saved in the reduced use of energy for heating and cooling in energy renovated public sector buildings.



	TOTAL INVESTMENTS (€) IN YEAR				
SECTOR	2025	2026	2027	2028	2025 – 2028
WATER RESOURCES	32.019.000	130.924.000	146.935.000	106.809.260	**416.687.260**
AGRICULTURE	625.000	875.000	875.000	875.000	**3.250.000**
FORESTRY	3.891.500	4.751.500	4.691.500	4.351.500	**17.686.000**
BIODIVERSITY	4.444.000	1.010.000	860.000	1.910.000	**8.224.000**
WASTE MANAGEMENT	11.438.200	6.976.000	54.676.000	90.176.000	**163.266.200**
ENERGY	5.493.000	5.815.000	6.150.000	5.920.000	**23.378.000**
TRANSPORT	103.075.000	158.800.000	161.950.000	129.550.000	**553.375.000**
BUILDING	31.215.000	97.185.000	32.135.000	32.835.000	**193.370.000**
TOURISM	1.400.000	1.410.000	1.450.000	1.490.000	**5.750.000**
HEALTHCARE	260.000	2.000.000	1.500.000	1.000.000	**4.760.000**
SPATIAL PLANNING	420.000	444.000	448.000	452.000	**1.764.000**
RISK MANAGEMENT	420.000	400.000	380.000	380.000	**1.580.000**
OTHER MEASURES	100.000	100.000	100.000	100.000	**400.000**
TOTAL (€)	**194.800.700**	**410.690.500**	**412.150.500**	**375.848.760**	**1.393.490.460**

10

List of Abbreviations

APN	Agency for Transactions and Mediation in Immovable Properties (Cro. *Agencija za pravni promet i posredovanje nekretninama*)
CUPOVZ	Central waste water treatment plant of the City of Zagreb (Cro. *Centralni uređaj za pročišćavanje otpadnih voda Grada Zagreba*)
DHMZ	Croatian Meteorological and Hydrological Service (Cro. *Državni hidrometeorološki zavod*)
EBRD	European Bank for Reconstruction and Development
EEA	European Environment Agency
ERDF	European Regional Development Fund
EFSI	European Fund for Strategic Investments
EIB	European Investment Bank
EIHP	Energy Institute Hrvoje Požar
ELENA	European Local Energy Assistance
Eprim	Annual primary energy
ESCO	Energy Service Companies
EPEEF	Environmental protection and energy efficiency Fund
GEOS	City Office for Economy, Environmental Sustainability and Strategic Planning (Cro. *Gradski ured za gospodarstvo, ekološku održivost i strategijsko planiranje Grada Zagreba*)
GSKG	City Housing and Public Utility Services (Cro. *Gradsko stambeno komunalno gospodarstvo*)
GUP	General Urban Plan (Cro. *Generalni urbanistički plan*)
HAK	Hrvatski autoklub
HAPIH	Croatian Agency for Agriculture and Food (Cro. *Hrvatska agencija za poljoprivredu i hranu*)
HBOR	Croatian Bank for Reconstruction and Development (Cro. *Hrvatska banka za obnovu i razvitak*)
HKA	Croatian Chamber of Architects (Cro. *Hrvatska komora arhitekata*)
HKIG	Croatian Chamber of Civil Engineers (Cro. *Hrvatska komora inženjera građevinarstva*)
HZJZ	Croatian Institute of Public Health (Cro. *Hrvatski zavod za javno zdravstvo*)
HŽ	Hrvatske željeznice
IMI	Institute of Medical Research and Occupational Medicine (Cro. *Institut za medicinska istraživanja i medicinu rada*)
IPCC	Intergovernmental Panel on Climate Change
IPZP	Integrirani promet zagrebačkog područja
JASPERS	Joint Assistance to Support Projects in European Regions
PPP	Public-private partnership
LST	Land surface temperature
MING	Ministry of the Economy (Cro. *Ministarstvo gospodarstva*)
MKIM	Ministry of Culture and Media (Cro. *Ministarstvo kulture i medija*)
MMPI	Ministry of the Sea, Transport and Infrastructure (Cro. *Ministarstvo mora, prometa i infrastrukture*)
MPUGDI	Ministry of Physical Planning, Construction and State Assets (Cro. *Ministarstvo prostornoga uređenja, graditeljstva i državne imovine*)
MRDEUF	Ministry of Regional Development and EU funds (Cro. *Ministarstvo regionalnoga razvoja i fondova Europske unije*)
MTIS	Ministry of Tourism and Sports (Cro. *Ministarstvo turizma i sporta*)
MUP	Ministry of the Interior (Cro. *Ministarstvo unutarnjih poslova*)
MZOZT	Ministry of Environmental Protection and Green Transition (Cro. *Ministarstvo zaštite okoliša i zelene tranzicije*)
NBS	Nature-based solutions
NDVI	Normalised difference vegetation index
NPOO	National Recovery and Resilience Plan (2021-2026)
nZEB	Nearly zero energy buildings
OCD	Civil Society Organisations (Cro. *organizacije civilnog društva*)
RES	Renewable Energy Sources
P0	Climate reference period (1971-2000)
P1:	Near climate period (2011-2040)
P2	Further climate period (2041-2070)
$Q_{H,nd}$	Annual heat energy required for heating
RCP 2.6	Low Emissions Scenario in the Sixth Report of the International Climate Change Committee
RCP 4.5	Moderate Emissions Scenario in the Sixth Report of the International Climate Change Committee
RCP 6	Moderate Emissions Scenario in the Sixth Report of the International Climate Change Committee
RCP 8.5	High Emissions Scenario in the Sixth Report of the International Climate Change Committee
TZGZ	Tourist Board of the City of Zagreb (Cro. *Turistička zajednica Grada Zagreba*)
ViO	Vodoopskrba i odvodnja
ZET	Zagrebački električni tramvaj
ZGH	Zagrebački holding
ZI	Zelena infrastruktura
ZICER	Zagrebački inovacijski centar
ZSK	Zagrebački sunčani krovovi

11

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Zagreb, 23 January 2025

President
of the City Assembly
Joško Klisović (original signature)

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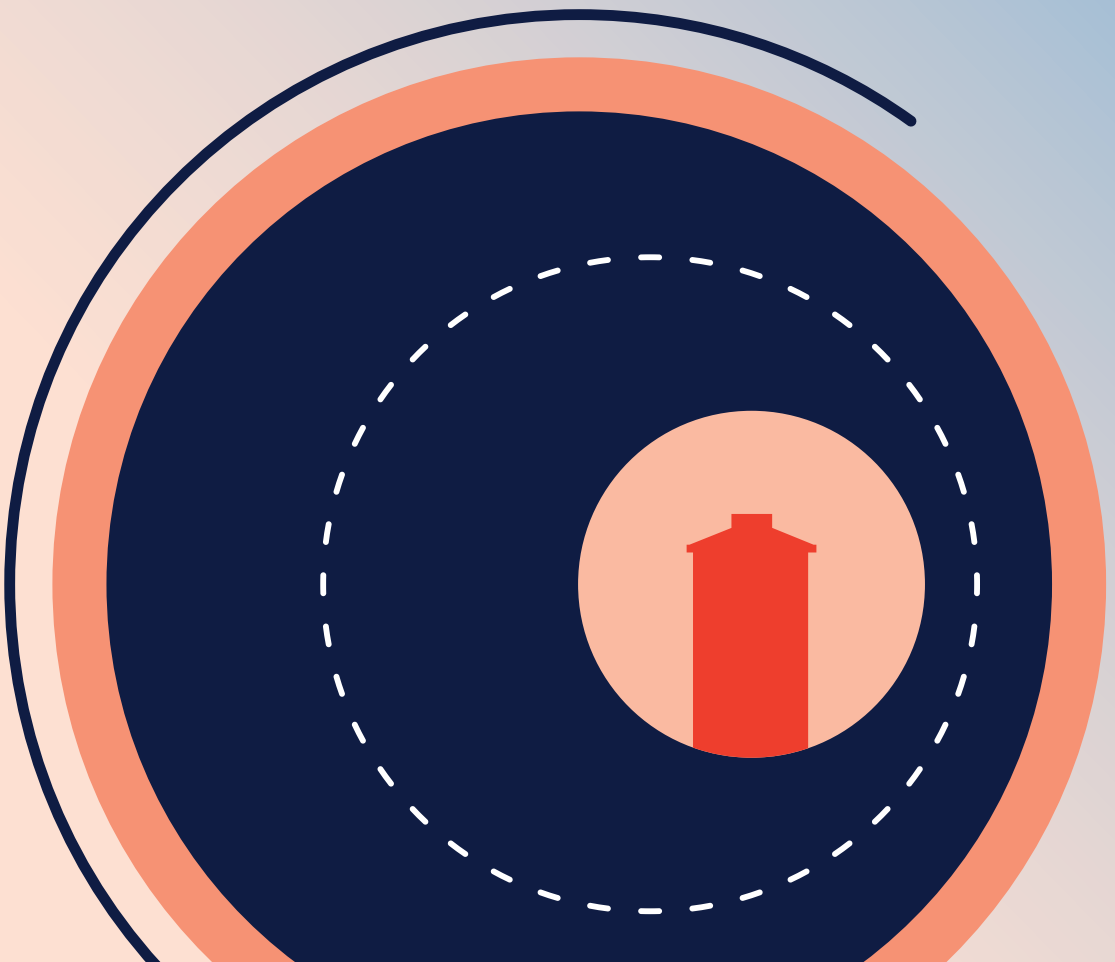

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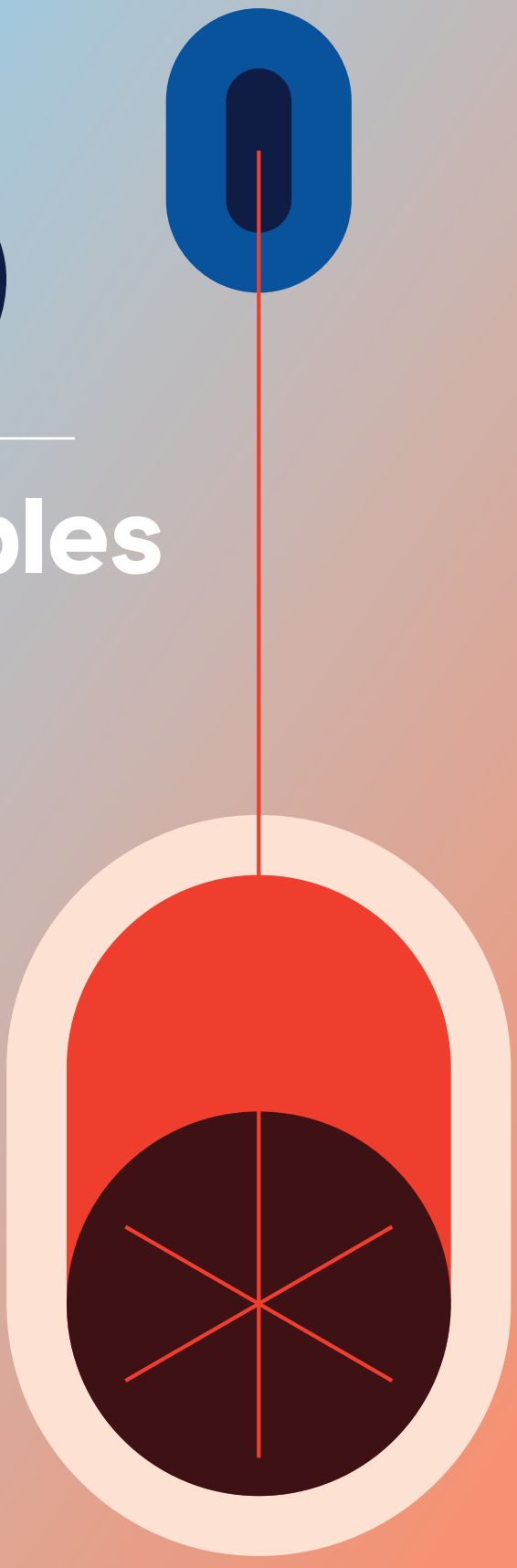

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