

“Implementation of a forecAstring System for urban heaT Island effect for the development of urban adaptation strategies” (LIFE ASTI)

Action C.8 Development of UHI adaptation action plans, good practice guides, and financial tools

C.5.1 UHI Adaptation Action Plans Portfolio for Thessaloniki & Rome

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ABBREVIATIONS

AP	Action Plan
AUTH	Aristotle University of Thessaloniki
CDD	Cooling Degree Days
ER	East Rural
EU	European Union
EU	East Urban
GLCNMO	Global Land Cover by National Mapping Organizations
HDD	Heating Degree Days
HHWS	Heat Health Warning Systems
HHWW	Heat health warning systems
ICT	Information and Communication Technology
MoT	Municipality of Thessaloniki
NBS	Nature-based Solutions
NCAR	National Centre for Atmospheric Research
POSD	Pilot Operational Simulations Database
PPT	Post-Processing Tools
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
SDGs	Sustainable Development Goals
SECAP	Sustainable Energy and Climate Action Plan
SLUCM	Single Layer Urban Canopy
SMEs	Small and Medium-sized Enterprises
SuDS	Sustainable Drainage Systems
TAPP	Apparent Temperature
UHI	Urban heat island
UHI	Urban Heat Island
UHI AAPP	UHI Adaptation Action Plans Portfolio
UHI-FCAR	Urban Heat Island Future Climate Change Scenarios
UHI-OFS	Operational Urban Heat Island Forecasting System

WHO	World Health Organisation
WR	West Rural
WRF	Weather Research Forecast
WU	West Urban

Executive Summary

The LIFE ASTI project focuses on addressing the impact of Urban Heat Island (UHI) effect on human mortality, by developing and evaluating a pilot system of numerical models that will result to the short-term forecasting and future projection of the UHI phenomenon initially in two Mediterranean cities: Thessaloniki (Greece) and Rome (Italy). Also, the city of Heraklion, Pavlos Melas (Greece) and Civitavecchia (Italy) were added during the duration of the project.

The phenomenon of UHI has an impact on human health, which becomes more intense, as the duration of the heat wave episodes is expected to increase due to climate change. The spread of urban areas has become alarming in recent years; almost 73% of Europe's population lives in cities, a rate which is expected to reach 80% by 2050. Extensive urbanization is triggering significant changes to the composition of the atmosphere and the soil, which result in the modification of the thermal climate and the temperature rise in urban areas, compared to neighbouring non-urban ones.

This document reports the UHI Adaptation Action Plans Portfolio (UHI AAPP) (action C.5.1), which address the concerned local/regional authorities, stakeholders, and professionals from different sectors.

This deliverable includes information about the Urban Forecasting System of UHI Effect that was created/used in LIFE ASTI (Action A.1, C.1), including its pilot application (Action C.2), its function as a short-term adaptation tool, and the benefits associated with it. The LIFE ASTI UHI forecasting system, specifically, combines data on temperature and humidity to offer the apparent temperature, which refers to the temperature as felt by people in terms of thermal discomfort. The technique, which has already been tested in Rome and Thessaloniki, significantly demonstrated the variation in felt temperature between metropolitan centers and rural and sub-urban locations. Furthermore, because the Heat Warning System is a key element of Heat Adaptation Plans, a general description of it, was provided, outlining its role as a crucial tool for the implementation of soft short-term adaptation measures as well as its capacity to forecast urban heat waves and the effects they will have on human health.

In order to combat climate change, advance sustainable development, and improve the resilience of cities and their inhabitants, the United Nations and the European Union have put in place a number of policy frameworks and programs. This document presents the main policies and strategies relevant to UHI effect and briefly analyses them.

Taking into consideration all the above information the UHI Adaptation Plans for the cities of Thessaloniki and Rome are developed and presented. Each plan in order to obtain a more comprehensive view of both cities, includes an analysis of the demographic and geospatial data, the areas' environmental and socio-economic, weather and climate conditions, with emphasis on UHI effect. Moreover, pertinent stakeholders and pertinent existing plans, strategies, and activities are provided. As far as the adaptation measures is concerned, they include:

- (i) Short-term adaptation measures to reduce exposure to heat.
- (ii) Long-term adaptation measures based on the assessment of future climate change on UHI effect and the impact assessment of selected adaptation scenarios.

In this action plan measures are being suggested per different level of necessity to face and adapt to the UHI effect.

- Level 0 – green - corresponds to no risk for the UHI effect (maximum temperature near to normal – comfortable temperature with no cautionary action required), thus it involves the systematic assessment of meteorological and of health risks, as well as the dissemination of information documents and the design and implementation of long-term measures allowing the Municipality to better deal with UHI effect's consequences in the long term.
- Level 1 – yellow - corresponds to a vigilance level of alert and readiness for the UHI effect (heat wave conditions at isolated pockets persisting for 2 days): It refers to moderate temperatures where heat is tolerable for the general public, but moderate concerns apply for vulnerable groups.

It mainly involves a level of reinforced monitoring, anticipation, and preparation for the reinforcement of management measures by the regional agencies of health, in particular through the implementation of local and targeted communication actions.

As such the municipality may examine all municipal buildings reassuring their readiness both in terms of manpower, infrastructure and acquired know-how / training, while in parallel reassuring the continuation of level 1.

- Level 2 – orange – This level corresponds to increased temperatures with a strong likelihood of heat illness symptoms for people that are either exposed to sun for a long period or carry out a heavy work, while the risk is quite high for the vulnerable groups of population. It corresponds to a vigilance level of a "Heat wave alert", triggered by the competent services, the General Secretariat for Civil Protection, in conjunction with the regional authorities considering the National Meteorological Service's scenarios and data. All the above initiate in collaboration with the municipalities and the regional health centres, specific measures facilitating the prevention or mitigation of the phenomenon, reassuring optimal communication among all stakeholders involved and strategic and crisis management, depending on the intensity and duration of the phenomenon (that in this case is up to 2 days maximum since if it lasts more, then it is considered as level 4, while not severe but heat wave persists for more than 4 days).
- Level 3 – red - corresponds to the vigilance level for the "heat wave". The heat wave is proven to be exceptional, very intense, and long-lasting (severe heat wave for more than 2 days, total number of heat / severe heat wave days exceeding 6). There is thus a very high likelihood of developing heat illness or heat stroke to all ages.

Within this framework level 4 requires the maximum mobilization of all stakeholders, meaning ministries and relevant secretariats and services, regional and local authorities, health institutions and civil protection organizations, under the supervision of the General Secretariat for Civil Protection. This situation undoubtedly leads to the reinforcement of all previously mentioned dynamic measures and the implementation of an "emergency" action plan and a relevant mechanism.


Measures for the mitigation to the UHI effect proposed:

- Recording of all municipal buildings and public spaces and their relevant infrastructure, under the aim to properly set relevant goals (e.g., proceed with measures to confront energy poverty such as the installation of panels, energy efficiency with the replacement of old frames, better insulation etc.).
- Integration of the health warning system and all relevant data for UIA effect to the city's smart platform in order to facilitate their management, operation and repairs.
- Development of the urban green at least by 30% in combination with the reinforcement of the sub-urban green parks and forests.
- Enhance bioclimatic design to the municipal buildings' construction and maintenance and provide relevant incentives for the private in order to turn private buildings "greener".
- Develop shading in the city through natural and / or technical means (canopies, permanent or temporary awnings, umbrellas, pergolas, sheds, fences) with emphasis on the "busiest" pedestrian paths in order to reduce heat exposure with emphasis on routes, along school routes and public, popular spaces.
- Develop and maintain the "blue" element and ensure the existence of drinking water in open, public spaces, through drinking water fountains and the making of municipal swimming pools available to the general public for longer periods of time.

The Action Plans are developed around four main axes, after elaborating the above measures:

- Axis 1: Prevent the UHI effect's influence on human health through the prevention of the effects of a heat wave (it should be constantly implemented from alert level 1 and intensified and monitored towards level 4).
- Axis 2: Protect the population by implementing appropriate management measures per meteorological vigilance level as provided to the municipality by LIFE ASTI's Heat health watch warning (HHWW) system or the national relevant service and of course considering the data of the municipality's meteorological stations (it should be constantly implemented from alert level 1 to 4).
- Axis 3: Inform and communicate (the preparation of the informative material should be carried out in alert levels 1-2, while their dissemination should start from level 2 and intensified on wards to level 4).
- Axis 4: Capitalize on the Region's experience (after taking action at level 4).

Lastly, an assessment of LIFE ASTI's contribution to local and interregional plans, strategies, and initiatives is covered.



The main results were that both cities should take immediate actions to tackle the UHI effect and its side effects or related problems. However, it is very evident that their main difference is that Rome already has a valuable amount of private green areas making it less vulnerable to heat waves.

In general, the Adaptation Action Plan measures per UHI scenario have a common goal, that of supporting future adaptation plans and providing a wider perspective.

1. INTRODUCTION

1.1 The LIFE ASTI Project

LIFE ASTI addresses the urban heat island (UHI) effect in the Metropolitan areas of Thessaloniki Greece and Rome Italy. The project aims in the development and implementation of a forecasting system which will contribute to the development of urban adaptation strategies.

Within this framework, two (2) adaptation action plans will be developed, taking into account the objectives of the EU Adaptation Strategy focused on adaptation to UHI impacts, especially during summer heat waves, reducing the heat wave risk in metropolitan areas by introducing heat prevention services, and better-implementing energy efficiency guidelines in Mediterranean cities.

The specific objectives of LIFE ASTI that need also to be considered in each of the project's actions and deliverables are:

- 1) To design, implement, test, and validate a set of UHI forecasting systems in Thessaloniki and Rome, based on state-of-the-art numerical models. These modelling systems will provide stakeholders with several UHI-related, high-resolution forecasting products, including thermal bioclimate indices, as well as Heating and Cooling Degree Days to estimate the energy demand of buildings. Furthermore, they will drive the Heat Health Warning Systems that will be developed and operationally tested in both cities, helping the local authorities to react appropriately to extreme events.
- 2) To establish dissemination tools and allow open access to UHI-related information and products to the end-users with Information and Communication Technology (ICT) applications. These tools will help the concerned authorities and the general public to fill the knowledge gap on local climate vulnerabilities and risks.
- 3) To assess the impact of future climate change scenarios on UHI for the two selected cities.
- 4) To evaluate the impact of promoting green activities (e.g., green roofs, ventilation areas, etc.) in urban areas to combat the UHI effect using the developed modelling systems for the two selected cities.
- 5) To develop good practice guides and efficient strategic plans for mitigating future UHI effects in the involved cities, as well as in other EU urban areas which face the same UHI adverse impacts.
- 6) To raise awareness and encourage authorities to apply the above urban adaptation strategies and mitigation initiatives. This will contribute and support the Signatories' commitment to "Mayors Adapt" and "Covenant of Mayors".
- 7) To organize events to promote, replicate and transfer the designed modelling systems and the best urban adaptation

Project LIFE ASTI is highly relevant to EU's climate policy and contributes directly to the Commission Communication "An EU Strategy on adaptation to climate change" (COM/2013/0216) by providing

short-term and long-term adaptation tools for the support of local/regional authorities and stakeholders to plan their strategies towards sustainable management of urban environments in a changing climate. LIFE ASTI promotes climate resilience and recourse-efficient low-carbon economy.

1.2 About this document

The purpose of this document is to present the Action Plans for the adaptation of Thessaloniki and Rome to the climate change effects regarding the UHI and that resulted by the assessment of the impact of future climate change scenarios on UHI for the two selected Mediterranean cities (Action C.4).

Action C.4 *“Future climate impact assessment of UHI effect and assessment of adaption plans”* presented a future projection simulation of a time slice within the short-term period 2041-2050 and the distant future period 2091-2100 (sub-Action C.4.1), which provides input and constitute the basis for the development of the Action Plans. The simulations that were developed, were based on the Weather Research Forecast (WRF) mesoscale meteorological model, which was used as a Regional Climate Model (RCM).

The results for Thessaloniki suggest that the expected temperature increase is 1°C and ~3.5°C for the periods 2046-2050 and 2096-2100, respectively. Focusing on the greater area of Thessaloniki (thus, the entire urban area and the rural areas close by the city), the southeastern regions located relatively far from the coastline (>6km) seem more vulnerable to the UHI effect during summertime compared to the northwestern regions (+1.4°C and +4.4°C respectively for the 2 reference periods). In spring, also the effect is evident (+0.7°C and +3.8°C respectively), while autumn and winter do not show significant fluctuations.

Rome shows similar trends, as the expected temperature increase is 1°C and ~3.4°C for the periods 2046-2050 and 2096-2100, respectively. Same, in the greater area of Rome, the further the distance to the sea, the largest the temperature increase in the future. The temperature increase at the west (by the sea) is lower than in the eastern areas of the city of Rome. The largest differences between west and east regions are observed during summer and autumn (up to 0.7°C), while the lowest ones (0.3°C) are noticed during winter and spring for the period 2046-2050. However, along the period 2096-2100, the temperature increase difference is greater for spring, summer, and autumn (0.7-1°C), while during the winter this difference remains low (~0.3°C).

Based on these estimations and other data resulted by the Analysis in Action C.4, the Municipality of Thessaloniki (MoT), coordinates the development of the Adaptation Plans for the metropolitan cities of Thessaloniki and Rome.

Each LIFE ASTI partner was responsible to contribute to this document according to the instructions received by the activity coordinator, MoT. MoT was responsible to finalise the document in terms of document consistency and comprehension, as well as to develop the adaptation plans for the two (2) cities.

An action plan (AP) is an essential part of the strategic planning process and usually has the form of a written document with steps and/or tasks that need to be followed and competed in order the goals that have been set to be achieved. It is proven that Action Plans increase institutional efficiency and accountability, and lend credibility (University of Kansas, 1994-2021).

In general, an AP:

- describes the actions or/and changes that will occur
- refer to those who will carry out these changes
- suggests the time-plan for the proposed actions/changes
- describes the resources (i.e., money, staff) that are needed to carry out these changes
- elaborates in the communication scheme that should apply for its implementation

At this point it is crucial for readers to understand the impact of the UHI effect at the environment and health in order to define the problem and to set the quantitative and qualitative objectives and expected results of the adaptation Action Plans.

The proposed actions will address these objectives and results and will also contribute to raising awareness and create know-how to the administrative bodies and relevant authorities.

The Action Plans that will be developed within Action C5, will give input to Actions C6, C7 and C8, as described in the LIFE ASTI Application Form.

1.3 UHI effect and its impacts on several sectors

Climate change is considered to be one of the most significant global threats of the current century, while it has been proven that the leading contribution to global warming is made by the anthropogenic emissions of greenhouse gases (Keppas, Stavros Ch, et al., 2021).

The Mediterranean is recognized among the most responsive regions to climate change, with annual temperatures projected to increase by 1–5 °C until 2100. Large cities may experience an additional stress discomfort due to the Urban Heat Island (UHI) effect. The UHI is considered a cross-sectoral environmental problem, observed in all big EU cities. Heat-related health problems and deaths are among the most noticeable impacts on the UHI phenomenon, especially under summer heat wave weather conditions (Keppas, Stavros Ch, et al., 2021). Other impacts concern high energy requirements in dense urban environments, air pollution, reduced water quality, negative effects in tourism and local economy based on this sector, even social problems as anti-social behaviours.

1.3.1 On health

The short-term effects of temperatures and extreme events have been extensively studied in environmental epidemiology (Benmarhnia et al. 2015; Bunker et al 2016). In particular, heat has been related to an increase in total and cause-specific mortality (Basu et al. 2008) as well as non-fatal outcomes such as hospital admissions, emergency room visits and ambulance calls (Ye et al. 2011). Health effects of heat are shown in Figure 1. The vulnerability of human populations to extreme weather events such as heat waves, is a function of their sensitivity to extreme temperatures, and of the adaptation measures and actions in place (WHO 2021). Subgroups most vulnerable to the effects of heat include the fraction of the population with a greater than average adverse response either resulting from intrinsic susceptibility factors (chronic clinical conditions), individual characteristic (age, gender, socio-economic status, education, occupation) as shown in

Figure 2. Furthermore, factors that modify exposure, typically area-level characteristics (urban heat island, green space, proximity to water, impervious surfaces, building density also affect vulnerability (WHO 2021, Bunker et al. 2016, Goggins et al. 2012).

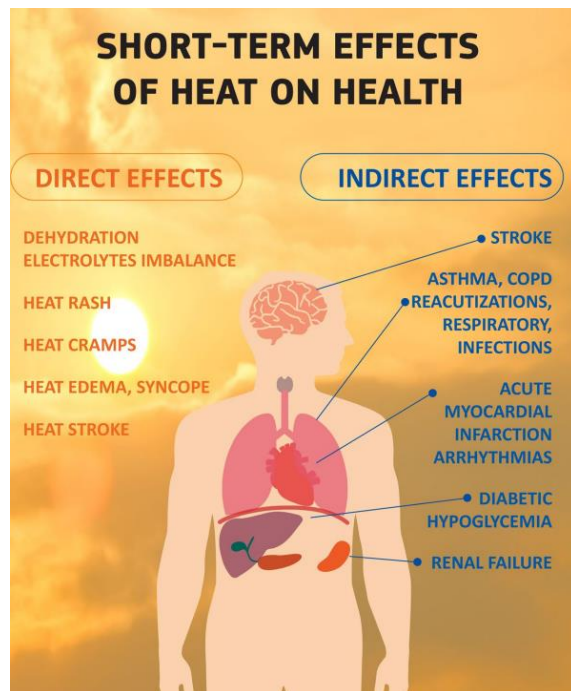


Figure 1: LIFE ASTI Infographic on heat-related direct and indirect health effects (Source : [Asti Life](#))

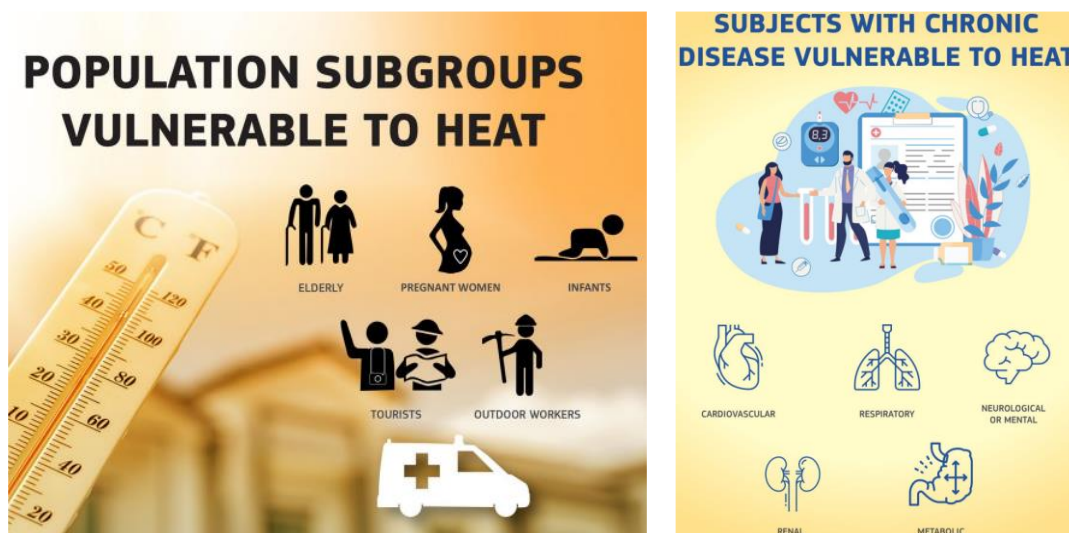


Figure 2: Population Subgroups Vulnerable to Heat – Subjects with chronic disease vulnerable to heat (Source: [Asti Life](#))

The association between temperature and mortality has been identified and described as a non-linear U-, J- or V-shaped function, with the lowest mortality rates recorded at moderate temperatures, rising progressively as temperatures increase or decrease (Baccini et al. 2008, Gasparrini et al. 2015, Anderson et al. 2009). Figure 3 shows the association between daily mortality and maximum apparent temperature in Rome and Thessaloniki.

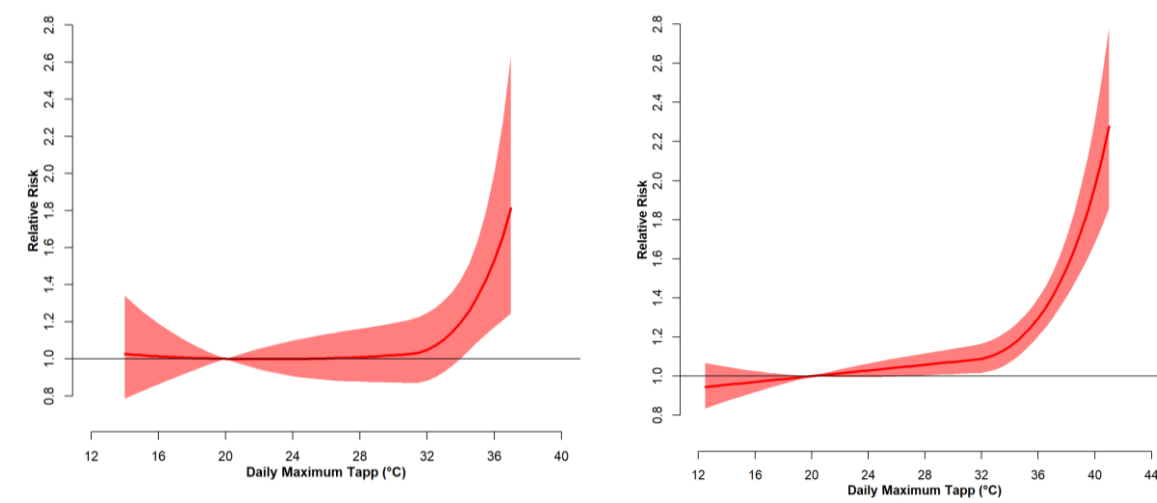


Figure 3: Association between daily mortality and maximum apparent temperature in Thessaloniki (left) and Rome (right) (Source : [ASTI LIFE](#))

Effects of heat and heat waves vary geographically (Zanobetti et al. 2013; Guo et al. 2014) and depend on local climatic conditions and population characteristics (demography, socioeconomic conditions, health status) (Benmarhnia et al. 2015). A multi city multi country network study shows how Italian and Greek cities are among the cities with the highest heat effects, with a 14% increased risk of death (pooled estimate for all Italian cities) for a rise in mean temperatures between the 90th and 99th percentile compared to a 9% in Spain and 3% in Australia (Gasparrini et al. 2015).

Recent epidemiological studies have accounted for the UHI as a spatial effect modifier of the temperature-mortality association. Several studies conducted in large cities worldwide found that subjects living in areas of the city with higher surface temperatures had a higher risk of dying during hot days (Smargiassi et al. 2009, Laaidi et al. 2012, Goggins et al. 2012, Xu et al. 2012, Milojevic et al. 2011).

When considering heat wave episodes, epidemiological studies have shown that extreme events have an even stronger impact on mortality (Guo et al. 2017). According to a recent study conducted in the UK, the future impact of heatwaves in terms of mortality burden will increase the most in urban areas (Heaviside et al. 2016). This aspect is very important not only for the promotion of mitigation measures to reduce GHG emissions within cities but also to raise awareness on the future heat risks and promote adaptation measures.

Furthermore, when considering the potential role of socio-economic conditions and UHI a differential effect was observed; with a greater heat-related risk among the socio-economic disadvantaged groups when stratifying by UHI (Goggins et al. 2012; Xu et al. 2012). Moreover, when considering urban vulnerability factors, a number of studies found that hotter areas within a city were also those with lower income, higher poverty, less education, more ethnic minorities, more

elderly people and greater risk of crime (Huang et al. 2011, Johnson 2012, Wong et al. 2016, Taylor et. al 2012, Morabito et al. 2015).

These parameters need to be considered when studying the differential effect of heat within urban areas and it stresses the need for high resolution temperature data to identify risk areas and promote adaptation measures in urban areas.

1.3.2 On energy

Many cities around the world are already facing the challenge of thermal change resulting from global climate change (Spinoni et al., 2014; Grimmond, 2007). Almost half of the world's population lives in urban areas, which has led to a large expansion of metropolitan areas. Cities have to deal with the Urban Heat Island (UHI) phenomenon, which attributes to the urban planning of a city. The increase of buildings contributes to the fact that energy consumption has become a relevant international issue and different policy measures for energy saving are under discussion in many countries (De Rosa et al., 2014). The LIFE-ASTI project addresses the calculation of the reductions in energy consumption and CO₂ emissions after the energy upgrade of two buildings of the Municipality of Thessaloniki. The Municipality of Thessaloniki is committed to designing and implementing projects based on the local bioclimatic characteristics, in order to adapt to climate change impacts.

Buildings of Interest

This case study concerns the buildings of Centre of Architecture and the Central Municipal Library. The Centre of Architecture is located at 13 Aggelaki str. (N 40.628, E 22.953) in the city of Thessaloniki and uses only electricity for heating and cooling needs. In Central Municipal Library, which is at 27 Ethnikis Aminis str. (N 40.629, E 22.951) 200m away from the first building, electricity is utilized for the needs of the building, while at the same time for the years 2009 - 2015 natural gas was used. The energy upgrade construction works started in August 2015 and were completed in December 2016. The buildings were upgraded from energy class D to A and from C to B+ respectively.

For municipal buildings the monthly electricity consumption data for the period 01/2011 - 07/2020 and natural gas data for the period 01/2012 - 12/2015 is available. The data were provided by Hellenic Public Power Corporation (HPPC) and proprietary firm Zenith, respectively.

Methodology – Results

The monitoring of the Sustainable Energy Action Plan (SEAP) of the Municipality of Thessaloniki, in the context of the Covenant of Mayors (March 2017) expresses the calculation of CO₂ emissions for which the standard emission factors were used (CO₂ conversion factor: 1.149 kgCO₂/kWh). Figure 4 presents the mean energy consumption of the two buildings before and after the energy upgrade and Figure 5 the CO₂ emissions. In total, the buildings after the upgrade are saving yearly about 220000kWh in energy consumption and 250tn in CO₂ emissions, achieving 62.85% of the LIFE ASTI project goal in energy saving and entirely in CO₂ emissions.

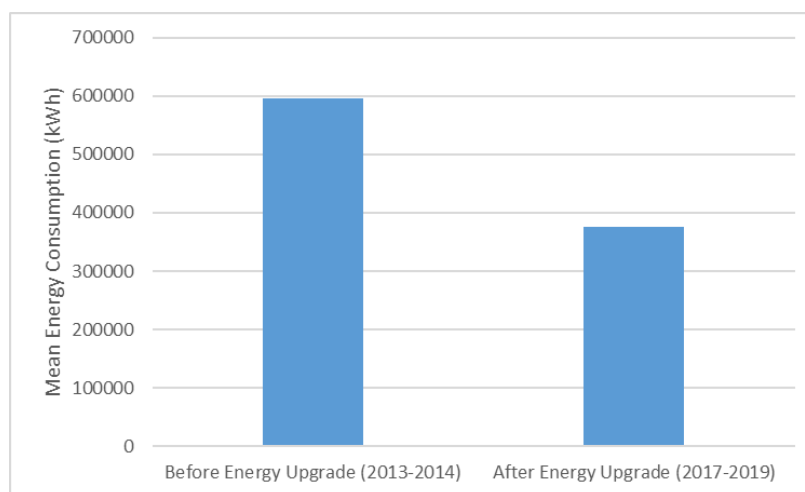


Figure 4: Mean Energy Consumption of both buildings

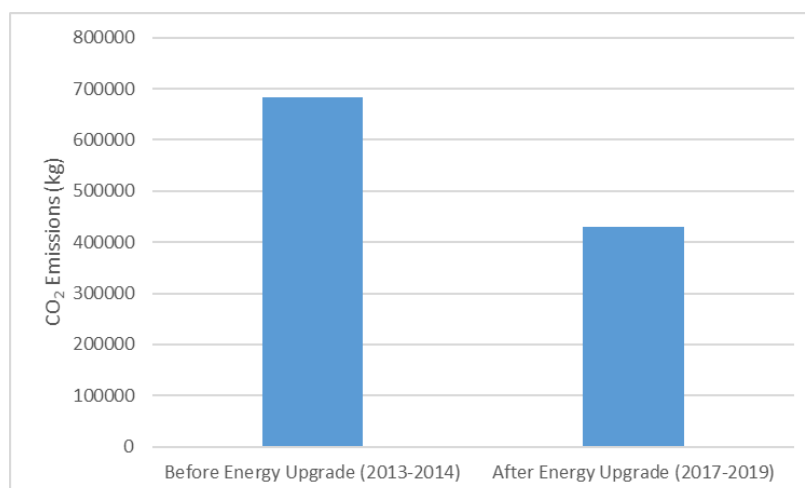


Figure 5: CO2 Emissions of both buildings

1.3.3 On tourism

According to the document "Climate Change and Tourism: Responding to Global Challenges", prepared by the World Tourism Organization (UNWTO), in partnership with the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO), resulting from the 2nd Inter-national Conference on Climate Change and Tourism (Davos, Switzerland, 1-3 October 2007), climate change will affect tourism destinations, their competitiveness, and sustainability in four major areas: Direct climate impacts; Indirect impacts of environmental changes; Impacts of mobility policies and the reduction of tourism; and Indirect impacts of social change (Brasil, 2008).

Particularly, the Mediterranean region is vulnerable to climate change due to its sensitivity to drought and rising temperatures. Tourism in Mediterranean regions has been affected and is

expected to be affected more in the next decades due to climate change and consequently to the increase of natural disasters and extreme climate conditions.

The UHI effect is more perceptible to areas with high tourism flows, as human activities are more intense, and result in more anthropogenic heat emissions. The UHI effects increase significantly during the high tourism season. Water availability and supply are heavily impacted, as well as energy supply and demand (Stankov, et al., 2014). City authorities worry that intense summer heat could lead further to uncomfortable conditions for residents and will consequently lead to reduced tourist attraction in summer months (United States Environmental Protection Agency, 2021).

Cities which attract large number of tourists suffer the most, as visitors, along with the residents, seek places to cool off. Authorities put speed and traffic restrictions out of concerns over the heat's effect on the road surfaces. Temporary misting stations and designated cooling rooms are also some of the measures that city authorities apply to protect visitors and residents, and more importantly the vulnerable groups. Warnings for travellers are announced in countries without widespread air-conditioning or with so many outdoor attractions the trip is planned around them, in order to avoid heat exhaustion. Some tour companies are adjusting their routes to spend more time in the shade and less time strolling or adding more activities in the morning or evening to avoid being in the elements during the hottest part of the day (Sampson, 2019).

The frequency of extreme heat brings changes to visitation patterns. A gradual shift of tourist destinations has been already observed, from the coastal areas to cooler destinations, such as mountainous parts of the inland. Northern and Western Europe seem to become more popular to tourists, because of their relative coolness. Higher summer temperatures may further lead to a gradual decrease in summer tourism in the Mediterranean but an increase in spring and perhaps autumn (Zhang & Wu , 2015). However, scientific research has also shown that Mediterranean countries will experience a lengthening and a flattening of their tourism season by 2030. Occupancy rates associated with a longer tourism season in the Mediterranean will spread demand evenly and thus alleviate the pressure on summer water supply and energy demand.

Nevertheless, climate change lead to more frequent, more severe, and longer heat waves during summer months, meaning that at the end, more and more tourist destinations will be affected, In 2019, nine (9) heat waves were recorded worldwide, while eight (8) in 2021, three (3) of them in Europe during the summer months, affecting both Mediterranean (Turkey, Greece, Italy) and Central-Northern countries (Germany, France, UK, Finland, Sweden etc).

In conclusion, the tourism sector is highly vulnerable to climate change and at the same time contributes to the emission of greenhouse gases (GHG), which cause global warming, thus increase the UHI effect when it comes to urban tourism. This is a vicious cycle that cities need to break in order to become resilient and sustainable.

1.3.4 Other (e.g., environment)

Rising temperature, enhanced by UHI effect, causes not only thermal discomfort to citizens, but also brings harmful consequences on several other sectors.

Increased Energy Consumption

UHI makes cities hotter in summer and warmer in winter; therefore, it has a direct impact on energy demand patterns. Especially in summer months, cooling processes can be energy-consuming and may lead to high energy cost during extreme weather conditions.

A report for the City of Melbourne indicates that, for every degree beyond threshold temperatures the UHI effect adds to the temperature, it is likely to induce 0.137GWh increase in electricity demand in summer. In other words, the UHI effect is expected to increase the maximum energy demand by approximately 22.0 MVA for every Celsius degree added to the maximum temperature in summer (Raalte et al., 2012).

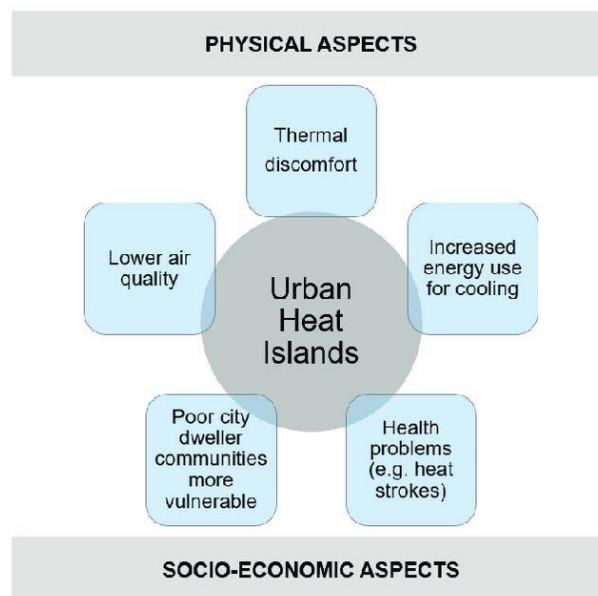


Figure 6: Physical and socio-economic impacts of UHI (Source: Leal Filho et al., 2021)

Peak energy demand, which is the highest electrical power demand that has occurred over a specified time period, is an index used to evaluate the consumption increase of electricity. Peak urban electric demand can rise up to 2–4% for each 1°C rise in daily maximum temperature above a threshold of 15 to 20°C; therefore the additional air-conditioning use caused by this urban air temperature increase is responsible for 5–10% of urban peak electric demand (Akbari, 2005) .

According to US Global Change Research Program, 2018, energy systems are already affected by extreme weather events, and due to climate change, they are projected to be increasingly threatened by more frequent and longer-lasting power outages affecting critical energy infrastructure. Such extreme events (thunderstorms, hurricanes, heat waves, extreme rainfall) can interrupt energy generation, damage energy resources and infrastructure, and interfere with fuel production and distribution systems, causing fuel and electricity shortages or price spikes.

As regards the future projection of the phenomenon, increased ambient temperatures and extreme phenomena may cause 14-23% additional investments on electricity capacity in USA, relative to a non –climate change scenario for the years 2010-2055 (Santamouris, 2020).

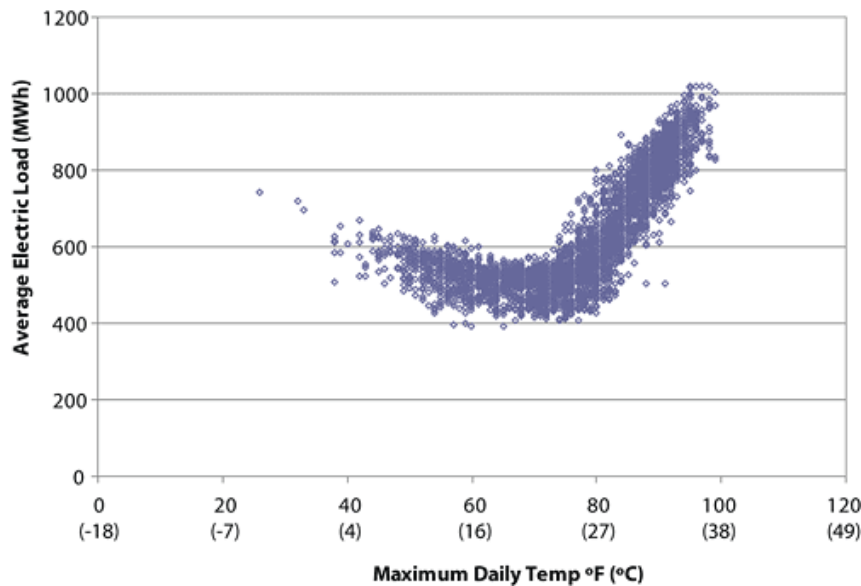


Figure 7: Relation between electric load and maximum daily temperature, example from New Orleans. Adapted from Sailor, D. J. 2002. Urban Heat Islands, Opportunities and Challenges for Mitigation and Adaptation. Sample Electric Load Data for New Orleans, LA (NOPSI, 1995). North American Urban Heat Island Summit. Toronto, Canada. 1–4 May 2002. Data courtesy Entergy Corporation.

Greenhouse Gas Emissions and Air Pollution

Increasing temperatures lead to increasing energy demands especially during summer, which lead to subsequent increase in greenhouse gas emissions and air pollutants. This vicious cycle of using electricity to reduce heat, causes more environmental damage in the long run.

High temperatures accelerate certain atmospheric chemistry cycles, most of which lead to enhanced ground-level ozone production, higher emission of biogenic hydrocarbons and higher evaporation of synthetic volatile organic compounds from vehicle engines (Ulpiani, 2021).

Weather factors such as low wind speed, low relative humidity, and cloudlessness, which are important for UHI development, easily trigger air pollution episodes. Moreover, certain weather patterns are found to favour the concentration increase of air pollutants (e.g. NO₂ and CO) with the UHI intensity (Lai & Cheng, 2009).

Last but not least, increased temperatures in the urban area are associated with the formation of secondary pollutants such as ozone (William et al., 2004).

According to World Health Organization, exposure to high levels of air pollution can cause a variety of adverse health outcomes, including respiratory infections, heart disease and lung cancer.

Reduced water quality

Construction materials such as concrete and cement absorb heat very effectively, rising their temperature significantly. High temperatures of pavement and rooftop surfaces can heat up stormwater runoff, which drains into sewers and raises water temperatures as it is released into streams, rivers, ponds, and lakes.

This effect causes water sources in the areas around a city to be warmer than they would naturally be. Even small temperature changes in aquatic ecosystems resulting from warm stormwater runoff can be particularly stressful to aquatic life, affecting their metabolism and reproduction (Somers, Bernhardt, McGlynn, & Urban, 2016).

Other results

High temperatures have adverse impacts in many aspects of everyday life and environment.

Anti-social behaviours such as collective crime, assault, domestic violence and burglary have been found to be positively related to temperature in the United States, while hot weather is highly correlated with violent crimes such as assault and homicides (Anderson, Bushman, & Groom, 1997; Raalte et al., 2012).

Increased temperatures have been found to affect animals both directly and indirectly, through heat-related health impacts and impacts to flora which are used as habitat and sources of food (Raalte et al., 2012).

Transport operations and infrastructure can be compromised from high temperatures that affect material integrity, causing damages and potentially dangerous failures.






	Operations	Infrastructures
 Heat waves	<ul style="list-style-type: none"> Impacts of lift-off load limits on shorter runways. Limits on periods of construction activity. 	<ul style="list-style-type: none"> Thermal expansion of bridges. Pavement integrity and softening. Deformation of rail tracks.
 Rising sea levels	<ul style="list-style-type: none"> Frequent interruptions of coastal low lying road, rail and air traffic due to storm surges. 	<ul style="list-style-type: none"> More frequent flooding of infrastructure (and potential damage) in low lying areas. Erosion of infrastructure support. Changes in harbor facilities to accommodate higher tides and surges.
 Intensity of precipitation	<ul style="list-style-type: none"> Increase in weather related delays and disruptions, particularly road and air transport. 	
 More frequent hurricanes	<ul style="list-style-type: none"> Frequent interruptions of air services. Frequent and extensive evacuations of coastal areas. Debris of road and rail infrastructures. 	<ul style="list-style-type: none"> Greater probability of infrastructure failure. Greater damage to port infrastructures.
 Increase in arctic temperatures	<ul style="list-style-type: none"> Longer shipping season. More ice-free ports in northern regions. Availability of trans-arctic shipping routes. 	<ul style="list-style-type: none"> Damage to infrastructure because of the thawing of the permafrost. Shorter season for ice-roads.

Figure 8: Impacts of high temperatures on infrastructure. Adapted from National Research Council (2008) Potential impacts of climate change on U.S. Transportation. Transportation Research Board.

In other words, during the summer season, the urban areas tend to become uncomfortable places to live in because of discomfort during daytime and an increasing number of sweltering nights due to higher temperatures. Higher temperatures also boost the demand for air conditioning, thus resulting

to increased energy consumption. In addition to the above, they “contribute to localized torrential downpours and the production of photochemical oxidants” (Yamamoto, 2006).

While during winter air pollution is being increased due to dust domes – mixed layers formed when ascending air currents are being trapped under inversion layers during calm winter nights (Yamamoto, 2006).

Finally higher temperatures in combination with the material used in the urban environment may result to decreased evaporation, thus making urban areas drier (Yamamoto, 2006).

1.4 Structure of this document

UHI Adaptation Action Plans Portfolio (UHI AAPP) is structured in 7 parts. Except from the first (introductory) and last chapter (conclusions), chapter 2 illustrates the urban forecasting system of UHI effect that developed/employed in LIFE ASTI (action A.1, C.1) including its pilot application (action C.2), its role as a short-term adaptation tool and the respective benefits. Chapter 3 presents the Heat Health Warning system, describing its capability of predicting urban heat waves along with their impacts on human health, its pilot operational application (action C.6) and its role as a key component for heat prevention plans and a tool for the application of soft short-term adaptation measures.

Chapter 4 refers to the EU and international strategies and policies for combating climate change and the UHI effect.

Based on the previous chapters, Chapter 5 constitutes the core chapter where the UHI Adaptation Plans for the cities of Thessaloniki and Rome are developed. A general description of the examined urban area, including administrative data (e.g., demographics), environmental and socio-economic conditions is presented, along with an outline of weather and climate conditions of the region, with emphasis on UHI effect. Relevant existing plans, strategies, and actions, as well as relevant stakeholders are also presented.

Then, in the same chapter, the adaptation measures are elaborated and include:

- (i) Short-term adaptation measures to reduce exposure to heat, such as air-conditioned rooms, civil protection announcements, surveillance of susceptible subgroups, UHI and Heat Health Warnings forecasting which will alert in cases of extreme heat events and identify UHI hotspots.
- (ii) Long-term adaptation measures such as green roofs, ventilation areas, etc., based on the assessment of future climate change on UHI effect and the impact assessment of selected adaptation scenarios.

Chapter 6 concerns the assessment of the contribution of LIFE ASTI to local and interregional plans, strategies, and initiatives, such as the development of Sustainable Energy and Climate Action Plans (SECAPs) under the 2030 Covenant of Mayors and (ii) actions in the framework of 100 resilient cities initiative in Thessaloniki.

2. THE URBAN FORECASTING SYSTEM OF UHI EFFECT

2.1 The role of the Urban Forecasting Systems for the development of the UHI AAPP

The Forecasting Systems are tools for the analysis of data to predict future events based on past occurrences (*The Law Dictionary*). In this context, the LIFE ASTI UHI forecasting system has been developed based on meteorological, surface, upper-level atmospheric and land-soil variables. The LIFE ASTI UHI forecasting system has been designed to provide information concerning the urban thermal conditions over Thessaloniki, Heraklion, and Rome (see also relevant deliverables A1 and C1), and additionally provides warnings when the thermal conditions threaten public health. The system also includes information regarding the effects of heat on human health (see next chapter).

The LIFE ASTI UHI forecasting system combines information about temperature and humidity to present the apparent temperature, meaning the perceived temperature by humans in terms of thermal discomfort. The system that has been already tested in Thessaloniki and Rome, significantly showed the difference of perceived temperature in the urban centres compared to sub-urban and rural areas (see also relevant deliverable C2).

The UHI AAPP uses the data of the UHI forecasting system to create adaptation scenarios based on the heat alarming level (green: no risk, yellow: Alert and readiness, orange: Alarm, red: Heat wave). The UHI forecasting system is dynamic and provides urban heat trends over the years, thus the UHI AAPP could be adapted when necessary.

A brief description of the LIFE ASTI UHI forecasting system follows, as well as examples of the pilot application in Rome and Thessaloniki.

2.2 General Description of the forecasting system and application results

The LIFE ASTI UHI forecasting system is based on the mesoscale atmospheric Weather Research and Forecasting (WRF) model, version 4.1. WRF is a state-of-the-art numerical model, developed to serve both atmospheric research and operational forecasting needs (Skamarock et al., 2019). Over the study urban areas WRF is coupled with the Single-Layer Urban Canopy Model (SLUCM; Kusaka et al., 2001; Kusaka and Kimura, 2004) to represent the physical processes in the urban environment better. Also, a downscaling technique is applied for producing the high-resolution (250 m) urban forecasts. The UHI-related forecasting products include thermal bioclimate indices and Heating/Cooling Degree Days (HDD/CDD) to assess the energy demand of buildings. Moreover, they are used as forcing data to drive the Heat Health Warning Systems over the study cities (Figure 9).

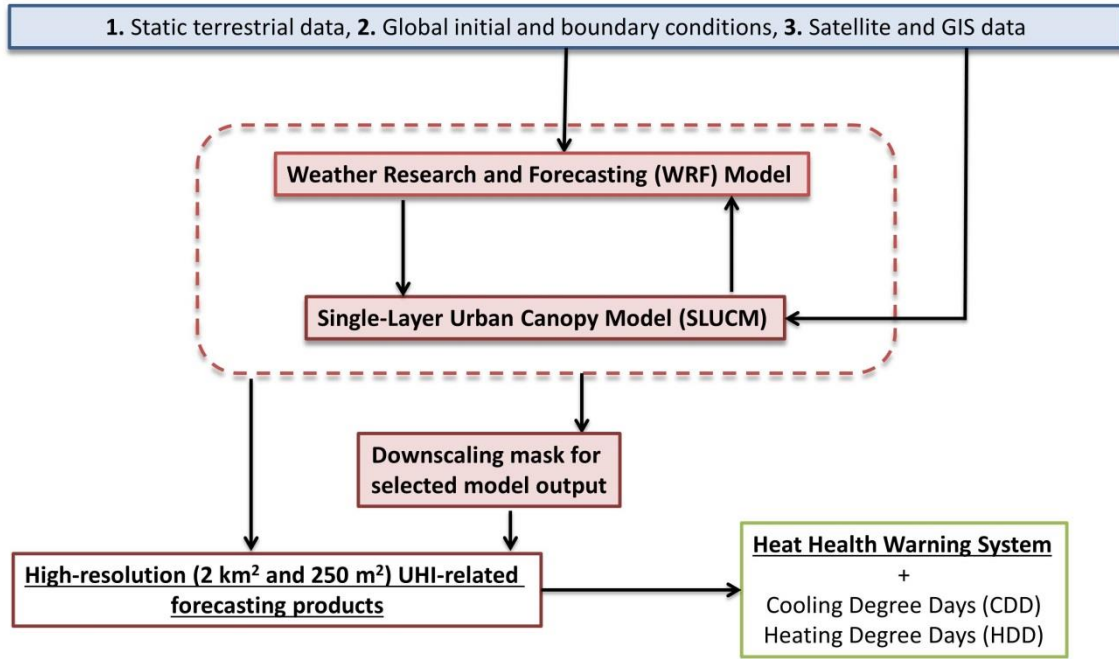


Figure 9: Flowchart of the pilot UHI modelling system

The modelling system's spatial coverage aims at the easy transferability and replicability of the system over other European cities that face the same problems that arise from the UHI effect. At the present set-up, there are five nested domains (Figure 10) having spatial resolutions of 18 km (d01), 6 km (d02) and 2 km (d03, d04, d05). The first domain (d01) cover most of the Europe, the North Africa, and the Middle East to simulate the synoptic meteorological conditions. The second domain (d02) includes the eastern Mediterranean, while the three innermost domains focus on the studied urban areas of Thessaloniki (d03) and Heraklion (d04) in Greece, and Rome (d05) in Italy. All modelling domains have the same vertical structure composing of 35 unevenly spaced full sigma layers from the lowest layer near the surface (~ 30 m) to the model top, defined at 100 hPa.

The meteorological fields needed to feed the coarse (d01) domain are taken from the Global Forecast System (GFS; <http://www.emc.ncep.noaa.gov/GFS/doc.php>) of National Centres for Environmental Prediction (NCEP). The 00:00 UTC forecast in 3h temporal resolution are used to provide the various surface and upper-level atmospheric and land-soil variables at horizontal grid resolutions of 0.25° . Also, The NCEP SST product is utilized (<https://polar.ncep.noaa.gov/>), additionally to the other fields, with a horizontal resolution of 0.0833° . The 00:00 UTC forecast of the previous day is used during the simulation of LIFE-ASTI modelling system. The physics options applied are summarized in Table 1, while the updated high-resolution static terrestrial data used as input in the forecasting system include the Global Land Cover by National Mapping Organizations (GLCNMO) version 1 (Tateishi et al., 2014) and CORINE (Giannaros et al., 2018) land use datasets, and the SRTM (Farr et al., 2007) dataset for topography.

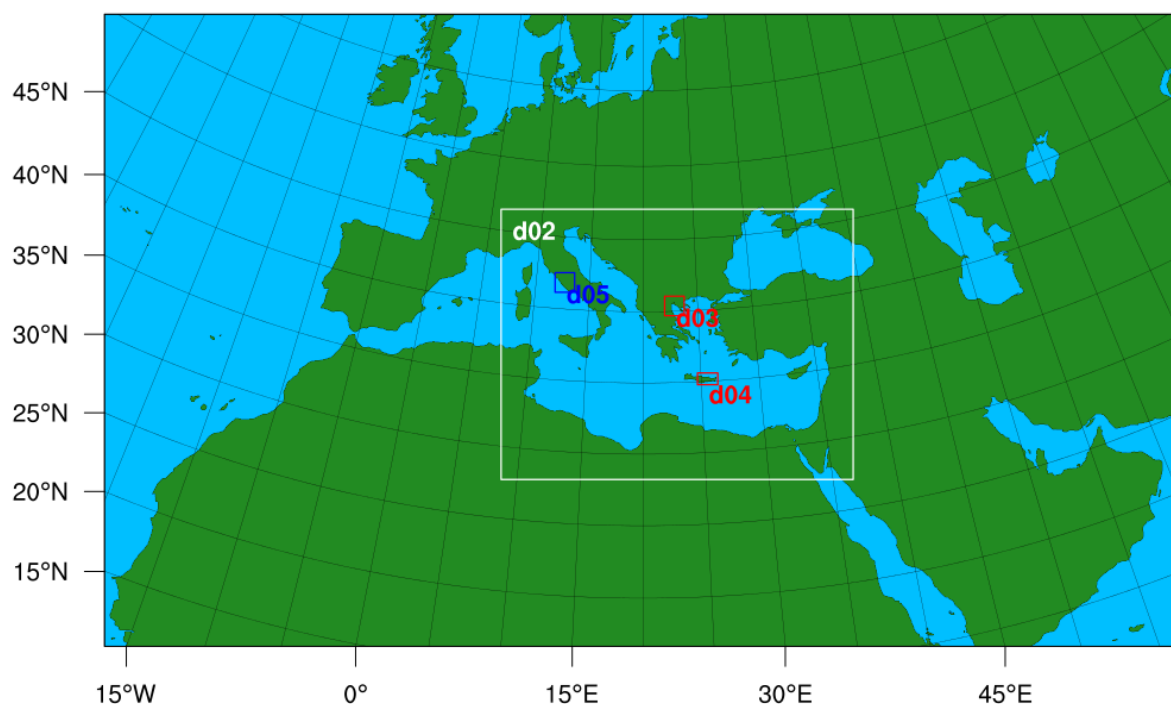


Figure 10: Configuration of the five (2-way) nested WRF modelling domains

Physics	Parameterization	References
Microphysics (clouds)	WRF single-moment 5-class (WSM5)	Hongetal. (2004)
Cumulus (convection)*	Kain-Fritsch (KF)	Kain (2004)
Planetary boundary layer	Yosei University scheme (YSU)	Hong et al. (2006)
Surface layer	Revised MM5	Jiménez et al. (2012)
Land surface	Noahmodel	Tewari et al. (2004)
Short-wave radiation	Dudhia	Dudhia (1989)
Long-wave radiation	rapid radiative transfer model for global circulation model (GCM) applications (RRTMG)	Iacono et al. (2008)

* Cumulus parameterization will be used only for domains d01 and d02

Table 1 . Summary of the WRF physics options

The downscaling mask is a post-processing step after the weather forecasting. It uses observational data in order to apply some adjustments and corrections to the previous results, in order to mitigate

some systematic observed deviations and to take into account effects of the land use in the small scale. In brief there are four process steps on the fine scale. (a) Adjust temperatures with a vertical temperature gradient using a fine digital elevation model (DEM). (b) Apply a predefined multivariable polynomial fitting function. (c) Apply a predefined support-vector machine model (SVM). And last (d) constrain and select the results, within some physical limits. The described algorithm is applied on rural areas, where both the polynomial fitting and SVM models, were developed and trained with the use of observational data.

Forecasting system's role as a short-term adaptation tool and the respective benefits

The LIFE ASTI UHI forecasting system serves primarily as a short-term adaptation tool by providing 4-dayhigh-resolution forecasts concerning the urban thermal conditions over Thessaloniki, Heraklion, and Rome.

Additionally, the Heat-Health Warning component of the LIFE ASTI forecasting system is capable of predicting the potential effects of heat on human health regarding daily deaths and thus, providing warnings at high spatiotemporal resolution considering the differential effect of heat within the targeted cities due to the UHI effect. The UHI-related forecasting products and heat-health warnings are effectively disseminated to all interested parties through a dedicated web platform and a mobile application, allowing for the increase of awareness of the general public concerning forthcoming heat-related events that are expected to put stress on the local communities. The system also supports the local authorities in their efforts to counteract the potential heat-related problems, as the provided information is used for a scientific-driven decision making with respect to the application of short-term interventions and preventive measures in order to minimize the associated health risks. In overall, the application of the LIFE ASTI UHI forecasting system as a short-term adaptation tool supports (a) the increase of heat-related awareness, (b) the increase of local adaptation initiatives, (c) the potential reduction of heat attributable deaths, (d) the increase of resilience to heat and (e) the improvement of life support over the study urban areas. Thus, the system can be considered as a cornerstone of heat prevention planning and a valuable tool for supporting effectively the social and health-related welfare of citizens.

The UHI Operational Forecasting System's pilot application

The UHI Operational Forecasting System described above began its pilot operation since July 2019, aiming at continuous monitoring and improvement of the forecasts. The operational UHI forecasting system (UHI-OFS) have been employed automatically through a structured system of scripts, which operate continuously at IT infrastructures of AUTH. The pilot operational UHI forecasting system consists of four main components: a) the implementation of WRF-SLUCM modelling system and b) the Post-Processing Tools (PPT) and c) the Unified Post-Processing Database. The output is retrieved automatically from d) the LIFE-ASTI platform and the results are available at the web site and the mobile application of the project. An overview of the UHI-OFS is illustrated in Figure 11.

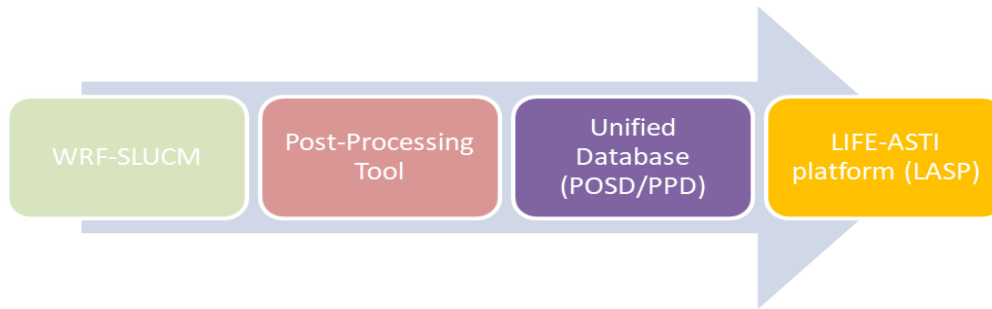


Figure 11: Overview of the operational UHI forecasting system.

The WRF-SLUCM modelling system is running at the Linux systems of AUTH, with a series of shell scripts developed from AUTH team for the automated download of the initial/boundary conditions and its daily operation. Every day the operating system start running at 8 a.m. Greek local time (6 a.m. UTC), with the first simulated forecasting time at 00:00 UTC of the same day. The operation of WRF consists of two steps: 1) downloading of GFS and SST data and 2) running the WRF-SLUCM. The spin-up period was selected to be 1 day, ensuring the elimination of potential errors from the initial conditions. Thus, the next 4 forecasted days are considered as valid for the post-processing. Each simulation of the WRF-SLUCM for all domains lasts ~9 hours.

Once the WRF-SLUCM forecast is finished, the Post-Processing Tool (PPT) utilize its output by performing four main tasks: a) the downscale method described above, b) calculation of the UHI related products, c) implementation of the Heat-Health Warning System and d) reformatting of the product, compatible with the LIFE-ASTI platform. All data are stored in the Post-Processing Database (PPD), dedicated for this purpose, and can be read-only accessible through ftp for authorized users, after communicating with the AUTH team.

The UHI-OFS products become available to the end-users, such as citizens and local authorities, through the web and mobile LIFE-ASTI platform. An example of the temperature map for the city of Rome at 21 UTC of September 15th, 2021, is given in Figure 12. It is evident the effect of urban fabric of Rome relative to the adjacent rural areas.

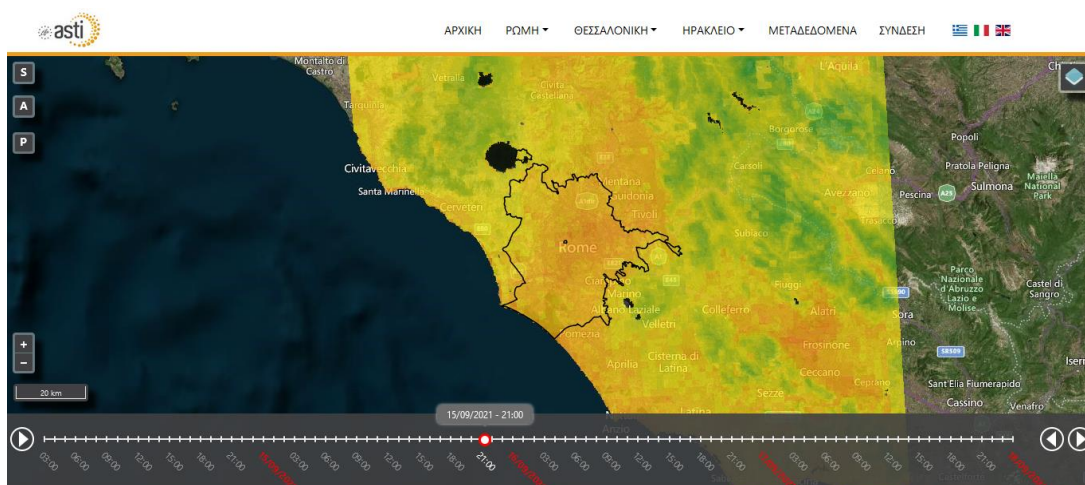


Figure 12: Example of temperature's map, as presented in LIFE-ASTI web application, for the 15th of September 2021 in Rome.

The citizens and the local authorities can also retrieve more direct information about the prominent temperatures, as well the heat health warning for the area of interest, through the Dashboard option. An example is given for Thessaloniki for 17th of September 2021 in Figure 13.

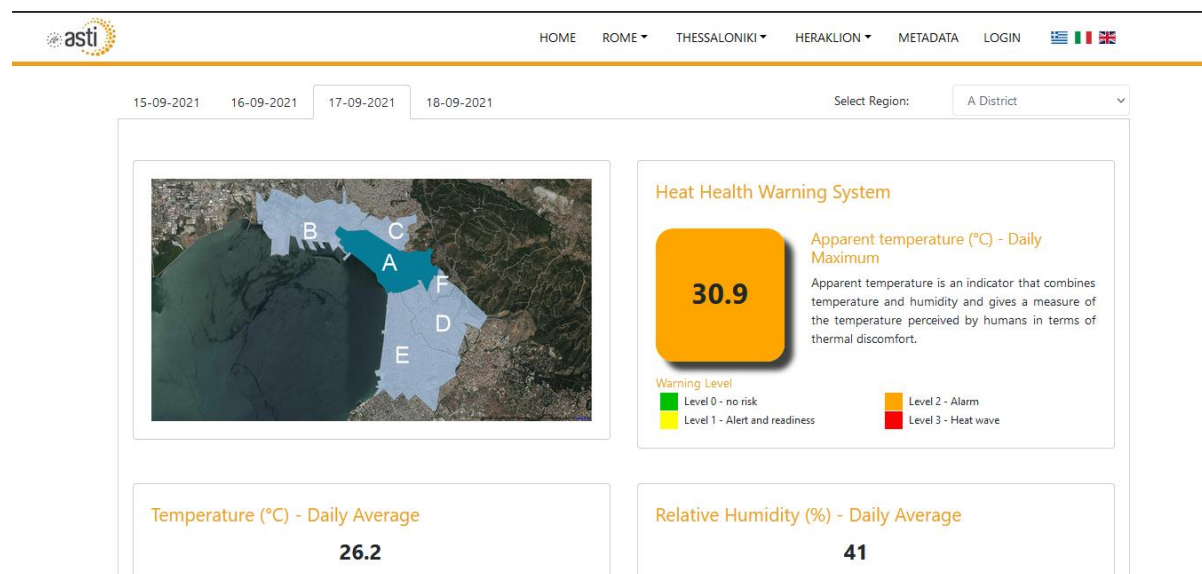


Figure 13: Example of the Dashboard in LIFE-ASTI web application, for the 17th of September 2021 in Thessaloniki.

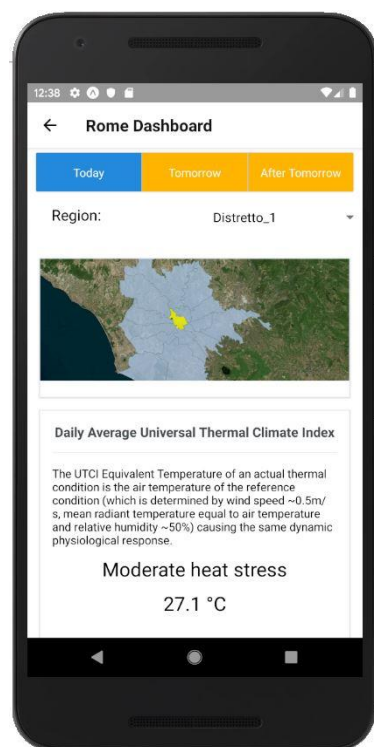


Figure 14: Example of the Dashboard in LIFE-ASTI mobile application for Rome.

The end-user can find immediately for the district of interest the daily maximum apparent temperature. Also, the heat health warning is depicted with specific colours in the Dashboard, based on the alarming level (green: no risk, yellow: Alert and readiness, orange: Alarm, red: Heat wave). In this example the alarming level is orange, and the citizens as well as the local authorities should be cautious and prepared for this day.

Similar information can be also found in the mobile application of LIFE-ASTI (lifeASTI at Google Play). An example of the Heat Health Warning System in the mobile application is illustrated in Figure 14.

2.3 Future climate impact assessment of UHI effect and assessment of adaptation plans

For the purposes of the future climate impact on the Urban Heat Island (UHI) of Thessaloniki and Rome, regional climate simulations were conducted for the present climate, but also for the middle and the end of the century under the worst-

case emissions scenario (RCP8.5).

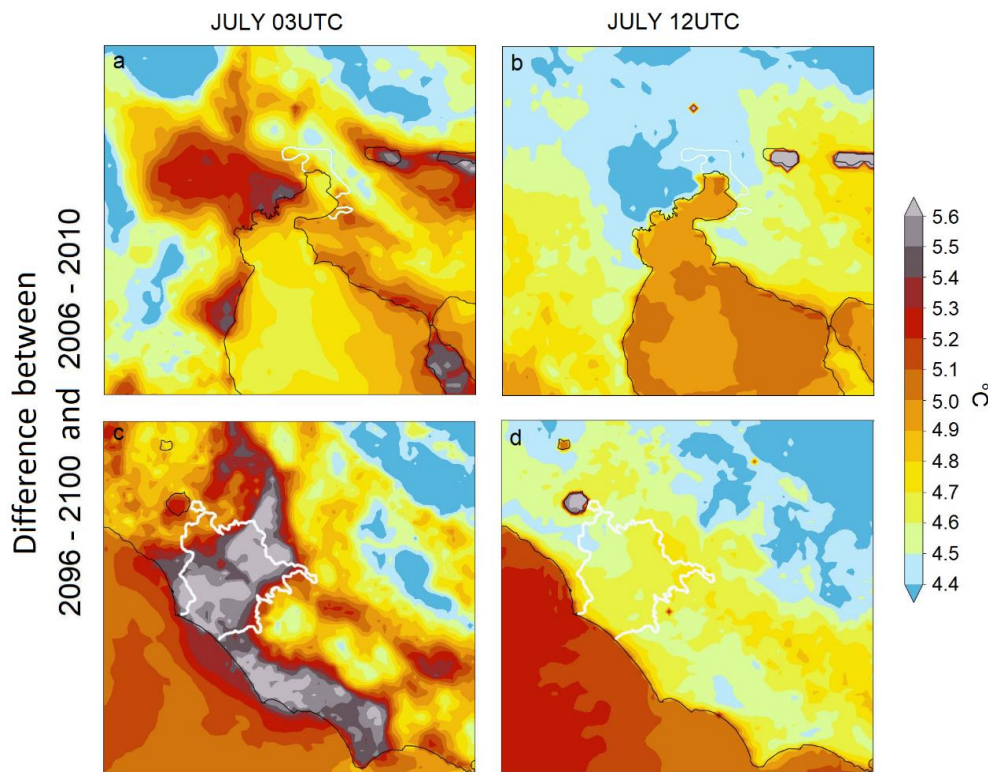


Figure 15: Apparent temperature difference between periods 2006-2010 and 2096-2100 for the cities of Thessaloniki (a, b) and Rome (c, d) for 03 and 12UTC respectively. The urban areas are indicated by the white contour.

In an annual basis, the temperature is expected to increase by 1°C and 3.5°C in 2050 and 2100 comparing to 2010 in both cities. The highest increases are estimated in future summers, as the average temperature will increase by 1.4°C and 4.4°C (slightly lower in Rome) by the middle and the end of the century. Thus, although no changes are expected in the UHI effect (under a constant size and shape of the cities), the urban microclimate of both cities will change to warmer and the heat discomfort during the summertime will enhance. In particular, the apparent temperature (TAPP) is estimated to increase by $\sim 2.5^{\circ}\text{C}$ and $\sim 5^{\circ}\text{C}$ in both cities by 2050 and 2100 respectively during an average July morning (Figure 15). TAPP increase seems to be slightly lower during the afternoon. This actually means that average TAPP in an average July (which is climatically the hottest month) will reach or exceed 37°C by 2100 in both cities doubling the mortality risk comparing to the present average July (Figure 16).

Regarding the assessment of the adaptation plans, first results are expected. However, it should be highlighted that, under a constant size and shape of the cities and no adaptation plans applied, for the city of Thessaloniki temperature in July may increase in a slightly higher rate (i.e., $+0.2^{\circ}\text{C}$) over the western/eastern parts of the city comparing to the central till 2100. This may have a corresponding impact on TAPP (Figure 15a, b). For the city of Rome, larger temperature increases in

a typical July in 2100 should be expected over east and south urban areas by 0.2°C comparing to other urban areas having a corresponding impact on TAPP especially during the day (Figure 15d). In an average July morning TAPP seems to be uniformly increased in most urban areas (except for northwest and southeast ones) (Figure 15d).

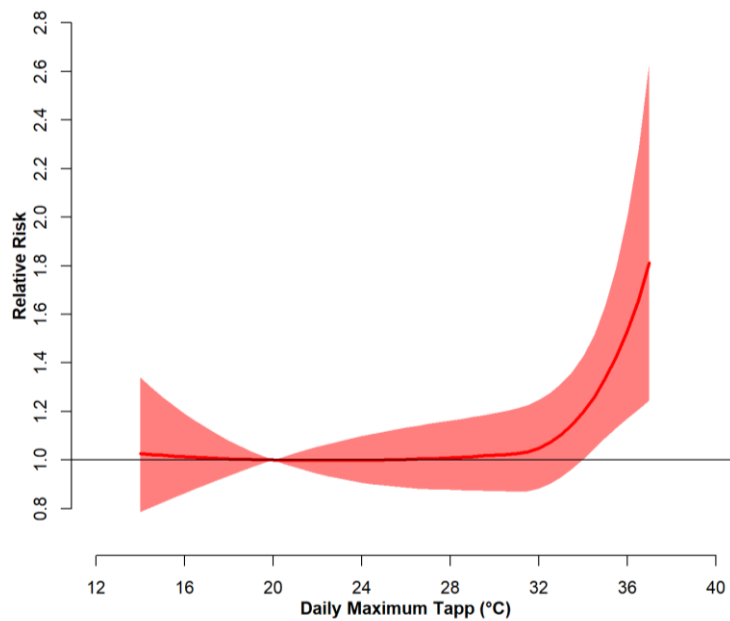


Figure 16: Relationship between apparent temperature (TAPP) and mortality during summer (May-September) in Thessaloniki, period 2013-2018. [Adopted from Francesca de'Donato, DEASL]

3. HEAT HEALTH WARNING SYSTEMS

3.1 General Description of the Heat health warning system

Heat health watch warning (HHWW) systems are core elements of heat adaptation plans as defined by World Health Organisation (WHO) Guidance (WHO, 2008; WMO, 2015). To date, 16 European countries have national HHWW systems in force, as active part of their Heat health adaptation plan (WHO, 2021).

Warning systems worldwide have been developed using different temperature exposure indicators and approaches to set thresholds (Casanueva et al., 2019, WHO\WMO, 2015). When considering heat wave episodes, epidemiological studies have shown that extreme events have an even stronger impact on mortality. Also considering climate change and the increase in the frequency and intensity of extreme events, these will have a greater impact on health (Guo et al., 2018), thus making HHWW systems necessary tools for adaptation.

HHWW systems serve as tool on which prevention and emergency measures should be modulated based on the severity of risks for a given population and help raise awareness on the risks associated to heat. As mentioned in the WMO and WHO guidance (WHO and WMO, 2015) key aspects a HHWW should include are:

- accurate forecasts
- identification of risk conditions for health (scientifically sound threshold levels)
- graded levels of alerts
- information network for dissemination
- timely communication of warnings (awareness raising)

HHWWS are different from a weather forecast of heat wave events in that they identify temperatures that are harmful for health, specifically in this case we consider the association of temperatures to an increase in mortality looking at observed times series of temperature and daily mortality data. Thresholds and levels of warning are set based on specific health risk thresholds (increases in daily mortality).

Within LIFE ASTI these HHWWS models were developed for 3 cities: Rome, Thessaloniki and Heraklion and using the forecasting system developed in the project they were run operationally.

3.2 Pilot application and results

Thresholds and levels of warning are set based on specific health risk thresholds (increases in daily mortality) as briefly described below and defined in deliverable C6.1 and C6.2.

In order to develop a HHWW, weather and mortality data are needed to estimate the association between temperature indicators and health outcomes (mortality). Daily mortality counts for at least 5 years were collected and temperature indicators for the same time frame were calculated and used as exposure, with maximum apparent temperature, an indicator that combines air temperature and humidity was selected as exposure in our HHWW.

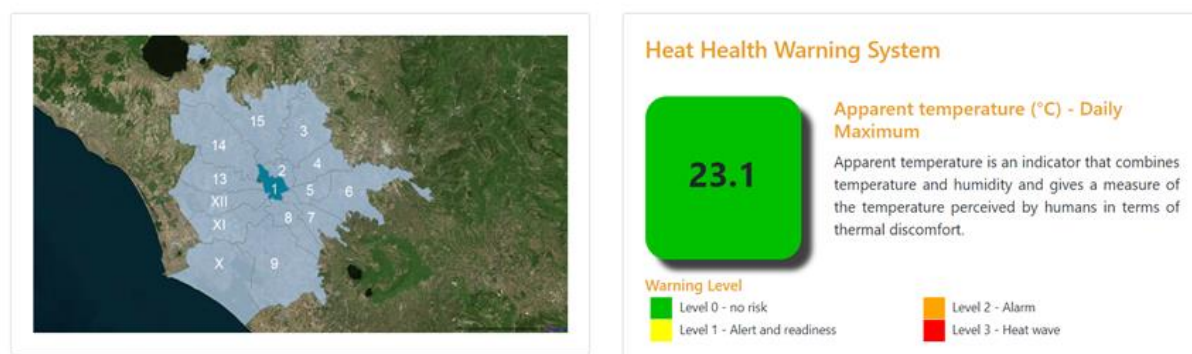
The tappmax threshold models are defined on the basis of the relationship between mortality and Tappmax investigated through a city-specific Poisson regression model (Michelozzi et al., 2010). The explicative variables included in the model are:

- holidays, month (May–August),
- the interaction between Tappmax and month
- the number of consecutive hot days with Tappmax above the threshold (defined as the mean temperature value corresponding to all days for which excess mortality was greater than 10%)

For each value of Tappmax, the model estimates the associated excess in daily mortality and, on the basis of these results, defines monthly thresholds. Excess mortality is defined as the difference between observed daily values and a baseline reference expected value. Baseline mortality is defined as the average daily mortality by week and day of the week based on historical time series data (Thessaloniki: 2013-2018; Rome: 2013-2018).

Within LIFE ASTI, high resolution HHWW were developed for Rome, Thessaloniki, and Heraklion. New systems were developed for the Greek cities while for Rome, the operational model already in place since 2005, is adapted within LIFE ASTI, using high resolution forecasts developed in C2. For all cities warnings are provided by administrative or health district areas within the Municipality (see details in deliverables C2, C6.1 and C6.2 and web APP) and figure 3.2.1.

Forecasts meteorological data produced by AUTH in C1 is then used in the HHWW model to define daily warning levels in each city during the summer period. Model outputs are reported in the LIFE ASTI platform and APP as shown in Figure 17 below. The App allows to select a zone within the city and view the forecast level of warning and a series of different temperature indicator forecast values. Results from the model for summer 2020, gave 4 days of warnings for Rome and 34 for Thessaloniki, while in 2021 an above average summer with record high temperatures issued 44 days of warning in Thessaloniki and 10 days of warning in Rome. The model for Heraklion was developed in summer 2021.



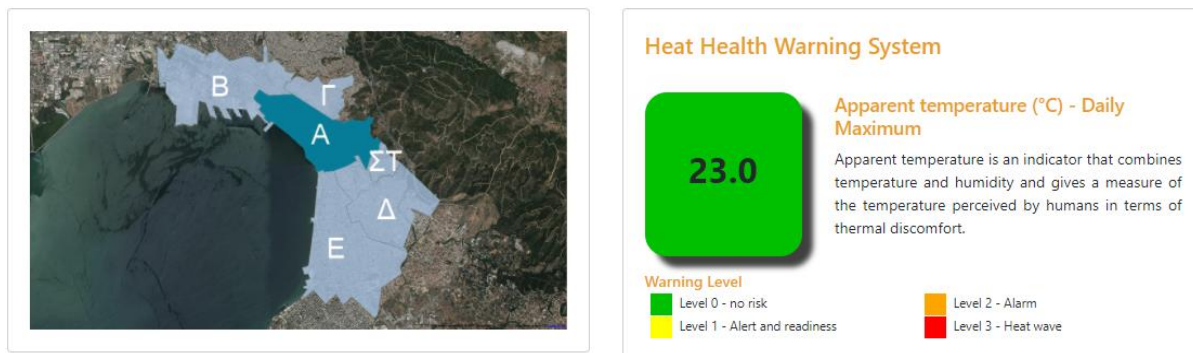


Figure 17: HHWW in LIFE ASTI PLATFORM

4. INVENTORY OF STRATEGIES FOR COMBATING UHI

4.1 Introduction

The way cities are designed has a strong influence on the urban climate. Due to poor urban planning practices, cities can experience challenges such as the urban heat island (UHI) effect, strong winds, stagnant air, captured heat, rainfall flooding, and more. These can affect the prosperity, health, safety, and well-being of urban populations. Moreover, urbanisation and climate change trends can worsen extreme conditions experienced in the urban environment. As the climate change progresses, cities need to adapt in order to remain liveable, functional and prosperous in the future. Adaptation is the process of adjustment to the actual or expected climate and climate hazards, seeking to reduce the negative impacts or exploit beneficial opportunities. Similarly, as in the case of reducing greenhouse gas emissions, there is also urgency in preparing for the unavoidable impacts of climate change. Cities need to act now to avoid or reduce weather-related deaths (i.e., due to heat waves) and economic losses from climate-related extremes in the future ([Climate Adapt](#)). The number of cities and towns committed to acting on adaptation to climate change has grown substantially in Europe, supported by the emphasis on urban adaptation in EU policy and key international frameworks (EEA, 2020).

According to Yamamoto (2006) the following factors are the major causes of the urban heat island effect:

- (i) Increased anthropogenic heat release
 - Heat release resulting from energy consumption in urban areas
- (ii) Changes in surface cover
 - Reduced surface evapotranspiration capacity due to less green area
 - The heat storage effect of construction materials such as concrete and asphalt
- (iii) Urban structure
 - Heat stagnation due to densely packed buildings
 - Expansion of urban areas
- (iv) Other
 - The greenhouse effects of fine-particulate air pollution in the urban atmosphere” (Yamamoto, 2006).

In order to visualize these causes here after is presented a figure describing them.

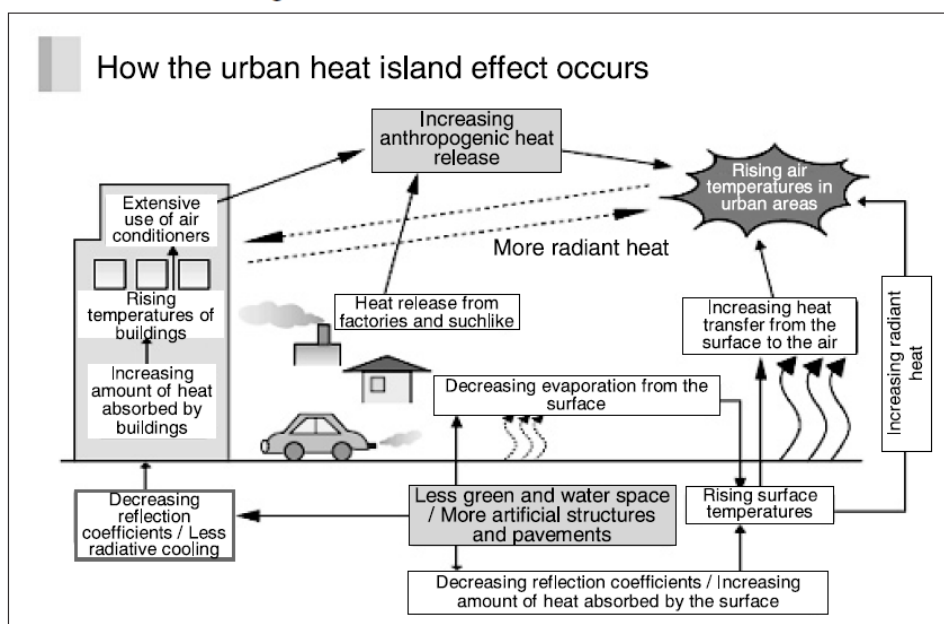


Figure 18: the causes of the UHI effect

(Source: The Ministry of the Environment. For the Promotion of Urban Heat Island Mitigation Measures (Brochure), 2000. (Japanese): http://www.env.go.jp/air/life/heat_island/pa_nf01.pdf] Yamamoto, 2006)

Considering that all policies targeting to mitigate the UHI effect should confront the above-mentioned causes.

4.2 International Frameworks – European Policies and Initiatives

The United Nations and the European Union have several policy frameworks and initiatives in place to combat climate change, promote sustainable development and increase the resilience of cities and their residents. Some relative key policies and strategies are presented below:

International Frameworks – European Policies & Initiatives

2030 Agenda for Sustainable Development 2015

Paris Agreement 2016

European Green Deal (2019)

European Biodiversity Strategy 2030 (2020)

European Strategy on Adaptation to Climate Change (2021)

European Climate Law (2021)

Initiative – Covenant of Mayors for Climate & Energy (2016)

Initiative – Green City Accord (2020)

Figure 19: International Frameworks – European Policies & Initiatives

2030 Agenda for Sustainable Development (2015)

The 2030 Agenda for Sustainable Development is a plan of action for people, planet, and prosperity, adopted by all United Nations Member States in September 2015. The 2030 Agenda established 17 Sustainable Development Goals (SDGs), containing 169 global targets aiming to create a better world by 2030, by ending poverty, fighting inequality, and addressing the urgency of climate change. Special reference to sustainable cities was made through Goal 11 which emphasizes on the necessity for new, intelligent urban planning that creates safe, affordable, and resilient cities with green and culturally inspiring living conditions. Additionally, the 2030 Agenda introduced Goal 13, which suggest taking urgent action to combat climate change and its impacts.

Paris Agreement (2016)

The Paris Agreement is the first-ever universal, legally binding global climate change agreement, adopted at the Paris climate conference (COP21) in December 2015 and entered into force in November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century. The Paris Agreement is a landmark in the multilateral climate change process because, for the first time, a binding agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects.

European Green Deal (2019)

The European Green Deal is a roadmap launched by European Commission in December 2019 aiming to make Europe the first carbon-neutral continent by 2050. The European Green Deal is at the heart of the Commission's strategy to implement the *2030 Agenda on Sustainable Development* and has a strong focus on climate action. It is an ambitious package of measures ranging from ambitiously cutting greenhouse gas emissions, to investing in cutting-edge research and innovation, to preserving Europe's natural environment.

European Biodiversity Strategy 2030 (2020)

The European Biodiversity Strategy 2030 is a comprehensive, ambitious, and long-term plan to protect nature and reverse the degradation of ecosystem, launched in May 2020. The strategy is a core part of the *Green Deal* and highlights that the promotion of healthy ecosystems, green infrastructure and nature-based solutions should be systematically integrated into urban planning, including in public spaces, infrastructure, and the design of buildings and their surroundings.

European Strategy on Adaptation to Climate Change (2021)

The New European Strategy on Adaptation to Climate Change is among the first climate action initiatives developed under the *Green Deal*. The New Strategy which builds on the *2013 Climate Change Adaptation Strategy*, was adopted by the European Commission in February 2021. The

Strategy promotes policymaking, new investments and urban planning that are climate-informed and future-proofed. It also highlights the global goal on adaptation established by the [Paris Agreement](#) and the need to avoid “climate-blind” decisions by recording, collecting, and sharing data on climate-related risks and losses among different sectors, including cities.

European Climate Law (2021)

The European Climate Law writes into law the goal set out in the [European Green Deal](#) for Europe’s economy and society to become climate-neutral by 2050. The law, which entered into force in July 2021, also sets the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. Climate neutrality by 2050 means achieving net zero greenhouse gas emissions for EU countries as a whole, mainly by cutting emissions, investing in green technologies and protecting the natural environment. The law aims to ensure that all EU policies contribute to this goal and that all sectors of the economy and society play their part.

Initiative - Covenant of Mayors for Climate & Energy (2016)

The [Covenant of Mayors for Climate & Energy](#) is an initiative which took its current shape in 2016, when the Covenant of Mayors, which started in Europe in 2008, joined forces with the [Compact of Mayors](#) to become the Global Covenant of Mayors for Climate & Energy, including the European chapter. The signatory cities commit to submitting a Sustainable Energy and Climate Action Plan (SECAP) within 2 years after the local council decides to join the initiative, outlining the key planned actions. Since October 2015, local authorities have committed to reduce their GHG emissions by at least 40 %, increase their resilience to the impacts of climate change and secure access to sustainable and affordable energy by 2030. The support offered to signatories involves technical guidance, feedback on the SECAP and access to knowledge. Additionally, the Covenant of Mayors office manages jointly with the European Energy Agency the Urban Adaptation Support Tool. By April 2020, close to 3.000 cities and towns across Europe had committed to taking action on adaptation under the Covenant of Mayors, and this number is increasing. Thessaloniki and Rome are among the cities which have also committed in taking action by signing the Covenant.

- [Sustainable Energy Action Plan of Thessaloniki \(2014\)](#)
 - Overall CO₂ emission reduction target: 20% for 2020
 - Energy saving target: 20%
 - Renewable energy sources target: 20%
- [Sustainable Energy Action Plan of Rome \(2021\)](#)
 - Overall CO₂ emission reduction target: 51% for 2030

Initiative - Green City Accord (2020)

The Green City Accord is an environmental initiative launched by the European Commission in October 2020 to accelerate the implementation of the [European Green Deal](#). The Accord aims at making cities greener, cleaner, and healthier thereby improving the quality of life of citizens by 2030.

So far, 23 cities throughout Europe have signed the Accord thus have committed to address the following five environmental areas: air, water, nature and biodiversity, circular economy and waste, and noise. Signatory cities will set targets and an action plan for 2030 but will also report on their progress every three years.

4.3 Strategies

Besides the international and European policy landscape briefly presented above, literature review reveals that there are several adaptation and mitigation strategies which can be used by urban planners, architects, and landscape designers in order to combat the negative effects of climate change in cities and to deal with phenomena such as the UHI. Specifically, according to Lenzholzer et al. (2020), attention to local urban climate variables, combined with effective urban planning and design approaches can help cities adapt to climate change. The four (4) main strategies identified in literature to positively influence urban climate are the following:

1. **The layout of cities** (i.e., building volumes and configurations, street widths etc.) that can influence heat and wind patterns
2. The amount and spatial distribution of urban green and vegetation (i.e., grass, trees, green walls etc.)
3. **The use of different materials** (i.e., building and paving materials, coatings, etc.) to lower urban temperatures
4. Minimising anthropogenic heat sources (i.e., air condition usage etc.)

4.4 Measures & Solutions

The aforementioned strategies include several measures and interventions aimed at alleviating climate change impacts, such as increased precipitation, higher temperatures, rainfall flooding, heat waves and more. Some of the strategies include the **enhancement of urban green and blue infrastructure**, as well as **additional measures**, which can be implemented at different spatial scales. Increased greenery and shading and the installation of water features can mitigate urban heat, which in addition to lowering temperatures, can increase citizens' comfort by 50%-60% (City of Parramatta Council & CRC for Low Carbon, 2019).

Different interventions/ measures aiming to deal with the UHI effect are presented briefly in the following figure (Figure 20) and in more detail below. As indicated in Figure 21, these interventions are mitigation or adaptation measures (or both), are implemented on several spatial scales (building/ neighbourhood/ district/ city), and offer different kinds of solutions (social, environmental, technological, etc.).

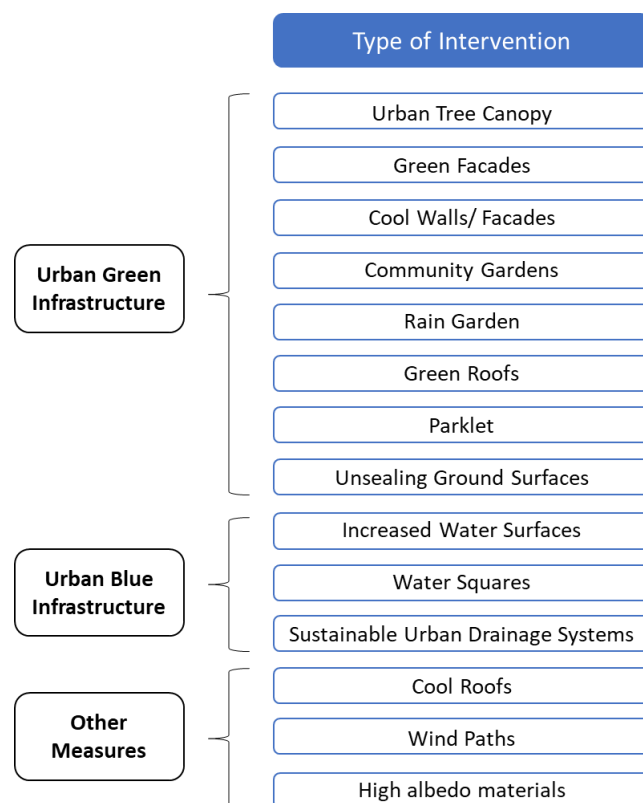


Figure 20 : Measures/ Interventions

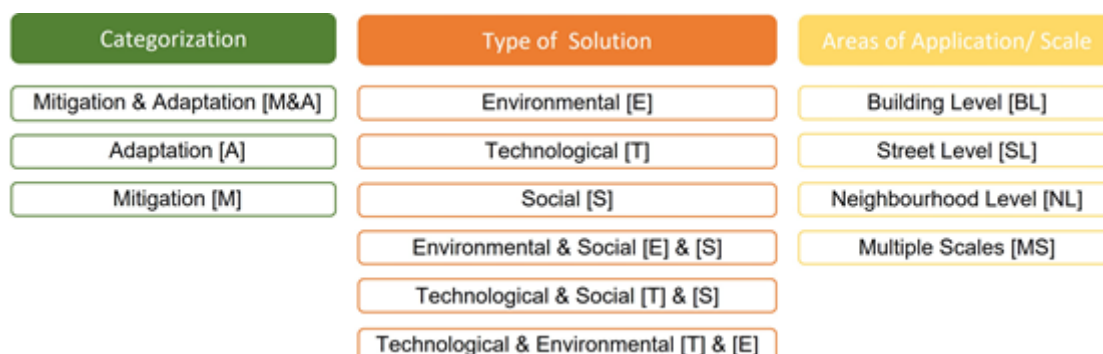


Figure 21: Measures/ Interventions Categories

Urban Green Infrastructure will play a significant role in achieving EU policy objectives, especially when using nature-based solutions (NBS) to preserve the natural capital found in urban areas. Green infrastructure is defined as “a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services” in both rural and urban settings (EEA, 2020).

Nature-based solutions (NBS) are inspired and supported by nature. They are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience. Such solutions increase the amount as well as the diversity of nature, natural features and processes in cities, landscapes, and seascapes, through locally adapted, resource-efficient, and systemic interventions (European Commission, 2020).



Image 1 - Urban tree canopy

Image source: (The Nature Conservancy, n.d.)

Type of intervention: Urban tree canopy

Categorisation: Mitigation & adaptation

Type of solution: Environmental

Areas of application/scale: Street level (local scale)

Impact: Provides cooling through shading and evapotranspiration. Shaded surfaces may be 11–25°C cooler than the peak temperatures of unshaded materials. Evapotranspiration alone or in combination with shading, can help reduce peak summer temperatures by 1–5°C.

Details: Trees and vegetation are most useful as a mitigation and adaptation strategy when planted in strategic locations around buildings or to shade pavement in parking lots and streets. Research indicates that the right type of tree and treetop shape can help prevent pollutants from accumulating (United States Environmental Protection Agency, n.d.).

Example: This type of intervention was implemented in the context of the LIFE CLIVUT - LIFE18 GIC/IT/001217 project. More details about this project can be found in Deliverable C.5.2.



Image 2 - Facade gardens, Gouda

Image source : (Wa, n.d.)



Image 3 - Rubens Palace hotel

Image source: (Rubens at the Palace, 2016)

Type of intervention: green façades/ Living walls

Categorisation: Mitigation and adaptation

Type of solution: Technological

Areas of application/scale: Building level (local scale)

Impact: Allow rainwater to infiltrate the ground, climbing plants increase urban biodiversity and keep the facade cool in higher temperatures.

Details: These interventions are the result of greening vertical surfaces with plants: whether plants are rooted into the ground, in the wall, or in modular panels that are attached to the façade. They are classified into two categories (i) green facades and (ii) living walls (Sclar, 2013):

- Green façades: façades systems in which climbing plants are rooted in the soil or containers, either growing upwards or cascading down. They require a structure to maintain their position, growth, and overall survival. With green façades, a broad variety of plant species can be used, and this system is easily scalable
- Living walls: a technology system that depends on prefabricated modular or monolithic vertical soil or hydroponic systems to root plants on a vertical plane. They are made of panels and/or geotextiles. A living wall can be thought of as a vertical garden; it requires irrigation, drainage, and vertical organisation.

Example: This type of intervention was researched in the context of the LIFE EU-Horizon 2020 – SOLOCLIM - Grant agreement ID: 861119 project and implemented in another project in Madrid (Vertical Garden – Patrick Blanc). More details about this project can be found in Deliverable C.5.2

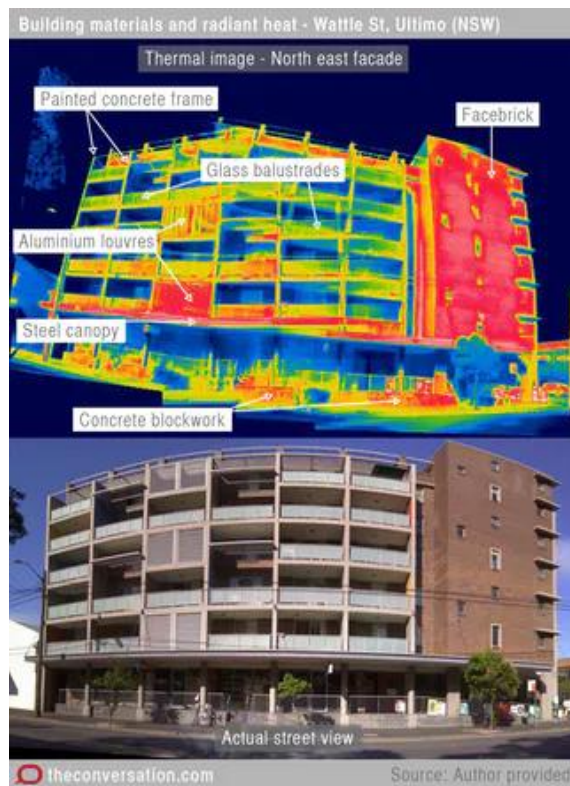


Image 4 - Cool facade

Image source: (Osmond & Fox, 2016)

Type of intervention: Cool walls /facades

Categorisation: Mitigation & adaptation

Type of solution: Technological

Areas of application/scale: Building level (local scale)

Impact: Cooling, lower buildings' energy demand

Details: Light-coloured materials with a high albedo heat up less. Materials with less mass, that absorb less heat, allow the facade and the immediate surroundings to maintain lower temperatures. However, a universal conclusion regarding the effectiveness of cool walls/facades cannot be achieved, since the role of wall albedo significantly depends on additional factors, such as urban morphology, building design, and human interaction with buildings. Among these factors, the local climate zone (dominated by urban density) and building operations significantly influence the range and variability of building thermal loads and UHI, while window properties regulate the indoor-outdoor heat/radiation exchange. Compared to the aforementioned factors, the impact of wall albedo is small. Nonetheless, in contrast to altering the urban morphology or building design, the modification of wall albedo represents a more (financially and practically) feasible strategy and can be beneficial depending on the overall design of the surrounding urban environment. Therefore, the role of wall albedo should be evaluated on a case-by-case basis (Nazarian, Dumas, Kleissl, & Norford, 2019).

Example: This type of intervention was implemented in the context of the LIFE HeatLand – LIFE CCA/ES/000077 project. More details about this project can be found in Deliverable C.5.2.



Image 5 - Community Garden, Dublin

Image source: (Greennews, 2019)

Type of intervention: Community gardens

Categorisation: Mitigation & adaptation

Type of solution: Environmental & social

Areas of application/scale: Neighbourhood level

Impact: Cooling, recreational and educational opportunities, food security, stormwater runoff management

Details: Green vegetation can reflect sun radiation, reducing the UHI effect and cooling the climate in urban areas. Urban and community gardens, as a form of urban vegetation, influence the urban micro-climate, mitigate local temperature increases, and control of stormwater runoff. Moreover, they improve the social and environmental value of the local urban environment, offering recreational and communal areas where citizens can socialise and interact. Exposure to community gardens can provide educational opportunities to young children as well as adults, regarding the source of fresh produce. Moreover, they demonstrate community stewardship and introduce the importance of environmental sustainability. Community gardens offer great places for promoting an environment-based educational model. Urban green space vary in cooling capability and urban gardens are subject to social forces that influence their composition and may affect their cooling capability (Veron & Jackson, 2017).

Example: This type of intervention was implemented in Paris, France, in the context of the municipal program 'Main Verte'. More details can be found in Deliverable C.5.2.



Image 6 - Rain Garden

Image source: (Groundwater Foundation, n.d.)

Type of intervention: Rain gardens

Categorisation: Mitigation & adaptation

Type of solution: Technological, environmental & social

Areas of application/scale: Neighbourhood level

Impact: Cooling, water management, aesthetic value

Details: A rain garden is made up of native shrubs, perennials, and flowers planted in a small depression, designed to temporarily hold and soak in rainwater runoff that flows from roofs, driveways, patios, or lawns. Rain gardens are effective in removing up to 90% of nutrients and chemicals and up to 80% of sediments from the rainwater runoff. Compared to a conventional lawn, rain gardens allow for 30% more water to soak into the ground (Groundwater, n.d.).

Example: This type of intervention was implemented in the context of the EU-Horizon 2020 – UNaLAB – Grant agreement ID: 730052 project. More details about this project can be found in Deliverable C.5.2.



Image 7 - Fairmont Waterfront, Vancouver

Image source: (© Fairmont Hotels & Resorts, n.d.)

Type of intervention: Green roofs

Categorisation: Mitigation & adaptation

Type of solution: Technological, environmental & social

Areas of application/scale: Building level (local scale)

Impact: Green roofs (i) manage and clean stormwater, (ii) clean pollutants from the air, (iii) extend the lifespan of roofs, (iv) create and preserve biodiversity, (v) provide additional open spaces for food production, (vi) increase property values, (vii) lower building's energy demand

Details: Vegetated landscape built from layers installed on a roof surface. They provide shading to building materials thus reducing temperatures. Evapotranspiration from vegetation and soil provides a cooling effect.

Example: This type of intervention was implemented in Rotterdam, the Netherlands, through a Municipal subsidy for roof owners. More details can be found in Deliverable C.5.2.



Image 8 - Parklet intervention, London

Image source: (MERISTEM Design, n.d.)

Type of intervention: Parklets

Categorisation: Mitigation & adaptation

Type of solution: Social & environmental

Areas of application/scale: Street level (local scale)

Impact: Parklets encourage non-motorized transportation, and contribute to UHI mitigation / adaptation through greening, water management, as well as through reducing the amount of space within the city that is designated for cars.

Details: Parklet or pocket park provides opportunities for people to create small but important public spaces in urban neighbourhoods. Parklet repurposes part of the street next to the sidewalk into a space meant for public use. Depending on the parklet's design and the neighbourhood's needs, it can provide amenities such as seating, planting, bicycle parking, and art (UrbanGreenUp, n.d.).

Example: This type of intervention was implemented in the context of the EU-Horizon 2020 - Urban GreenUP - Grant agreement ID: 730426 project. More details about this project can be found in Deliverable C.5.2.

Examples of surfaces with different infiltration capabilities

(1) Macadam or water-bound surfaces

Permeability 50%, for parking spaces with light to medium-weight vehicles

(2) Gravel lawn

70% - 90% permeability, for parking spaces with light to medium-weight vehicles

(3) Lawn joint pavement

50% - 60% permeability, for parking spaces with light to medium-weight vehicles

(4) Grass and lawn pavers

60% permeability, also suitable for heavy vehicles

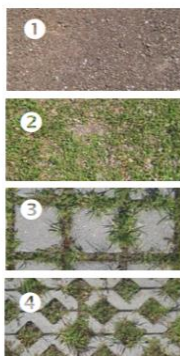


Image 9 - Examples of surfaces with different

Infiltration capabilities

Image source : (Storch, et al., 2020)

Type of intervention: Unsealing ground surfaces

Categorisation: Adaptation

Type of solution: Technological

Areas of application/scale: Street level (local scale)

Impact: Permeable pavements can cool a surface through the evaporation of moisture stored in the pavement. Other advantages include cooler air temperatures and increased stormwater management.

Details: Typical pavements have a lower solar reflectance (albedo) and a higher thermal diffusivity as compared to natural surfaces, which cause them to absorb and store more heat (Sen, Roesler, Ruddell, & Middel, 2019). Therefore, transforming paved surfaces to unpaved and planted ground plots can contribute to biodiversity, improve water management, and limit heat capture.

Example: The impacts of this type of intervention is assessed and quantified in the context of the LIFE UrbanProof - LIFE15 CCA/CY/000086 project. More details on this project can be found in Deliverable C.5.2.

Urban Blue Infrastructure refers to water elements found in urban areas, such as rivers, canals, ponds, fountains, lakes, and water treatment facilities (Bioveins, 2020). Such interventions can contribute to minimising the impacts of the UHI effect, through additional cooling, improved water management and local microclimate regulation.



Image 10 - Urban Water channels

Image source: (© atelier GROENBLAUW, n.d.)

Type of intervention: Increased water surfaces

Categorisation: Adaptation

Type of solution: Technological & environmental

Areas of application/scale: Neighbourhood level

Impacts: They create additional cooling through evaporation and the improved evapotranspiration of vegetation.

Details: Adaptation strategies introduce additional water features (fountains, pools, ponds) or pavement water sprinkling systems as cooling measures during warmer temperatures. However, standing water or excess evaporated water increase humidity and can lead to increased temperatures and lower thermal comfort.

Example: This type of intervention was implemented in the context of the LIFE LUNGS - LIFE18 CCA/PT/001170 project. More details about this project can be found in Deliverable C.5.2.



Image 11 - Water Square, Benthemplein, Rotterdam, Netherlands

Image source: (De Urbanisten, 2012)

Type of intervention: Water squares

Categorisation: Adaptation

Type of solution: Technological & social

Areas of application/scale: Neighbourhood level

Impact: Such interventions often result in (i) the dynamics of water being made more visible, (ii) an enhanced aesthetic value, (iii) the creation of spaces with multiple purposes, (iv) allowing substantial fluctuations in water levels and for large volumes of water to be buffered, (v) water management, (vi) cooling.

Details: Water squares are systems that collect rainwater during periods of increased precipitation. They are often linked to other urban uses such as playing areas, green areas, and residential functions, offering multiple benefits.

Example: This type of intervention was implemented in Benthemplein, Rotterdam, The Netherlands. More details can be found in Deliverable C.5.2.



Image 12 -Different types of SuDS: Detention ponds, green roofs, permeable pavements, and trenches (clockwise from top left)

Image source: (Mishma, 2019)

Type of intervention: Sustainable Urban Drainage Systems (SuDS)

Categorisation: Adaptation

Type of solution: Technological

Areas of application/scale: Multiple scales (street level, building level, neighbourhood level)

Impact: SuDS can be designed to (i) convey surface water, (ii) attenuate runoff before it enters watercourses, (iii) provide areas to store water in natural contours, (iv) allow water to infiltrate into the ground or evaporate from surface water and lost or transpired from vegetation (known as evapotranspiration), (v) provide additional cooling, (vi) increase biodiversity.

Details: Approaches to manage surface water that take account of water quantity (flooding), water quality (pollution) biodiversity (wildlife and plants) and amenity are collectively referred to as SuDS. SuDS mimic nature and typically manage rainfall close to where it falls. SUDS are drainage systems that are considered to be environmentally beneficial, causing minimal or no long-term detrimental damage. They are often regarded as a sequence of management practices, control structures and strategies designed to drain surface water efficiently and sustainably, while minimising pollution and managing the impact on water quality of local water bodies (SusDrain, n.d.).

Example: This type of intervention is reinforced in the context of the regeneration of the Potsdamer Platz, in Berlin, Germany. More details about this project can be found in Deliverable C.5.2.

Other measures

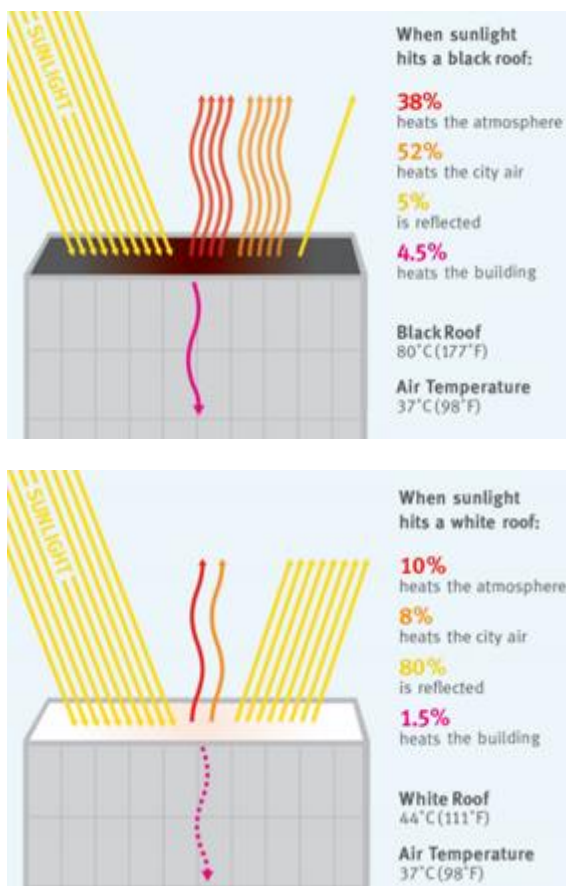


Image 13 - Cool roofs

Image source: (GCCA & R20, 2012)

Type of intervention: Cool roofs

Categorisation: Mitigation

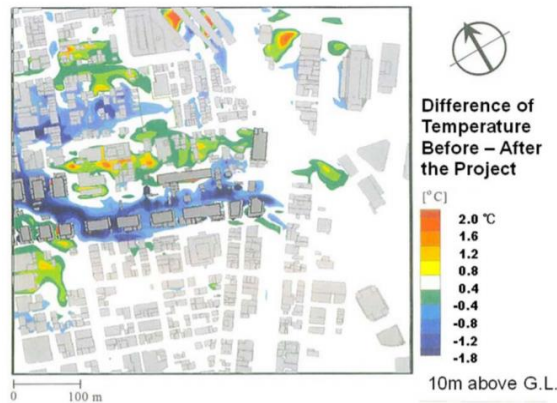
Type of solution: Technological

Areas of application/scale: Building level (local scale)

Impact: Cooling, lower buildings' energy demand

Details: Highly reflective and highly emissive roofs minimise the amount of light converted into heat and maximise the amount of heat radiated away. When sunlight hits a white roof, 10% of that heats the atmosphere, 8% heats the city air, 80% is reflected and 1.5% heats the building. The respective numbers for a black roof are 38%, 52%, 5% and 4.5%. Additionally, white roofs contribute to cost savings as a result of reduced air-conditioning and improve the life and performance of rooftop equipment (GCCA & R20, 2012).

Example: This type of intervention was implemented in the context of the LIFE HEROTILE – LIFE 14 CCA/IT/000939 project. More details about this project can be found in Deliverable C.5.2.



Map 1 - Differences of temperature before & after a project proposing a spatial slit between skyscrapers.

Image source: (Yamamoto, 2006)

Type of intervention: Wind paths

Categorisation: Mitigation

Type of solution: Technological

Areas of application/scale: Neighbourhood level

Impact: Wind paths (i) bring in cool air from the sea, lower daytime urban temperatures, (ii) bring in cool air currents that flow down mountain slopes and valleys, cooling hot urban air at night, and (iii) help alleviate air pollution by bringing in cleaner sea winds and cool air currents.

Details: The concept of “wind path” design consists of a common mitigation measure against the UHI effect. Winds that blow along paths are locally circulating winds such as those blowing from sea to land or from mountain to valleys. Positioning buildings and other urban structures in alignment with the wind, channel the wind in (Yamamoto, 2006).

Example: Wind pattern / flow was taken into consideration in the context of the regeneration of the square (Place) de la République, in Paris, France. More details about this project can be found in Deliverable C.5.2.

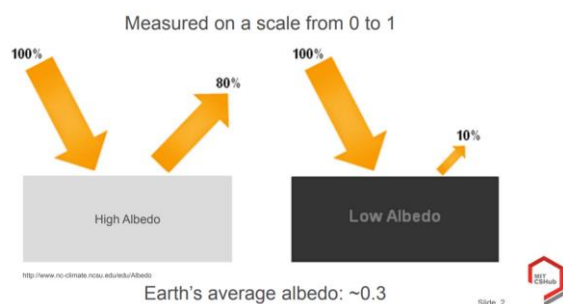


Image 14 – Albedo

Image source: (Gregory, Xu, Xu, Schlosser, & Kirchain, 2018)

Type of intervention: High albedo materials

Categorisation: Mitigation

Type of solution: Technological

Areas of application/scale: Multiple scales (building, street level)

Impact: The use of high albedo materials helps reduce the temperature increase experienced UHI, mitigating the impacts of climate warming. It can limit the use of cooling systems in buildings, as the external temperatures around the building are lower due to the more moderate UHI, lowering energy consumption. Finally, reducing UHI lowers the risk of smog, as smog is more likely to form in higher temperature environments, with subsequent benefits to public health (GCCA, n.d.).

Details: Albedo is the fraction of solar radiation reflected from a materials' surface. In general, lighter-coloured materials reflect more sunlight than darker colours and therefore have a higher albedo. The choice of highly-reflective surfaces falls within the class of geoengineering known as solar radiation management (SRM), which focuses on increasing the whiteness – and therefore reflectivity – of urban areas.

Example: This type of intervention is reinforced in the context of the LIFE HeatLand – LIFE CCA/ES/000077 project. More details about this project can be found in Deliverable C.5.2.

5. ACTION PLANS FOR ADAPTATION

5.1 Adaptation Action Plans Portfolio for the city of Thessaloniki

5.1.1 General description of the targeted urban area

Within this paragraph an analysis of the demographic and geospatial data, the area's environmental and socio-economic, weather & climate conditions with emphasis on UHI effect are being analysed under the aim to have a more integrated approach of the urban area of Thessaloniki.

5.1.1.1. Administrative data (Demographics, Geospatial etc.)

Demographic data

Hereafter is presented a table demonstrating the population of the city of Thessaloniki along with the municipalities of the Thessaloniki's Metropolitan Area in total and divided among men and women. The data refer to the year 2011 as the processing of the statistical data of the 2021 census has not yet been completed by the Hellenic Statistical Authority (ELSTAT). The total population of the Municipality of Thessaloniki demonstrates a downward trend between the years 2001 and 2011 equal to 18.12%, from 397,156 inhabitants in 2001 to 325,182 in 2011 (Table 2). Women make up 52.49% of the population, while men make up 47.51%.

Table 2: Population per permanent residence

Geographic level	Geographic code	Permanent residence	TOTAL	MEN	WOMEN
0	000	COUNTRY'S TOTAL	10.816.286	5.303.223	5.513.063
1	1	NORTH GREECE	3.110.835	1.519.890	1.590.945
2	11	Decentralized Administration of Macedonia – Thrace	2.490.290	1.212.336	1.277.954
3	111	REGION OF EASTERN MACEDONIA AND THRACE	608.182	299.643	308.539
3	112	REGION OF CENTRAL MACEDONIA	1.882.108	912.693	969.415
4	11207	R.U. OF THESSALONIKI	1.110.551	531.102	579.449
5	1120701	MUNICIPALITY OF THESSALONIKI	325.182	148.470	176.712
		MUNICIPALITY OF AMBELOKIPOI AND			
5	1120702	MENEMENI	52.127	24.721	27.406
5	1120703	MUNICIPALITY OF VOLVI	23.478	11.742	11.736
5	1120704	MUNICIPALITY OF DELTA	45.839	22.829	23.010
5	1120705	MUNICIPALITY OF THERMAIKOS	50.264	24.777	25.487
5	1120706	MUNICIPALITY OF THERMI	53.201	26.137	27.064
5	1120707	MUNICIPALITY OF KALAMARIA	91.518	43.169	48.349
5	1120708	MUNICIPALITY OF KORDELIO AND EVOSMOS	101.753	49.613	52.140
5	1120709	MUNICIPALITY OF LAGKADA	41.103	20.358	20.745
5	1120710	MUNICIPALITY OF NEAPOLI – SYKIES	84.741	40.406	44.335
5	1120711	MUNICIPALITY OF PAVLOU MELA	99.245	48.337	50.908
5	1120712	MUNICIPALITY OF PYLAIA - CHORTIATI	70.110	34.296	35.814
5	1120713	MUNICIPALITY OF CHALKIDONA	33.673	16.755	16.918
5	1120714	MUNICIPALITY OF ORAIOKASTRO	38.317	19.492	18.825

The image of 2011 compared to the data of the respective surveys of 1991 and 2001 still shows Thessaloniki in a phase of urban sprawl since its population is being transferred from the central Municipality (Municipalities) to the peripheral ones (ELSTAT, 2011)

In addition, people are the ones who are most affected by the impact of the UHI effect, especially minors and the elderly, whose immune system cannot handle the intensity of temperatures during the day and night. Factors such as the economic crisis, poverty, the use of old appliances, result to the fact that several inhabitants do not have ways of sufficient cooling.

Table 3. Demographic characteristics of the Municipality of Thessaloniki (Hellenic Statistical Authority, reference year 2011, by own means)

Municipality	Index / factor	Residents
Thessaloniki	Population	Population according to the 2001 census: 397.156 Population according to the 2011 census: 325.182
	Profession	1. Senior managers and administrators: 6.127 2. Professionals: 30.465 3. Technicians and practitioners of related professions: 10.956 4. Office employees: 8.702 5. Employees in the provision of services and salespeople: 23.990 6. Skilled farmers, stockbreeders, foresters, and fishermen: 836 7. Specialized craftsmen and practitioners of related professions: 9582 8. Operators of industrial installations, machinery and equipment and assemblers: 4.770 9. Unskilled workers, manual workers, and small professionals: 7.815 Total: 103.243
	Sectors of economic activity	Agriculture, Forestry and Fishery: 877 Constructions: 4.926 Wholesale and retail trade - repair of motor vehicles and motorcycles: 20.139 Transportation and storage: 4.282 Activities of accommodation services and catering services: 7.132 Administrative and support activities: 3.107 Public administration and defence - mandatory social security: 8.207 Education: 13.173 Activities related to human health and social welfare: 9.290 Other service activities: 32.110 Total: 103.243
	Households by number of cars	0 Cars: 66.126 1 Car: 62.429 2 + Cars: 18.845 Total: 147.400
	Economically active and inactive residents	Employees: 103.243 Unemployed: 31.329 Retirees: 71.571 Students: 64.752 Others: 54.287 Total: 325.182
	Workplace of citizens of Thessaloniki	In the Municipality of permanent residence: 83.275 In another municipality or in a foreign country or in a non-permanent place: 19.968 Total: 103.243

Hours of regular employment	Less than 20 hours: 6.175 20-29: 9.431 30-39: 13.188	40-49: 52.907 50+: 21.542 Total employees: 103.243
Buildings - Houses Construction period	Before 1945: 2.774 1946 – 1960: 16.869 1961 – 1970: 67.274 1971 – 1980: 63.039 1981 – 1990: 22.857	1991 – 2000: 16.884 2001 – 2005: 7.777 2006 and after: 7.924 Total: 205.398
Insulation type	Double glazing: 86237 Exterior wall insulation / Other type of insulation : 13483	Two or more types of insulation: 19085 No insulation at all: 86593 Total: 205398
Ordinary homes with heating availability	Central (autonomous and non-autonomous) heating: 140.208 Another type of heating: 52.879 There is no heating: 12.311 Total: 205.398	
Main energy source used for heating	Electricity: 26.991 Natural gas: 68.291 Petroleum: 44.188	Other source: 3.859 No source: 4.071 Total: 147.400
Main energy source used for cooking	Electricity: 144.833 Natural gas: 1.261	Other source / No source: 1.306 Total: 147.400
Main energy source used for hot water	Electricity: 75.640 Other source / No source: 71.760 Total: 147.400	

(Source: Hellenic statistical office, 2011, own elaboration)

From the demographic survey conducted in 2011, 32% of the residents of the municipality of Thessaloniki are employees, 22% retired, 20% students, 17% other (economically inactive population) and 10 % unemployed. It is pointed out that, according to the definition of the unemployed and the economically inactive population, if a person who is not working, is not actively looking for work and is not available to take up work immediately, is not classified as unemployed but in the economically inactive population.

The workplace of the residents of Thessaloniki, by 81% is the Municipality of permanent residence, while 19% is employed in another municipality or in a foreign country or in a place of non-permanent residence.

As for the hours of their regular employment the majority (51%) works 40-49 hours per week, 21% works more than 50 hours per week, 13% works 30-39 hours, 9% works 20-29 hours and 6% less than 20 hours per week. However, when asked if they work the same or more than normal working hours, 94% answered in an affirmative way.

The main source of air pollution, for the city centre, is the traffic, with the urban road network of the Municipality of Thessaloniki covering 379.06 kilometres and 70% of its traffic passing over it. As for the number of cars per household, 45% of the residents don't own a car, 42% own 1 car and 13% own 2 cars

The quality of the urban environment has deteriorated through the dense construction and industrialization of materials, while at the same time the lack of ecological approach to the design of cities and buildings, led to environmental degradation (Siamari, 2015). The old style of building houses with building materials characterized by high heat capacity, low reflectivity, and unsatisfactory resources, as well as dense construction, significantly burdens the UHI effect. To this contribution is added another reason that negatively affects the way buildings cool down, the geometric features of roads and buildings, which create “urban ravines” and restrict the view of the sky. In the Municipality of Thessaloniki, the majority (84%) of the houses have been built before 1990 (Table 3), fact which demonstrates the need to upgrade most of the buildings for the successful mitigation of the UHI effect.

It should also be mentioned that of the total buildings 42% have no means of insulation, however 42% of the houses have double glazing, 9% have two or more types of insulation and 7% have exterior wall insulation or other type of insulation. It could be assumed that there’s much room for improvement.

It’s also very important to mention that 94% of the households have heating availability, either central heating (autonomous and non-autonomous aka dependant and non-dependant) or another type of heating. The economic crisis, unemployment and poverty make it difficult to upgrade heating systems, thus contributing to the reduction of the UHI effect.

The main energy source used for heating, in the Municipality of Thessaloniki, is by 46% natural gas, other heating methods used are heating oil (30%), electricity (18%) and other source (3%). As for the main energy source used for cooking, 98% of the households uses electricity. With regards to the supply of hot water electricity prevails, as used by 51% of the households and other sources or no means constitute the remaining 49%. (Table 3)

Geospatial data

In the urban fabric of the Municipality of Thessaloniki there are areas with special characteristics that play a specific role in the development of the city. These areas create 4 distinct spatial units which are the central part of the Municipality, which is considered as its shopping centre, the area north of Egnatia Street to the boundaries of the Municipality and west of the University to Lagada Street, the eastern part of the Municipality and the western one. Here after are being presented more thoroughly the functions and land uses that are being developed in each one of the aforementioned spatial units:

1. The **city centre – commercial centre** of the Municipality which is located on the west of the Thessaloniki International Fair (TIF) area, from Egnatia Street to the sea front and from Lagada Street to the western wall and the Eleftherias Square. Here is concentrated the largest percentage of the central functions (commercial, public, municipal, educational, cultural, entertainment services), of supra-local importance, to serve both the Municipality and the entire Thessaloniki metropolitan area, but also its wider area. To a much smaller extent, the residential use is also present, scattered from the first floor of buildings and upwards, mixed with offices.
2. The area north of Egnatia Street to the boundaries of the Municipality and west of the University up to Lagada Street, includes as main use the **intermediate residential level** “MK”. There are also activities of the tertiary sector mixed with the residential use, mainly on the ground floor of the buildings. The area, at its north-north-eastern part of the Municipality, includes the district of

Ano Polis and Eptapyrgio, which is of historical and cultural interest, with the predominant use of the neighbourhood level K2.

3. In the eastern part of the Municipality defined by the AUTH - TIF – YMCA (XANΘ) Park to its borders with the Municipalities of Kalamaria and Pylea - Chortiatis and from the forest of Kedrinos Hill to the sea front, the main use is the residential, combined to the greatest extent with intermediate level housing services and with localized residential areas, mainly in the NE borders of the Municipality (e.g., area of 40 Ekklesies). However, during the recent years a network of central functions has been developed along the main roads (V. Olgas, Mpotsari, Gr. Lambraki, etc.) with a metropolitan character. Tertiary sector activities have been developed that serve the needs of the residents not only at the neighbourhood level but also at the city and metropolitan levels.

4. The **western part**, from Demokratias Square and the Courts up to the western borders of the Municipality. In this part of the city there is a mixture of uses, such as central functions, workshops, warehouses, entertainment, while scattered housing can be detected mainly in areas on either side of the west entrance. The uses of the secondary sector and wholesale trade are gradually either ceasing to function (due to the economic crisis and economic trends) or are being transferred out of the city. At the same time, it is the hinterland of Limenas, where unstructured areas are included, while the area is crossed by main roads.

Thus, the current model of uses for the entire Metropolitan Area refers to a compact city centre, which develops in parallel with the traditional settlement of Ano Polis and Eptapyrgio, with linear extensions mainly to the east and west. This model resembles the shape of a butterfly, in the area of the Metropolitan Area, with its body being the city centre with the adjacent area of the metropolitan park (areas of museums, parks, TIF and AUTH), while its wings are eastern and western areas of residence and other uses, with linear extensions of central functions as wing ribs.

A more thorough review of the city's structure reflects a diffusion of the centre to the west with areas of mainly mixed productive uses of the secondary and tertiary sector and to the east along neuralgic road axes and the foreseen subway train's development. This diffusion is more intense in some areas further from the centre.

Within this framework, several landmarks define the city and are providing to it a particular colour and character, the White Tower and its promenade, the Port, TIF and the University, the Kastrá with the Eptapyrgio, the traditional settlement of Ano Poli, the Concert Hall, the Passenger Railway Station to mention a few and without pointing out its numerous monuments, museums, public buildings of architectural or historic interest and green areas that all together form an interactive and dynamic network of elements of interest and functions, which all together consist the endogenous development poles of Thessaloniki.

The plot ratios (P.R.) within the boundaries of the Municipality of Thessaloniki, as they appear at its website and specifically from the site <https://gis.thessaloniki.gr/sdi/>, range from 0.66 to 4.8 with the largest P.R. located in the centre of the Municipality.

As for the area's green spaces, in the Metropolitan Area of Thessaloniki, the total area of the designated green spaces, including protected areas of the Gallikos and Seih Sou, reaches 47,350 acres and gives 55.71 square meters of green space per inhabitant! However, this number is exceptionally disorienting since the above-mentioned areas do not consist of "urban green", but suburban areas. Leaving thus, only 5,570 acres of the above (or 12%) is included in the boundaries of urban areas.

As a result, the proportion of green spaces per inhabitant is in reality limited to 6.55 sq.m. This size can still be considered as satisfactory, since it exceeds the 5.5 sq.m. that is characterized as acceptable by standards set by the Ministry of Environment, Physical Planning and Public Works. The WHO, however, has set the relevant limit to 9 square meters per inhabitant. In comparison with other cities London possess the equivalent of 9 square meters, Amsterdam 27, Bonn 35, while considering the research of the European Environmental Agency (which considered parts of Seih Sou as urban green (TEE-TCG, 2018)), Thessaloniki does not exceed the relatively poor 2.73 sq.m. (Karamitsos & Zourna, 2021). That was calculated through the most accurate research for Thessaloniki's green spaces carried out in 1979 by the Coordinating Committee of Scientific Associations for the Protection of the Environment of Thessaloniki. However, ever since its population augmented by 40% and the green spaces decreased by 20%, facts that lead to about 1.6 sq.m. / inhabitant (unknown, 2018). This less promising estimation is proven by a research of the National Technical University of Athens (NTUA) when excluding the Seih Sou forest (TEE-TCG, 2018). Based on the data of this study, Thessaloniki is covered by 77% by buildings, 19% by paved roads and only 4% consists of greenery and free spaces (TEE-TCG, 2018).

Thus, the 2.73 is a relatively optimistic picture which describes previous situation or potential green spaces and is by far misleading for the actual situation lived by the citizen. In addition to that, the existing green spaces are mainly big spaces concentrated in certain areas such as the YMCA park, the TIF and AUTH. Thus, within the Urban Complex of Thessaloniki the ratio of green per inhabitant is 1.6 sq.m., while in the district of Toumba is even worse 0.76 sq.m.

A bit more optimistic percentage appears according to data gathered by a Municipality's initiative, the Urban green management web application "greentree" as a result of the "Creation of an integrated Model System for Governance in Urban Forestry Management and for Adapting Cities to Climate Change", are presented at the table 4:

Table 4: green spaces per municipal district

Municipal district	Number of parks	Green Spaces (m ²)	Net green parks (m ²)	Percentage of net green parks out of the total area (%)	Net green parks per inhabitant (m ²)
1 st	129	269.881	161.981	4,41	3,53
2 nd	60	122.676	81.893	1,61	2,63
3 rd	81	138.212	93.538	7,60	3,40
4 th	98	95.333	61.614	1,61	0,77
5 th	155	257.646	188.154	3,85	1,45

6 th	32	21.736	14.657	0,99	1,47
Not defined	1	1.534	100	0,00	0,00
Total of the Municipality of Thessaloniki	556	907.018	601.937	2,98	1,85

(Source : https://greentree.gr/greentreemanager/index.php?r=site/statistika_parkon_1)

According to the General Urban Plan of Thessaloniki, that is under revision, the ratio is estimated at 3.35 sq.m. of green/inhabitant, based on the 2011 census and the statutory green spaces. Considering the above the necessity of the creation of urban green and / or even blue spaces is more than evident. Within this framework the efforts carried out by the Municipality of Thessaloniki should be mentioned. The relatively new green spaces (Katsimidi street, in Nea Elvetia etc.) and the installation of green rooftops and bioclimatic school yards in school buildings constitute a new asset for the city, while the Municipality constantly works for the re – appropriation of several spaces. The obsolete military camps in the neighbouring municipalities are a great example of re-appropriation, since 13 camps exist in total at the urban complex of Thessaloniki with 2 of them already being granted to the relevant municipalities. The school and municipal buildings and its surroundings, (in Thessaloniki there are more than 90 school complexes comprising of one or more buildings and more than 130 municipal buildings) that should be considered as the basis for a new greener era. Apart from several other projects, within the framework of LIFE ASTI five (5) additional green spaces have been created as presented to the infographic of figure 22.



Figure 22 Infographic of the LIFE ASTI Project / the project's interventions, (Source: LIFE ASTI Project)

It is important in this framework to cite a research carried out from 3/2/21 to 3/3/21 by the spatial planning and sustainable development research unit of the School of Spatial Planning and Development, Department of Engineering of the Aristotle University of Thessaloniki, with the advisory support of ierax analytix (ierax.gr), to 1049 residents of the Urban Complex of Thessaloniki, aged over 17 years old (Latinopoulos, 2021). This research revealed the following:

- Only 20% of the inhabitants visit a park at a distance up to 400m. from their residence (Euclidean distance – as counted with a straight line on the map). About 50% choose to travel at least one kilometre, while the average distance travelled by a resident of Thessaloniki was found equal to 1.8 km.
- Considering the above most inhabitants are using their car or another way of transport instead of walking. Thus, during COVID 19 era and considering the relevant restrictions the percentage of people visiting the parks once a week decreased from 83% to 77%.
- 90% of residents evaluate these spaces below average (below 5 on a scale of 1 to 10), whether the question concerns the parks of the neighbourhood or the entire Urban Complex.

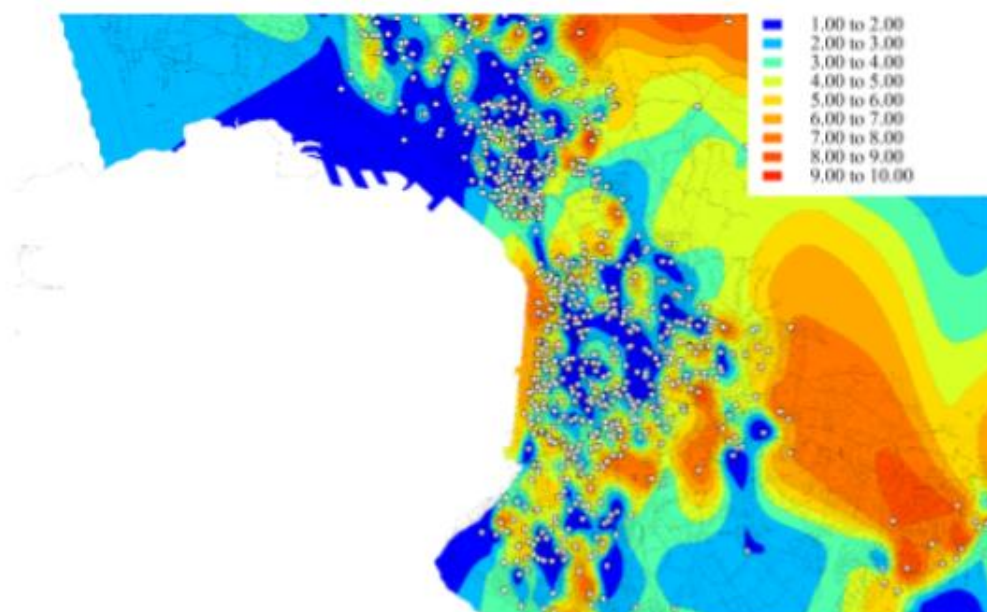


Figure 23: Evaluation of the Thessaloniki's parks, (Source: <https://parallaximag.gr/epikairota/thessaloniki-kai-astiko-prasino-to-simera-kai-to-orama-ton-katoikon>)

- 61% of the (questioned) inhabitants choose to visit green areas located either on the new coast or in areas far from the city centre (Sheikh Sou, Dam of Thermi, Panorama, Filiro, etc.). As a result, less than half of the inhabitants (only 4 out of 10) choose in priority one of the remaining green spaces located within the urban fabric.

Considering all the above, the necessity for additional green spaces of good quality is more than evident. However, along with the creation of new green spaces it is crucial to carefully maintain and even refurbish the existing ones.

Nowadays, Thessaloniki is a multicultural, extroverted, vibrant, and youthful city, with growing tourism and international ties. Citizens consider culture and history to be its core assets, supported by a number of cultural, tourism and creativity events and initiatives. Thessaloniki is hosting the annual international fair (TIF) and it is home of two world-wide famous public universities.

5.1.1.2 Environmental conditions and Socio-economic conditions

The natural environment within the area of the municipality of Thessaloniki

In the broader study area, the main environmental resource and "lung" of green and oxygen of the city is the suburban forest of Thessaloniki "Sheikh-Sou", also known as "Cedar Hill". The forest lies at the Northeast area of the city of Thessaloniki and is one of the most important suburban forests of the country and the most important environmental ecosystem of the city of Thessaloniki. On this regard flood protection, soil protection from erosion, biodiversity support, space for leisure and outdoor sports, environmental education activities ground, being also adequate for research, as well as a reference point of tourist interest, social events and entertainment for the visitors and residents are being reassured. It is undoubtedly necessary for the preservation, protection and upgrading of the quality of life of the inhabitants of the wider area.

Nevertheless, a study on the urban green of Thessaloniki that was published in 1979, by the Coordinating Committee of Scientific Associations for the Protection of the Environment of Thessaloniki, examined the landscaped green spaces and based on the population of the Urban Complex in 1979 it was estimated that the average for the urban complex was 2.73 square meters of green space per capita, a ratio about four times lower than the international bottom limit acceptable, which is 10 sq.m. per inhabitant. From 1979 until today the population has grown by about 40%, while open spaces and green areas have been reduced by 20%.

Calculations reflect that the area of the free and green spaces has decreased by 20%. with the average reaching approximately 1.6 sq.m. per inhabitant, i.e., six times lower than the lower limit. And in fact, according to studies of the urban model of the National University of Athens, based on the climatic conditions and its population, the Urban Complex had to have a ratio of 20 sq.m. green per inhabitant, i.e., 12 times higher than today.

Furthermore, according to a study by the National Technical University of Athens, in which only the greenery in the city was measured, the ratio of estimated greenery was 1.6 square meters per inhabitant. Based on these data, Thessaloniki is covered by 77% buildings, by 19% asphalt roads and only the remaining 4% is consisted of green and free spaces (Kardalis, 2019).

Through an integrated model system for government policy in the management of urban forestry and the adaptation of cities to climate change, Green Tree, a digital inventory of all the trees and parks of the Municipality of Thessaloniki was established and a total of 500 parks has been recorded. Their economic value was estimated at € 83,623,263 and the possibility of carbon dioxide absorption up at 17,063,641 kg. (<https://app.greentree.gr>).

The centre of Thessaloniki is characterized by a very densely populated area with a high building rate, unruly construction, and significant vehicle load. The absence of green areas significantly enhances the environmental degradation of the city. It is also associated with an increase in the number of hot days (maximum daily above 35 degrees Celsius) and tropical nights (minimum night above 20 degrees Celsius). The situation is even worse in densely populated, low-altitude and remote areas of the sea. Few new green spaces have been formed with bright exceptions the park in the named area of "Nea Elvetia" and the remodelling of the coastal parks. Today in the Municipality of Thessaloniki, the area of green spaces amounts to 905,245 sq.m., which corresponds to 2.95% of its area.

Economic activity

Examining employment by sector of economic activity, from the demographic survey conducted in 2011, (Table 3, Figure 19), the highest percentage is recorded in the category " Other service activities " with 31.10% of all employees. This section (as a residual category) includes the activities of membership organisations, the repair of computers and personal and household goods and a variety of personal service activities not covered elsewhere in the classification. Hence a large percentage is concentrated in the sectors of "Wholesale and retail trade - repair of motor vehicles and motorcycles" (19.51%) and "Education" (12.76%). Among the other sectors, the most represented one is "Activities related to human health and social welfare" with a percentage of 8.99%, followed by "Public administration and defence - mandatory social security" (7.95%), "Activities of accommodation services and catering services" (6.91%), "Constructions" (4.77%), "Transportation and storage" (4.15%), "Administrative and support activities" (3.01%) and finally "Agriculture, Forestry and Fishery" (0.85%).

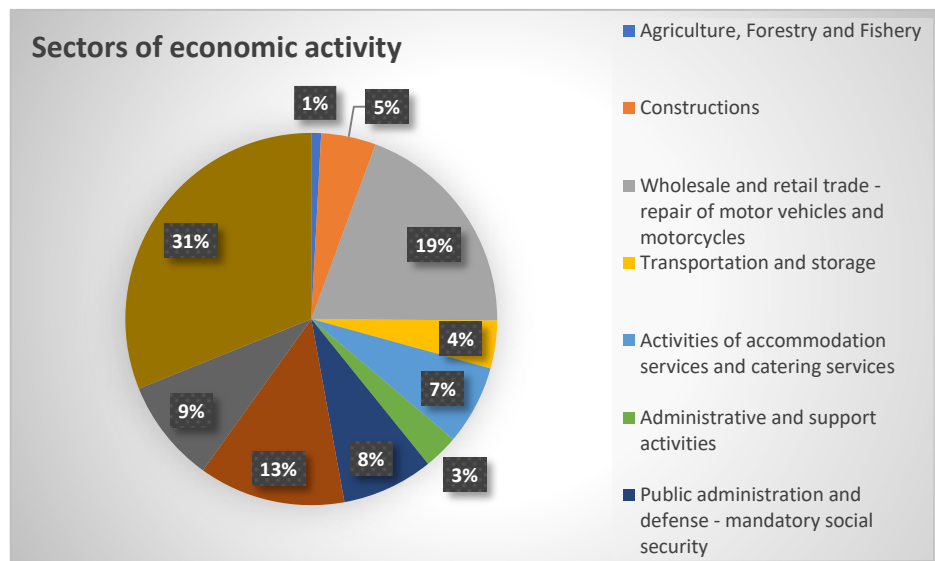


Figure 24: Sectors of economic activity

Regarding the professions, the highest percentage (29.51%) of the employees is gathered in the category "Professionals" while the category "Employees in the provision of services and sellers", is very close with 23.24 %. The lowest percentage corresponds - as can be derived for an urban area - to "Skilled farmers, stockbreeders, foresters and fishermen" (0.81%)

The port of Thessaloniki is the second largest export and transport port in Greece and the closest to the E.U., the Balkan countries and the Black Sea.

In the central part of the city, uses of retail trade, catering - leisure and offices as well as public services are being developed and still developing to a significant degree.

Tourism

As the tourism sector is concerned, it is worth mentioning the evolution of arrivals and overnight stays in the wider study area, in order to identify trends. It is pointed out that in 5 years (2014-2018) the relevant data are available from ELSTAT (2018) for the largest part of the wider study area, i.e., for the seven out of the ten Municipalities that consist of the Thessaloniki's metropolitan area: the Municipalities of Thessaloniki - Pavlos Melas (as a single spatial unit), Pylaia-Chortiatis, Themi, Thermaikos and Delta-Chalkidonos (also as a single unit). The seafront is the most important landmark of the city as it is considered as a modern open public space. It is noted that during the period under review there is a significant increase in arrivals by about 19%, as well as overnight stays by about 21%. The evolution of these two is similar, with the most important observation being the continuous increase of arrivals until 2016 and the transfers since then, while the overnight stays demonstrate continuous increase until 2017 and reduction in 2018. It is also worth mentioning that in the whole examined period, the average stay in the area is just two nights.

5.1.1.3 Weather & Climate conditions of the AREAS with emphasis on UHI effect

The climate of Thessaloniki is characterized by hot and dry summers and mild and wet winters. The city is significantly influenced by the sea located to the south. The present average annual temperature is $\sim 17^{\circ}\text{C}$, increased by $>1^{\circ}\text{C}$ comparing to the average of the period 1959-1997 (15.9°C). The average UHI intensity during the night is estimated at $2\text{-}3^{\circ}\text{C}$ with cases of intensities $>4^{\circ}\text{C}$, while during the day the UHI effect is eliminated or even reversed. It should be noted that the UHI effect is slightly more intense (by $\sim 0.5^{\circ}\text{C}$) between central urban and western/northern non-urban areas comparing to central urban and eastern non-urban areas, meaning that the wester non-urban areas are colder during the night.

5.1.2 Current situation of existing adaptation plans, strategies and actions regarding the adaptation and mitigation of UHI

5.1.2.1. Stakeholders involved

Several stakeholders are being involved to the research and planning measures and development strategies for the adaptation and mitigation of the UHI effect. These are:

- Public authorities, such as the Ministry of Environment and Energy, the Ministry of Health, Regional authorities and institutions – in this case the Region of Central Macedonia, the Decentralized Administration of Macedonia and Thrace, Regional Units and in this case the R.U. of Thessaloniki, local authorities and relevant institutions and in particular the Municipality of Thessaloniki and the adjacent municipalities, the Major Development Agency Thessaloniki, the Central Union of Municipalities of Greece and others.
- Within this framework services related to civil protection are also of fundamental importance, as such the Department of Civil Protection/Municipality of Thessaloniki, the Directorate for Civil Protection/Region of Central Macedonia, the Departments/Offices of Civil Protection of adjacent municipalities should also be considered as part of the relevant stakeholders list.
- Private and Public universities and research institutes and the scientific community in general and in specific the departments of Urban Planning, Engineering and Physics of the Aristotle University of Thessaloniki, the Centre for Renewable Energy Sources, and other related actors. Furthermore, since the education should start at a very early stage and the youngsters should learn how to deal with the UHI effect all educational levels are concerned in order to provide the adequate incentives to their students. Thus, the Directorates of Secondary Education of Thessaloniki, the Directorates of Elementary Education of Thessaloniki, private schools, Institutes of Vocational Training and all teachers, tutors and professors of all levels are also concerned.
- Private companies dealing with this issue and in particular companies measuring the UHI effect and relevant phenomena, construction companies, companies producing material used in urban planning and in particular the ones confronting the UHI effect and related projects such as Urwatair, Commons in Residency, Thessaloniki Allios.

But also, stakeholders studying and working on this regard at the European and international level such as Copernicus Climate Change Service, ECMWF employees etc.

- Companies, associations and people concerned about scientific issues and human health such as: a) The medical community including the city hospitals, the Medical Association of Thessaloniki, Municipal Clinics and others, b) The tourism sector, interested in improvements in human comfort in the cities involved to attract more tourists: Hellenic Hoteliers Federation, Tourist Guides Association of Thessaloniki and Northern Greece, Greek Tourism Confederation, Federation of Hellenic Associations of Travel & Tourist Agencies, c) the social services, including caregivers, the Municipal Open Care Centres for the Elderly, the centres for people with disabilities, other public and private relevant institutions, Education Sector:, athletic clubs, concerned on the wellbeing of their athletes (PAOK, ARIS, Iraklis, Nautical Club Thessaloniki, Sailing Club Thessaloniki, Nautical Club of Thermaikos Coast, Yacht Club Greece.
- Within this framework other stakeholders serve as the mediators of raising awareness on this regard and in general. These are the local media and in particular ERT3, TV100, FM100, Makedonia TV, Athens News Agency – Macedonian Press Agency (ANA-MPA), Thestival.gr, Voria.gr, ThesNews.gr, ThesToday.gr, CityMagThess.gr, Lifo.gr not to mention but a few.
- Last but not least local NGOs that promote public participation in several projects and integrate sustainable principles in their framework, such as the Hellenic Rescue Team, Volunteers Samaritans, Rescuers and Lifeguards Corp, Doctors of the World / Médecins du Monde – Greece and environmental associations and other groups concerned by the environmental sustainability and / or public health of the society as a whole or a certain group such as student groups, citizens' movements etc. should also be considered.

5.1.2.2. Sectors influenced on this regard

With regards to the UHI effect and considering its consequences, mainly on health and energy it is more than evident that nearly all sectors are highly influenced. Considering that the high temperatures cause discomfort and noting that this later one is being confronted either through avoiding certain tasks or by using cooling systems, it results to relative economic loss and all sort of delays.

Apparently within this framework the following sectors are the mostly affected:

- The whole public sector and thus all companies and individual interacting with it due to alterations on the working hours, teleworking, and other implemented measures.
- The health care sector is influenced due to the increased workload caused by incidences occurred as a consequence of high environmental temperatures.
- The construction sector, athletic activities and all other professionals and sectors that impose works in external environment.
- The energy sector is also highly affected due to the extensive use of air-conditioning as a result of confronting high temperatures and related discomfort.
- As a way to face high temperatures more people than usually choose to use their private cars, fact that results then to additional traffic jams and thus multiplied discomfort, air-pollution, time and energy losses and thus unavoidably to economic losses or further expenses as well.

5.1.2.3. Presentation of relevant existing plans, strategies & actions

The General Urban Plan

The general strategic goal of the General Urban Plan of Thessaloniki that is currently under revision, is more focused on strengthening the development perspective of the Municipality and focuses in the "emergence of Thessaloniki as a modern European metropolis, tourist, transit, exhibition - technological center of the wider region, able to undertake the organization of international events, with upgraded quality of life of citizens and provision of expanded services by a strong Local Government".

The main objectives of the General Urban Plan are as follows:

- Utilization of innovating and ongoing projects to strengthen business networks and connect the city with international integrated service systems and create a pole of innovative services based in Southeast Europe.
- The development of strategic activities in the tertiary sector (business services)
 - The location of uses and zones of supra-local importance within the Municipality in the context of sustainable development.
 - The spatial regulation of chaotic concentrations of uses that disturbs and degrade the urban environment and the attractiveness of Thessaloniki, for the development of dynamic services of the tertiary sector.
- The development of a modern and integrated combined transport system and the creation of a functional entrance for the Balkan peninsula, for the development of the city as a freight / business transport portal including the trans-European road axes, the railway network, the commercial port, and an airport capable of serving passenger and commercial flights.
- The promotion of Thessaloniki as a tourist destination through the networks of alternative tourism, such as religious, cultural, conference, city-breaks among others, which are offered in the city of Thessaloniki, with parallel use of the city's transport infrastructure.
- The maximum utilization of the existing infrastructures and landmarks of the city (monuments, sea, higher education establishments, hotels, international events, etc.) by development planning per sector with the proper governing bodies of the relevant infrastructure
- The protection and promotion of the natural environment (suburban forest, sea front, existing free spaces of public and public bodies, streams), the monuments and the historical image of areas of the city, their parallel connection with the tourism sector, with upgrading and tourist use of spaces of archaeological and cultural interest
- The transformation of the city to be more attractive to its inhabitants. The improvement of the quality of life of the inhabitants within the modern standards of sustainable housing development and urban organization, the balanced development of the urban space and the alleviation of the inequalities by dealing with specific spatial problems of population categories and avoiding degradation

- The integration of the excluded areas in the urban fabric, with the aim of the functional organization of the land-uses, the improvement of the environment, as well as the quality of life of the inhabitants, and the utilization of the development possibilities and perspectives that these areas present.
- The correlation of the program of the Municipality of Thessaloniki for the protection against natural disasters with proposed areas that could cover the needs of gathering people in cases of natural disasters (earthquake and flood protection).

The strategic and operational plan 2020-2023

The Municipality of Thessaloniki, as a local Government body, is obliged to issue a strategic and operational plan for a predefined period. In this regard, for the period 2020-2023, the Strategic and Operational Plan of the Municipality overviews:

- The profile of the Municipality, where is analyzed and evaluated (environment, networks and infrastructure, local economy and employment, social infrastructure and services, infrastructure and services of education, culture, and sports), in order to record the problems and the needs and are presented possibilities and opportunities
- The internal environment of the Municipality, where is analyzed and evaluated the organization and procedures, human resources, equipment and Information and Communication Technologies, building facilities, finances, in order to identify the advantages that can be employed but also the weaknesses that must be overcome
- The forecasts of the existing spatial planning, as well as the national planning (National Development Program) that specify the framework for the planning of the Municipality are examined, determined, and recorded.
- The vision, principles, and strategic goals, which are composed by thematic axis
- The axes are specialized in measures and specific objectives per measure (based on the conclusions of the previous evaluation) and the services or Legal Entities responsible for their implementation are noted.

The Resilience Strategy 2030

The Resilience Strategy is based on eight city values (Social Cohesion, Local Identity & Heritage, Environmental Management, Health & Well-being, Youth Empowerment, Multi-stakeholder Engagement, Technology Adaptation, Economic Prosperity), which represent the city's identity and the guide for the future planning. The values cut across four main goals that together form the basis of the strategy:

- Shape a thriving and sustainable city: Design and deliver urban and mobility systems that serve people with efficiency, environmental integrity, and strategic use of resources. This includes an integrated mobility system, smart urban logistics plan, clean power, air quality management, and upgraded waste management system.
- Co-create an inclusive city: Invest in human talent, including skills, leadership, and entrepreneurship; align education and training to career paths; expand the role of boroughs as social labs; empower citizens and community-led projects; make the city welcoming to new residents; and enable co-creation in open and public spaces.

- Build a dynamic urban economy and responsive city: Develop an urban economy policy agenda which recognizes and supports existing and prospective local economic cluster activities and zones. Initiate new cross - sector partnerships and update governance approaches to allow the city to respond more effectively to the needs of its citizens and a changing world through financial resilience, metropolitan collaboration, capital investment, and risk reduction management plans.
- Re-discover the city's relationship with the sea: Integrate the economic and urban development of Thermaikos Bay by investing in the cultural and natural capital of the Bay for improved city life, restoring the ecosystem, monitoring environmental resilience, and designing a new governance system for managing these activities.

5.1.3 Proposal of an implementation framework

5.1.3.1 The urban planning rules (At local, regional, national & EU legislative level)

The general environmental - energy goal set by the European Union can be summarized to the widely known “20-20-20”, i.e., the reduction by 20% of greenhouse gas emissions, the penetration of RES into the energy production by 20% and in energy savings by 20% by 2020.

However, in January 2014, the European Commission has suggested a binding target to reduce its gas emissions by 40% for 2030 and achieve a 27% share of renewable energy sources in the EU energy mix, without the EU Member States being bound by it and without, however, setting a binding target for energy efficiency.

In the European Commission's Communication of July 2014 [EU COM (2014) 520 final, Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy], the European Commission, assessing the contribution of energy efficiency to the reduction of carbon dioxide emissions, the assurance of energy supply, the reduction of energy dependence and its costs and the strengthening of the competitiveness of the European economy, and considering the efforts and progress made by the Member States in achieving the objective of 20% energy savings by 2020, finally proposes the introduction of 30% energy saving target by 2030 accordingly.

In September 2015, the 193 Member States of the United Nations adopted a plan, the “Agenda 2030”, aiming to achieve a better future for all by planning a roadmap to be followed the next 15 years in order to make disappear extreme poverty, confront inequality and injustice and protect our planet. Its focus is the 17 Sustainable Development Goals (SDGs) and 169 more specific targets, related to the later ones that are all considered as the most important (economic, social, environmental and governance related) challenges of our time. These goals can be summarized as follows:

1. no poverty
2. zero hunger
3. good health and well being
4. quality education
5. gender equality
6. clean water and sanitation

7. affordable and clean energy
8. decent work and economic growth
9. industry, innovation, and infrastructure
10. fewer inequalities
11. sustainable cities and communities
12. responsible consumption and production
13. climate action
14. life below water
15. life on land
16. Peace, justice, and strong institutions
17. partnerships for the goals

These objectives should be integrated into European policy with quantified indicators so that each country can take initiatives to achieve them primarily at national but also at regional level. Goals directly or indirectly related to the UHI effect are the target 7 affordable and clean energy for all, the target 13 Climate change, the target 3 good health and well-being and the target 15. life on land.

The Law 3855/2010 (Government Gazette, A, 95, 23-06-2010) "Measures to improve energy's end-use efficiency, energy services and other provisions, "sets the "necessary" - adequate framework for the promotion of energy saving measures in Greece, harmonizing at the same time the Greek legislation with the Directive 2006/32/EC on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

Just recently, the Law 4843/2021 (OJ 193/A/20-10-2021) refers to the integration of the European Commission's and Council's directive 2018/2002 of 11th December 2018 , "according to the amendment of the Directive 2012/27/EC for energy efficiency", amending and adjusting Regulations 2018/1999/EC and 2019/826/EC dealing thus with the setting in place of an evaluation system of efficient heating and cooling potential and other relevant arrangements for energy efficiency in the construction sector, in addition to the enhancement of Renewable Energy Sources, the opening of the power energy market and other urgent provisions.

The requirement to amend Directive 2006/32/EC on energy services and the adoption of the new Energy Efficiency Directive 2012/27 / EU as a result of indications of deviation from the objective of Directive 2006/32/EC, (OJ, A, 95, 23-06-2010), was based on the already submitted National Energy Efficiency Action Plans of the Member States, in addition to the need for a framework update for the energy efficiency in the European Union. The Directive 2012/27/EC was integrated into the Hellenic Law with the provisions of Part B of the Law 4342/2015 (OJ 143A/9-11-2015), even though in the framework of the National Energy Efficiency Action Plan (December 2014), which is written in the frames of par.2 Article 24 of the Directive 2012/27/EC, the national goal of energy efficiency was updated and the final energy consumption level was set at 18,4 Mtoe for 2020, while enacted as national indicative goal for energy savings until 2016, the decrease of 9% of average annual energy consumption. Unfortunately, the many years of economic crisis in Greece, caused a decrease in energy demand, which is not helpful to this achievement, not to mention changes in consuming

models and the creation of atypical ones. The decreased demand, due to the economic crisis covers practically the inefficiency of the implementation of measures such as acts and programs for the improvement of energy efficiency, integration of Renewable Energy Sources and achievement of energy savings in the final consumption and the primary energy production.

The construction sector covers most part of the energy consumption approximately 55% of internal consumption in 2012. On December 2014, the review for the renovation of the national building stocks that consists of residential areas and commercial buildings, which are both public and private, as provided by Article 4 of the Directive 2012/27/EC was implemented. This review is oriented by the transition roadmap with a view to a Sustainable Building Stock with a timescale until 2050. More specifically, the goal is the progressive and coordinated update of the building stock, in order to achieve high energy efficiency to all buildings until 2050, and ideally, zero to minimum possible energy consumption in accordance with the maximum utilisation and integration of renewable energy sources. Here again, the COVID 19 pandemic and related crisis led to the above mentioned atypical consuming models, since most households increased due to the lockdown, while the relevant energy consumption share of most companies decreased, changing the regular pattern, and thus creating instability and requiring additional measures and crisis management due to the unknown and unforeseen factors that seem to prevail.

Major assessment methods / tools can also be used in order to measure and thus develop energy savings in the built environment and suggest techniques for the improvement of the ambience. The “Building Research Establishment Environmental Assessment Methodology” (BREEAM), the “Leadership in Energy and Environmental Design” (LEED), the “Comprehensive Assessment System for Built Environment Efficiency” (CASBEE) not to mention but a few include criteria for the mitigation of UHI effect. Unfortunately, unlike the USA, France, Germany etc. none of them is widely used in Greece. However, several steps are being made with the creation of guides on how to introduce materials and measures that may mitigate the UHI effect.

At national level a tool that can fund Green Infrastructures, under the Regional Operational Programmes is the “save – go autonomous” Programme that is a co-funded incentive that funds green actions in buildings all over Greece in the form of a grant (direct aid) and loan with interest rate subsidy, with the co-operation of Greek Banks (for further information cf. deliverable C.5.2.). Furthermore, currently another promising initiative has been introduced through the NSRF 2014-2020 PROGRAMME, ministerial decision ΥΠΕΝ/ΕΣΠΑΕΝ/61929/864, since individuals/households are being subsidized for the replacement of specific categories of energy-consuming household electrical appliances, with new, environmentally friendly and more energy efficient ones, while parallel recycling of the old electrical appliances is also previewed. That way air-cooling systems would be replaced in a significant number of households indirectly contributing to the confrontation of the UHI effect. To sum up, either effective or not, a legislative framework is not enough for the mitigation of the UHI effect. A more dynamic, fast-developing and adjusting procedure should be set in place including assessment, programming, implementation, evaluation and redesign...Within this framework EU funded projects may contribute significantly in the sense that several ones considering the relevant priorities are filling the knowledge gap providing accurate data and thus facilitating the better understanding of several phenomena and the design and implementation of effective policies and strategies to confront them.

The analytical process of the implementation of the UHI effect mitigation measures can be summarized as follows:

A group of relevant stakeholders is responsible for the design and implementation of an effective action plan. Since the municipality and the central government have the relevant services no additional costs in manpower is required on this regard. Besides, this project along with others develop relevant data that can be used within this framework. The same applies to the monitoring of the relevant situation unless considered appropriate by the relevant services to hire additional employees on this regard. Several public services of course such as the fire department hire seasonal employees in order to face additional related needs i.e., fires that may occur due to higher temperatures during the summer season. While no additional costs are being previewed on this regard in terms of manpower, a small amount can be previewed for the training of the existing employees to the use of the LIFE ASTI's systems and the municipal monitoring infrastructure (platform).

It should be noted here that apart from the LIFE ASTI's HHWW system, the municipality of Thessaloniki is developing several complementary systems mainly through the smart cities programme and considering the development of ICT. These include the monitoring of RES, smart grids, automatizations for the reduction of energy consumption in buildings, energy saving tools not to mention but a few. All the above can be monitored through the same platform, in parallel with the environmental indicators.

With regard to these later ones, in terms of monitoring, in the municipality there are at this point at least 8 operational stations that were used within the framework of the project (Egnatia, Airport, Pedio Areos, Emporiou Square, Eptapyrgio, Malakopi, Lagada & Martiou, while two other stations at the city hall and at Paparigopoulou are operational). Considering that eventually additional stations can be implemented for the area's better coverage, the municipality may consider whether there is a need to cover additional parts of it such as the sea front, YMCA, the TIF or other regions, since as already pointed out through these areas one may be led to false results considering that the microclimate there due to the sea or the relatively wide green areas is quite promising. However, the relatively pleasant environment is quite limited in terms of spread of the effect.

Here after are being presented indicative costs per meteorological station. Each meteorological station should operate continuously in an autonomous way, based on a rechargeable battery through a photovoltaic system. The purpose of each station is to evaluate in real time the components of pollution such as the levels of particles (PM 1, PM 2.5, PM 10), ozone (O3), nitrogen dioxide (NO2), carbon monoxide (CO), carbon dioxide (CO2) and sulfur dioxide (SO2) and at the same time measure basic meteorological parameters (temperature, humidity, atmospheric pressure), which contribute to the accumulation of pollutants but also to a feeling of discomfort of the citizens. The data from this network will be "open" to access to the citizens and to those bodies of the Municipality that will wish to use them, together with their historical statistical data. The station should be able to support 6 sensors with the possibility of expansion to additional ones, while the possibility of parameterization of the measuring frequency should be provided. Communication and data transmission to the central platform should be provided via GPRS / 3G or Wi-Fi or Ethernet or LoraWAN.

It should be noted here that the municipality already possess such a system. However, hereafter is presented all relevant costs in terms of additional stations and eventually a new upgraded software. It should be noted here that all costs are indicative and based on market research conducted during February 2022.

Infrastructure / station (including 24% VAT)	9,760.00 euros
Software (flat rate)	3,100.00 euros
Installation Services / station	930.00 euros
Software Configuration Services (Flat rate)	1,860.00 euros
User Training Services (flat rate)	1,240.00 euros

These meteorological stations should consist of an integrated part of the Thessaloniki's "smart cities" platform that is already foreseen and about to be implemented through the "ANTONIS TRITSIS" programme AT08. Costs foreseen within this concept include among others the design and implementation of a smart cities' platform in SaaS, able to include up to 3000 sensors. Related costs include among others the platform's initial installation, its appropriate configuration, the creation of the necessary forms and reporting systems, its connection with third party systems and applications of the Municipality, training sessions of all relevant stakeholders. In parallel, a system of operation, management and monitoring should also be implemented. The relevant costs include the design, implementation and starting operational activities of a control room and data centre, including a space provided by the municipality and appropriately refurbished on this regard, including the appropriate infrastructure in terms of furniture, electronic equipment and software, such as core switches, a storage system, data analytics server, datacentre switches, the necessary cables, plugs and networks, screens, teleconference equipment and rooms, telephone devices and other. The total budget of the above-described system is estimated around 1.400.000 € (the estimation is based on a market research carried out for the ANTONIS TRITSIS Project). Additional costs may be required for the configuration of the meteorological stations' system on the platform and the training of certain employees to have the appropriate reflexes when required. However, both the above-described platform and the integration of data relevant to environmental conditions while contributing to the confrontation of the UHI effect are much wider in terms of competences and advantages providing a much wider source of information than the required to this action plan and allowing the organization and implementation of a much wider range of actions, enhancing thus the municipality's organization and monitoring on a holistic and effective way.

A medium price for a tree varies according to Foster et al. from \$50-\$500 to establish and \$15-\$65 annually in upkeep (Foster et al., 2011 in "Reeve & Kingston, 2014"). In Greece it is estimated that a reasonable cost per tree may be between 8 - 80 euros depending on its category. There is no cost "A University of California –Davis study estimated that for every 1,000 deciduous trees in CA's Central Valley, stormwater is reduced nearly 1 million gallons, a value of about \$7,000" (Stoner et al., 2006 in "Reeve & Kingston, 2014"). "Each tree is estimated to provide \$30-\$90 annually when considering all benefits, such as interception and filtration of stormwater, improved water and air quality, and regulation of urban heat island effect. Strategically placed shade trees can reduce air conditioning costs by up to 30%. Windbreaks (rows of trees) can save 10-50% in heating costs" (Stoner et al., 2006 in "Reeve & Kingston, 2014"). Considering all the above and expecting simultaneous results in Greek cities as well, it can be derived that the cost of planting a tree should not be considered just as a number, but its side advantages should be considered as well. "The Centre for Clean Air Policy estimated that the net annual economic benefit of a mature urban tree ranges from \$30-\$90" (Foster

et al., 2011 in Reeve & Kingston, 2014). As for the regeneration study on an indicative manner costs may vary from 5.000-10.000 euros.

To be more specific, the remuneration of the person conducting the study including the technical report for the procurement of the necessary equipment – infrastructure and plants is calculated as follows:

- For a scientist, having experience up to 10 years: $300 * \tau\kappa * \text{days or months required for the completion of the job}$
- For a scientist, having experience 10 to 20 years: $450 * \tau\kappa * \text{days or months required for the completion of the job}$
- For a scientist, having experience more than 20 years: $600 * \tau\kappa * \text{days or months required for the completion of the job}$

For the monthly rate 22 working days are being considered.

“TK” is at this point 1,199 considering the 89943/2.4.21 circular “Adjustment of the rate value (tc) of the Regulation of Estimated Fees for Studies and Services for the year 2021” (εγκύκλιος αναπροσαρμογής τιμής συντελεστή (τκ) του Κανονισμού Προεκτιμώμενων Αμοιβών Μελετών και Υπηρεσιών για το έτος 2021).

For further information please cf. article ΓΕΝ 4 of the "Approval of the Regulation of Estimated Fees for studies and the provision of technical and other related scientific services during the procedure of par. 8 d of article 53 of law 4412/2016 (AD 147)" National Decree, Government Gazette Β' 2519/20.07.2017 / άρθρο 4 “Έγκριση Κανονισμού Προεκτιμώμενων Αμοιβών μελετών και παροχής τεχνικών και λοιπών συναφών επιστημονικών υπηρεσιών κατά τη διαδικασία της παρ. 8 δ του άρθρου 53 του ν. 4412/2016 (Α' 147)” ΕΦΗΜΕΡΙΔΑ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ Τεύχος Β' ΦΕΚ 2519/20.07.2017) and / or the circular as a whole.

5.1.4 Adaptation measures of the UHI-AAPP

The Action Plan should be developed around the following actions as presented to the figure here after:

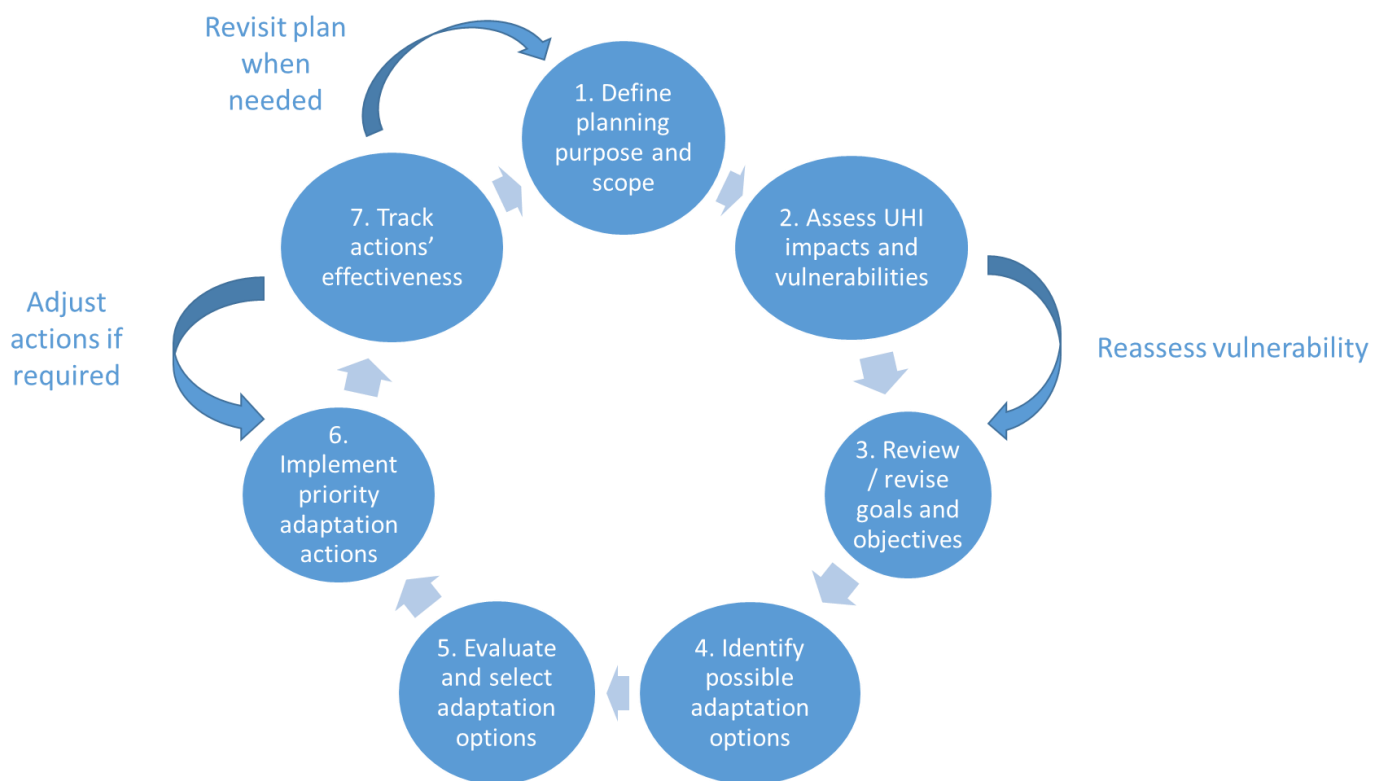


Figure 25: Action plan's development actions, (Source: Stein, B.A., P. Glick, N. Edelson, and A. Staudt (eds.). 2014. Climate-Smart Conservation: Putting in Reeve & Kingston, (2014). Adaptation Principles into Practice. National Wildlife Federation, Washington, D.C.& own elaboration).

Thus, having in mind its purpose and UHI impacts, the identification of possible mitigation actions and their implementation and assessment follows. Considering that, the Action Plan should be developed around 4 main axes (the alert levels mentioned below are being described in paragraph 5.1.5):

- **Axis 1:** Prevent the UHI effect's influence on human health through the prevention of the effects of a heat wave (*it should be constantly implemented from alert level 1 and intensified and monitored towards level 4*).

The prevention system consists of preventing and anticipating the effects of a possible heat wave, particularly since UHI effect result to serious heat waves, in a manner adapted to the different categories of population identified and especially for certain people at risk. Considering that the Directorate of Social Protection and Public Health and particularly the department of protection and promotion of public health should be involved in the design and implementation of this axis, along with other departments of the municipality. In particular the following actions should be implemented per group concerned:

- for isolated and vulnerable populations, it is necessary to ensure implementation actions to identify these people, coordinate and mobilize the services and associations that interact with these segments of population so as to better embrace them in case of an emergency. The "help at home" (βοήθεια στο σπίτι) municipal project and / or relevant municipality's structures should be mobilized

on this regard. A phone call desk (emergency – help line) should be set in place in order to correspond, monitor and deal with citizens' (reasonable) needs.

- for people in a precarious situation or homeless, it is necessary in particular to ensure the availability of accommodation and day care places, the mobilization of mobile teams or any other social monitoring mechanism. The same applies in a more general manner to low-income populations, particularly people without air conditioning and / or without cars that are less able to adapt to extreme heat due to fewer options for reaching air-conditioned spaces. In particular for the Municipality of Thessaloniki, the relevant services considering the situation decide which spaces should be available to the citizens. In an indicative non restricted way it is suggested that the following rooms or buildings accept citizens in need:

- The 3rd branch of the Open Care Centre for the Elderly (Κέντρο Ανοιχτής Προστασίας Ηλικιωμένων – ΚΑΠΗ), 9 Charalambou Mouschou, Ano Poli.
- The 4th branch of the Open Care Centre for the Elderly, 42 Grigoriou Lampraki, tel. 231 0 212.002
- The 5th branch of the Open Care Centre for the Elderly, 27. Alexandrias, tel. 231 0 820.110
- The Foyer of the Thessaloniki City Hall.
- The Ground floor of the Centre for Architecture, 13 Angelaki, tel. 2313 318.400.

It is more than evident that in emergency cases other community centres for seniors may remain operational beyond their normal working hours and provide help:

1 ^o Branch	ERMOU 18 ^A , P.C 546 24	2310-516614	1parartima@kapidthes.gr
2 ^o Branch	LAGADA 35, P.C 546 24	2310-514456	2parartima@kapidthes.gr
3 ^o Branch	MOSCHOU 9, PC 546 23	2310-213836	3parartima@kapidthes.gr
4 ^o Branch	GR.LAMBRAKI 42, P.C 546 42	2310-212002	4parartima@kapidthes.gr
5 ^o Branch	ALEXANDREIAS 27, P.C. 546 44	2310-820110	5parartima@kapidthes.gr
6 ^o Branch	STEF.NOUKA 10, P.C. 542 50	2310-314424	6parartima@kapidthes.gr
7 ^o Branch	AKROPOLEOS 14 ,P.C. 546 23	2310-206051	7parartima@kapidthes.gr
8 ^o Branch	ARTAKIS 9, P.C. 554642	2310-951474	8parartima@kapidthes.gr
9 ^o Branch	EVZONON 20 & VELISSARIOU 3, P.C. 546 40	2310-851131	9parartima@kapidthes.gr
10 ^o Branch	SACHTOURI 1, P.C. 546 23	2310-234352	10parartima@kapidthes.gr
11 ^o Branch	OLYMPIAS & IFIGENIAS 2 , P.C. 543 52	2310-951970	11parartima@kapidthes.gr
12 ^o Branch	KAPETAN VAGGELI 4, P.C. 546 46	2310-416283	12parartima@kapidthes.gr
13 ^o Branch	GAMVETA 56 & FLEMINGK 36, P.C. 546 42	2310-838601	13parartima@kapidthes.gr
14 ^o Branch	IROON 4, P.C. 553 37	2310941901	14parartima@kapidthes.gr

Furthermore, it is more than recommended that these data including addresses, hours that are open to the public and telephone numbers are constantly updated and easily accessible by all citizens, whether they are computer literate or not.

At the same time, the overnight homeless shelter at 13, Andreou Georgiou Street (tel. 2310-528811) and the open day shelter (62, Monastiriou Street, tel. 2310527938) should operate continuously, while the municipal police should continue to visit parks and places in the city where there is a concentration of citizens and mainly the elderly. The municipal police officers should inform the citizens about the instructions that they must follow, in order to be protected from the heat, when necessary and eventually offer water or provide help and directions.

Apart from the above, particular directions are being provided per employees' segment and / or per specific population group as follows:

- for young children, facility managers and / or school – kindergarten - nursery staff members should be reminded and remind to children the recommendations of actions to be carried out in order to ensure the refreshment of children and infants and thus the avoidance of any discomfort.
- for workers, athletes and other people exposed to extreme heat during their work, it is necessary to ensure the implementation of measures allowing to limit the effects of heat waves (such as longer breaks, intake of bigger water quantities, flexibility related to working hours etc.).
- for people at risk in medical and social establishments, care should be continuous and the living conditions adequate.
- for the general public, it is a question of recalling the health consequences of a heat wave for raise awareness and protect the population through communication actions. Furthermore, UHI effect may result to increased air pollution, reduced night-time cooling, and increased temperatures which all are susceptible of creating great discomfort and consist of a danger to human health for all and as such should be carefully addressed since their birth.

A thorough presentation should be provided allowing the maximum percentage of population to know how to react and be able to deal with a case where a co-citizen, colleague, co-worker, or classmate feels discomfort.

All these indications have a dual vocation, therapeutic management on the one hand and implementation of preventive actions to limit the health risks related to the UHI effect in particular during heat wave episodes, on the other hand. This includes alerting the entire population and trigger a solidarity movement, while increasing the general public's know-how of dealing with such cases. That way, in most circumstances, the worst-case scenarios and municipal authorities working beyond their full capacity will be avoided by small supportive actions.

In parallel, all municipal buildings from Open Care Centres for the Elderly, schools, medical structures, and public services buildings should be appropriately maintained in order to avoid any malfunction on their cooling systems.

- **Axis 2:** Protect the population by implementing appropriate management measures per meteorological vigilance level as provided to the municipality by LIFE ASTI's Heat health watch

warning (HHWW) system or the national relevant service and of course considering the data of the municipality's meteorological stations (*it should be constantly implemented from alert level 1 to 4*).

As pointed out on paragraph 2.2. General Description of the forecasting system and application results and demonstrated on chapter 3 Heat health watch warning (HHWW) systems, the vigilance is interpreted by the use of 4 different colours indicating the necessity of acting by the municipality and the risk level to which citizens' health is exposed. Within this framework, preventive actions should be elaborated during the first levels in order to mitigate the effect and ex-post mitigation measures

- **Axis 3:** Inform and communicate (the preparation of the informative material should be carried out in alert levels 1-2, while their dissemination should start from level 2 and intensified on wards to level 4).

Specific communication actions should be implemented during the summer period where heat waves are more likely to take place.

This "communication system" aims to raise awareness and protect population from the heat wave health consequences. That is carried out considering simultaneously the 4 levels of awareness of the action plan. That is achieved through the use of different means / tools in order to address all people concerned such as leaflets, posters, press releases, spots, etc.

- **Axis 4:** Capitalize on the Region's experience (*after taking action at level 4*).

Following the occurrence of an episode of heat wave or high temperatures, feedback should be provided by all stakeholders at local and national level, based in particular on the information provided by all relevant actors and other information collected at local level. In other words, the Region and relevant regional units and the concerned municipalities should initiate and organize such procedures.

A Monitoring and Evaluation Committee for the National Heat Wave Plan and the National Guide for the prevention and management of extreme weather conditions should be established and meet regularly eventually at least twice a year, considering the best practices applied in other countries (e.g., France).

In parallel, long-term measures should be designed and implemented within this axis, under the scope to be tested in terms of effectiveness when completed and following an episode.

5.1.4.1 Short-term adaptation measures to reduce exposure to heat (e.g., air-conditioned rooms, civil protection announcements, surveillance of susceptible subgroups, etc.).

Several short-term measures can be identified in order to reduce exposure to heat. These of course are being implemented when heat temperatures reach critical levels and alternative ones should be suggested in order to avoid similar situations in the long term. These are:

- Air-conditioning / cooling systems including ventilators and air-conditions, permanent or portable. These have become a necessity in both private and public buildings and also private cars and means of public transport.
Furthermore, citizens are encouraged to keep the shutters down during the day and open during the night.
- Civil protection announcements and campaigns: When a heat wave is expected civil protection announcements in both signs in public spaces, radio and TV spots and cell phones are being foreseen at national level and eventually locally targeted, aiming to the provision of

the necessary directions to all citizens and visitors. To be more specific, apart from suggesting to the general public to “stay at home” and “avoid pointless movements”, civil protection services provide directions regarding what to do when you do not feel well and general instructions on how to deal the heat wave (do not open the windows during the day, avoid alcohol, drink a lot of water etc.).

In parallel, the concerned municipalities often dedicate a telephone platform in order to provide to their citizens adequate advice and solutions such as which spaces remain open to host people in a comfortable environment, particular directions for susceptible groups, how they can receive help at home and other relevant information.

Several indications insinuating a lifestyle compatible to UHI effect through relevant campaigns is more than recommended. In the annex I, a few examples of relevant informative campaigns providing directions are being presented.

Particular directions should also be provided for the medicines that required to be preserved to a certain temperature, normally between +2°C to +8°C » or to a temperature lower than 25°C or 30°C. In this case the relevant medicines should be kept in the fridge and be left just for a couple of minutes at environmental temperature before their reception. While it is evident for certain citizens it may not cross the mind of the majority, thus this information should be made available to all parties concerned. The same applies for certain provisions that would be better preserved in the fridge.

- The creation of shadows (e.g., through the use of awnings and sun blinds such as tents and canopies of different materials), the development of greener spaces (green or greener terrace, roof, etc.) and one’s choice to prefer them instead of other measures are also techniques that slightly help us reduce the exposure to heat.
- The construction of green roofs is considered as an ideal heat island reduction strategy, providing both direct and ambient cooling effects, while improving air quality both by reducing the heat island effect and absorbing pollutants (U.S. EPA, 2021). Many countries provide incentives for their installation or taking action in general. For instance, dictating the promotion of greening, subsidizing the cost of greening, and / or providing other incentives for rooftop greening such as granting higher floor- area ratios to buildings that implement it. (Yamamoto, 2006).

The same applies for green walls. Please confer to the municipality’s relevant page where national programmes are being published.

- Pavement watering is considered to be quite effective in terms of reducing maximum heat stress, while also having UHI-mitigation effects. However, this measure does not always contribute significantly on this regard (Hendel, Gutierrez, Colombert, Diab & Royon, 2016).
- The integration of small green areas, besides the municipality’s restricted free space, into grassy or barren areas, vacant lots, and even sidewalks should also be considered (U.S. EPA, 2021) both as a way of improving the area’s microclimate but reducing the noise pollution in the surrounding area and improving the air quality as well. One form of them are the “parklets” which can be either permanent or in a short of temporary / mobile construction aiming to be transferred elsewhere when and if considered appropriate.

Such an “islet” may reduce the average temperature of a hot spot by 2-3 degrees during the summer, clean the air and aesthetically improve the urban environment (Karamitsos & Zourna, 2021).

Here after a couple of parklet examples are being presented:

Picture 1.” Parklet” examples



“A PARKLET IN LONDON”
[[HTTPS://WWW.CONTEMPORIST.COM/11-PARKLETS-YOU-WISH-YOUR-CITY-HAD/](https://www.contemporist.com/11-parklets-you-wish-your-city-had/)] in
<https://www.archisearch.gr/student-works/small-scale-urban-voids-residual-spaces-in-the-city-research-thesis-by-olga-strongylou/>

<https://www.in.gr/2020/07/17/life/design/ti-einai-ta-parklets-kai-giati-exounginei-anarpasta-logo-koronaion/>

A parklet in Valencia Street in San Francisco
<https://www.wikiwand.com/en/Parklet>

- Finally, all relevant stakeholders and particularly the new generation of engineers, should be educated accordingly through university courses and seminars in order to be able to consider bioclimatic design and other techniques to mitigate the UHI effect.

In Japan since mid-2004, the Ministry of Land, Infrastructure and Transport laid down “Guidelines for Architectural Design to Mitigate the Urban Heat Island Effect”, under the scope of encouraging building owners to be proactive and foresee mitigation measures (Yamamoto, 2006). This proactive consideration should be embraced by all relevant stakeholders in all urban areas. In the figure here after are being summarized the relevant guidelines.

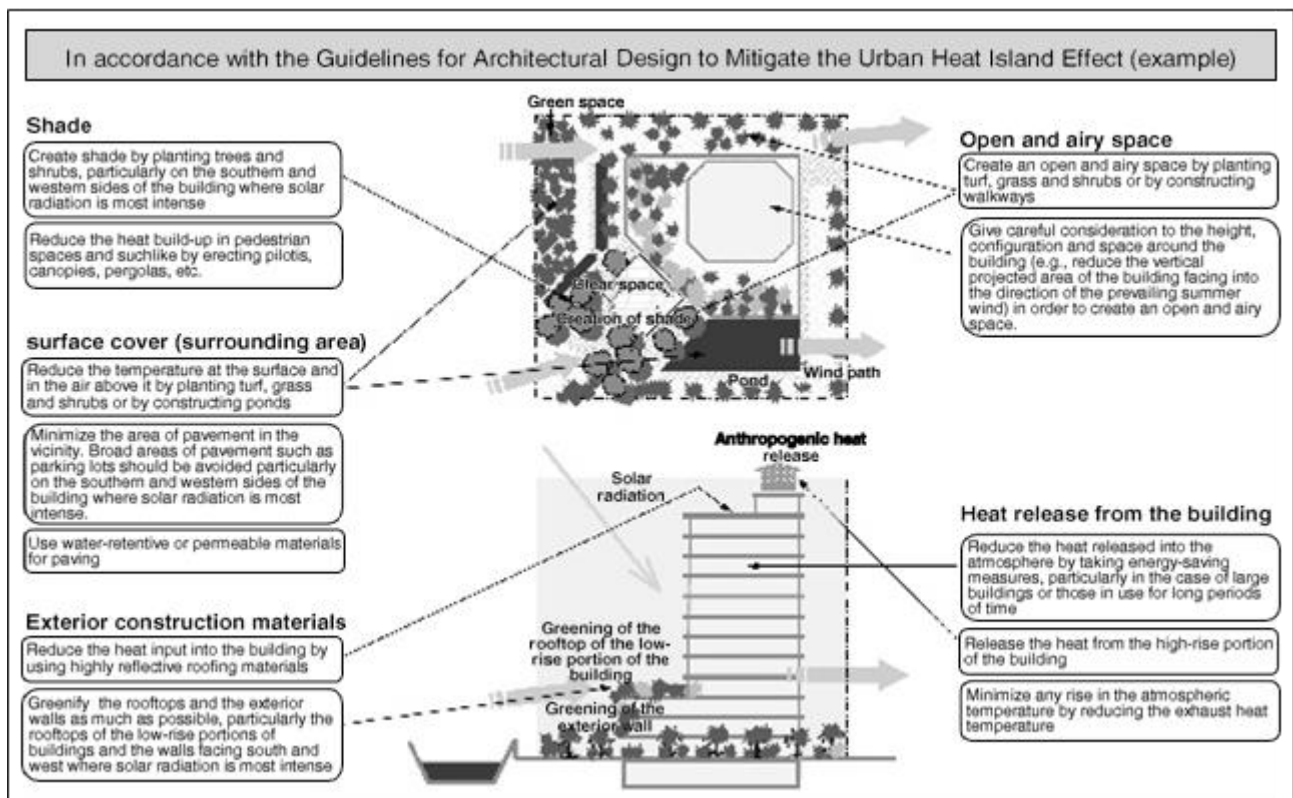


Figure 26 how to mitigate the UHI effect, (source: The Ministry of Land, Infrastructure and Transport. (Japanese): http://www.mlit.go.jp/kisha/kisha05/07/070719_2/05.pdf in Yamamoto, 2006)

5.1.4.2 Long-term adaptation measures to reduce heat and confront the UHI effect (e.g., green roofs, ventilation areas, etc.)

It is indispensable when designing for the long-term to have the adaptation measures implemented through the local urban plans and strategies considering of course the national and European policies. Risk assessment and management should be also integrated in all forms of relevant policies and planning (civil protection, urban design, environmental, strategic planning department etc.).

The combined effects of climate change, rapid urban sprawl, and Urban Heat Island (UHI) introduce an emerging health concern for the urban residents, all the above lead to the destruction of natural ecosystems and degradation of the environment of urban areas (we have already seen that Thessaloniki's green spaces have been significantly reduced since 1979). It is urgent to develop countermeasures and strategies that alleviate these combined effects and improve living conditions in urban agglomerations (Voogt, 2004). Within this framework several long-term measures can be suggested for the mitigation of UHI effect along with other complementary advantages. Here after are presented the most important among them:

- Greening through the implementation of green medians, green roofs, green walls, increased and maintained vegetation in parks and forests

Local municipal bodies conduct large tree planting projects to provide habitats and ecosystem services such as carbon sequestration, microclimate regulation, visual and acoustic comfort, air quality control, and storm water attenuation (Schwendenmann et al., 2014; Gaffin et al., 2012). Urban trees can mitigate the impacts of climate change through the absorption of the CO₂ that takes part in greenhouse gases and act as carbon sinks (Sandhya et al., 2011). Tree canopies provide a

cooling effect on microclimate directly by shading with their foliage the ground surface and indirectly through their evapotranspiration (Tsitsoni et al., 2014; Scott et al., 1999, World Bank, 2020). Therefore, the concern for the restoration of the existing ones and the creation of new urban green spaces is important.

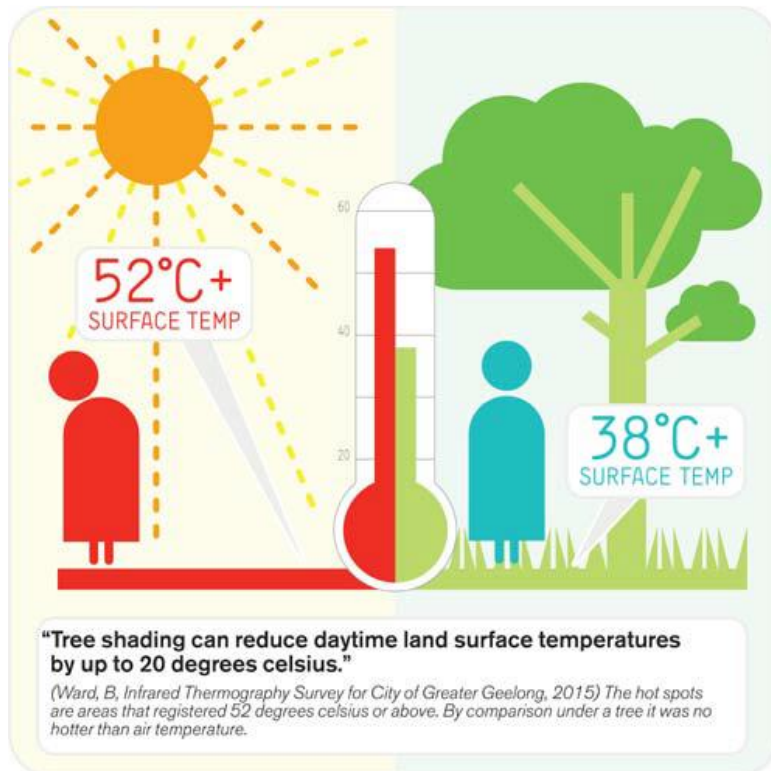


Figure 27: The advantage of tree shading, (source: Moreland City Council. (2016). Moreland Urban Heat Island Effect Action Plan 2016/2017 – 2025/2026.

<https://www.moreland.vic.gov.au/globalassets/areas/esd/esd-uhie-urban-heat-island-effect---action-plan---final-draft-for-council-june-2016.pdf>)

"Green roofs provide effective insulation for the buildings on which they are located. A study in Long Island City in Queens, NY, found that a 1,000m² green roof saved roughly \$400/year in heating costs and \$250/year in cooling costs" (Gaffin et al., 2010 in "Reeve & Kingston, 2014").

"A University of Michigan study determined that, while a 21,000ft² green roof would cost \$129,000 more to install than a traditional roof, it would save the homeowner about \$200,000 in heating, cooling, and air quality improvements over the course of its life" (Foster et al., 2011 in "Reeve & Kingston, 2014").

"TreePhilly (a Philadelphia Parks and Recreation Department initiative) is engaged in extensive outreach to encourage tree plantings on private property. These efforts complement the city's efforts on public lands to further enhance the urban forest. Giving away trees to private landowners is a straightforward way to enhance the urban forest on private land. The City of Philadelphia partnered with a local park conservancy group to sponsor a free yard-tree giveaway" (Reeve & Kingston, 2014).

"Changes to zoning policy can help ensure green infrastructure, such as trees, is prioritized during new construction projects. Washington DC is updating its zoning requirements to include a mandatory "Green Area Ratio" to ensure any new developments include a certain percentage of

green space (including tree canopy)” (Reeve & Kingston, 2014). The same applies in Greece, considering the new construction regulation, article 17 and the laws 4014/11 and 4030/11.

Street trees are often planted and maintained by cities. By planting native, resilient species, a robust urban forest can be created to provide shade and storm water management (Reeve & Kingston, 2014). New York’s sustainability plan urges its improvement by the initiation of an ordinance, since 2008, directing the planting of a tree every 25 feet along street frontage (Reeve & Kingston, 2014).

Another advantage of green roofs considering the floods of the last decades is that a properly managed green roof can reduce the annual overflow of storm water by 50-60% (Foster et al., 2011). Within the framework of LIFE ASTI Project 5 relevant projects have been carried out. These should be maintained, and other ones should follow.

- The creation of “wind paths”

To cities such as Thessaloniki that hold a large waterfront it is more than recommended to take advantage of the “wind paths” that can be created. Thus, it is more than recommended to consider the buildings orientation and position in order to create the necessary corridors so as to expand and disseminate the sea winds’ positive effect to the city. Noting the positive effect of wind paths, their creation should be considered, designed, and implemented through urban planning

- The introduction of blue elements

Indeed “water bodies such as ponds, lakes, or rivers can cool by evaporation, heat absorption, and heat transport. Water spray from mountains, for example, can locally have an even greater cooling effect because of the large contact surface between the water and air, stimulating cooling through evaporation” (World Bank, 2020). Cooling is achieved through evaporative cooling and increased ventilation, while as additional benefits positive impacts in recreation and biodiversity’s increase can be pointed out.

- The introduction of “white elements”

White surfaces counteract causes of the UHI effect, such as the high absorption of solar radiation as well as heat storage of paved surfaces or built-up areas. These are confronted with the use of „cool materials” that are generally lighter or reflect more solar radiation than traditional darker materials. That way reduced heat absorption through the reflection of solar radiation is achieved while in parallel building energy savings are being observed (World Bank, 2020).

- The use of alternative material in general

The emission of stored heat from building materials in the environment increases the air temperature in the urban space (noticeable heat flow). Cold materials that do not absorb a large quantity of sunlight, maintain low surface temperatures, emit a small amount of heat, and contribute to the maintenance of low temperatures.

Water permeable surfaces (e.g., perforated cobblestones) and porous paving materials (e.g., alabaster, ceramics), which allow the flow of water to the natural soil and the evaporation of moisture from it, have a particularly positive effect on temperature during the summer, due to their contribution to evaporative cooling.

Materials with high heat capacity or mass tend to balance or reduce large environmental temperature fluctuations. The high heat capacity of the urban materials, not only of the ground but also construction materials of buildings, has a positive effect on the day, during the summer season, absorbing and storing heat until night, when heat is returned back to the environment

The large heat capacity of the city network as a whole, including buildings (concrete, asphalt), in combination with reduced view of the sky, is largely responsible for the UHI effect / the increase of medium temperature in the urban environment during the night

It has also been observed that the reflective surfaces (with high albedo), although they retain lower temperature, have a negative effect in thermal comfort during the day-with intense sunshine and high temperatures, as they cause high rates of thermal indicators (PMV, PET, SET), compared to more absorbent surfaces. In contrast, at during summer nights, high reflective materials result to a positive effect on pedestrian comfort due to the lower surface temperature. It should also be noted here that light coloured material in big surfaces may cause visual discomfort, thus the use of a mixture of different material is recommended.

The properties of the natural soil that affect living in the urban microclimate is the low plasticity, which does not burden the thermal pedestrian traffic, and the high heat capacity which mitigates the daily fluctuation of mainly the surface temperature but also of ambient temperature. Furthermore, the possibility of evaporation of soil moisture is the main acquisition of permeable or perforated application of coating materials and porous surfaces in the urban environment and what defines it as one of the most effective interventions for the microclimate's improvement.


Table 5: indicative rates of materials reflectivity, emissivity, and thermal capacity of different material, (**source:** Santamouris 2000, Cengel 2005, Asaeda κ.α 1996, ISO 10456, Asaeda & Ca 2000, T.O.T.E.E. 20701-2/2010 in Chatzidimitriou, 2012).

material	reflectivity
Asphalt	0,05 - 0,2
Walls of dark brick blocks or dark slabs	0,20
Cultivated soil	0,20
Sand	0,24
Deciduous plants	0,20 - 0,30
Red, brown, or green colour	0,20 - 0,35
Concrete	0,30
Red brick	0,30
Soil	0,30
Limestone walls	0,30 - 0,45
Light brick walls	0,30 - 0,5
Wood (freshly cut)	0,40
White and off-white colours	0,50 - 0,90
White marble	0,55
Light coloured sand	0,40 - 0,60
Gravel	0,72
Green pigment	0,73
White plaster	0,75
Whitewashed stone walls	0,80
Aluminum colour	0,80

White pigment	0,85
material	emissivity
Aluminum colour	0,27 - 0,67
Concrete tiles	0,63
Sand	0,76
Asphalt	0,85 - 0,93
Roof tiles	0,85
Rock	0,87
Gray pigment	0,87
Black colour in aluminum	0,88
mudbricks	0,90
Wood	0,90
Concrete	0,94
Marble	0,95
White pigment	0,96
material	Thermal capacity (kJ/(m ³ ·K))
Plasterboard	900
Wood	800 - 1120
Tar	1050 - 1100
Soil	1280
Ceramic floor tiles	1680
soft Limestone	1800
Medium density concrete	1800 - 2200
Asphalt	2100
Marble, stone slabs	2800
Basalt	3000
Water (10 ° C)	4190

Considering a research carried out during the summer season, the measurements showed differences “up to 13 ° C between surface temperatures of different materials, mainly due to differences in reflexivity and presence of low planting, and differences above 20 ° C due to shading. Significant differences were also recorded in sphere temperatures, which correspond to the thermal conditions perceived by the pedestrians. In particular, up to 5 ° C between areas with light and dark coloured floors and up to 14 ° C between areas exposed to the sun and shaded by trees. The ambient temperature was similarly higher at the exposed surfaces (with differences up to 0.5 ° C), but in areas with trees and natural soil up to 2.5 ° C lower temperatures have been observed.

In particular, it was observed that, while surfaces with high reflectivity were up 14.5% cooler compared to dark surfaces, sphere temperatures there were up to 4,5% higher, resulting thus to more thermal discomfort. On the contrary, materials with low reflectivity and high thermal capacity low surface and sphere temperatures have been observed, compared to materials with lower heat capacity and similar reflectivity. Furthermore, the surfaces with grass where up to 24% colder than the hard floors, with a sphere temperature around up to 5% lower. The surfaces in the shade of trees were 40% colder or even more compared to surfaces exposed to the sun, with a sphere temperature up to 27% lower.



The grassy surfaces in tree shade were up to 50% cooler than exposed hardwood floors, with sphere temperatures up to 28% lower and temperature up to 4% lower than temperatures measured on exposed hard surfaces. A water surface exposed to the sun was 43% colder, with an average sphere temperature above water up to 6.5% lower and air temperature 1% lower than the measured on asphalt” (Chatzidimitriou, 2012).

Thus, the thermal behaviour of construction materials, both of buildings and public spaces depends on several characteristics Chatzidimitriou points out the necessity of using different kinds of material in order to succeed comfort and cover different needs of different people (Chatzidimitriou, 2012). The use of a combination of different material so as to create comfortable zones for different types of people and during all day and night long is a stake that all designers of public spaces must take.

5.1.5 Adaptation Action Plan measures per UHI scenario

5.1.5.1 Different measures per scenario based on the results of Action C.4 (Adaptation Strategies Assessment Report)

For both cities of Rome and Thessaloniki, a downscale algorithm was applied on the WRF model forecasted data. This algorithm increases the spatial resolution from 2 km to 250 m, by reassigning and adjusting the parameters of temperature and relative humidity, based on the existing environmental parameters. The adjustments are the result of statistical analysis of weather station data.

Due to the difference in the land usage and the other characteristic of the two cities, different approaches were followed for each, in order to investigate and apply the effect of adaptations strategies.

For the city of Thessaloniki, which is characterized by low variability of land use and climatic conditions within the city, two simulations are being conducted for a certain period of time. The first simulation was conducted under the actual land use of the city, while on the second one we altered a grid cell of dense urban fabric into green urban area (e.g., park or other vegetated recreational areas). Then, the diurnal difference of those, in temperature and relative humidity, were applied to the downscaled data, over the regions that the municipality of Thessaloniki has already changed the land use into green/parks or has plans to change it in the future. With this approach, we aim to describe the way that such adaptation strategies are affecting the microclimate of the regions within the urban fabric.

In this action plan measures are being suggested per scenario, each one of them corresponding to a different level of preparedness and necessity to face the UHI effect. Along with all other measures Public-Private Partnerships and of course volunteer actions and private funding may be set in place in order to contribute on this regard

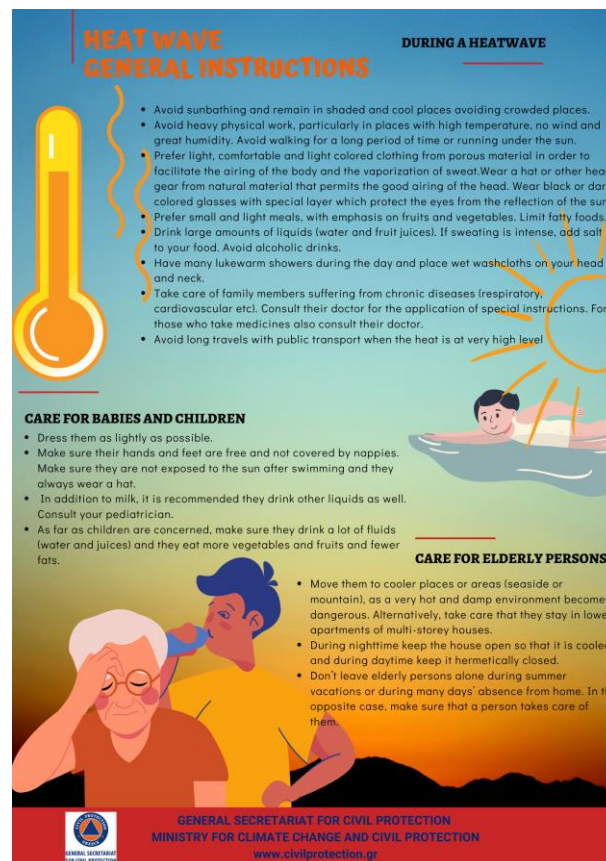
To be more specific:

- **Level 1 – green** - corresponds to no risk for the UHI effect (maximum temperature near to normal – comfortable temperature with no cautionary action required), thus it involves the systematic assessment of meteorological and of health risks, as well as the dissemination of information documents and the design and implementation of long-term measures allowing the Municipality to better deal with UHI effect's consequences in the long term.
The “green level” corresponds to the activation of a seasonal watch of the phenomenon, including the implementation of a system disseminating preventive information and the design and implementation of long-term measures for the future mitigation of the effect.

Considering the above:

- The replacement of conventional roofs with cool ones (white or green), particularly in cities with relatively high temperatures such as the Greek ones is a measure that should not be neglected. “1,000m2 white roof is estimated to save \$200 annually in cooling costs” (“Gaffin et al., 2010” in “Reeve & Kingston, 2014”).
- The implementation of green roofs, terraces and walls projects in all public buildings and pressure to the central government to promote relevant incentives for the private sector.
- The enhancement of urban forests and the strategic planting of trees must be set as a priority considering all the advantages that plants provide to their surrounding area.

- The reduction of impervious surfaces is also a measure that should be considered as a driver for the reduction of UHI effect. In Philadelphia, managing 50% of all impervious surface runoff through green infrastructure would provide about \$2.8 billion in benefits through 2049 thanks to reduced emissions, improved air and water quality, recreational space, reduced heat, etc. (“City of Philadelphia, 2009” in “Reeve & Kingston, 2014”).
- The provision to the citizens of all necessary information for the advantages of such actions in order to undertake such initiatives even without the existence of relevant national programmes.
- The drafting and editing of brochures, webpages and in general information and dissemination material regarding the UHI effect and in particular directions on how to deal with it such as avoid unnecessary movements, “stay at home” or “at work” indications, directions on what to eat and wear and so on.
- The pressure set to all relevant stakeholders to carefully maintain their network and infrastructure and be in general prepared (e.g., the energy providers, the health centres, etc.). In parallel, the competent services should also create relevant action plans.



- **Level 2 – yellow** - corresponds to a vigilance level of alert and readiness for the UHI effect (heat wave conditions at isolated pockets persisting for 2 days): It refers to moderate temperatures where heat is tolerable for the general public, but moderate concerns apply for vulnerable groups.

It mainly involves a level of reinforced monitoring, anticipation, and preparation for the reinforcement of management measures by the regional agencies of health, in particular through the implementation of local and targeted communication actions.

As such the municipality may examine all municipal buildings reassuring their readiness both in terms of manpower, infrastructure and acquired know-how / training, while in parallel reassuring the continuation of level 1.

- **Level 3 – orange** – corresponds to a vigilance level of a "Heat wave alert", triggered by the competent services, the General Secretariat for Civil Protection, in conjunction with the regional authorities considering the National Meteorological Service's scenarios and data.

All the above initiate in collaboration with the municipalities and the regional health centres, specific measures facilitating the prevention or mitigation of the phenomenon, reassuring optimal communication among all stakeholders involved and strategic and crisis management, depending on the intensity and duration of the phenomenon (that in this case is up to 2 days maximum since if it lasts more, then it is considered as level 4, while not severe but heat wave persists for more than 4 days).

This level corresponds to increased temperatures with a strong likelihood of heat illness symptoms for people that are either exposed to sun for a long period or carry out a heavy work, while the risk is quite high for the vulnerable groups of population. Within this framework:

- All national and local media, including TV and radio channels, journals and webpages and platforms should broadcast information responsibly from accurate sources and avoiding the disorientation of the citizens. All information must be to the point and produced by official sources (the national meteorological service, the competent ministries and local authorities and other relevant stakeholders, such as doctors, local medical units, and hospitals).
To be more specific the disseminated information should include all necessary subjects including guidelines on what to eat and wear, avoid intensive outdoor work and exercise, what to do in case of an emergency or when being in need and particular directions for specific vulnerable groups.
- Local medical units should be ready to treat related to the phenomenon cases. In parallel, the general public should be informed in order to be able to confront that kind of situations and / or ask on time for help accordingly.
When the ambient temperature exceeds certain limits tolerated by the human body and in combination with certain other factors (humidity, apnea, etc.), pathological conditions are being created, varying from not important at all to coma and death. The initial symptoms may be severe headache, lethargy, having the feeling or literally fainting, drop in blood pressure, nausea, vomiting and palpitations. Heat stroke syndrome is manifested by increased body temperature, convulsions, vomiting, diarrhoea, blood clotting disorder, absence of sweating. Myocardial infarction may also occur. Coma and death ensue. The treatment of people who experience the above-mentioned symptoms when the ambient temperature is high, should preferably be carried out in hospitals. However, first aid would help the patients safely arrive to hospitals and receive treatment. In this case first aid include immediate actions to reduce the body temperature, such as complete stripping of clothes, placing ice packs or cold compresses on the neck, armpits and groin area, immersion in a cold-water bath, etc.
- **Level 4 – red** - corresponds to the vigilance level for the "heat wave". The heat wave is proven to be exceptional, very intense, and long-lasting (severe heat wave for more than 2 days, total number of heat / severe heat wave days exceeding 6). There is thus a very high likelihood of developing heat illness or heat stroke to all ages.

Within this framework level 4 requires the maximum mobilization of all stakeholders, meaning ministries and relevant secretariats and services, regional and local authorities, health institutions and civil protection organizations, under the supervision of the General Secretariat for Civil Protection. This situation undoubtedly leads to the reinforcement of all previously mentioned dynamic measures and the implementation of an "emergency" action plan and a relevant mechanism.

Thus, in this framework a municipal "hot-line" may be indispensable in order to deal with crisis management and provide along with municipal and governmental police, social workers and other municipal employees, along with doctors and relevant professionals in order to provide help to citizens in need that do not have other alternatives. In parallel the short-term measures are being implemented and on this regard several announcements reminding this information are being widely broadcasted and relevant leaflets are being disseminated.

Considering all the above the related to health measures become more intense and the ones related to renovation and energy savings' implementation less intense while approaching level 4 from 1.

The measures for the mitigation of the UHI effect can be summarized to the table here after.

Table 6: Categories of urban heat island mitigation measures, (Source: "Saka, S. Development of Urban Space Forming Technology Contributing to Urban Heat Island Mitigation Measures. The National Institute for Land and Infrastructure Management, 2004. (Japanese): <http://www.nilim.go.jp/japanese/report/lecture/kouenkai2004/image/saka1.pdf> » in « Yamamoto, 2006»).

Description	Scale	Period	Degree of Effect		Administered by
			Sweltering nights	Rise in daytime temperatures	
(1) Reduction in anthropogenic heat release (reduction and substitution)					
(i) Improvement in the efficiency of energy-using products					
Office automation equipment and electric consumer appliances	Individuals	Short term	B	B	Individuals, business institutions, local governments
(ii) Improvement in the efficiency of air conditioning systems					
Refrigerators and heat source equipment	Buildings	Short term	B	B	Individuals, business institutions, local governments
(iii) Optimal operation of air conditioning systems					
Proper placement of outdoor units	Buildings	Short term	B	B	Individuals, business institutions, local governments
Use of cooling towers	Buildings	Short to medium term	—	A	Individuals, business institutions, local governments
Voluntary restraints on nighttime operations	Buildings	Short	A	—	Individuals, business institutions, local

		term			governments
(iv) Improvement in the heat insulation and thermo-shield of buildings					
High-performance heat insulation materials (interior heat insulating materials)	Buildings	Short to medium term	C	C	Individuals, business institutions, local governments
High-performance heat insulation and thermo-shield materials (exterior heat insulating materials)	Buildings	Short to medium term	A	D	Individuals, business institutions, local governments
(v) Greening of buildings and adoption of water-retentive materials					
Greening of buildings and adoption of water-retentive materials (Exterior heat insulating materials)	Buildings	Short to medium term	A	A	Individuals, business institutions, local governments
(vi) Improvement in the reflectivity of walls and roofing materials					
Light colored walls and highly reflective roofing materials	Buildings	Short term	A	A	Individuals, business institutions, local governments
(vii) Introduction of traffic-control measures					
Traffic demand management and introduction of low emission vehicles	Cities	Medium to long term	B	C	Individuals, business institutions, local governments
Promotion of alternatives such as bicycles	Wards	Short to medium term	B	C	Individuals, business institutions, local governments
(viii) Introduction of district heating and cooling					
Central control of exhaust heat from buildings (at the regional level)	City blocks	Medium term	A	A	Business institutions, local governments
(ix) Use of untapped energy					
Use of sea, river, and ground water	Wards	Medium to long term	B	B	Business institutions, local governments
Use of exhaust heat from urban facilities					
Use of exhaust heat from industrial plants, subways, buildings, power plants, substations, etc.	City blocks	Medium term	B	B	Business institutions, local governments
Recovery of energy from waste materials					
Waste power generation and heat supply	Wards	Medium term	B	B	Local governments
(x) Use of natural energy					
Photovoltaic generation	Buildings to cities	Short to medium and long term	B	B	Individuals, business institutions, local governments
Use of solar heat	Buildings to cities	Short to medium and long term	B	B	Individuals, business institutions, local governments

(2) Improvement of artificial surface covers (reduction of sensible heat transfer and expansion of latent heat transfer)					
(i) Improvement in the reflectivity and water-retentivity of paving materials					
Adoption of colored and permeable paving materials	Cities	Short term	B	B	Local governments
(ii) Greening					
Maintenance and improvement of parks and greenspaces	Wards to cities	Medium to long term	A	A	Business institutions, local governments
Greening of streets	Wards to cities	Medium term	B	B	Local governments
Greening of dwellings	Individuals	Short term	B	B	Individuals, business institutions, local governments
(iii) Greening of buildings and adoption of water-retentive materials (reduction of sensible heat)					
Greening of buildings and adoption of water-retentive materials	Buildings	Short to medium term	A	A	Individuals, business institutions, local governments
(iv) Open water spaces					
Conversion of small rivers into open channels and construction of ponds in parks	Wards to cities	Medium to long term	B	A	Local governments
(3) Improvement of urban structure (improvement and integration of advection currents)					
(i) Improvement of the orientation of buildings					
Improvement of orientations of buildings and roads, and effective use of wind or water paths	City blocks to cities	Medium to long term	B	B	Local governments
(ii) Improvement of land use					
Construction of large-scale parks and green spaces, and reorientation of industrial or commercial facilities	Cities	Long term	A	A	Local governments
(iii) Creation of eco-energy cities					
Cascade use of energy, and organic integration of energy use in industrial and private sectors	Wards to cities	Medium to long term	B	B	Local governments
(iv) Creation of a recycling-based society					
Effective use of energy and resources, and creation of eco-friendly cities based on recycling	Wards to cities	Long term	B	B	Local governments
(4) enhancement of lifestyles					
(i) actions to improve the urban lifestyle					
campaigns to encourage light clothing in summer	cities	Short term	B	B	Individuals, business institutions, local governments

campaigns to reduce the idling of automobile engines	cities	Short term	B	B	Individuals, business institutions, local governments
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Note) Degree of effectiveness: A (very effective), B (effective), C (somewhat effective), D (counter effective)

Having in mind all the above it is worthy to point out the priorities as set by Guardaro et al., 2020 following a survey carried out to citizens of three neighbourhoods in metropolitan Phoenix. Citizens consider important actions to:

- Provide more shade and reduce exposure to heat (through the creation of additional shading on public transit routes, along school routes and improvements along vacant lots and generally by reducing pedestrians' exposure and direct contact with sun radiation).
- Provide drinking water (through sinks at 1/2 mile intervals).
- Provide additional "cooling opportunities" (either by introducing sprinklers and rest points with shades and water or by initiating longer hours at the nearby public pool, operational, clean fountains in public spaces).
- Guarantee advocacy training for urban heat solutions (through targeted actions giving emphasis on vulnerable groups of population, heat health emergency first aid training certification).
- Guarantee community funds for tree maintenance and planting (Guardaro, Messerschmidt, Hondula, Grimm & Redman, 2020).

These pointed out it is more than recommended that the Municipality of Thessaloniki:

- Proceeds with a recording of all municipal buildings and public spaces and their relevant infrastructure, under the aim to properly set relevant goals (e.g., proceed with measures to confront energy poverty such as the installation of panels, energy efficiency with the replacement of old frames, better insulation etc.).
- Integrates all relevant data to a smart platform in order to facilitate their management, operation and repairs.

Having pointed out these technical issues and considering all the above analysed measures, the Municipality of Thessaloniki should implement the following adoption of coloured and permeable paving materials in order to successfully tackle the UHI effect:

- Development of the urban green at least by 30% in combination with the reinforcement of the sub-urban green parks and forests. This will be achieved with the identification of the vacant spaces, public spaces and buildings that can be potentially turned into green areas, the studies for their regeneration and efforts carried out under the aim of their inclusion to identified funded programmes. The conduction of seminars, eventually carried out by the municipality (for instance relevant courses are being offered in Paris, France and more turned to the development of agricultural activities in Catalca, Turkey) may also help both public and private initiatives (in several cases the neighbourhood takes the lead of transforming a space into a green asset even when the ownership of the space is not clear). Within this framework, several initiatives to mobilize the private sector should also be foreseen (cf. case studies presented in paragraph 5.1.4.2)

- Enhance bioclimatic design to the municipal buildings' construction and maintenance and provide relevant incentives for the private sector (e.g., support for the integration of citizens to the “save – go autonomous” Programme (“εξοικονομώ – αυτονομώ”) in order to turn private buildings “greener”).
- Develop shading in the city through natural and / or technical means (canopies, permanent or temporary awnings, umbrellas, pergolas, sheds, fences) with emphasis on the "busiest" pedestrian paths in order to reduce heat exposure with emphasis on routes, along school routes and public, popular spaces.
- Develop and maintain the “blue” element and ensure the existence of drinking water in open, public spaces, through drinking water fountains every 2-3 km and the making of municipal swimming pools available to the general public for longer periods of time.

5.2 Adaptation Action Plans Portfolio for the city of Rome

5.2.1 General description of the targeted urban area

Administrative data (Demographics DEASL, Geospatial, etc.), environmental and socio-economic conditions

Rome is a city of over 2.7 million residents, with 64% of the population aged 65 and over, 23% in the adult age group 15-64 and 13% children (0-14 years of age) (figure 5.2.1). As for the Italian population in Rome the ageing index has been steadily increasing reaching 179.1 in 2021 compared to 158.1 in 2011. The mortality rate in Rome is 9.8 x1000 inhabitants in 2021. The elderly dependency index expresses the burden of the elderly population on the population of working age. It is the ratio between the number of people over 65 and the active population (15-64 years) and again it has been rising steadily in Rome, reaching 35.6 in 2021. Conversely the young population is very low, only 13% of the population, with a birth rate (average number of births in one year for every thousand residents) of 6.5 in 2020.

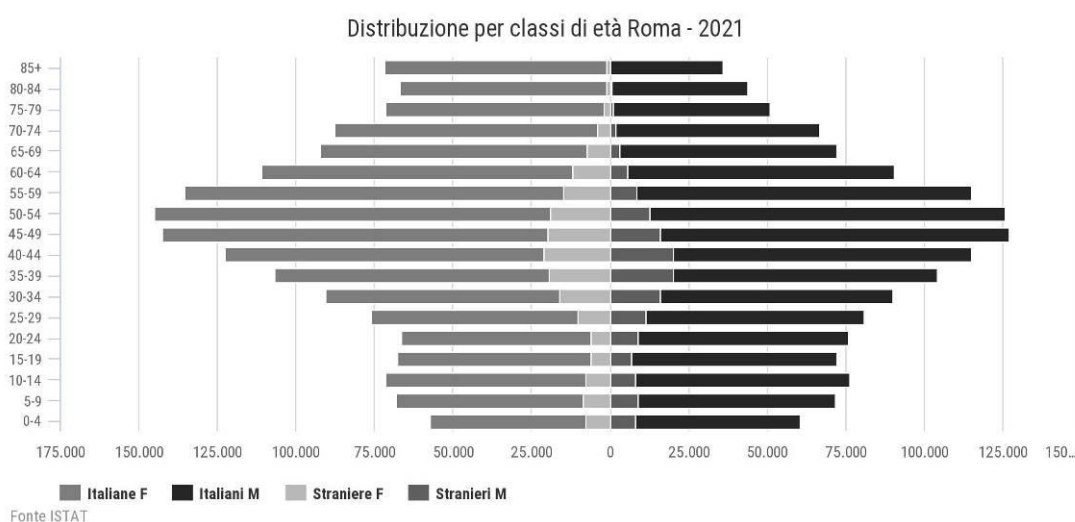


Figure 28: Population pyramid and distribution by age classes of the resident population in Rome for 2021. (Source: www.opensalutelazio.it)

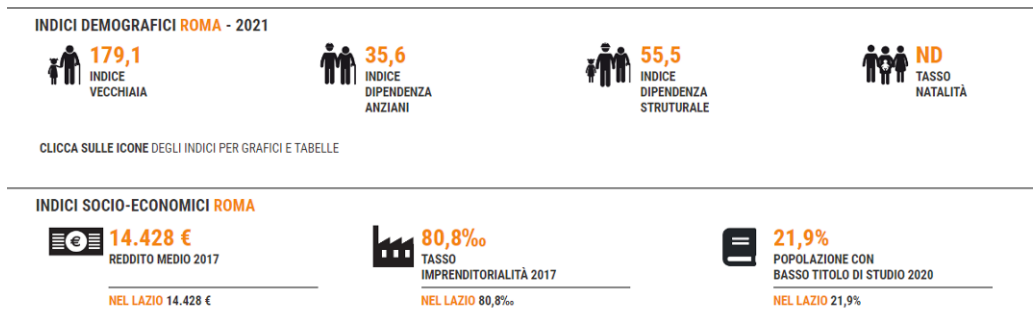


Figure 29: Characteristics of the population in Rome and socio-economic indices. (Source: www.opensalutelazio.it)

In socio-economic terms the average per capita income in 2017 was of 14428€ and the entrepreneurship index is of 80.8%. The structural dependency index expresses the social and economic load of the non-active population (0-14 years and 65 years and over) on the active population (15-64 years) and corresponds to 55.5 in 2021. In Rome 21.9% of the population has a low level of education (elementary school). The socio-economic index derived from data from the 2011 census shows that for the three health authorities in Rome (ASL ROMA 1, ASL ROMA 2, ASL ROMA 3) around 20% of the population has a low socio-economic status, around 55% have a middle socio-economic status and around 25-30% have a high socio-economic status with some slight differences by area of residence with ASL ROMA 2 having a higher proportion of the population of higher socio-economic status. (Figure 30)



Figure 30: Socio economic status by local health authority and gender. (Source: www.opensalutelazio.it)

In terms of health status, the illnesses with a higher prevalence are non-communicable diseases such as hypertension, cardiovascular disease, ischemic disease, diabetes, COPD, hypothyroidism as shown in figure 3. A total of over 199 thousand cases of cancer were registered in Rome. The forms of cancer with a highest incidence in Rome are breast cancer, prostate cancer, lung cancer and colon cancer. In terms of hospital admissions around 5.9% of the population accessed hospitals for treatment with 164,520 people admitted to hospital in 2020.

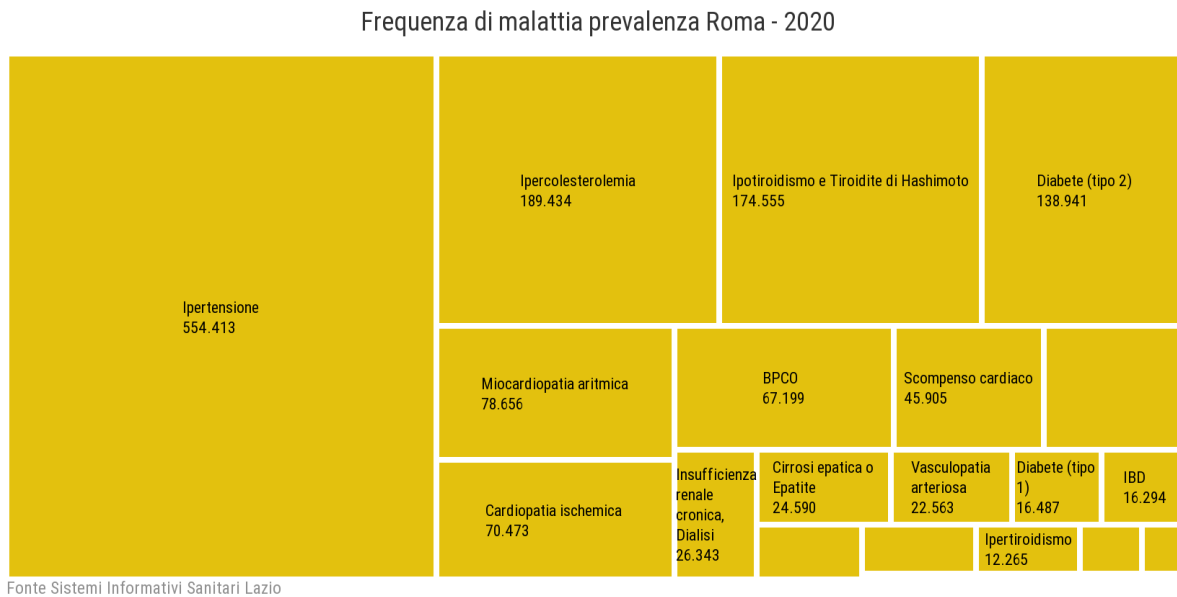


Figure 31: Frequency of Illness prevalence in Rome for 2020. (Source: www.opensalutelazio.it)

Geospatial data

According to the Italian National Institute of Statistics, the district of Rome is the most populous in Italy and the third in the entire European Union. It is placed in the central-western part of Italy and characterised by a complex orography, bordering the Monti della Tolfa and Monti Sabatini anti-Appennine group to the northwest, the Lazio sub-Appennines to the east, the Alban Hills to the southeast and the Tyrrhenian Sea to the west. The city itself is also crossed by the narrow Tiber Valley.

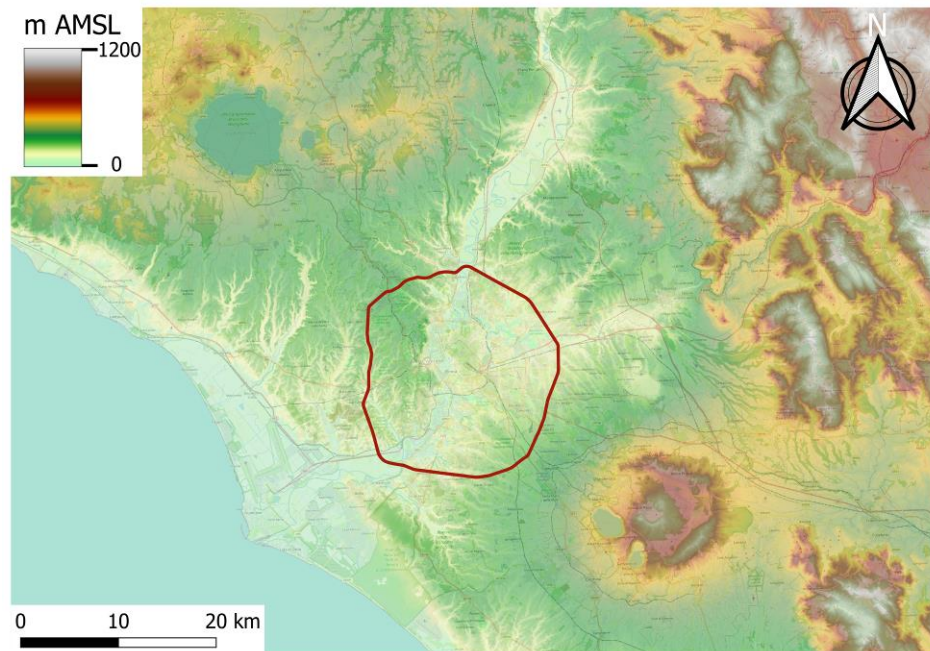


Figure 32: Elevation map of Rome in its geographical context. The study area is enclosed within the A90 Grande Raccordo Anulare (GRA, red line).

The most urbanised part of Rome is enclosed within the A90 motorway (Figure 32, red line), with an elevation between 13 and 120 m a.s.l. After the Second World War, and more specifically during the period between 1945 and 1971 the city underwent the most important expansion of its whole history, growing in disorganized way which lead to a large variety of different urbanised areas alternated with green areas. As a result, Rome urban fabric comprises a multiplicity of very localised microclimates, which can be characterised in terms of Local Climate Zones (LCZ, Stewart and Oke, 2012).

According to the map reported in Figure 33, which shows the geographical distribution of the different LCZ of Rome with a spatial resolution of 500 m, the most diffuse built types are as follows (expressed as a percentage of the total surface comprised within the A90 motorway).

- LCZ 5 – Open midrise (28.6%). Open arrangement of midrise buildings (3–9 stories). Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.
- LCZ 6 – Open lowrise (15.7%) Open arrangement of low-rise buildings (1–3 stories). Abundance of pervious land cover (low plants, scattered trees). Wood, brick, stone, tile, and concrete construction materials.
- LCZ 8 – Large lowrise (13.3%). Open arrangement of large low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Steel, concrete, metal, and stone construction materials.
- LCZ 2 – Compact midrise (7%). Dense mix of midrise buildings (3–9 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.

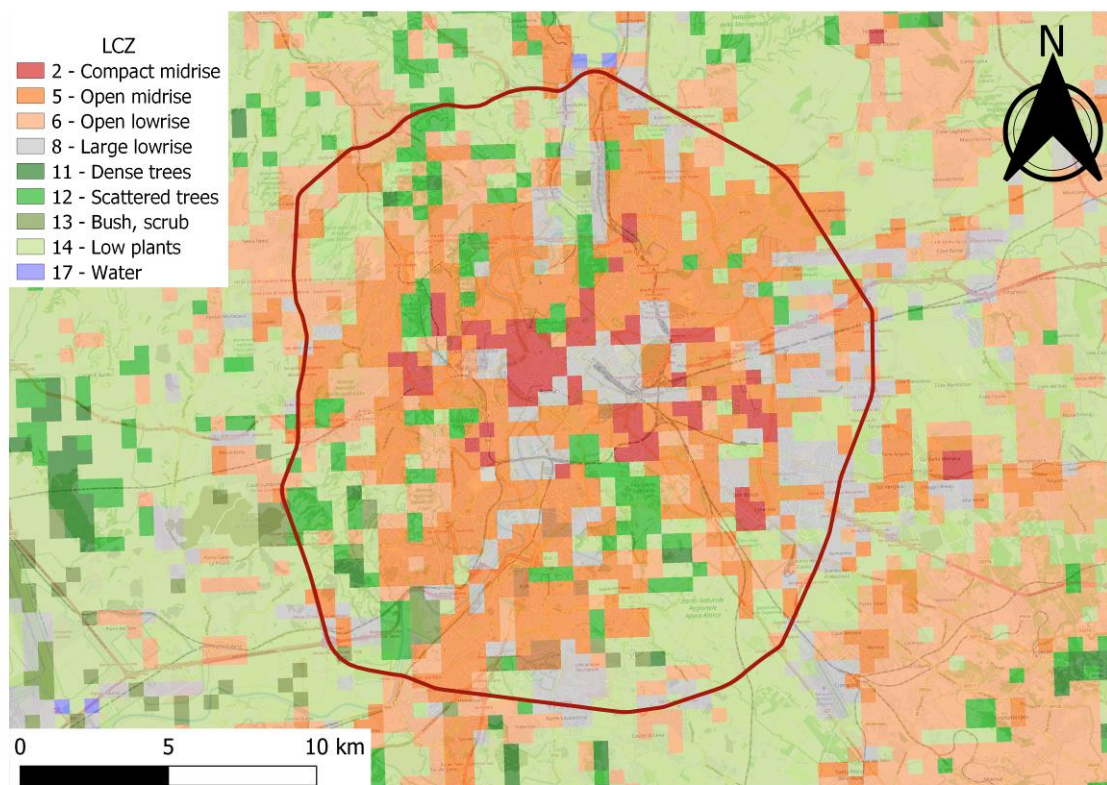


Figure 33: Local Climate Zones map of Rome, with a spatial resolution of 500 m. The red line identifies GRA.

A relatively large part of the city consists of green areas, divided in different LCZ according to their prevalent land coverage. It is worth to mention that water bodies (LCZ 17) do not appear in the city LCZ classification because of the spatial resolution used to make the map reported in Figure 33 – 500 m is too low a resolution get relatively small water bodies such as the river Tiber.

- LCZ 14 – low plants (17.2%). Featureless landscape of grass or herbaceous plants/crops. Few or no trees. Zone function is natural grassland, agriculture, or urban park
- LCZ 12 – scattered trees (10.6%). Lightly wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
- LCZ 11 – dense trees (0.9%). Heavily wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park
- LCZ 13 – bush, scrubs (2.4%). Open arrangement of bushes, shrubs, and short, woody trees. Land cover mostly pervious (bare soil or sand). Zone function is natural scrubland or agriculture.

Action A.2 report on the installation of supplementary urban weather stations in Rome and Thessaloniki also contains (Annex 1) the LCZ classification for all the 37 weather stations forming the LIFE ASTI Urban Heat Island network in Rome.

Weather & Climate conditions of the AREAS with emphasis on UHI effect

Rome has a Mediterranean climate (like Thessaloniki), characterized by hot summers and mild winters. During summer, maximum temperatures can be as high as approximately 32 °C in the urban center, somehow mitigated by the close distance (25 km) from the Tyrrhenian Sea and the related sea breeze circulation, almost always present in the daytime. Such a circulation, blowing from WSW,

is more effective in the western district of Rome, resulting in a temperature difference up to 3 °C between the eastern and the western areas. The average annual temperature is currently ~17°C, increased by ~1.8°C in comparison with the period 1974-2000 (15.2°C). The average UHI intensity during summer nights is ~3.5 °C, and it is basically suppressed during the day.

5.2.2 Current situation of existing adaptation plans, strategies and actions regarding the adaptation and mitigation of UHI

5.2.2.1. Presentation of relevant existing plans, strategies & action, including stakeholders involved and sectors influenced

In terms of climate change and heat wave adaptation the [Italian Heat Health Adaptation plan \(HHAP\)](#) has been operational since 2004 and is managed, on behalf of the Italian Ministry of Health, by the [Department of Epidemiology ASL ROMA 1](#) who is also involved in the Lazio Regional Heat Plan (Michelozzi et al, 2010). The plan is based on the core elements defined by the [WHO Europe Guidance](#) to ensure an effective response to heat for local populations.



Figure 34: Italian heat Adaptation plan components (Source: www.salute.gov.it/caldo)

The heat plan is based on Heat health warning systems and a [rapid mortality surveillance system](#) to rapidly notify the impact of rising temperatures and heat waves. Health guidance and recommendations have been developed for by the Ministry of health including information and training material for health care professionals and care workers assisting subgroups most at risk like the elderly, people suffering from chronic conditions, outdoor workers, pregnant women, and young children.

Each summer the Lazio Region defines a heat plan which is centred around health service response and heat warning systems. Furthermore, in the Lazio region it is traditionally based on the formal identification of elderly subjects most at risk during heat waves and the active surveillance by GPs, which has been extended to the use of tele-monitoring services from health care services and nursing staff at local health authority and district level. On heat wave days health care professionals carry out home visits and tele-assistance calls checking the health status of patients, adjusting medical treatments, or referring elderly to hospital or nursing homes when needed. The heat plan, through the use of an operational web-based platform, and the APP “Lazio Advice” GPs, health care professionals and primary care services carry out surveillance and patient care during heat waves. An information network is set up to disseminate warning bulletins in a timely manner throughout the network and ensure emergency, health care and social services respond accordingly. For Rome stakeholders and sectors involved include: the Lazio regional health service, Civil Protection, the Municipality of Rome, all local health authorities, district health services as well as social and voluntary services dealing with the elderly and in deprived districts together with the Department of Epidemiology that coordinates the warning systems and mortality surveillance. Since 2021 the plan

has been adjusted to account for COVID-19 restrictions and distancing protocols in place also in the Health system and specific advice on heat and covid has been issued (see ANNEX).

5.2.3 Adaptation Action Plan measures per UHI scenario

Unlike Thessaloniki, Rome already has a high percentage of public and private green areas (31.3%), as evidenced by the LCZ map of the city reported in Figure 33. Consequently, the UHI forecasting modelling system (Action C.2 and C.7) was used to investigate three simulated scenarios more focused on albedo reduction than on green areas addition, with the goal of supporting future adaptation plans and providing a wider perspective.

For the city of Rome, the following 3 scenarios were investigated.

1. Counterfactual scenario. Reducing green areas by replacing specific current planted areas in the city with urban structures to examine the effect of converting a green area into an urban one.
2. Urban areas albedo reduction. Reducing the albedo of continuous and discontinuous urban areas by 10%, 25% and 50%. It should be noted that green areas were characterized by lower albedo.
3. Industrial and commercial albedo reduction. Reducing the albedo of industrial, commercial, road and rail network areas by 10%, 25%, 50%. This reduction could be succeeded by using different materials.

The first scenario worsened the UHI by both increasing urbanization density and reducing green areas by 2.3%. It led to a temperature increase between 0.2 and 1.5 °C for a major part of the day, along with a relative humidity decrease between 0.5 and 7%.

Both the second and the third scenarios are expected to mitigate the UHI phenomenon by modifying the surface albedo and, as a consequence of using materials and structure characterized by different physical properties, the emissivity. Depending on the emissivity variations, assumed to range between 5 and -10% with respect to the current values, the aggregated analysis of scenarios 2 and 3 led to a temperature variation between -0.54 and 0.1 °C, with relative humidity ranging between -4.24 and 11.7%.

All considered, the three scenarios briefly described above suggests that both the addition of green areas and the reduction of albedo can contribute significantly to achieve cooler cities, but the emissivity variations associated with the use of different building materials should be carefully addressed. Further details can be found in Action C.7 report “Implementation of a forecasting System for urban heat Island effect for the development of urban adaptation strategies”.

Considering that Rome already has a significant percentage of green areas within its municipal borders, and with reference to the four different levels set up in Section 5.1.5, the adaptation measures proposed are the following.

Level 1 – green

- Replacement of conventional roofs with cool ones (white or green) and implementation of green walls
- Provide citizens with information about all the measures undertaken

- Provide citizens with information on how to deal with the UHI effect, including recommendations about movements, clothing, diet, etc.
- Encourage all relevant stakeholders and public services to maintain their network and infrastructure at a good level of preparedness.

Level 2 – yellow

In addition to level 1 measures, the municipality is strongly advised to examine all municipal buildings to check their readiness in terms of manpower, infrastructure and acquired know-how/training.

Level 3 and 4 – orange and red

Implement measures described in Section 5.1.5

With reference to Table 6 reported in Section 5.1.5, which summarizes all UHI mitigation measures, the municipality of Rome should implement the following actions and measures.

- Enhance bioclimatic design of municipal buildings and their maintenance and support the private sector to implement similar measures.
- Develop shading in the city through natural and/or artificial structures (e.g., canopies, permanent or temporary awnings, umbrellas, pergolas, sheds, fences) with emphasis on the "busiest" pedestrian paths to reduce heat exposure.
- Develop and maintain the "blue" element and ensure the presence and distribution of drinking water in open and public spaces, e.g., by deploying drinking water fountains every 2-3 km.

6. FURTHER ACTIONS AND ASSESSMENT FOR THE CITY OF THESSALONIKI

6.1 Assessment of the LIFE ASTI contribution to local plans

The Department of Civil Protection of the Municipality of Thessaloniki is responsible for the formulation of planning suggestions, the actions' coordination for the disasters' prevention, response, and restoration in the Municipality's region.

More specifically, the Civil Protection Department:

- a. Makes suggestions for the planning of a civil protection framework in the area of the Municipality, in the context of the annual national planning and ensures the implementation of the relevant programs, measures, and actions in the context of national and regional planning.
- b. Monitoring and managing the Civil Protection's actions on the prevention, readiness, response, and restoration of disasters that occur in the area of the Municipality.
- c. Composes in case of emergencies, in coordination with the Municipal Services involved, separate action plans per risk category (such as earthquakes, fires, extreme weather conditions, etc.) in the area of the Municipality. Additionally, updates of these plans when required.
- d. Provides the appropriate human resources and technical means for the prevention, preparedness, response, and restoration of the disasters in the region of the Municipality.
- e. Determines the reception homes, where people affected by disasters should go to by taking into account the disaster type, as well as the development of appropriate infrastructure, which ensures the welfare of the abovementioned people, in cooperation with the appropriate Services.
- f. Informs the civilians and students on the existing preventive measures and ways of responding in case of an emergency.
- g. Cooperates with Volunteering Groups, while coordinating their acts in case of implementing Emergency Plans and assists them on matters of logistics.
- h. Addresses issues of the Independent Emergency Design Policy Department within the Municipality's responsibilities.
- i. Provides information to the public for the offering services of the department

6.1.1 TPS-Thessaloniki Strategic Review of Environmental Effects

OVERVIEW AND LOCAL DESIGN TEXT OVERVIEW CARD

A. TEXT IDENTITY

1	Type	Local
2	Title	TPS-Thessaloniki Strategic Review of Environmental Effects
3	Objective	Town-Planning Scheme
4	Year of elaboration	2019
5	Implementation Area	Thessaloniki
6	Institutional Level	Under institutionalization
7	Agency	Municipality of Thessaloniki
8	OJ	

B. TEXT CONTENT

The study for the Revision of the General Urban Plan of Thessaloniki concerns the regional territory of the Municipality. The analysis of the Strategic Environmental Impact Assessment Study (SEIAS) was implemented at an agglomeration level, as most of the environmental issues concern and are affected by the whole territory.

The SEIAS aims at sustainable development with the integration of the environmental component in the design phase of programs and plans of strategic importance, as in this case the study of the Review of the General Urban Plan of Thessaloniki. The integration of the environmental dimension in the design is expected to result in the minimization of unwanted consequences.

1.1 SUMMARY DESCRIPTION OF THE PROPOSAL

1.1.1 SPATIAL ORGANISATION PLAN

The spatial organisation proposal aims at:

- strengthening of the city centre and its extension to the west
- its development to serve residential areas in the east
- maintaining houses and attracting new settlers, especially of the Historic Centre
- improving visitors' experiences and improving residents' living conditions
- investigating whether there are main and secondary free spaces in the urban fabric and securing them

2030 is the year that is set as target, and the number of inhabitants was estimated in 360,000 inhabitants.

1.1.3 GENERAL URBAN PLANNING ORGANISATION AND SETTLEMENT OF OTHER URBAN AREAS

1.1.3.4 Built-Surface Ratio (BSR)

The following are suggested:

A. In the area within the plan, determination of Built-Surface Ratio in sections of Districts and of the corresponding limits of the existing Building Factors of each area.

B. In the extensions of the city plan, definition of BSR within the limits provided by the relevant institutional framework

C. Validity of the provisions of NOK (L.4067 / 2012) only to the extent that the final level does not exceed 2.4 except for the unification of uncovered spaces.

D. Functions and activities that are governed by the same institutional framework of building conditions are not affected by the regulations, unless otherwise explicitly stated.

E. Cases of special provisions of building codes still apply, even if they exceed the proposed BSR.

For areas that show special features the following are suggested:

I. Area of "Building Units"

the maintenance of the zone as an area of special (approved) codes

II. City Centre Area

Preparation of a special study with a view to determine the SR framework adapted to the specifics and the special characteristics and needs of development and protection of the target area.

III. Ano Polis Area

Maintaining the current special regulations of the area

IV. Allatini Ceramics Area - SE Gate

It is proposed to determine the area within which it is possible to build in derogation of the provisions for SR (exclusively for state or municipal plots, including any products of land contribution), in the percentage of coverage, building height, location, and building use, after the observance of the prescribed procedures.

V. Expansion of Lachanokipi area

In the proposed extensions of the area of Lachanokipi it is desirable to:

- Ensure the layout of buildings and the continuity of the courtyard, in order to maximize the public environmental benefit for the area.
- Implement pilot urban development or reconstruction programs.
- Address the degradation problem of residential areas, development problems and economic cohesion

1.1.3.5. Special Interest Areas

Metropolitan Park (White Tower, YMCA park, free spaces of the Archaeological and Byzantine

Museum, City Hall, western part of today's Thessaloniki International Fair, free green spaces of the Aristotle University of Thessaloniki, park of the Tellogleio Foundation, the parks that will be formed in the area of Evangelistria, the gardens of Passas' and the east walls, and the free spaces that may arise in the area of the NRDC-GR(Γ'ΣΣ) and the Military Museum)

It is proposed to be treated and organized as a single area ensuring and promoting its character as a Green Space and Cultural Centre of Metropolitan Level.

Thessaloniki International Fair (TIF)

The proposal of the TPS is summarised:

- i. In the planning of the implementation of a new exhibition area of high standards with the possibility of supporting large events outside the central urban area
- ii. In the transformation of the TIF and its reconstruction into a smaller exhibition-conference area, with the removal of part of the existing building facilities.
- iii. In the removal of about half of the current area and its inclusion in the Metropolitan Park.

Sea Front - Nikis Avenue

Palia Paralia - Nikis Avenue

It is proposed to investigate the undergrounding of Nikis Avenue, with a simultaneous beach extension, and the rendering of its above-ground area as a public space, with simultaneous pedestrianization of the blind sections of the vertical streets that will be created.

Nea Paralia - Concert Hall / Poseidonio / Allatini Mills

It is proposed to prepare a special, multifactorial study, with a comprehensive approach to address the typical and substantive problems of the area.

Nea Paralia - Zone between M. Alexandrou Avenue and Building Units

An intervention similar to that of the area downstream of M. Alexandrou Avenue is proposed.

Marines

It is proposed to provide the possibility of locating up to two marines (either alternatively or as a network development) in positions '2' (in the extent of the naval groups) and '4' (behind Poseidonio).

Southeast Gate (Allatini Ceramics)

Proposal of Urban Planning Organisation

It is proposed to designate the area as a "special regulation", which will be based on the elaboration of a comprehensive Urban Plan for Expansion/Revision (UPE/R), given the fact that the intervention area is suggested to belong to a single Urban Unit.

Part of the Large Stream/Kyvernio Stream

An Urban Expansion Study (integration) is already being prepared based on the corresponding forecast and the current ΓΠΣ-Θ/1993.

Military installations within the urban area

Referring to the following facilities:

- i. Formerly-Farmaki's Military Camp
- ii. Pedion tou Areos Military Camp – NRDC-GR(Γ'ΣΣ)
- iii. Former-Military Camp-TIF area- Park of Anthokomiki
- iv. Kotta Camp - formerly 424 General Military Hospital
- v. Foka Camp - Military School of Officers
- vi. Mystakidis Camp
- vii. Maritime Administration Camp of Northern Greece

The possibilities of interventions for the provision of spaces or areas of social services or the possibility of public access to free spaces are expanded.

1.1.3.7. Interventions for upgrading and revitalizing urban space

Integrated territorial and urban strategies

Network for the enhancement of the non-motorized transportation - Urban space improvements

To shape this network, interventions are proposed on roads ranging from sidewalk widening, road remodelling, to even creation of sidewalks. The main streets that are included are: Nikis Avenue, Mpotsari Str., P. Syndika Str., Solonos Str., Karakasi Str., Ermou Str., V. Heraklion Str., Agia Sofia Str., D. Gounari Str.

Renewals - Urban Reconstruction

The suggested areas are the following: Chrimatistiriou Sqr- Ag. Minas, b) Area of western walls and 12 Apostolon, c) "Armenika" district

1.1.3.8 Transportation Network – Traffic

Road network

Interventions on the streets are proposed:

- Nikis Avenue (undergrounding, pedestrianisation)
- Ermou (by K. Dil-Venizelou, convert to mild traffic)
- 3rd of September (connection with Eastern Region)
- Ethnikis Aminis- Evangelistria - East. Ring road
- Botsari - Syndika (one-way or one-way pedestrian, sidewalk extension of both)
- Solonos (creation of sidewalks)

- Karakasi (creation of sidewalks)
- Completion (opening) Michael Psellou - M. Psellou - Ypsilandou - Papanastasiou

Parking

The following areas are proposed to be looked up to secure parking spaces:

- i. Parking in the area of N. Elvetia, in the area of the Theatre 'Gis', in the area of the Intermodal Freight Centre of Thessaloniki
- ii. Parking spaces in the wider area of the west entrance of the centre. There are 2 areas on either side of the west entrance on the City Gate Road, one of which is again in the area of Intermodal Freight Centre of Thessaloniki, as well as four (4) areas at the intersection of Agiou Dimitriou and Lagada streets.
- iii. Parking spaces in the wider area of the north entrance of the centre. Included:
- iv. Public space at the intersection of Agios Dimitrios and Katsimidi streets
- v. Underground parking under the university football field (on A. Dimitriou Street)
- vi. Utilisation of an old building of AUTH (intersection of 3rd of September and A. Dimitriou)
- vii. Utilisation of the old facilities of TEFAA as well as the former residences intended for officers serving in the NRDC-GR(Γ'ΣΣ). The existing open space in front of Alexandreio Melathron will be added to the utilisation of the space (intersection of September 3rd and K. Karamanli)

4.3.2 PROGRAMMED SIZES-DENSITIES

4.3.2.1 Capacity Calculation

The programmed size of the population of the Municipality is 360,000 inhabitants. The distribution of this size in the proposed Districts is done with care to be in harmony, with the corresponding Capacity.

Population program size table and average mixed densities

District Code	District Name	Capacity	Area (Ha)	Design population	Design's density
Σ1	Aristotelous sqr.	4.002	49.8	2.500	50
Σ2	White Tower	20.130	66.1	20.000	302
Σ3	Kamara-Rotonta	23.897	58.0	23.000	397
Σ4	Dioikitirio	21.434	59.3	21.000	354
Σ5	Ano Poli-Eptapirgio	15.134	94.5	15.000	159
Σ6	40 Ekklesies	7.120	47.6	7.000	147
Σ7	Panagia	9.066	28.0	9.000	322

	Faneromeni				
Σ8	Xirokrini	11.387	51.8	11.000	212
Σ9	Giannitson-Terminal Station	7.187	101.5	6.500	64
Σ10	FIX-Lachanokipi	4.357	130.1	4.000	31
Σ11	Ag. Triada	22.110	65.6	21.000	320
Σ12	Ippokrateio-Faliro	21.733	65.0	21.000	323
Σ13	Analipsi-Botsari	27.700	74.5	27.000	362
Σ14	Martiou	23.822	61.2	23.000	376
Σ15	Depo	23.877	113.9	23.000	202
Σ16	Voulgari-Kifisia	6.075	46.8	6.000	128
Σ17	N. Elvetia	4.112	50.3	4.000	80
Σ18	Trochiodromika	7.105	51.0	7.000	137
Σ19	Charilaou	22.828	76.8	22.000	286
Σ20	Kato Toumba	25.579	83.3	25.000	300
Σ21	Papafi	13.212	59.0	13.000	220
Σ22	Ano Toumba	18.145	82.5	18.000	218
Σ23	Malakopi	20.069	77.6	20.000	258
Σ24	Triandria	11.182	50.7	11.000	217
Total		371.261	1.644,9	360.000	219

F. UTILIZATION FRAMEWORK

1	Comments / Observations	For the location of the charging points of electric vehicles, the interventions in the road network and in the parking lot should be taken into account, as well as the interventions of upgrading and regenerating the urban space.
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6.2 Assessment of the LIFE ASTI contribution to the SECAPs under the 2030 Covenant of Mayors

The European Covenant of Mayors, launched in 2008 on climate and energy, brings together thousands of local authorities who voluntarily commit themselves to implement EU 's climate and energy objectives. The goal set by the Municipality of Thessaloniki through the Sustainable Energy

Action Plan is to reduce by 20% carbon dioxide emissions by 500,000 tons approximately i.e., 20% (SEAP, 2014).

The urban heat island (UHI) effect is an important parameter of the urban microclimate, turning large urban centres into sources of pollution and heat. Materials with high absorptivity such as asphalt and concrete, as well as the corresponding contribution to the absorption of heat from parked cars, turn buildings and cars into "heat conductors" that emit the heat that they have absorbed during the day. This phenomenon is directly burdened by activities related to the needs for heating and cooling during the year but also those that arise from travel needs. An aggravating and equally important element is the phenomenon of energy poverty. Finally, the lack of green spaces and open water spaces like ponds or fountains in the cities is aggravating the adverse effect of UHI.

The impact of climate change on urban areas through the relationship of microclimate with the UHI effect can be reduced through the proposed interventions outlined in the Action Plan for Sustainable Energy (SEAP) under the Covenant of Mayors.

According to the Sustainable Energy Action Plan of the Municipality of Thessaloniki (SEAP, 2014), the proposed interventions concern:

Advanced energy-saving interventions in municipal buildings

- ✓ Energy Upgrade of Building Shells
- ✓ Energy upgrading of electromechanical installations (upgrading of central heating system, air conditioning system upgrade)
- ✓ Installation of Renewable Energy Sources (RES)
- ✓ Installation of an Integrated Energy Management System
 - Bioclimatic upgrades of public spaces (Bioclimatic upgrading of public spaces aims to improve the microclimate and quality of urban space, as well as thermal / visual / acoustic comfort, which also implies the reduction of energy consumed in adjacent buildings, but also the reinforcement of walking and reducing movements with means of transport.)
 - Green roots (refers to improving the microclimate by planting donations and bioclimatic design in the surrounding area of buildings.
- ✓ Energy Upgrading of Municipal Infrastructures and public buildings
 - The long-term vision of the Municipality is to apply energy-saving interventions in all existing buildings that have this possibility. It is estimated that such intervention will reduce energy consumption by 21.017,000 kWh annually (50% of base consumption) and will lead to a reduction of carbon dioxide emissions of 11.614 tons of CO₂

Municipal street lighting

The proposed interventions seek to improve the lighting conditions, the Colour Efficiency Index of the emitted light, to reduce the light pollution and the released heat and mainly to reduce the energy consumption for lighting.

- ✓ Completed short-term pilot interventions (Energy management and upgrade of the network and the quality of the electric lighting of the Municipality, supply of integrated supervisory control system and management of electric light installations)
- ✓ Completed interventions of medium and large scale (Long-term program, where it is estimated that the energy saving potential in the Municipal lighting is of the order of 55%, amounts to 13.888,000 Kwh per year and corresponds to a reduction of 15.957 tons of CO₂)

Buildings, equipment / tertiary sector facilities (non-municipal)

- ✓ Energy upgrading of buildings (Saved energy 40% per building for mild interventions, as recorded in a national funding program for energy saving at home)
- ✓ Energy saving with smart meters (Consumers will benefit, by recording their energy consumption in real time and capturing the energy consumption profile on a 24-hour basis.)
- ✓ Energy saving with rational energy behaviour through informing the citizens

Interventions in the field of Transport

- ✓ Energy efficient municipal vehicles (Short-term measure of the Municipality concerning the supply of anti-pollution technology vehicles)
- ✓ Pilot urban mobility measure (Medium-term measure of the Municipality that concerns the information of pedestrians for measures to promote gait and increase the pedestrian movements in combination with the extension of the bicycle path)
- ✓ Long-term integrated urban transport plan under the Action Plan (Municipal fleet interventions, public and private transport that will result in total energy savings of 24% and correspond to a reduction of approximately 176.736 tons of CO₂)

Renewable energy sources

- ✓ Photovoltaics (Installations of solar photovoltaic systems in Public and Private spaces)
- ✓ Production of electricity from biogas (The operation of the unit is based on the decomposition of waste through which biogas is produced which is collected through special piping, burned in special machines, and produces electricity of 5 MW, capable of illuminating a city of 5,000 inhabitants)
- ✓ Biofuels (Production of 2nd generation biofuels, with increased sustainability)

Briefing / providing information to citizens and bodies

- ✓ Energy Days (The Municipality undertakes to organize Energy Days, in collaboration with the European Commission and other stakeholders, in order for the citizens to benefit directly from the opportunities and benefits arising from the more intelligent use of energy, as well as to inform regularly the local media on developments in the Action Plan.)
- ✓ Local Energy Forums (Aims at the participation of local stakeholders both in the configuration of the Municipal Action Plan for Sustainable Energy, as well as in their implementation and monitoring)
- ✓ Training / information of employees of the Municipality (Training for the adoption by the employees of the Municipality of those daily practices that contribute to energy saving)

Within this framework LIFE ASTI will contribute to the fulfilment of the covenant's goals since several efforts are being carried out in order to save energy and / or avoid its reckless consumption. In parallel, LIFE ASTI also include raising awareness campaigns and training seminars of similar to the covenant's issues.

6.3 Assessment of the LIFE ASTI contribution to the resilience strategy of Thessaloniki

Contribution to actions in the framework of 100 resilient cities initiative in Thessaloniki

The city of Thessaloniki has a dense urban structure with limited open or green spaces. There is currently, according to several studies about 2.6m² of green space per resident, compared to the European average of 8-10m². The absence or fragmentation of green and open space creates a shortage of suitable leisure environments and intensifies the impact of natural phenomena such as

high temperatures during the summer and intense rainfalls during the winter. This is further exacerbated by the high density of old, poorly maintained and energy inefficient buildings, particularly in the most popular neighbourhoods.

Thessaloniki is exposed to extreme conditions such as earthquakes, flooding, forest fires, snow, and heat waves. These events cause troubles to the proper operation of city services and local businesses. It is essential to get prepared for these events and incorporate disaster resilience into long term planning primarily through risk management and then by foreseeing future needs and design and react with empathy. This will enhance internal coordination and planning's continuity, in relation to emergency response alert and strengthening of stakeholders' collaboration.

Among the primary stresses which concern the city of Thessaloniki are the unemployment and diverse livelihood opportunities, the aging of buildings and mobility infrastructure, the lack of access to affordable health care and the insufficient integration of these points in planning.

As for the shocks, Thessaloniki is also exposed to some major natural hazards and shocks such as earthquakes, urban floods, and forest fires, as well as seasonal and weather-related events that interrupt city services and business continuity, such as snow, sub-zero temperatures, floods, and heat waves. Extensive flooding in 2009 and 2014 demonstrated that, despite Thessaloniki's favourable topography, flood mitigation infrastructure needs to be improved. Seven streams in the metropolitan area of Thessaloniki have been classified as prone to flooding. Due to poor historic urban development regulation, the combined sewer system currently cannot handle peak flows during flood events. The dense urban environment also prevents significant retention and storage of stormwater. This has contributed to infrastructure failures and localized flooding.

Part of the city's bypass road is now on the limits of the forest, and some of the city's infrastructure is located within the forest area. Consequently, the threat from wildfire to the city has increased. Climate change is also creating additional challenges for the protection of the peri-urban forest.

In 1978, an earthquake measuring 6.5 on the Richter scale struck the city leading to 49 deaths, severe damage to infrastructure and property, and an economic cost of USD 250 million. Projections indicate that an earthquake of the same magnitude today would cause 4% of the city's building stock to be damaged beyond repair.

The 100RC initiative is promoting the networking and communication among cities all over the world but also among cities and high caliber experts aiming to the exchange of know-how, experiences, and good practices.

The project "Resilient Thessaloniki" sets as a prerequisite for the establishment of effective strategic planning, the direct cooperation of the city with the civil society, local businesses, and agencies. Here after are being stated the most relevant parts of Resilient Thessaloniki project and how the LIFE ASTI may contribute on this regard.

With regards to Goal 1 (Shape a thriving and sustainable city with mobility and city systems that serve its people)

Its objectives are:

- Build an integrated resilient mobility system
- Adopt Transit Oriented Development (TOD)

- Develop smart urban logistics
- Move to clean power for transport
- Reduce air pollution and urban noise
- Reframe waste management
- Strengthen environmental public awareness for a stronger environmental policy
- Provide reliable communications & mobility
- Ensure continuity of critical services
- Maintain and enhance natural & man-made assets

Under the aim of fulfilling these objectives it is expected to improve intermodal transportation, reduce air pollution and tailpipe emissions, reduce congestion and delays, enhance recycling rate, and reduce carbon footprint.

About Goal 2 (Co-create an inclusive city that invests in its human talent)

In Objective H. Nature based solutions for green neighbourhoods, it is pointed out that

- ✓ “Thessaloniki has a dense urban structure with limited open and green spaces. It also has ageing building stock and extreme weather conditions including high temperatures during the summer and intense rainfall during the winter compound. These conditions are more evident in poorer neighbourhoods, where building stock is often poorly maintained.
 - ✓ To address environmental impacts on the city, we will develop the limited open spaces while creating spaces for social interaction. We will implement a combination of bottom-up and top-down solutions including green infrastructure (permeable surfaces, rain gardens, and green walls to manage storm water and mitigate the heat island effect) and low-cost solutions such as urban agriculture in inner courtyards, and on private balconies and rooftops.
 - ✓ Nature based solutions will help to harness the power and sophistication of nature to turn environmental, social, and economic challenges into opportunities. These solutions will contribute to creating green growth and “future-proofing” our society, as well as enhancing citizen well-being, and providing business opportunities. By creating multiple benefits for human health, the economy, society, and the environment, nature-based solutions represent more efficient and cost-effective solutions than traditional approaches – something particularly important during times of fiscal austerity” (Resilient Thessaloniki)
- Within this framework it is suggested to Action 01: Create a new natural landscape within the built environment, action 02: Install green roofs and green walls on schools and municipal buildings, action 03: Create pocket community gardens and action 04: Develop 'Adopt your Green Spot'.
- In parallel, objective I Child friendly city is also partially relevant since it enables actions to allow children play in the street and safely go to school. Green areas and shading may contribute on this regard.

About Goal 3 (Build a dynamic urban economy and responsive city through effective and network governance)

Objective H: Local risk reduction and risk management systems.

Action 06: Develop citizen emergency preparedness platform and networks

- We will develop a platform to empower local citizens to better prepare for and respond to emergency situations.
- This will include education programs, training, and volunteering opportunities, with a special focus on involving disabled people and the elderly, who are often at the greatest risk in times of crisis.
- We will create volunteering opportunities for local citizens to help their neighbours and support their community against threats from natural disasters and other emergencies.
- We will employ real-time technologies to improve communication between City departments and communities.

Objective I: Informed citizens and decision makers: The City of Thessaloniki will initiate new forms of interaction between citizens and businesses. Data is being collected by organizations, citizens and businesses which can be used to establish more responsive ways of managing city services including transportation, social services, tourism, air quality and so on. This will improve communication, enhance service provision, create more inclusive decision-making processes, and guarantee citizens' feedback on urban issues.

About Goal 4 (Re-discover the city's relationship with the sea - Integrated Thermaikos Bay)

Objective B: Environmental resilience monitoring: Thermaikos Bay has a fragile ecosystem. Currently, environmental data and physical measurements are collected by various stakeholders at multiple locations with varying sampling frequencies. The data is processed in an uncoordinated way. This goal will help to coordinate and integrate environmental data to produce valuable and meaningful information that can be used to inform decision making. Guidelines for monitoring will be set and data analysis will identify hot-spots where new frequency and density techniques should be established. Multi-stakeholder involvement is essential to create synergies, raising awareness and promote better regulation of the implementation.

Objective C: Restoration of the ecosystem: An efficient water monitoring system (addressing water quality, marine fauna, coastal erosions, etc.) provides the opportunity to plan projects that improve the overall marine quality and mitigate the consequences of prospective infrastructure. Examples of such projects include the rehabilitation of natural beaches, the upgrade of CSOs of the Water Company, the elimination of uncontrolled waste and wastewater point pollution sources, reduction of stormwater runoff through Sustainable Urban Drainage Systems, and implementation of large-scale projects beyond the metropolitan scale (e.g., the reduction of nutrient inflow from the Axios Delta area).

Cities can also request more specific technical advice from experts in the network and carry out Workshops with other cities to work on earthquakes management, fires, floods etc. and relevant risks.

Project **Life ASTI** will contribute to strengthen environmental public awareness for a more solid environmental policy. The tool created by Life ASTI will give the opportunity to residents and tourists to be informed or warned about urban heat Island effect, as for protecting their health, and especially those who belong to a vulnerable group and / or to amend their schedule accordingly when appropriate. Furthermore, the project also enhances green infrastructure and embraces activities already foreseen through 100 resilient cities initiative, such as turning neighbourhoods greener. The management of water resources in the city is also a common ground for both projects,

while pointing out of course its sustainable and reasonable use. Another common action of both projects is the collection and monitoring of reliable data. The development of the LIFE ASTI's tool may consist of the basis of a wider smart platform integrating also the characteristics foreseen by Resilient Thessaloniki. Last but not least, raising awareness is also foreseen by both projects. LIFE ASTI in particular has conducted several events addressed to the general public and / or relevant stakeholders, produced informative material and press releases.

6.4 Assessment of the LIFE ASTI contribution to the Strategic and Operational Planning of Thessaloniki

All local authorities of A' degree (Municipalities) are obliged to formulate an Operational Plan (4 years). These plans are formulated by the competent Municipal Unit (Dpt. of Operational Planning and Development Programmes Monitoring), which has taken actions to incorporate the fundings of the LIFE ASTI project in the Operational Plan of MoT.

More specifically, out of the 4 Pillars of MoT's Operational Plan, the project's findings are contributing to Pillar 1 "*Environment and Quality of Life*" (Measure: Increasing the resilience of MoT against climate change, Target: Climate change mitigation actions), and Pillar 2 "*Social Policy – Health – Education – Culture – Sports*" (Section: promotion and protection of public health, Measure: Health and social care, Target: Improvement of municipal health care services).

The inclusion of the Project's findings in the Operational Plan of MoT, is an additional asset in securing funds for implementing future technical projects, such as those that have been positively evaluated within LIFE ASTI.

7. FURTHER ACTIONS AND ASSESSMENT FOR THE CITY OF ROME

7.1 Assessment of the LIFE ASTI contribution to local plans

Results from the LIFE ASTI project can be contribute to other local plans in Rome such as the "Piano d'azione per l'energia sostenibile e il clima di Roma capitale – PAESC" which is included in the Covenant of Mayors actions for climate and energy in Europe presented by the municipality of Rome. The plan entails promoting mitigation measures that help contrast climate change and improving adaptation and resilience in particular understanding areas within the city most at risk to heat exposure and measures that while mitigation GHG emissions (green areas, active and sustainable mobility renewable sources energy) reduce heat exposure and UHI intensity and have health co-benefits thus promoting healthy lifestyles as well as improving adaptation to climate change. Monitoring of temperatures with the high resolution UHI monitoring network and forecast model set up by ISAC-CNR will help provide valuable data to support policy and actions. The PAESC aimed at improving resilience also includes actions to improve adaptation and early warning, here results from the LIFEASTI in terms of the UHI forecast on the web platform and more so the high-resolution Heat Health warning systems can help raise awareness and promote timely actions during heat waves.

In the Rome Resilient strategy of the 100 Resilient Cities network - pioneered by The Rockefeller Foundation (100RC), supports the introduction and integration of a vision of resilience that includes not only sudden events (earthquakes, floods, epidemics, etc.) but also chronic events that weaken the fabric a city every day or cyclically (high unemployment, inefficient or expensive public transport systems, forms of endemic violence or chronic food and water shortages, etc.). By mitigating the sudden and chronic events, a city may improve its ability to respond effectively and provide better basic services to the population.

Goal G - PREPARE THE CITY'S ADAPTATION TO CLIMATE CHANGE also addresses monitoring of heat waves and improving adaptation actions to reduce impacts. Data from LIFE ASTI using the monitoring network of temperature sensors set up by ISCA-CNR and the heat health warning system developed by DEASL can support local policy makers of the Municipality, of Health Services and well as the regional environment protection agency ARPA to detect critical areas at risk and address response measures as already mentioned in the sections above. The LIFE ASTI heat health warning is complementary to the one already in place in Rome as it is developed based on the same methodology but has the added value of providing specific forecast for each of the 15 districts of the Municipality of Rome. Furthermore, greening of urban areas to abate emissions as well as reducing heat (Goal G.1. Create green and blue infrastructure to reduce urban heat islands can also be supported by LIFE ASTI UHI campaigns again identifying areas most critical and providing updated and continuous monitoring data to evaluate interventions as well. Within LIFE ASTI simulations on how changing the albedo and land surface coverage, mentioned above, can help reduce heat was also carried out and this can support policy actions and selection of intervention in specific areas. Training material and information material developed (videos, infographics etc) can be used to help raise awareness and promote policies at local level as well as expertise by local researchers to include among expert working tables on these topics in the future in both the resilience strategy goal G2 - Assess the impacts of climate change and raise awareness among citizens and also mentioned in the PAESC.

8. CONCLUSIONS


To sum up, the Municipality of Thessaloniki faces the UHI effect due to significant air pollution related to urban development, its geographic relief, the concentration of population, the “using the car” mentality, the lack of sufficient – effective for its confrontation construction materials, the quality of the combustibles and fuels used for heating and transport, the meteorological conditions and all other factors that encourage the spread of the UHI's impact.

Particularly currently, that population struggles to recover from the economic crisis and the pandemic consequences that resulted to the reduction of living standards and the rise in oil prices, a sharp rise in energy poverty is being caused, resulting to the creation of new conditions, responsible for the cause of long-lasting episodes of air pollution, especially during the cold period of the year.

It is more than evident that this recently created situation calls for immediate actions. The Municipality of Thessaloniki, understanding this need proceeded to its participation at LIFE ASTI Project and this action plan to tackle the UHI effect and its side effects or related problems consists one of its solutions.

When it comes to the adaptation plans portfolio for the city of Rome, it is important to note some general information regarding the Italian population of Rome, the socio-economic situation, some geospatial, and climate data. For instance, the city after its expansion grew in a disorganized way which led to a different urbanised area alternated with green areas. Also, the Mediterranean climate that characterises Rome, as well as Thessaloniki, provides hot summers and mild winters resulting in a high UHI intensity during summer.

It is also important to mention the Italian Heat Health Adaptation plan (HHAP) to understand the current situation of existing adaptation plans. The heat plan is based on Heat health warning systems to be proactive regarding the impact of rising temperatures and heat waves. The involved stakeholders carry out all appropriate services to respond accordingly when it comes to heat waves



and high temperatures. The main difference between Thessaloniki and Rome is that Rome already has a valuable amount of private green areas making it less vulnerable to heat waves. In general, the Adaptation Action Plan measures per UHI scenario have a common goal, that of supporting future adaptation plans and providing a wider perspective.

Finally, the Municipality of Rome should implement actions and measures to mitigate the UHI effect and its consequences. Some of such measures could be the enhancement of bioclimatic design of municipal buildings, the development of shades throughout the city, and the maintenance of water presence in public spaces.

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10. ANNEX

CIRCULAR of the Ministry of Health for the Prevention of the effects of high temperatures and heatwave

<p>ΑΔΑ: 60Ψ2465ΦΥΟ-3ΗΞ</p> <p>ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ ΥΠΟΥΡΓΕΙΟ ΥΓΕΙΑΣ ΓΕΝΙΚΗ ΔΙΕΥΘΥΝΣΗ ΔΗΜΟΣΙΑΣ ΥΓΕΙΑΣ & ΠΡΟΤΗΝΤΙΑΣ ΞΕΝΩΝ ΔΙΕΥΘΥΝΣΗ ΔΗΜΟΣΙΑΣ ΥΓΕΙΑΣ & ΥΠΕΙΝΙΚΗΣ ΠΕΡΙΒΑΛΛΟΝΤΟΣ</p> <p>Ταχ. Δ/ση : Αριστοτέλους 17 Ταχ. Κώδικας : 104 33 Πληροφορίες : Τμήματα Α, Β Τηλέφωνο : 21032561344, 21032161325 e-mail : ddyg@moth.gov.gr</p> <p>Αθήνα, 26-07-2021 Αρ. Πρωτ: Δ1/ΓΠ οικ. 47303</p> <p>ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΘΕΜΑ: Πρόληψη των επιπτώσεων από την εμφάνιση υψηλών θερμοκρασιών και καύσωνα</p> <p>ΕΓΧΕΙΡΗΔΙΟ</p> <p>α. Η με κ.π. Δ1/ΓΠ οικ. 38795/22-06-2021 εγκύκλιος της Υπηρεσίας μας με θέμα «Πρόληψη των επιπτώσεων από την εμφάνιση υψηλών θερμοκρασιών και καύσωνα» (ΑΔΑ: 660Κ465ΦΥΟ-ΟΜΕ)</p> <p>β. Η με κ.π. Δ1/ΓΠ οικ. 30790/15-05-2020 (εγκύκλιος της Υπηρεσίας μας με θέμα «Επικαιροποίηση της Δ15/ΓΠ οικ. 26335/23-04-2020 Εγκύκλιος – Διευκρίνιση για τη χρήση κλιματισμού κατά τη θερινή περίοδο» (ΑΔΑ: 6ΥΥ6465ΦΥΟ-Φ705)</p> <p>γ. Το έντυπο «Οδηγίες Προστασίας από τον Καύσωνα» της Γενικής Γραμματείας Πολιτικής Προστασίας (στην ιστοσελίδα https://www.athenscity.gr/sa/roods/6863)</p> <p>δ. Το από 26-07-2021 Δελτίο Επιχειρήσεων Ευρωπαϊκού Φωτισμού της ΕΜΥ (http://www.hemg.gr/emg/his/meteorology/meteorological_news.htm και http://www.hemg.gr/emg/his/meteorology/meteorological_news.htm)</p> <p>1. Εμφάνιση συνθηκών ανόδου της θερμοκρασίας στη χώρα</p> <p>Σύμφωνα με τα (5) σχετ., οι θερμές αέριες μάζες που κινούνται από την Β. Αφρική προς τη χώρα μας αναμένεται να προκαλέσουν αισθητή άνοδο της θερμοκρασίας από αύριο Τρίτη 27-07-2021. Η θερμοκρασία αναμένεται να είναι ιδιαίτερα υψηλή από την Πέμπτη 29-07-2021 έως και την Τρίτη 03-08-2021 σε ολόκληρη τη χώρα.</p> <p>Σύμφωνα με τον ΠΟΥ*, η κλιματική αλλαγή συνεπάγεται να επηρεάσει δυσμενώς τη συχνότητα και την ένταση ακραίων φαινομένων, συμπεριλαμβανομένων και των φαινομένων καύσωνα.</p> <p>* Heat waves: risks and responses, Health and Global Environmental Change Series, vol. 2, World Health Organization, 2008</p>	<p>ΑΔΑ: 60Ψ2465ΦΥΟ-3ΗΞ</p> <p>Ως καύσωνα μπορεί να οριστεί μία περίοδος με ασυνήθιστα υψηλές θερμοκρασίες και πολύ χαμηλή ή πολύ υψηλή (ανάλογα με την περιοχή) σχετική υγρασία, χωρίς σαφώς καθορισμένη στιγμή έναρξης και πάους, διάρκειας τουλάχιστον 2-3 ημέρες και σημαντική επίδραση στην ανθρώπινη δραστηριότητα και στα οικοσυστήματα².</p> <p>Στον ανθρώπινο οργανισμό ο κυριότερος μηχανισμός ρύθμισης της θερμοκρασίας του σώματος είναι μέσω της εδάφησης του ιδρώτα (~75%) και έντονη η αντανάση και η άμεση εκπομπή θερμότητας. Αντίστοιχα, ο κύριος μηχανισμός πρόληψης θερμικής ενόχλησης παραμένει η άμεση και έμμεση έκθεση στην ηλιακή ακτινοβολία. Όταν η εξωτερική θερμοκρασία και η θερμοκρασία του σώματος έχουν μικρή διαφορά, η μείωση της θερμοβαθμίδας (διαφορά θερμοκρασίας σώματος και εξωτερικής θερμοκρασίας) μειώνει και το ρυθμό ανταλλαγής θερμότητας με το εξωτερικό περιβάλλον, με αποτέλεσμα να δυσχεραίνεται η αποτελεσματική ρύθμιση της κορπιακής θερμοκρασίας, το οποίο ενδέχεται να οδηγήσει σε δυσμενείς επιπτώσεις στην υγεία³.</p> <p>2. Οδηγίες προστασίας</p> <p>Λαμβάνοντας υπόψη το (δ) σχετ. δελτίο της ΕΜΥ, υπενθυμίζονται οι συστάσεις της (α) σχετ., οι οποίες έχουν ως ακολούθως:</p> <p>2.1. Παθολογικές καταστάσεις από υψηλές θερμοκρασίες και οδηγίες αντιμετώπισής τους.</p> <p>Όταν η θερμοκρασία του περιβάλλοντος ανέλθει σε όρια μη ανεκτά από τον ανθρώπινο οργανισμό σε συνάρτηση με άλλους παράγοντες (υγρασία, άπνοια κ.λπ.), δημιουργούνται παθολογικές καταστάσεις ποικίλου βαθμού βαρύτητας, που μπορούν να οδηγήσουν σε βαριά νόσηση έως και στο θάνατο. Τα αρχικά συμπτώματα μπορεί να είναι: δυνατός πονοκέφαλος, ατονία, αίσθημα καταβολής, τάση για λιποθυμία, πτώση της αρτηριακής πίεσης, ναυτία, έμετος και ταχυπαλμία. Το σύνδρομο της θερμοληξίας εκδηλώνεται με: ζαφνική αύξηση της θερμοκρασίας του σώματος (>40.5° C), κόκκινο, ζεστό και ξηρό δέρμα (η εφίδρωση έχει σταματήσει), ήπρη προημένη γλώσσα, ταχυπαλμία, ταχύνοτα, έντονη δίψα, πονοκέφαλος, ναυτία, έμετος, ζάλη, σύγχυση, αδυναμία προσανατολισμού και καθαρή ομιλία, επιθετική ή παράενη συμπεριφορά, σπασμοί, απώλεια συνείδησης ή κώμα.</p> <p>Η θεραπεία των ατόμων που παρουσιάζουν τα παραπάνω συμπτώματα, όταν η θερμοκρασία του περιβάλλοντος είναι υψηλή, πρέπει να γίνεται κατά προτίμηση σε νοσηλευτικό ιδρύματα, αλλά ως πρώτες βοήθειες μέχρι τη διακομδή τους σε αυτά θα πρέπει να εφαρμοστούν άμεσα μέτρα ελάττωσης της θερμοκρασίας του σώματος. Μεταφορά του θερμοληξικού άμεσα σε μέτρο δροσρό, εύδρο, σκιερό κατά προτίμηση κλιματιζόμενο (ανιέρω σχετ.), πλήρης</p> <p>² Heatwaves and HealthQ Guidance on warning system development, World Meteorological Organization and World Health Organization, 2015, p.17</p> <p>³ Heatwaves and HealthQ Guidance on warning system development, World Meteorological Organization and World Health Organization, 2015, p.20</p>
<p>ΑΔΑ: 60Ψ2465ΦΥΟ-3ΗΞ</p> <p>έκδοση από τα ρούχα, τοποθέτηση παγκοστών ή κρίων επιθεμάτων στον τράχηλο, τις μασχάλες και τη βουβωνική περιοχή, εμφάνιση σε μπανιέρα με κρύο νερό ή ντους ή ψεκασμό με κρύο νερό, παροχή μικρών γυάλινων δροσερών υγρών (νερού ή αραιωμένου χυμού φρούτων, 1 μέρος χυμού σε 4 μέρη νερού) αν μπορεί να καταπεί κ.λπ.</p> <p>2.2. Ποιός κινδυνεύει από τις υψηλές θερμοκρασίες:</p> <ul style="list-style-type: none">• ηλικιωμένοι• μωρά και μικρά παιδιά• έγκυες και θηλάζουσες γυναίκες• άτομα που είναι υπέρβαρα ή παχύσαρκα• άτομα που εργάζονται ή ασκούνται έντονα σε ζεστό περιβάλλον• άτομα με χρόνιες παθήσεις (καρδιαγγειακές παθήσεις, υπέρταση, σακχαρώδη διαβήτη, πνευμονοπάθειες, νεφροπάθειες, ηπατοπάθειες, ψυχική νόσο, άνοια, αλκοολισμό ή κατάχρηση ναρκωτικών ουσιών κ.λπ.)• άτομα με οξεία νόσο, όπως λοίμωξη με πυρετό ή γαστρεντερίτιδα (διάρροια ή / και έμετο)• άτομα που για καθαρά ιατρικούς λόγους παίρνουν φάρμακα για τα χρόνια νοσήματά τους, όπως π.χ. διουρητικά, αντιχολινεργικά, ψυχοφάρμακα, ορμονόχα (συμπεριλαμβανομένης της ινσουλίνης και των αντιδιαβητικών δισκίων). Ιδιαίτερα κατά την περίοδο των υψηλών θερμοκρασιών περιβάλλοντος θα πρέπει να συμβουλευούνται το γιατρό τους για την ανεχόμενη τροποποίηση της δοσολογίας. <p>2.3. Οδηγίες προφύλαξης του κοινού</p> <ul style="list-style-type: none">• Παραμονή σε χώρους που κλιματίζονται. Ειδικότερα κατά το χρονικό διάστημα που ισχύουν τα μέτρα πρόληψης και αντιμετώπισης της πανδημίας SARS-CoV-2, να τηρούνται σε όλους τους χώρους, δημόσιους και ιδιωτικούς οι διατάξεις της ανωτέρω σχετ. εγκύκλιου για τη χρήση των κλιματιστικών μονάδων, με σκοπό την προστασία της δημόσιας υγείας από τη μετάδοση του νέου κορωνοϊού. Στο πλαίσιο αυτό τονίζεται η αναγκαιότητα για τον συνεχή ή τουλάχιστο συστηματικό φυσικό αερισμό του χώρου μέσω ανοιγμάτων (παράθυρα, εξωτερικές θύρες) ακόμη και με την παράλληλη λειτουργία κλιματιστικών μονάδων (ανωτέρω σχετ.).• Ντύσιμο ελαφρύ και άνετο με ανοιχτόχρωμα ρούχα από πορώδες υλικό, ώστε να διευκολύνεται ο αερισμός του σώματος και η εδάφηση του ιδρώτα.• Χρήση καπέλου από υλικό που να επιτρέπει τον αερισμό του κεφαλιού.• Χρήση μαύρων ή σκουρόχρωμων γυαλίων ήλιου με φακούς που προστατεύουν από την ηλιακή ακτινοβολία.• Αποφυγή έκθεσης στον ήλιο, ιδίως για τα βρέφη και τους ηλικιωμένους.• Αποφυγή βαριάς σωματικής εργασίας.• Αποφυγή πολυώρων ταξιδιών με μέσα συγκοινωνίας που δε διαθέτουν κλιματισμό.	<p>ΑΔΑ: 60Ψ2465ΦΥΟ-3ΗΞ</p> <ul style="list-style-type: none">• Πολλά χλιαρά ντους κατά τη διάρκεια της ημέρας και τοποθέτηση δροσερών επιθεμάτων στο κεφάλι και στο λαιμό.• Μικρά σε ποσότητα και ελαφριά γεύματα φτωχά σε λιπαρά, με έμφαση στην λήψη φρούτων και λαχανικών.• Λήψη άφθονων υγρών (νερού και χυμών φρούτων), ιδιαίτερα από τα βρέφη και τους ηλικιωμένους και αποφυγή του αλκοόλ. Αν η εφίδρωση είναι μεγάλη, συνίσταται η πρόσθετη λήψη μικρών δόσεων αλατιού.• Άτομα που πάσχουν από χρόνια νοσήματα θα πρέπει να συμβουλευτούν τον θεράποντα ιατρό τους, από τον οποίο θα λάβουν επιρροσθετες οδηγίες ανάλογα με την κατάσταση τους καθώς και οδηγίες για την πιθανή αλλαγή της δοσολογίας της φαρμακευτικής τους αγωγής.• Οι ηλικιωμένοι να μην εγκαταλείπουν μόνοι τους αλλά να εξασφαλίζεται κάποιο άτομο για την καθημερινή τους φροντίδα.• Οι χώροι εργασίας πρέπει να διαθέτουν κλιματιστικά μηχανήματα ή απλούς ανεμιστήρες, κατά προτίμηση οροφής και σε κάθε περίπτωση φυσικού αερισμού των χώρων. Το ίδιο ισχύει και για τα ιδρύματα, που περιβάλλουν νεογνά, βρέφη, παιδιά, ηλικιωμένους και άτομα με ειδικές ανάγκες.• Τα μέσα μαζικής μεταφοράς πρέπει να φροντίζουν για την καλή λειτουργία του κλιματισμού τους λαμβάνοντας υπόψη τα προαναφερόμενα στο πρώτο εδάφιο των οδηγιών (-β- σχετ.), για την καλύτερη εξυπηρέτηση του κοινού. <p>2.4. Συνδυασμός συνθηκών καύσωνα και υψηλών συγκεντρώσεων ααωρούμενων σωματιδίων (ΑΖ₁₀)</p> <p>Ιδιαίτερη βαρύτητα θα πρέπει να δίδεται όταν οι υψηλές θερμοκρασίες συνδυάζονται και με φαινόμενα αυξημένων επιπέδων ααωσφαιρικής ρύπανσης.</p> <p>Συγκεκριμένα:</p> <ul style="list-style-type: none">• Για την περίπτωση υπέρβασης των ορίων του όζοντος στον ααωσφαιρικό αέρα, το Υπουργείο Υγείας έχει εκδώσει σχετικές οδηγίες για την ενημέρωση του κοινού με μέτρα προφύλαξης ειδικά των ευπαθών πληθυσμιακών ομάδων, οι οποίες έχουν ως εξής:<p>«Άτομα με αναπνευστικές και καρδιαγγειακές παθήσεις και γενικότερα άτομα ευαίσθητα στην ααωσφαιρική ρύπανση συνιστάται να παραμείνουν σε εσωτερικούς χώρους και να αποφεύγουν την κυκλοφορία στο εξωτερικό περιβάλλον. Επίσης, συνιστάται στα παραπάνω άτομα καθώς και τα παιδιά να αποφεύγουν την έντονη σωματική άσκηση, η οποία μπορεί να προκαλέσει ερεθισμό της αναπνευστικής οδού και να οδηγήσει σε αναπνευστικά προβλήματα».</p>• Για την προστασία της δημόσιας υγείας από ααωρούμενα σωματίδια (ΑΖ₁₀), το Υπουργείο Υγείας έχει εκδώσει την με αρ. πρωτ. ΔΥΤ2/Γ.Π.οικ.3191/14.1.14 (ΑΔΑ: ΒΨΠΘ-ΩΣ1) εγκύκλιο με συστάσεις προς το κοινό. Στον κάτωθι υπότοπο του Υπουργείου αναγράφονται συστάσεις

<p style="text-align: center;">ΑΔΑ: 60Ψ2465ΦΥΟ-3ΗΞ</p> <p>προς ενημέρωση και μέτρα προφύλαξης του κοινού, οποιαδήποτε ημέρα του έτους σημειωθεί υπέρβαση των συγκεντρώσεων των αιωρούμενων σωματιδίων, από τις οποίες μπορεί να ενημερώνεται το κοινό: (www.moh.gov.gr/articles/health/dieythynsh-dhmosias-ygieinhs/ygieinh-periballontos/prostasia-poiotitas-aera/3005-systaseis-gia-thn-atmosfairikh-rypansh).</p> <p>3. Χρήση κλιματισμού: ειδικές συστάσεις λόγω της πανδημίας του ιού SARS CoV-2</p> <p>Λαμβάνοντας υπόψη ότι για λόγους προστασίας ευπαθών ομάδων ενδέχεται να χρησιμοποιηθούν δημόσιες αίθουσες που διαθέτουν υποδομές κλιματισμού, υπενθυμίζεται η (β) σχετ. Εγκύκλιος της Υπηρεσίας μας, όπου λαμβάνεται υπόψη και η εξελισσόμενη πανδημία του κορωνοϊού SARS CoV-2.</p> <p>Επισημαίνεται ότι και οι Δήμοι, που συμμετέχουν στη συνολική προσπάθεια μεριμνώντας εγκαίρως για την οργάνωση και διάθεση δροσιστών και κλιματιζόμενων χώρων για το κοινό, πρέπει να ακολουθούν τις ισχύουσες οδηγίες για την πρόληψη και αντιμετώπιση της πανδημίας SARS-CoV-2 για την αποφυγή του συγχρωτισμού και την τήρηση των μέτρων ατομικής προστασίας. Επίσης, συστήνεται γενικότερα να συνεργάζονται με τις Υπηρεσίες των Περιφερειακών Ενοτήτων για την ενημέρωση του κοινού και για τη λήψη των αναγκαίων μέτρων.</p> <p>4. Πρόσθετες οδηγίες</p> <p>Επιπλέον οδηγίες διατίθενται και στο (y) σχετ. ενημερωτικό φυλλάδιο της Γενικής Γραμματείας Πολιτικής Προστασίας (https://www.civilprotection.gr/sa/node/4863)</p> <p>5. Ενημέρωση</p> <p>Συστήνεται στο κοινό να ακολουθεί τις οδηγίες των αρμόδιων Αρχών, οι οποίες φροντίζουν για την έγκαιρη και άμεση πληροφόρηση του κοινού με κάθε πρόσφορο μέσο. Δεν θα πρέπει να παραληφθεί ο σημαντικός ρόλος των Μ.Μ.Ε. της χώρας και της συνεργασίας μαζί τους, ώστε να επιτευχθεί μια ευρεία διάδοση των συστάσεων για τη λήψη των απαραίτητων μέτρων προστασίας.</p> <p>6. Επικοινωνία</p> <p>Τα τηλέφωνα των υπηρεσιών που βρίσκονται σε 24ωρη επιφυλακή και με τις οποίες μπορούν να επικοινωνήσουν οι πολίτες είναι τα ακόλουθα:</p> <ul style="list-style-type: none"> • Άμεση Δράση ΕΛΑΣ: 100 <p style="text-align: right;">5</p>	<p style="text-align: center;">ΑΔΑ: 60Ψ2465ΦΥΟ-3ΗΞ</p> <ul style="list-style-type: none"> • Πυροσβεστικό Σώμα: 199 • Υπηρεσία Επικοινωνιών Έκτακτης Ανάγκης: 112 • ΕΚΑΒ: 166 • ΚΕΠΙΧ Πολιτικής Προστασίας 210-3359002 <p>Το Υπουργείο Υγείας παραμένει σε πλήρη ετοιμότητα για να συνδράμει σε οποιαδήποτε ανάγκη ανακύψει.</p> <p style="text-align: right;">Ο ΓΕΝΙΚΟΣ ΓΡΑΜΜΑΤΕΑΣ ΔΗΜΟΣΙΑΣ ΥΓΕΙΑΣ</p> <p style="text-align: right;">Π. ΠΡΕΖΕΡΑΚΟΣ</p> <p><u>Πίνακας Αποδεκτών</u></p> <p>1. Όλα τα Υπουργεία Γραφεία κ.κ. Υπουργών (με την παράκληση να ενημερώσουν όλες τις υπηρεσίες και φορείς αρμοδιότητάς τους)</p> <p>2. Γενική Γραμματεία Πολιτικής Προστασίας Ευαγγελιστριάς 2, Τ.Κ. 105 63 – Αθήνα</p> <p>3. Κέντρο Επιχειρήσεων Πολιτικής Προστασίας (ΚΕΠΠ) Ριζαρείου 1, Τ.Κ. 152 33 - Χαλάνδρι</p> <p>4. Όλες τις Υ. ΠΕ. της χώρας Υπόψη κ.κ. Διοικήτων (με την παράκληση να ενημερώσουν τα νοσοκομεία και τους υγειονομικούς σχηματισμούς ευθύνης τους).</p> <p>5. Περιφέρειες της χώρας α. Γραφεία Περιφερειαρχών β. Γενικές Δ/νσεις Δημόσιας Υγείας και Κοινωνικής Μέριμνας (με την παράκληση να ενημερώσουν όλες τις Δ/νσεις Δημόσιας Υγείας και Κοινωνικής Μέριμνας των Περιφερειακών Ενοτήτων ευθύνης τους, οι οποίες με τη σειρά τους να προβούν στις δικές τους ενέργειες)</p> <p>6. Όλες τις αποκεντρωμένες Διοικήσεις (με την παράκληση να ενημερωθούν όλοι οι Δήμοι αρμοδιότητάς τους)</p> <p>7. Π. Ι. Σ. (με την παράκληση να ενημερώσει όλα τα μέλη του) Πλουτάρχου 3, Τ.Κ. 106 75 - Αθήνα</p> <p style="text-align: right;">6</p>
<p style="text-align: center;">ΑΔΑ: 60Ψ2465ΦΥΟ-3ΗΞ</p> <p>8. Ε. Κ. Α. Β., Λ. Μεσογείων 154, Τ. Κ. 156 69 - Αθήνα</p> <p>9. Ε.Ο.Δ.Υ Αγρόφων 3-5 Τ.Κ. 15121- Μαρούσι</p> <p>10. ΕΟΠΥΥ Υπόψη Προέδρου Κηφισίας 39, Τ. Κ. 151 23 - Μαρούσι</p> <p>11. Ο.ΚΑ.ΝΑ Αβέρωφ 21, Τ.Κ. 104 33 - Αθήνα</p> <p>12. Δ/ση Υγειονομικού ΓΕΘΘΑ Στρατόπεδο Παπάγου –Χολαργός (με την παράκληση να ενημερωθούν όλες οι Υγειονομικές Υπηρεσίες)</p> <p>ΕΣΩΤΕΡΙΚΗ ΔΙΑΝΟΜΗ</p> <ol style="list-style-type: none"> 1. Γραφείο Υπουργού 2. Γραφείο Υφυπουργού 3. Γραφεία Γενικών Γραμματέων 4. Γραφεία Γενικών Δ/ντών 5. Γραφείο Τύπου (με την παράκληση να ενημερωθούν τα Μέσα Μαζικής Ενημέρωσης) 6. Όλες τις Δ/νσεις και Αυτοτελή Τμήματα της Κ. Υ. του Υπουργείου μας 7. Δ/ση Δημόσιας Υγείας & Υγιεινής Περιβάλλοντος <p style="text-align: right;">7</p>	

(Source : <https://www.moh.gov.gr/articles/health/dieythynsh-dhmosias-ygieinhs/ygieinh-periballontos/prostasia-se-ektaktes-katastaseis/9128-prolhpshtwn-epiptwsewn-apo-thn-emfanish-ypsishwn-thermokrasiwn-kai-kayswna>)

General Secretariat's of Civil Protection Instructions / directions presented in 9 languages:

<https://www.civilprotection.gr/el>

SEVERE WEATHER PHENOMENA

GENERAL INSTRUCTIONS

- Be constantly informed by radio and television on the progress of the phenomena. The General Secretariat for Civil Protection and the National Meteorological Service are the formal sources of information.
- In case of emergency call alternatively: the Police (100), the Fire Service (199) the National Center for Emergency Care/ EKAB (166) or the European Emergency Call Number (112).
- Place the above mentioned phone numbers in a visible position inside the house and make sure that your children are informed of them, if they are able to use them.
- Help your children learn important family data such as their last name, the address and the phone number of your home.
- Explain to all family members when and how to switch off electric power, natural gas and water supply, how to use the fire-extinguisher and how to call for help.
- Be equipped with emergency equipment, such as a first aid kit, fire extinguisher, torch and batteries, a portable radio etc.
- Take special care of children and the elderly.

AFTER THE BAD WEATHER

- Be constantly informed by radio and television for formal warnings or advice.
- Check the house and the rest of your property to draw up a list of eventual damages.

If you are going to travel

- Be informed of the weather and the condition of the roads.
- Be prepared, according to your destination, for any weather phenomena you may encounter (snow, ice, hail, rainfall, etc.)
- Plan your movement in a way not to coincide with the peak of the weather phenomena.
- Travel during the day and prefer highways avoiding deserted and difficult to access roads.
- Inform all your relatives of the itinerary you intend to follow.
- Don't ignore the instructions of the General Secretariat for Civil Protection, the weather forecasts and the instructions of the Authorities, such as the Traffic Police, the Port Authority, the Fire Service, etc.
- Check the condition of your car before attempting any movement.
- Equip your car with all necessary equipment in order to face any heavy weather phenomena (tire chains, anti-freeze, umbrellas, raincoats, rubber boots, a torch, first aid kit etc).
- If you have to move on foot, put on suitable clothes and shoes.
- Be careful when walking in order to avoid being injured due to the slipperiness of the roads and pavements or due to objects falling by the wind or hail.
- Prefer public transport.
- Remain calm and be patient. Panic makes the situation worse.
- Facilitate the work of the Authorities.

Switch on immediately the central water supply valve and call a plumber.

- If you decide to defrost the pipes, start from the part of pipe near the valve so that the temperature change is gradual. If there are no results call a plumber.
- Check if the electrical installations are wet or in danger and insulate them.

HEAT WAVE

DURING A HEATWAVE

- Avoid sunbathing and remain in shaded and cool places avoiding crowded places.
- Avoid heavy physical work, particularly in places with high temperature, no wind and great humidity. Avoid walking for a long period of time or running under the sun.
- Prefer light, comfortable and light colored clothing from porous material in order to facilitate the airing of the body and the vaporization of sweat. Wear a hat or other head gear from natural material that permits the good airing of the head. Wear black or dark colored glasses with special layer which protect the eyes from the reflection of the sun.
- Prefer small and light meals, with emphasis on fruits and vegetables. Limit fatty foods.
- Drink large amounts of liquids (water and fruit juices). If sweating is intense, add salt to your food. Avoid alcoholic drinks.
- Have many lukewarm showers during the day and place wet washcloths on your head and neck.
- Take care of family members suffering from chronic diseases (respiratory, cardiovascular etc). Consult your doctor for the application of special instructions. For those who take medicines also consult their doctor.
- Avoid long travels with public transport when the heat is at very high levels.

CARE FOR BABIES AND CHILDREN

- Dress them as lightly as possible. Make sure their hands and feet are free and not covered by nappies.
- Make sure they are not exposed to the sun after swimming and they always wear a hat.
- In addition to milk, it is recommended they drink other liquids as well. Consult your pediatrician.
- As far as children are concerned, make sure they drink a lot of fluids (water and juices) and they eat more vegetables and fruits and fewer fats.

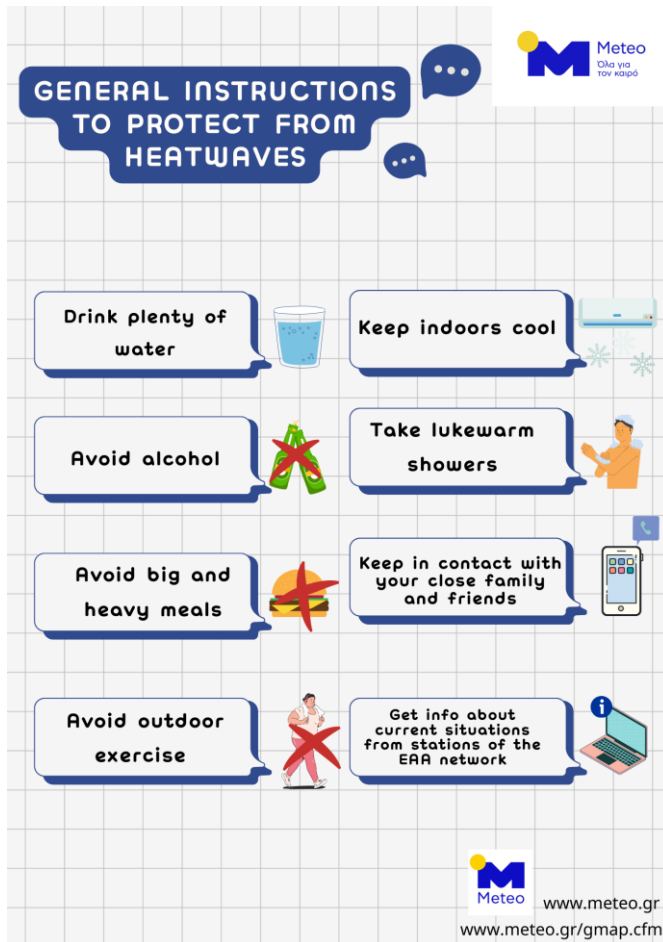
CARE FOR ELDERLY PERSONS

- Move them to cooler places or areas (seaside or mountain), as a very hot and damp environment becomes dangerous. Alternatively, take care that they stay in lower apartments of multi-storey houses.
- During nighttime keep the house open so that it is cooled and during daytime keep it hermetically closed.
- Don't leave elderly persons alone during summer vacations or during many days' absence from home. In the opposite case, make sure that a person takes care of them.

(source:

<https://www.patt.gov.gr/politis/22/%CE%B5%CE%BD%CE%B7%CE%BC%CE%B5%CF%81%CF%89%CE%BD%CF%8C%CE%BC%CE%B1%CF%83%CF%84%CE%B5-%CE%BA%CE%B1%CE%B9->

[%CF%80%CF%81%CE%BF%CF%83%CF%84%CE%B1%CF%84%CE%B5%CF%85%CF%8C%CE%BC%CE%B1%CF%83%CF%84%CE%B5/odigies-aftoprostasias-se-periptosi-ypsilon-thermokrasion-i-kai-kaysona/](#)).



GENERAL INSTRUCTIONS TO PROTECT FROM HEATWAVES

Drink plenty of water

Keep indoors cool

Avoid alcohol

Take lukewarm showers

Avoid big and heavy meals

Keep in contact with your close family and friends

Avoid outdoor exercise

Get info about current situations from stations of the ERA network

Meteo
Όλα για τον καιρό

Meteo
www.meteo.gr
www.meteo.gr/gmap.cfm

HEAT EXHAUSTION AND HEATSTROKE

What Are Symptoms of Heat Stroke?

- Throbbing headache.
- Dizziness and light-headedness.
- Lack of sweating despite the heat.
- Red, hot, and dry skin.
- Muscle weakness or cramps.
- Nausea and vomiting.
- Rapid heartbeat, which may be either strong or weak.
- Rapid, shallow breathing.



Who is at risk from high temperatures:

- Elderly.
- Babies and young children.
- Pregnant and breastfeeding women.
- People who are overweight or obese.
- People who work or exercise hard in a hot environment.
- People with chronic diseases (cardiovascular disease, hypertension, diabetes, lung disease, kidney disease, liver disease, mental illness, dementia, alcoholism or drug abuse).
- People with acute illness, such as fever or gastroenteritis (diarrhea or vomiting).
- People who for purely medical reasons take medication for their chronic illnesses, such as diuretics, anticholinergics, psychotropic drugs, hormones (including insulin and antidiabetic tablets).

How Can Heat Stroke Be Prevented?

When the heat index is high, it's best to stay in an air-conditioned environment. If you must go outdoors, you can prevent heat stroke by taking these steps:

- lightweight, light-colored, loose-fitting clothing, and a wide-brimmed hat.
- sunscreen with SPF of 30 or more.
- extra fluids. Drink at least eight glasses of water, fruit juice, or vegetable juice per day.
- additional precautions when exercising or working outdoors. The general recommendation is to drink 24 ounces of fluid two hours before exercise, and consider adding another 8 ounces of water or sports drink right before exercise. Reschedule or cancel outdoor activity. If possible, shift your time outdoors to the coolest times of the day, either early morning or after sunset.



MINISTRY OF HEALTH
www.moh.gov.gr



ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
Υπουργείο Υγείας





Beat the heat



what?

Extreme heat levels and heat waves occur whenever the temperature reaches high levels and the composition of heat and humidity makes the air suffocating.

who?



where?



Remember!

Temperatures that rise inside a closed, not air conditioned car, can be deadly



drink plenty of liquides and avoid sugar



stay inside cool places



wear light and light-coloured clothes

Save yourselves from

Heat stroke is a very serious medical emergency, that appears whenever the environment's temperature reaches high levels. Threatens life, due to insufficiency or malfunction of thermoregulatory mechanisms

symptoms



High body temperature $>40^{\circ}\text{C}$.



Pass out or loss of senses



tachycardia



muscle weakness or cramps



headaches



nausea and vomits



breathing discomfort



confusion and disorientation

Heat stroke

first aid



ASAP search for medical help



Move the person to a cool place with shade



Give plenty of fluids with small amounts of salt (to a conscious person)



Let the person lay down and lift their legs



Remove heavy clothing & let their body breathe



Cool patches on the body



www.pattikis.gr

Ministry of Health and Social Services
Government of the Republic of Armenia

HEAT WAVE SAFETY

LET'S BE SAFER THIS YEAR

- Avoid subbathing and stay in cool, dry places
- Avoid physically heavy work
- Avoid walking, jogging or running in the sun
- Prefer light, comfortable clothes
- Wear hats and sunglasses that reflect excessive sunlight
- Maintain a healthy diet which is essential for good health and nutrition



- Drink plenty of liquids (water & fruit juice)
- Lukewarm frequently showering
- Care about all of our family members, especially those suffering from chronic diseases (such as cardiovascular problems, respiratory problems etc.)
- Avoid long trips with public transportation, when temperature hits extremely high levels.



MINISTRY FOR CLIMATE CHANGE AND CIVIL
PROTECTION
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Heatwaves: Let's be safer this year

Babies:

- Dress them as lightly as possible. Make sure their hands and feet are free and not covered by nappies.
 - Don't let them stay under the sun after swimming and make sure they always wear a hat.
 - Apart from milk it is recommended that they drink other fluids such as chamomile, water etc.
- Especially for babies and children, it is a necessity that they consume more vegetables and less fat.



Elderly:

- Move them to cool places or areas like beaches or mountains, as a very warm environment with humidity can be dangerous. Alternatively, they should stay in low level apartments.
- Open the house at night so as to cool it down and keep it as closed as possible in the peak hours of heat during the day.
- Don't leave the older members of the family alone during summer vacation or long absence from the house. Alternatively, make sure that a person can take care of them.



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Telengana State successful visual informative material



CARE FOR THE OLD & FRAIL IN THE RISING HEAT

PRECAUTIONS FOR ELDERLY PEOPLE

- Check on them daily during extreme heat, especially if female live alone.
- Make sure they have access to a phone.
- If they seem to be suffering from heat stress, call them down.
- Use cool baths, showers, or place wet towels on their neck and wrists.
- Call a doctor at an emergency after taking steps to cool them down.
- Encourage them to keep a bottle of water with them at all times.

PROTECT YOUR ANIMALS FROM HEAT WAVE

PRECAUTIONS FOR PET DURING HEAT WAVE

- Provide shade and water at all times.
- If they seem to be suffering, take them to a vet immediately. Do not wait until it's too late. Check for signs of heat stress or dehydration, such as drooping ears, dry mouth, or lethargy.
- For those who cannot take them to a vet, call your vet for advice on how to cool them down.
- Take your pet to a shaded area, such as a garage or under a tree, and provide them with water.
- Consider using cooling mats or towels.
- Check on your pet daily, especially during the heat wave. If your pet is not eating or drinking, or if they seem to be suffering, take them to a vet immediately.
- Never leave your pet alone in a car, as the temperature inside can rise very quickly and become deadly.

PROTECT YOUR CHILDREN FROM THE HEAT WAVE

PRECAUTIONS FOR CHILDREN

Children should:

- Always carry a bottle of water. Drink more water than you think you need.
- Wear light-colored, lightweight, loose-fitting clothes.
- Cover their head and face with a hat and sunglasses.
- Avoid sunbathing, playing, or being outdoors for long periods of time.
- Stay out of direct sunlight, especially during peak hours from 11 a.m. to 3 p.m. They can get sunburned very easily.
- Take the 10-10-10 rule: 10 minutes of shade, 10 minutes of rest, and 10 minutes of water.

PROTECT YOUR INFANTS FROM THE HEAT WAVE

10 THINGS YOUR INFANTS SHOULD

- Go outdoors less frequently in hot weather. Vehicles can rapidly heat up for the geriatricians' reasons.
- Give them plenty of fluids to drink. Learn how to identify heat-related dehydration signs.
- Check on the child for concentrated (dark-colored) urine, which can indicate dehydration.

Do not go out barefoot

Avoid cooking during peak hours

Avoid going out in the sun, especially between 12.00 noon and 3.00 p.m.

Heatwave Hacks

Heatwave Hacks

- Create a breeze inside your home by strategically opening your windows on opposite ends to create cross ventilation.
- A cluttered room feels hot! Remove unnecessary clutter, furniture, books, newspapers and magazines from the room to make it more airy.
- White roof/terraces reflect the heat and help keep the house cool.



Fuori casa

- Evitare di esporsi al caldo e al sole diretto: temperatura e umidità elevate non possono prevenire il rischio di infezione, mentre possono provocare sintomi associati al caldo e ustioni.
- Uscire nelle ore più fresche, mantenendo la distanza di almeno un metro dalle altre persone. Quando disponibili, utilizzare i gel igienizzanti per le mani. Indossare i dispositivi di protezione secondo le norme vigenti, anche se fa caldo.
- Ritirarsi in luoghi pubblici come parchi e giardini nelle ore più fresche della giornata rispettando sempre le distanze di sicurezza. Evitare i luoghi affollati.

In casa

- Assicurare un adeguato ricambio di aria è utile per ridurre il rischio di trasmissione del virus: la ventilazione naturale determina il miglior ricambio dell'aria rispetto alla ventilazione meccanica.
- Assicurarsi che le stanze dove si soggiorna più a lungo siano mantenute fresche. Se si usa un climatizzatore, effettuare la pulizia dei filtri e comunque arieggiare spesso la stanza.
- Seguire le buone regole di igiene della casa, privilegiando detersivi a base di alcol o candeggina per eliminare possibili tracce del virus.

IN GENERALE, SCEGLIERE UNO STILE DI VITA FISICAMENTE ATTIVO E UNA DIETA SANA. BERE PIÙ SPESSO QUANDO FA MOLTO CALDO E RINFRESCARSI BAGNANDOSI CON ACQUA FRESCA

PER CHI È PIÙ VULNERABILE




- I sottogruppi suscettibili al caldo sono più a rischio di complicazioni in caso di infezione da COVID-19.
- Restare a casa, sia per proteggersi dal caldo, che per limitare il rischio di infezione da COVID-19. Garantire l'assistenza e la continuità delle terapie. Non sospendere le terapie in corso. Non ci sono farmaci che aumentano i rischi associati al COVID-19.

- Informarsi sulle nuove modalità da seguire per chi ha una malattia cronica affinché possa effettuare le necessarie visite programmate, terapie o analisi cliniche.
- Accertarsi che familiari, amici e vicini vulnerabili che vivono soli abbiano aiuto per la spesa e per i farmaci.

RICONOSCERE I SINTOMI

Riconoscere i sintomi COVID-19

- febbre $\geq 37.5^{\circ}\text{C}$ e brividi
- tosse di recente comparsa
- difficoltà respiratoria
- riduzione/perdita dell'olfatto e del gusto
- Sintomi meno specifici: cefalea, dolori muscolari, debolezza, vomito e/o diarrea.

Patologie associate al caldo

Disidratazione

- fate sudorazione e sete
- cute e mucose secche
- ridotta diuresi, urina scura

Crampi muscolari, edemi alle gambe, svenimenti, vertigini

Stress da calore

- malessere, tachicardia
- nausea, vomito
- cefalea, confusione

Colpo di calore

- cefalea, tachicardia
- iper ventilazione
- febbre
- aritmie, shock

RICORDARSI CHE LA FEBBRE PUÒ ESSERE ANCHE IL SINTOMO DI UN DISTURBO DOVUTO AL CALDO

Durante l'epidemia di COVID-19 se si ha febbre con tosse e debolezza è importante:

- Restare a casa per limitare i contatti con altre persone.
- Se possibile soggiornare in una stanza ben ventilata separata dal resto della famiglia.
- Indossare la mascherina se si è a contatto con altre persone.
- Separare asciugamani, lenzuola e stoviglie da quelle del resto della famiglia.

Se i sintomi persistono o si sospetta di essere stati a contatto con un malato di COVID-19, chiamare il medico di famiglia o i numeri verdi per il COVID-19 predisposti dalle regioni.

Utilizzare i numeri di emergenza 112/118 solo in caso di peggioramento dei sintomi o difficoltà respiratoria



Se hai bisogno di informazioni sul COVID-19
puoi contattare il numero verde
della Regione Lazio

Numero Verde
800.11.88.00

I bollettini di previsione e allarme sono pubblicati
giornalmente sul sito del **Dipartimento di Epidemiologia**
del SSR Lazio - ASL Roma 1

www.deplazio.net

Piano regionale per la prevenzione degli effetti sulla salute
delle ondate di calore in presenza dell'epidemia COVID-19

www.salutelazio.it

www.salutelazio.it/nuovo-coronavirus