asti

forecAsting System for urban heaT Island effect

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

Action C.5 **Development of UHI adaptation action plans**

C.5.2 **Good Practice Guidebook (GPG) for combating UHI and increasing resilience to heat**

Thessaloniki, December 2021

The project Implementation of a forecAsting System for urban heat Island effect for the development of urban adaptation strategies - LIFE ASTI has received funding from the LIFE Programme of the European Union”.

www.lifeasti.eu

Table of contents

–

Document Information	
Grant agreement number	LIFE17 CCA/GR/OOO108
Project acronym	LIFE ASTI
Project full title	Implementation of a forecAsting System for urban heaT Island effect for the development of urban adaptation strategies
Project website	http://www.lifeasti.eu/
Project instrument	EUROPEAN COMMISSION - European Climate, Infrastructure and Environment Executive Agency (CINEA)
Project thematic priority	Climate Change Adaptation
Deliverable type	Report
Contractual date of delivery	31/12/2021
Actual date of delivery	29/12/2021
Deliverable title	C.5.2 Good Practice Guidebook (GPG) for combating UHI and increasing resilience to heat
Action	C.5 Development of UHI adaptation action plans
Authors	Spiros Vasiliadis, Alexander Deliyannis, Elissavet Pavlidou, Aikaterini (Katia) Chagiou, Artemis Margaritidou and Ioanna – Vasiliki Pothitaki, Christos Giannaros and Serafeim Kontos, Giampietro Casasanta

Version History

Issue Date	Version	Author	Partner
12/7/2021	V.1	Spiros Vasiliadis and	SYMPRAXIS TEAM P.C.

		Alexander Deliyannis	
15/12/2021	V.2	Spiros Vasiliadis and Alexander Deliyannis	SYMPRAXIS TEAM P.C.
29/12/2021	V.3	Christos Giannaros and Serafeim Kontos	Aristotle University of Thessaloniki
		Giampietro Casasanta	Institute of Atmospheric Sciences and Climate, National Research Council of Italy ISAC - CNR
		Elissavet Pavlidou (ed.), Aikaterini (Katia) Chagiou, Artemis Margaritidou and Ioanna – Vasiliki Pothitaki (ed.)	Municipality of Thessaloniki (and LEVER S.A.)
		Spiros Vasiliadis and Alexander Deliyannis (eds.)	SYMPRAXIS TEAM P.C.

DELIVERABLE C.5.2: GOOD PRACTICE GUIDEBOOK (GPG) FOR COMBATING UHI AND INCREASING RESILIENCE TO HEAT

PART A: General presentation of the Project LIFE ASTI and UHI effect

A.1. The LIFE ASTI Project

The LIFE ASTI project focuses on addressing the Urban Heat Island (UHI) effect and its impact on human mortality by developing and evaluating a pilot system of numerical models. This pilot system will lead to the short-term forecasting and future projection of the UHI phenomenon in two Mediterranean cities: Thessaloniki (Greece) and Rome (Italy).

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

The modeling system, which will be developed in the framework of the LIFE ASTI project, will produce high-quality forecasting products, such as bioclimatic indicators, heating and cooling degree days, assessing the energy needs of buildings. In addition, it will guide the Heat Health Warning System to be implemented in both cities and will aim at informing the competent authorities, the general population and the scientific community.

A.2. Introduction on the UHI effect over Europe and especially over the Mediterranean Region

The Urban Heat Island (UHI) effect is attributed to increasing urbanisation trends, which cause structural and land cover changes in urban areas. The UHI effect appears in almost every type of urban area and is irrelevant of their size or climate (Stewart & Oke, 2012). In order to tackle this phenomenon and develop effective mitigation and adaptation strategies, it is important to identify the different causes and drivers of the UHI effect, as well as the risks and impacts for urban populations.

A.2.1 Causes of the UHI effect

Surfaces in urban areas are composed mostly of non-reflective and water-resistant construction materials, which absorb a considerable proportion of the incident radiation, which is released as heat. Moreover, the narrow building arrangements usually found in cities create an urban street canyon geometry that inhibits the escape of the reflected radiation, which is absorbed by the building walls, enhancing urban heat release. Additional factors contributing to the UHI effect are the: (i) scattered and emitted radiation from atmospheric pollutants, (ii) production of waste heat from air conditioning, refrigeration systems, industrial processes and motorized vehicular traffic, and (iii) obstruction of rural air flows by the windward face of the built-up surfaces (Figure 1) (Urban Heat Islands, 2019).

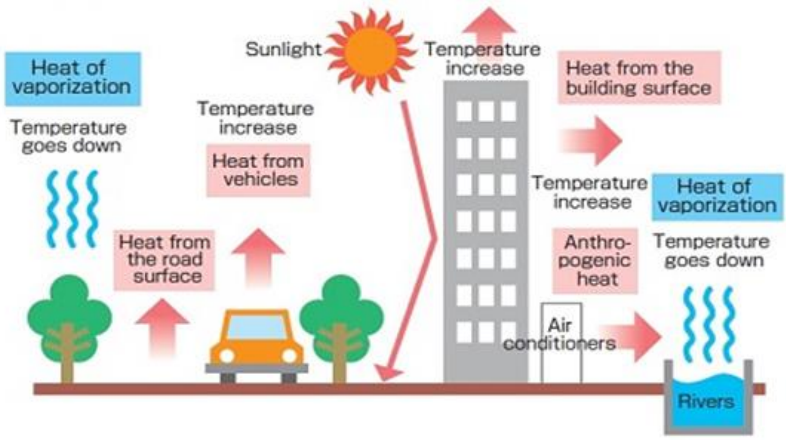


Figure 1: How the Urban Heat Island phenomenon occurs

Source: (Arizona State University, n.d.)

A.2.2 Drivers of the UHI effect

The drivers and the intensity of the UHI effect depend on several factors. Among others, these include (1) the size and structure of the city, (2) anthropogenic emissions related to waste heat from buildings, (3) industrial activities, (4) vehicles, (5) topography, (6) climate zone, (7) and meteorological conditions.

Topography affects local wind conditions and impacts temperature inversion in height - weakening or strengthening the UHI. The UHI has temporal variations dependent on climate conditions and human activities; studies in Central Europe show that maximum UHI values developed at night and do not show a relationship to the city size (Santamouris, 2007).

Weather factors that influence the UHI intensity are wind speed and cloudiness. If incoming solar radiation is decreased by clouds, temperature differences and UHI intensity are also decreased. Humidity plays an important role as well - cities in regions with variable wet and dry seasons have larger temperature differences during dry periods. Due to their small share of vegetation, built up areas have less water evaporation, contributing to increased surface and air temperatures.

The UHI can have secondary impact on local meteorology, including the modification of local wind patterns. Due to convection provided by extra heat, additional shower and thunderstorm activity can be greater than usual (Shepherd, 2005).

A.2.3 Risks and Impacts

Urban residents are exposed to heat-related risks, which are intensified and more frequent as a result of the UHI effect. Several factors need to be considered to determine long-term changes in heat load, such as (i) the historical development of cities, (ii) changes in the urban structure of cities, (iii) population increase, (iv) anthropogenic heat production, and (v) changes in weather patterns.

UHI increases human discomfort, especially in inner cities. Heat waves increase heat stress, affecting vulnerable population groups in particular (elderly, children and people with social or physical impairments). As a result of climate change, urban climate is expected to experience added heat load in the summer months and an increase of heat waves of higher intensities and longer duration. This creates an urgent need for mitigation and adaptation strategies, particularly through urban planning practices (IPCC, 2013; ZAMG, 2018; World Bank Group, 2020).

The overheating of buildings and other infrastructure during heat waves and the negative impacts those can have on residents have been characterised as public health issues. Therefore, heat can be considered as a severe hazard - among the deadliest in Europe, especially for population groups that have higher vulnerability. The direct and indirect impacts of the UHI effect are summarised in Figure 2 (World Bank Group, 2020; UNEP, 2004).

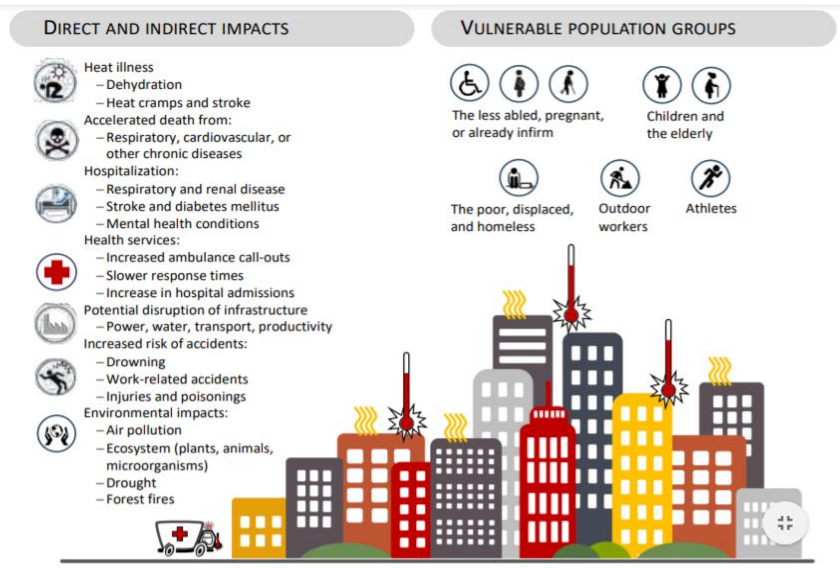


Figure 2: Direct and indirect health effects on the population groups most vulnerable to extreme heat

Figure source: (World Bank Group, 2020)

A.3 The UHI effect in European Cities

Extreme temperatures are one of the deadliest hazards in Europe; between 1980 and 2017, heat waves accounted for 68% of natural hazard–related deaths among countries in the European Economic Area, as well as 5% percent of economic losses. The increased intensity and frequency of heat events is strongly associated with climate change, posing a great challenge for urban areas in Europe (World Bank Group, 2020).

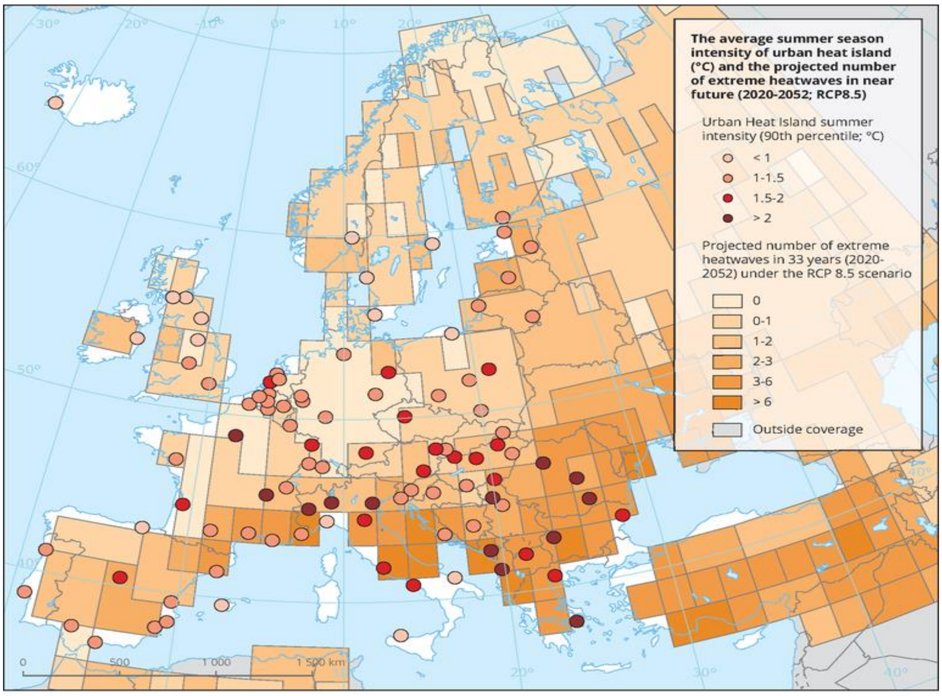
European countries are strongly affected by heat waves and prolonged periods of extreme temperatures - a natural hazard causing more deaths in Europe than any other. Recent examples of heat waves include the heat wave in Europe in 2003 and the Russia heat wave in 2010, which caused heat-related death tolls at unprecedented levels. More specifically, the heat wave that occurred in August 2003 caused over 14,800 deaths in France, with additional excess mortality rates in countries such as Belgium, the Czech Republic, Germany, Italy, the Netherlands, Portugal, Spain, Switzerland, and the United Kingdom. Overall, the 2003 heat wave resulted in more than 70.000 deaths in Europe. European countries were also affected by heat waves during the summers of 2015 and 2019, when record maximum temperatures were documented. Furthermore, southern and south-eastern countries in Europe were greatly affected by the heat wave of 2017 (World Bank Group, 2020).

According to a study (Bokwa, et al., 2018), an increase in heat load[1] is expected in urban areas located in Central Europe. Mean values for specific study areas are expected to increase by 2100, compared to 1971–2000, by 20– 50 days, depending on the scenario used. The regional spatial pattern of the predicted values of mean annual number of summer days depends on latitude, i.e. for cities located in the northern part of the study area; the values are lower than for cities located in the south – a difference which can reach approximately 40 days. The local spatial pattern reflects the impact of both land use/land cover as well as relief. The study underscores the high diversity of the Central Europe region in terms of the natural environment conditions, as well as clears a pattern for the whole Central Europe area, which is a recorded and a predicted increase in the heat load in urban areas (Bokwa, et al., 2018).

Another study estimated the intensity of the UHI phenomenon for 100 European cities, in the framework of the Copernicus European Health contract for the Copernicus Climate

[1] expressed in mean annual number of summer days

Change Service (C3S)[2] (EEA, 2020). As can be seen in Map 1, the UHI effect is more intense in southern and south-eastern countries in Europe, as well as in central Europe (i.e., in France).



Reference data: ©ESRI

Map 1: The average summer season intensity of UHI & projected number of extreme heatwaves in the near future (2020 - 2052)

Map source: (EEA, 2020)

The UHI phenomenon is particularly concerning in the Mediterranean zone, as climate change and UHI scenarios foresee a fast growth of energy consumption due to the widespread use of air conditioning systems and the increase of demand for cooling (Salvati, Coch Roura, & Cecere, 2017).

In the Mediterranean zone, studies in Rome, Lisbon, Aveiro, Madrid, Granada, Turkish cities, concentrated on heat island intensity during the night period. Heat island intensity varies between 2°C for Istanbul, 7.5°C for Aveiro, and 9.0°C for the medium-sized Turkish cities. In all the above cities, except Istanbul where data was unavailable, higher UHI intensities correspond to low wind speeds. For Lisbon, weather types with northern winds are associated with the highest air temperatures in the downtown area. Studies for Aveiro,

---

[2] High resolution (100m) hourly temperature (2008-2017) was simulated with the urban climate model UrbClim (De Ridder et al., 2015). Summer season is June, July and August.

Madrid and Granada show that the intensity of the UHI is at its maximum with a clear sky. For Aveiro and Madrid, classification of UHI values based on different types of weather shows that the highest values correspond to anticyclonic periods. Maximum UHI intensities are presented during the daytime in Athens and Parma. High intensities were measured in Athens, where the maximum is found during the summer period. Higher UHI intensities were found during the summer period in Rome, Madrid and Parma. By contrast, maximum UHI intensity in Lisbon was during the winter period (Santamouris, 2007).

As aforementioned, the reduction of UHI is a primary focus for many cities. This is attributed to the higher infrastructure and population densities in urban areas, as well as the more intense socio-economic activities. As a result, prolonged periods of heat pose a greater threat to the health and well-being of urban dwellers and generate additional economic losses. This is even more intense in southern, south-eastern Europe and the Mediterranean, considering that most urban areas located there are already hot in the summer. As a result, the already high temperatures recorded in the summer months, become even higher because of the UHI effect. A study that examined the contribution of urbanisation on the warming trends of air temperature in Athens found that, since 1975, the intensity of UHI increased by approximately +0.2 °C/decade, while on a seasonal basis, the rate of UHI changes is more pronounced in summer than in winter, accounting for approximately 40% of the observed warming rates of summer air temperature in the city (Papamanolis, Dimelli, & Ragia, 2015).

Furthermore, the more intense UHI effect occurring in the Mediterranean and southern Europe poses a threat to the tourism sector; a key part of the economy for most Mediterranean cities (Cutter, Griffin, & Hunt, 2018). Urban tourism relates to urban climate because of the modified conditions in urban areas. Problems associated with the urban climate, such as the UHI effect, affect several aspects of urban tourism. Besides the widespread and increased use of air conditioning (which indirectly exasperate the UHI effect), tourists spend some time outdoors, especially in summer months. However, extremely high temperatures for prolonged periods of time lower the thermal comfort of urban tourists. As a result, the touristic demand to visit cities in the Mediterranean region in summer could be significantly minimised (Stankov, et al., 2014).

For the aforementioned reasons, it is crucial to develop and implement solutions in urban areas, at different spatial scales, aimed at mitigating and adapting to climate change, which will contribute to minimising and alleviating the impacts of the UHI effect.

PART B: (A catalog of) available techniques for studying and analyzing the UHI effect.

B.1. The observational approach

B.1.1 Introduction

Techniques and instruments to characterise the Urban Heat Island (UHI) depend on how we define such a physical phenomenon. From a generic point of view, UHI is a local climate change phenomenon caused directly by urbanization, which leads to a warmer microclimate in urban areas than in the surrounding suburban and rural areas. Building a city radically changes thermal, radiative and circulation properties of the site on which it stands, varying its energy balance and producing a warmer environment (Oke et al., 2017). Concrete, cement and other building materials are able to absorb, retain and/or produce more heat than natural soil, leading to high temperature. As a consequence, UHI has a sensible impact on health, economy, environment, energy consumption, as well as deterioration of air quality, and leads to stressful bioclimatic conditions (Marinaccio et al., 2019). There are three different types of UHI that can be identified, strictly depending on how and where we measure urban and rural temperatures: the surface UHI (SUHI) is characterized by measuring the land surface temperature obtained from satellite observations, while the boundary-layer UHI (BLUHI) is mostly affected by mesoscale circulation, and requires profile measurements at the scale of 10-100 km; differently, the atmospheric UHI (AUHI) is more local, i.e. related to the urban canopy layer temperature, and is detected using *in situ* air temperature measurements. Even though they are somehow related to each other, these three UHI types have to be considered as different phenomena: for example, the maximum intensity for SUHI is observed during the day rather than, as for the AUHI, at night (Oke et al, 2017; Zhou et al., 2019). As pointed out in Marinaccio et al., 2019, when dealing with climate change in urban environment and the consequent biophysical stress that derives from it, the relevant phenomenon to be considered is the AUHI, which is usually characterised using conventional weather stations deployed on building rooftops.

Within the LIFE-ASTI project, the AUHI (hereafter indicated with UHI for the sake of simplicity) is monitored through both amateur and scientific networks of weather stations installed all around the studied cities, with temperature data specifically processed and filtered out to obtain hourly average values of guaranteed quality. Since the AUHI intensity peaks at night, air temperature in cities tends to be higher – with respect to the surrounding rural environment - during night. Particularly in summer and in conjunction with heat waves, such a behaviour is expected to lead to a notable heat stress capable of significantly increasing mortality in urban environments.

UHI is usually studied by either *in situ* or mobile measurements.

B.1.2 In situ measurements

By definition, the instantaneous UHI intensity ΔT is the urban-rural air temperature difference. The simplest and most used way to estimate it is to place two *in situ* temperature sensors: one within the city, usually in the city centre, and the other, taken as reference, in its rural surrounding. Defining the air temperature measured by the first and the second as T_U and T_R, respectively, the UHI at a time t is expressed as

$$\Delta T(t) = T_U(t) - T_r(t)$$

Clearly, this is the roughest estimation that can be made, as it does not take into account for spatial variability of the temperature field and is strictly dependent on the specific points where temperature data are acquired. Such an issue could be overcome simply by installing more temperature sensors and taking the average T_U and T_R values, or, with the aim of performing a more accurate analysis, introducing the 17 environment types of the LCZ classification developed by Stewart and Oke in 2012 (Oke t al., 2017), that allows for a better characterization of the urban area internal structure and establish a standard reference to simplify comparisons between different cities.

Recently, a more flexible approach was suggested in Schatz and Kucharik (2015), that estimate the UHI intensity in Madison (Wisconsin, USA) by assuming a linear relationship between the air temperature T, measured by *in situ* sensors, and the impervious surface area (I) provided by satellite remote sensing measurements[3], which quantifies the presence of artificially sealed surface as a percentage for each pixel:

$$T(I) = \alpha I + \beta.$$

The UHI intensity is then defined as:

$$\Delta T = T(100) - T(0) = 100\alpha$$

Thus, considering a network of N in situ temperature sensors, it is possible to estimate the slope α, and so the UHI intensity ΔT, running a linear fit on the data set of N couples $T - I$. This method simplifies significantly the evaluation of the degree of urbanization, substituting the sophisticated LCZ classification with a simple number $I = (0 \div 100)\%$, allowing to continuously characterize the UHI. Clearly, the more sensors are available, the more accurate the analysis is.

B.1.3 Mobile measurements

The special variability of the temperature field within a city can be better characterised through mobile measurement that can be obtained by installing temperature sensors on

[3] See, e.g., ESA Copernicus mission data available at https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness

GPS tracked mobile vehicles (i.e., public transportation vehicles). Anyway, while allowing to characterize the spatial distribution of temperature inside a city, such an approach lacks of temporal resolution, that is expected to decrease with.

In order to better explore the spatial variability of the temperature field, it is possible to take mobile measurements. This approach consists in mounting a temperature sensor on a vehicle, taking measurements while moving within the study area. Such a data set on one hand allows to accurately characterize the spatial distribution of temperature inside a city, on the other lacks of temporal resolution.

B.2. The modeling approach

Numerical modeling is considered to be an important supporting tool, showing a wide area of successful applications in studying the UHI phenomenon. One of the key requirements for applying meso-scale atmospheric models to study urban areas is to accurately parameterize the influences cities have on wind, temperature and humidity, and their collective impact on mesoscale atmospheric motions. These effects need to be accounted for in the land surface schemes used in atmospheric models, although the complexity of these schemes has to be balanced with their computational requirements. Over the last decade, several models have been developed to incorporate urbanization effects for a wide range of applications. By coupling such models to mesoscale atmospheric models, it is possible to simulate and eventually predict the climate of cities, in particular the UHI effect (Giannaros, 2013).

The better accounting for urbanization in numerical atmospheric models follows two main parameterization methods (Kusaka et al., 2001): (a) The bulk approach, in which the surface energy balance in the land surface models is modified by adjusting the soil and surface characteristics (e.g., heat capacity, surface albedo) to be representative of urban areas, (b) The coupling with an urban canopy model (UCM) for describing in more detail the sub-grid scale processes in cities.

In the framework of the bulk approach, the land surface models treat urban areas as flat and homogeneous surfaces (Figure 3). Properly calibrated thermal, moisture, radiative and aerodynamic parameters are used to consider the impact of the urban environment on the heat and moisture exchange and momentum-turbulence processes (Giannaros, 2018). It is worth empathizing that the above-mentioned surface properties vary significantly for different urban areas and their default values are not always appropriate for any given city. The adaptation of these properties based on the studied area may provide adequate model results (e.g., Lee et al., 2011; Giannaros et al., 2014). However, the main disadvantage of simple representing the urban areas as, impervious to water, slabs (Figure 3) remains, while urban environments are more complicated in reality, with various artificial and natural surfaces (Giannaros, 2018).

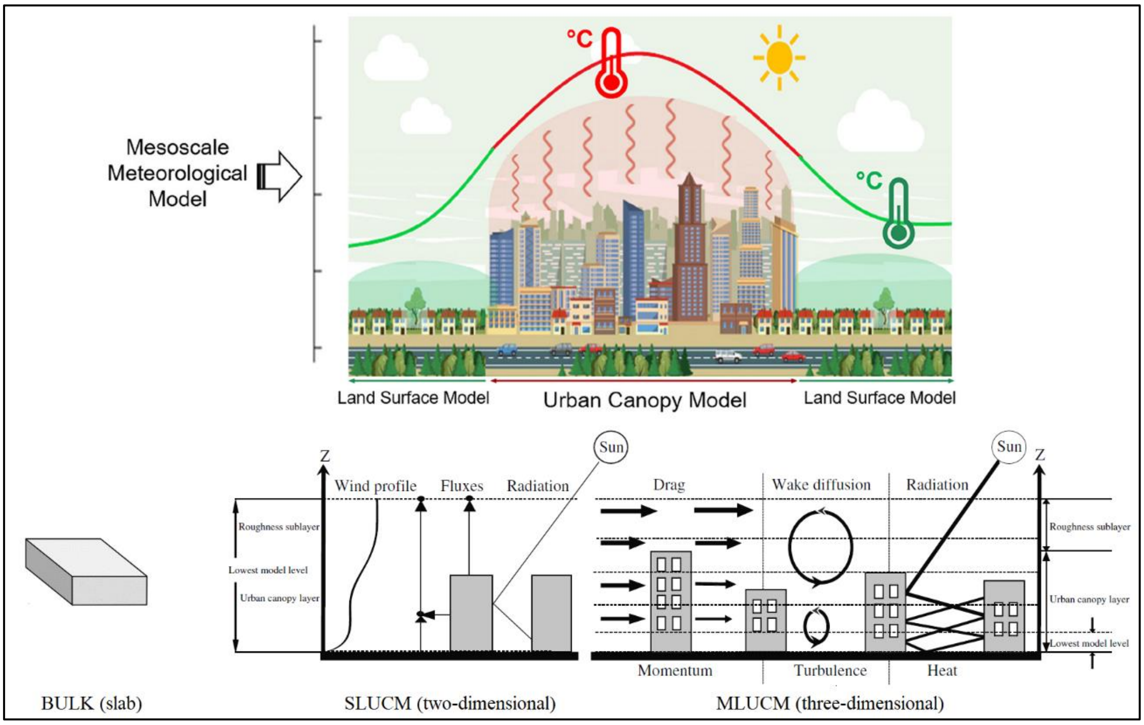


Figure 3: Schematic of urbnanization parameterization approaches in mesoscale atmospheric models. (Adapted from Conigliaro et al., 2020, and Chen et al., 2011).

As shown in Figure 3, the urban canopy models simulate explicitly the effects of the urban geometry and the various thermodynamic, radiative and dynamic processes that take place in the urban canopy layer (UCL). One of the major categorizations of UCMs takes into account the way the built environment is modeled (Giannaros, 2018). The single-layer urban canopy models (SLUCMs) simulate the urban energy fluxes at one atmospheric layer representing the city below the roof level. The multi-layer models, on the other hand, simulate the energy fluxes at several atmospheric layers that interact with the buildings within the UCL (Grimmond et al., 2009; Masson, 2006).

In single-layer models, the surface and the atmosphere interact only at the top of the canyons and roofs (Figure 3). In other words, when coupled to an atmospheric model, the lower boundary of the atmospheric model is defined at roof level. This allows for simplicity and portability, given that the characteristics of the canyon air are properly specified. Traditionally, wind is assumed to follow the logarithmic law in the layer found above the canyon top, whereas an exponential law is used below. Air temperature and humidity are assumed to be uniform within the canyon (Giannaros, 2013). The simplest of the single-layer UCMs is the Town Energy Balance (TEB) model of Masson (2000). Besides TEB, there are other such models that are characterized by a higher level of detail, including the SLUCM of Kusaka et al., 2001, the SM2-U (Soil Model for Submesoscales, Urbanized Version) of Dupont and Mestayer (2006), the VUCM (vegetated UCM) introduced by Lee and Park (2008), and the PUCM (Princeton UCM) developed by Wang et al. (2011, 2013).

The multi-layer urban canopy models (MLUCMs) are based on the drag force approach. According to this method, a drag term is added in the heat, momentum and turbulent kinetic energy equations to account for the obstacles drag. This technique allows for the simulation of the energy fluxes and meteorological variables on various atmospheric layers in the canopy layers, including the ground level, which is considered the lower boundary of the coupled mesoscale model (Figure 3). Some MLUCMs are capable of considering variances on the building heights or even differing road, wall and roof characteristics (Giannaros, 2018). One of the most analytical MLUCMs is the buildings effect parameterization (BEP) developed by Martilli et al. (2002). The BEP scheme was further improved and validated by incorporating a building energy model (BEM) to explicitly resolve the generation of energy within the buildings and its transfer to the atmosphere (Salamanca et al., 2010; Salamanca and Martilli, 2010). Similar MLUCMs have been designed by Dupont et al. (2004) and Kondo et al. (2005), while Krayenhoff et al. (2014) introduced a new method for accounting for the vegetation- and tree-building interactions. The execution of both single- and multi-layer UCMs requires the specification of a significant number of input data that include urban land use and canopy parameters describing the surface and urban morphology. The urban canopy parameters (UCPs) refer to basic morphology characteristics, such as the buildings heights and the roads widths, and to higher-level parameters, such as the sky view factor and building coverage ratio. They also include the radiative (e.g., albedo, emissivity) and thermal (e.g., heat capacity) characteristics of the urban facets, as well as anthropogenic heat (AH) emissions that can be incorporated as either state (i.e., inventory approach) or dynamic (i.e., direct modeling) variables. The specification of the above-described input data is considered the most demanding and challenging task in the urban-scale modeling because they vary substantially from city to city and they are characterized by a high level of uncertainty (Giannaros, 2018). Increasing efforts in recent years contributed to the development of urban surface and canopy parameters datasets based on in-situ surveying, regression modeling, remote-sensing and GIS (geographical information system) techniques (e.g., Taha et al., 2008; Sailor et al., 2015; Molnár et al., 2016; Agathangelidis et al., 2019; 2020). Moreover, the exploitation of Local Climate Zones (LCZs) framework (Stewart and Oke, 2012) for defining urban land cover in UCMs is increasingly gaining attention in the urban modeling community. LCZs are used to characterize urban areas in 10 classes, each of one having unique UCPs (Figure 4). This approach, fostered by the WUDAPT project (Ching et al., 2018), has been proven very successful for studying the UHI effect in different European cities, such as Vienna (Hammerberg et al., 2018), Barcelona (Ribeiro et al., 2021), Madrid (Brousse et al., 2016), Szeger (Molnár et al., 2019), Bologna (Zonato, 2016), Antwerp, Brussels and Ghen (Verdonck et al., 2018).

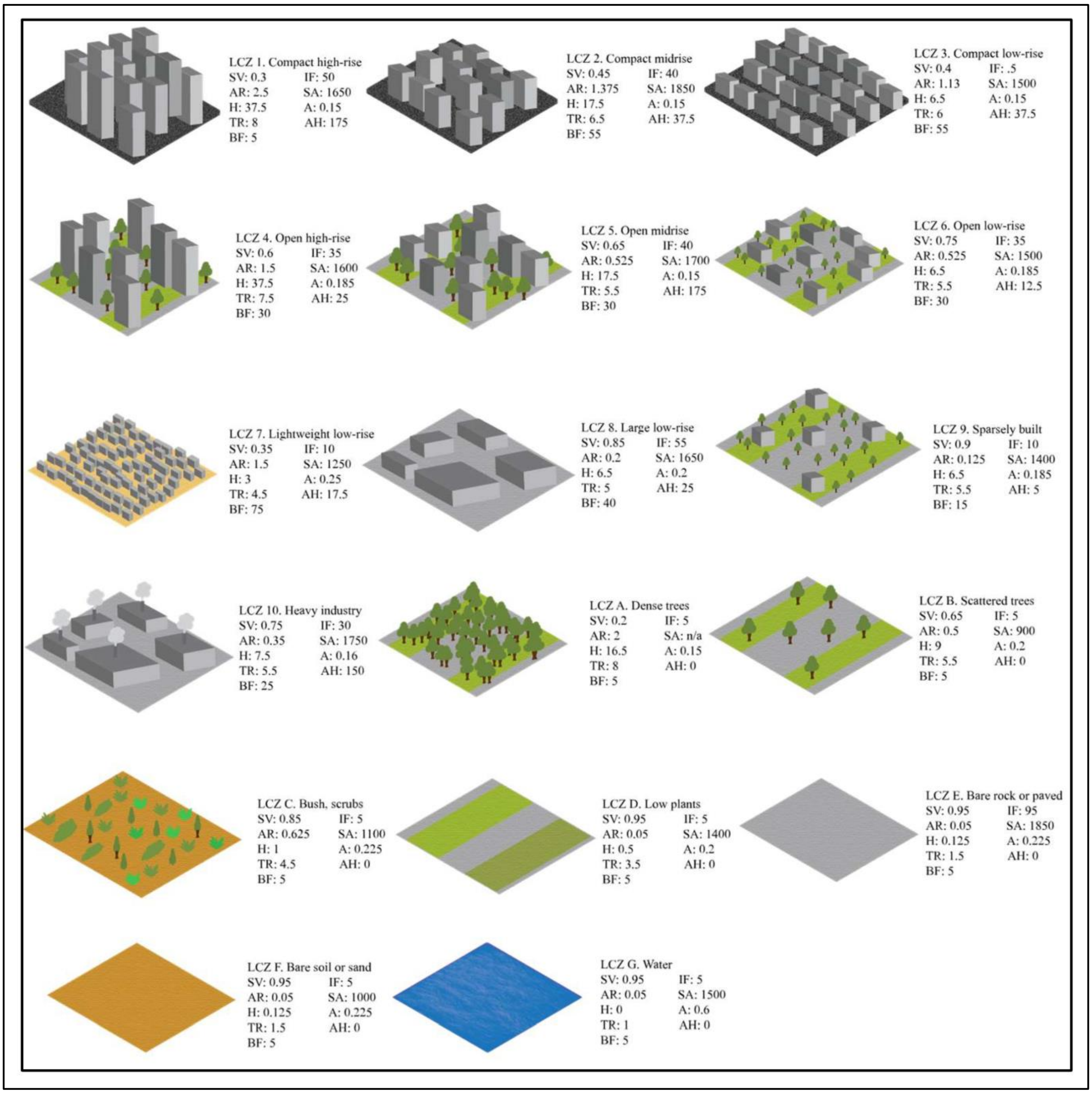


Figure 4: Graphical representation of LCZs and average values of some of their key UCPs. (Adopted from Johnson and Jozdani, 2019).

PART C: The LIFE ASTI's good practices with regards to the developed systems.

C.1. The pilot forecasting systems developed

C.1.1. Short description

The set-up of the pilot operational UHI forecasting system (UHI-OFS) implemented is capable of predicting the heat waves and urban heat island effect at urban scales, which is of concern for the local population and the authorities for the areas of interest. The UHI-OFS consists of a chain of three main parts: a) the meteorological prediction model WRF, b) the downscaling process and c) the post-processing of the meteorological fields. The meteorological forecasting model WRF, coupled with the Single Layer Urban Canopy Model (hereinafter as WRF-SLUCM), is applied over Europe at 18 km spatial resolution, south-eastern Mediterranean at 6 km and Thessaloniki and Rome at 2km spatial resolution in a nested way, resulting in prediction of the heat waves at 2 km spatial scales. Then, the downscaling process, implemented with the Support Vector Regression (SVR) tool is realized, predicting the meteorological fields at urban scale (250 m). Then, the Post-Processing Tools (PPT) is finally utilized, producing several fields related both on the urban heat island effect, like Urban Heat Island Intensity (UHII), as well with its' impact on human health, such as the Universal Thermal Comfort Index (UTCI) and the Discomfort Index (DI) at the regions of interest. The derived products are saved on the Post-Processing Database (PPD).

C.1.2. Good Practices

The set-up of the operational UHI forecasting system has been built is such a manner that ensures its' applicability, transferability and replicability in other cities of concern in Europe. Although the UHI-OFS can be directly applied to other areas of interest, several aspects related to the modeling of the UHI effect should be taken into account for the optimal prediction of the heat waves and of the UHI effect. These aspects are listed below as follows: a) Area of interest, b) Land cover and surface properties, c) Downscale method and d) Post-processing products.

a) Area of interest

Before the application of the UHI-OFS, the area of interest within the modeling system must be defined is such a way that appropriate application and prediction of the UHI related meteorological fields. An example of a good practice for the definition of the area of interest is illustrated in Figure 1 for Thessaloniki. Within WRF, the modeling domain consists of 75-by-75 grid cells at 2 km spatial resolution, with a total extent of 150-by-150 km. Although the city of Thessaloniki covers a small portion of the domain, significant spatial margins have been applied, of the order of 30-50 km in each direction. The reason for such large margins is the appropriate adjustment of the meteorological fields from the modeling domain of 6 km to the area of interest of 2 km spatial resolution. In a similar way, when UHI-OFS is foreseen for another city in Europe, the extent of the area of interest should be defined with margins of 30-50 km in each direction, with the city of concern located at the center of the modeling domain.

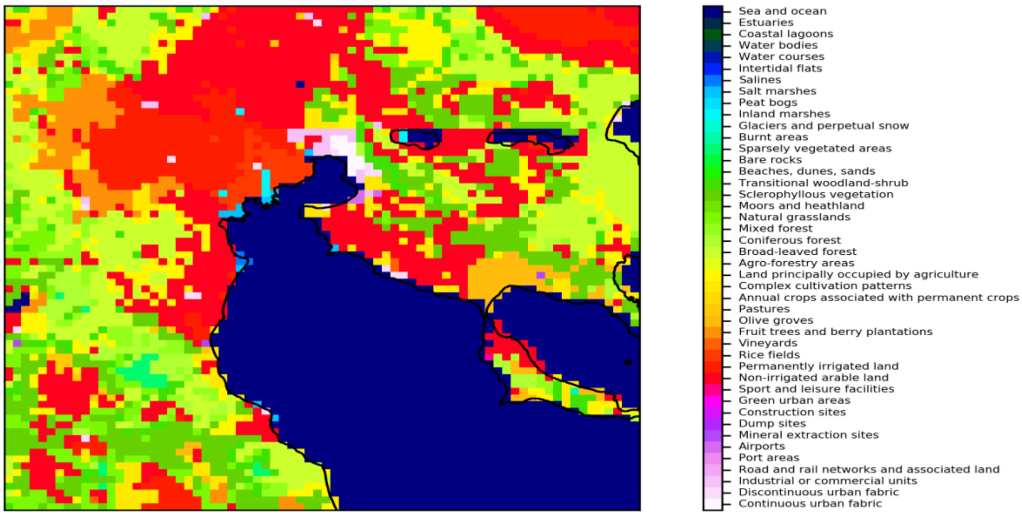


Figure 5: Corine land use for the modeling area of Thessaloniki within the UHI-OFS.

b) Land cover and surface properties

For the urban-scale domains of Thessaloniki and Rome the CORINE 2012 land cover database is utilized (https://land.copernicus.eu/pan-european/corine-land-cover/clc-2012?tab=download.), which provides land use data at urban scale (250 m). Within UHI-OFS all 44 classes are utilized. The surface properties needed for each category have been assigned based on the correspondence of CORINE and USGS land use classes and their recommended properties, as described in Pineda et al. (2004). The detailed information taken from this database is illustrated in Fig. 1 for the area of Thessaloniki.

Concerning the application of UHI-OFS, the CORINE land use database is recommended, unless more detailed land use data for the city of interest are provided elsewhere. Nevertheless, the assigned land use categories should always be checked for consistency with the existing land cover, since deviations might appear as a result of mismatch of CORINE's characterization of the land use and/or of significant changes of land use with time, due to intervention actions.

Another important factor which can affect the prediction of the heat waves and the UHI effect in the city of interest are the surface properties used, especially albedo and emissivity, which highly affect the amount of the net radiation over the urban fabric and hence the resultant temperatures. As mentioned above, these values are assigned based on land use, and should be considered as mean representative for these. Although the application of the UHI-OFS has shown that the assigned values produce satisfactory results, the used of the surface properties from external source, such as from satellite products, should be preferred.

c) Downscale method

The statistical downscaling method for the prediction of the 2-m air temperature and relative humidity at 250 m horizontal grid resolution over Thessaloniki and Rome is based on Support Vector Regression (SVR). SVR is capable of handling large amount of multidimensional data without requiring significant amounts of computation time. It is based on machine learning theory utilizing Kernel functions to estimate complex and multivariate relationships between a dependent variable SVR. An example of the methodology applied is illustrated in Figure 2.

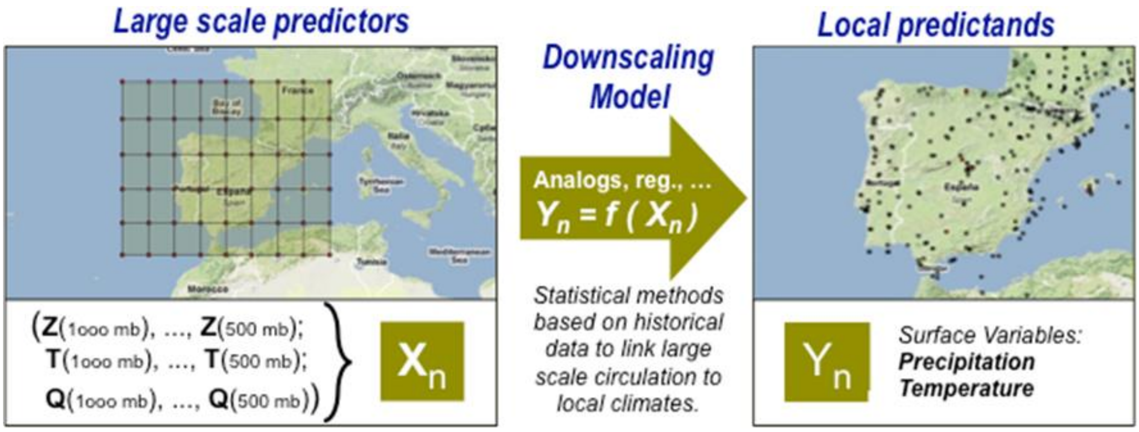


Figure 6: Schematic example of the statistical downscaling method (adopted from https://meteo.unican.es/downscaling/intro.html#)

The integration of the SVR method over Thessaloniki and Rome required as input the meteorological and static fields produced from UHI-OFS, as well observation from these cities for the training and the testing the downscaled fields. The performance with SVR was found to be satisfactory for the two cities of LIFE-ASTI project. The implementation of the SVR method within the UHI-OFS in other cities of Europe requires the re-train of the algorithm with observation, specific for the area of interest, in order to reproduce satisfactorily the UHI effect. Such retrained SVR could be easily added within UHI-OFS. While SVR is the recommended method for such application, the user could explore additional downscaling methods, like deep learning Artificial Intelligence methods (AI), which might fit for their city.

d) Post-processing products

The UHI-OFS provides all the information related to the heat waves (temperature, relative humidity, apparent temperature), the UHI effect (UHII), human health expected impact (UTCI, DI) and for the energy sector (Heating/Cooling Degree Days), needed by local/region stakeholders to take appropriate actions. Although the products described above are adequate, it is recommended for the potential user to review the literature and explore the indices which might fit for the area of interest.

C.2. **The pilot applied in the framework of the project**

C.1.2.1. Introduction

The set-up of the pilot operational UHI forecasting system (UHI-OFS) implemented in action C.1 started its' pilot operation since July 2019. The UHI-OFS produces systematically high-resolution 4-day forecasts of the UHI related products in the urban areas of Thessaloniki and Rome. The initialization and implementation of UHI-OFS, as well as the post-processing procedures, have been employed automatically through a structured system of scripts, which operate continuously at IT infrastructures of A.U.Th. The pilot operational UHI forecasting system consists of two main components: a) the implementation of WRF-SLUCM modeling system and b) the Post-Processing Tools (PPT). PPT is a package of automated scripts which performs three consecutive tasks, a) the downscale from 2km of WRF-SLUCM to 250m of the main meteorological parameters, b) the production of the UHI-related products and c) their transformation to usable from LIFE-ASTI platform format. In this chain, the Heat Health Warning System (HHWS) scripts, objective of Action C.6 framework, have been added, providing also the HHWS forecasts. The output of the WRF-SLUCM, the PPT, and the HHWS are stored in a unified database, which is result of the merging of the Pilot Operational Simulations Database (POSD) and the Post-Processing Database (PPD).

C.1.2.2. Good Practices

The pilot operation of the UHI forecasting system has been built is such a manner that ensures its' continuous operability, even with the extension of the system in other cities of concern in Europe. Also, it can be transferred in other Linux systems. Although the UHI-OFS can be directly applied to other areas of interest, several aspects related to the operation of the modeling system should be taken into account, mainly into two categories: a) Technical implementation and b) Monitoring as follows:

a) Technical implementation

The application of the UHI-OFS takes place in Linux operating system, utilizing a set of scripts in Python language. Thus, before any implementation of the UHI-OFS in other system, requires by the user a Linux server and a set-up of the software, in order to ensure the continuous operability of the system for the area of interest. The software of the server must include Python 3 language, the bash kernel, GDAL command for the reprojection of UHI-OFS's output into GeoTIFF format, and the "wget" command for the downloading of the initial/boundary conditions of the system.

Concerning the extension of the UHI-OFS in other European cities, irrespectively of the application of the system at A.U.Th. or user's infrastructures, storage management should be foreseen by the user(s). For example, the output of WRF-SLUCM for Rome, Thessaloniki and Heraklion, consists of 5 separate files in "netcdf format", one for each domain. The occupied space is 18Gb, 20Gb, 790Mb, Mb and 791Mb for the domains of Europe, South-eastern Mediterranean, Thessaloniki, Heraklion and Rome respectively. All files which are saved on the Pilot Operational Simulations Database (POSD), require at least a storage of 30T, dedicated for this purpose. Thus, purchasing storage of ~40T or more is recommended for the continuous operation.

The WRF-SLUCM for all domains lasts 11 hours, running on 2 Intel Xeon Gold 6152 and producing all the necessary parameters for the downscaling and the derivation of the UHI-related products. Before the application of the UHI-OFS in additional cities, the user(s) should test the performance and the computational efficiency of the hardware, in order to achieve realistic operational time on a daily basis, which should not exceed ~12 hours of operation.

b) Monitoring

Through the pilot operation of the UHI forecasting system, continuous monitoring of the system has been performed through LIFE-ASTI platform, in order to ensure that the UHI-OFS reproduces satisfactorily the heat waves and the Heat Health Warnings in Thessaloniki and Rome, for 2 consecutive years. It is recommended that the user(s) will qualitatively monitor for at least for 6-months. The monitoring period depends on the climatic zone of the area of interest, thus, the user should select as a monitoring timeframe the period where increased heat wave frequencies and temperatures are expected. For example, in Mediterranean the period of interest is between May and September, where these criteria are fulfilled. In case the user(s) have near-real time observation of temperature and relative humidity, it is advisable to compare the UHI-OFS results, in order to recognize possible issues with the set-up of the system and to improve its' overall performance.

PART D: Possible solutions and examples of excellence, that can be virtually adopted and applied to all EU cities facing UHI problem, especially over Mediterranean

D.1. LIFE ASTI Project's results

D1.1 Project overview & objectives

The LIFE ASTI project aims to design, implement, pilot and validate a set of UHI forecasting systems in Thessaloniki and Rome, based on state-of-the-art numerical models. It establishes dissemination tools and allows end-users open access to UHI-related information, using ICT applications (LIFE ASTI, n.d.).

The project assesses the impact of future climate change scenarios on UHI for the two cities and evaluates the impact of promoting green infrastructure/solutions/activities in urban areas to combat this effect. Moreover, the project develops modeling systems for the two cities, along with good practice guides and efficient strategic plans for mitigating future UHI effects. These can be adjusted and implemented in other European cities that face the same (or similar) UHI effects, increasing the added value of the project (LIFE ASTI, n.d.).

Furthermore, the project raises awareness and encourages authorities to apply such urban adaptation strategies and mitigation initiatives. In the context of the project, events are organised aimed at promoting, replicating and transferring the designed modeling systems and the best urban adaptation strategies to other European cities that face the same climate issues arising from the UHI effect (LIFE ASTI, n.d.)

In addition, the project addresses the following EU policy objectives:

a) Contribution to the development and demonstration of innovative climate adaptation technologies, suitable for being replicated;
b) Improvement of the knowledge for developing, monitoring and assessing effective climate adaptation and mitigation measures;
c) Facilitation of the development of comprehensive climate adaptation and mitigation strategies at local and national level.

The project's objectives and results include (Vasiliadis, 2019):

- To design, implement, pilot and validate a set of UHI forecasting systems in Thessaloniki and Rome, based on state-of-the-art numerical models. These modeling systems will provide stakeholders with several UHI-related, high-resolution forecasting products, including thermal bioclimatic indicators, 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

- Heat health warning systems providing differential alerts for each city, including the potential effects on health;
- To assess the impact of future climate change scenarios on UHI for the two selected cities;
- 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 modeling systems for the two selected cities;
- 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;
- Communication and dissemination actions to raise awareness of the general public, to increase knowledge, skills and competences of policy makers and to contribute to the scientific community research activities;
- To raise awareness and encourage authorities to apply the above urban adaptation strategies and mitigation initiatives. This will contribute to and support the Signatories' commitment to "Mayors Adapt" and "Covenant of Mayors";
- 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/citizens to fill the knowledge gap on local climate vulnerabilities and risks, thus improving adaptive capacities on a local scale and increasing citizen engagement in dealing with the UHI effect and other climate impacts;
- To organise events to promote, replicate and transfer the designed modeling systems and the best urban adaptation strategies to other European cities that face the same climate issues arising from UHI effect. This will lead to a substantial contribution to the overall aim of the EU Adaptation Strategy by developing policies for a better 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 European cities.

It is worth noting that the two Mediterranean cities were chosen to give a representative geographical coverage, to reflect different environmental conditions and support one of the major EU policy priorities for joint forces and transnational cooperation. The combination of socio-economic, environmental indicators, with additional more context-specific considerations allows the replicability and transfer of the results, knowledge and best practices. As a result, other urban as well as rural areas can adapt and implement this project in their local context and increase their resilience to heat waves and other climate-related impacts (LIFE ASTI, n.d.).

Throughout the LIFE ASTI Project, emphasis is given to the climate impact assessment of the UHI effect and on the sensitivity studies for the assessment of adaptation strategies (Action C.4) through the application of the developed modeling tools. The results of these assessments complement the design of urban adaptation action plans for combating the UHI effect and impacts, further increasing resilience to heat waves (Action C.5). Action C.7 includes a concrete plan that will support the replication of project's results by authorities of other regions in Greece, Italy, and other EU countries. The environmental, socio-economic, and communication impact of LIFE ASTI actions are monitored in Actions D. LIFE Performance and additional indicators are considered and regularly updated (LIFE ASTI, n.d.).

The Weather Research Forecast (WRF) modeling system, coupled with the Single Layer Urban Canopy (SLUCM) (Action C.1) has been running since June 2019 at the Aristotle University of Thessaloniki (AUTh), with a series of shell scripts developed by the AUTh team for the automated download of the initial/boundary conditions and its daily operation. This process' output files contain several meteorological factors, such as temperature, wind speed, precipitation, short-wave radiation etc., which are required for the derivation of the UHI related products, enabling their addition in future versions (LIFE ASTI, n.d.)

The operational UHI forecasting system (UHI-OFS) (Action C.2) has been employed automatically through a structured system of scripts, which operate continuously at AUTh's IT infrastructures. The pilot operational UHI forecasting system consists of two main components: a) the implementation of WRF-SLUCM modeling system and b) the Post-Processing Tools (PPT). The output is retrieved automatically from the LIFE-ASTI platform and the results are available on the project's website and mobile application. An overview of the UHI-OFS is illustrated in Figure 7.

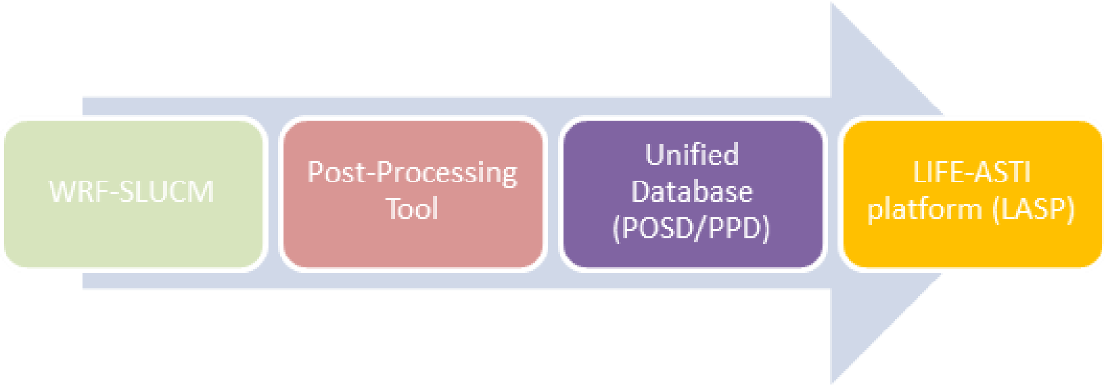


Figure 7: Overview of the operational UHI forecasting system

Heat health warning systems (HHWS) are one of the core elements of a heat adaptation plans as defined by World Health Organisation (WHO) Guidance. Heat warning systems serve as tool on which prevention and emergency measures should be modulated, based on the severity of risks. Heat warning systems are different from a weather forecast of heatwave event; they identify temperatures that are harmful for the populations' health. In this case, the association of temperatures to increased mortality are considered, during observed times series of temperature and daily mortality data.

Thresholds and warning levels are set based on specific health risk thresholds (increases in daily mortality). HHWW models ran in test mode in 2019 and became operational in the summer of 2020. Forecasts meteorological data produced by AUTh in Action C1 are used to define HHWW (Action C6). Model outputs are shared and made available for AUTh, GETMAP and DEASL, and they are reported in the LIFE ASTI platform and application.

The LIFE-ASTI programme focuses on UHI variables such as temperature, heating/cooling degree days and UHI intensity, which are discussed for the two cities: Thessaloniki and Rome. Action C4 has a two-fold objective: (a) to provide an assessment of the impact of future climate change scenarios on UHI for the two Mediterranean cities (UHI-FCAR) and (b) to assess and quantify the outcome of promoting mitigation measures in the cities to reduce/hinder the UHI effect (UHI-ASAR).

For Thessaloniki (domain d03), the annual average temperature for the reference period is around 17.5°C. The expected temperature increase is of 1°C and ~3.5°C for the periods 2046-2050 and 2096-2100 respectively. In the greater area of Thessaloniki, it can be noticed that the south-eastern regions located further from the coastline (>6km) indicate higher temperature increases compared to the north-western regions during summertime.

A comparison is made between three urban and two non-urban reference points, to represent the centre of the city and the ambient rural areas. On average, by the year 2050 (2100) in the five selected points the temperature is expected to increase by 0.8°C (2.7°C), 0.6°C (3.7°C), 1.3°C (4.1°C) and 1.7°C (4.2°C) in winter, spring, summer and autumn, respectively.

Regarding energy consumption, energy demand for heating will decrease in winter and cooling degree days (CDD) will increase in the summer. The winter average heating degree days (HDD) for the reference period is 5-7°C, which is expected to decrease by 0.85°C and 2.6°C by the year 2050 and 2100. However, looking at the summer average CDD during the reference period, this parameter fluctuates between 3-5°C over the urban area of Thessaloniki. The footprint of the city differs by 2°C or more from the areas around it. By 2050, CDD are expected to increase by 1.2-1.5°C, while by the year 2100, this increase will reach 4-4.4°C. It should be highlighted that the eastern regions of the city demonstrate the highest increase.

The apparent temperature (TAPP) is calculated for the typically warmer month of the year (July) for d03 as a function of temperature (T in °C) and dew point temperature (Tdew in °C) to represent the thermal discomfort of local populations.

On average, in d03, TAPP will increase by 2-3°C and 4-5°C by 2050 and 2100 respectively both during early morning and early afternoon in July. However, lower ground areas will have higher TAPP (~+0.5°C) compared to ambient elevated regions.

In Thessaloniki, major increases are expected at the very west and east parts, and especially at the south-eastern parts.

For **Rome (domain d04)**, the annual average temperature for the reference year is around 17°C. The expected temperature increase is 1°C and ~3.4°C for the periods 2046-2050 and 2096-2100 respectively. The largest temperature increases are expected in summer (+1.4 and +4°C) and the lowest during winter (+0.5 and +2°C, respectively). Focusing on the greater area of Rome, it can be noticed that the further the distance from the sea, the higher the future temperature increase is. The temperature increase difference between a western region (by the sea) and east of Rome is on an annual basis approximately 0.3°C and 0.7° for the periods 2046-2050 and 2096-2100, respectively. The largest differences between west and east 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, during the period 2096-2100, the temperature increase difference is greater for spring, summer, and autumn (0.7-1°C), while in winter the difference remains low (~0.3°C).

A comparison is made between three urban and two non-urban reference points, to represent the centre of the city and the ambient rural areas. On average, by 2050 (2100), the temperature is expected to increase by 0.5°C (2°C), 0.4°C (3.7°C), 1.2°C (4°C) and 1.4°C (3.6°C) in winter, spring, summer and autumn respectively in the five selected points.

During the reference period in the night and morning, the average UHI intensity is ~2-2.5°C (~1-1.5°C) between urban and west (east) reference points through the entire year. However, in the afternoon, the UHI effect between the urban and the eastern reference points is practically eliminated, whereas between the urban and west remains at ~2°C almost throughout the whole day. Regarding future periods, there are no significant changes in the UHI effect except in spring, when the UHI intensity seems to be slightly enhanced (by 0.2-0.3°C) in the afternoon.

Energy consumption for heating will decrease in winter and CDD will increase in the summer. In particular, the winter average HDD for the reference period is 4-6 degree days, which is expected to decrease by 0.5 and 1.8 degree days by the year 2050 and 2100 in Rome and the surrounding regions. CDD during the reference period is ~3-4 degree days, increasing by 1.1 and 4.1 degree days by 2050 and 2100, respectively.

In the present climate, TAPP presents increased values (24-26°C) close to the sea and lakes early in the morning, while in the afternoon maximum TAPP (~32°C) is observed in low ground regions far from the sea. The central and northeaster parts of the city of Rome exhibit the highest TAPP (24°C and 32°C respectively). Although TAPP for the entire domain will increase on average by 2-3°C and

4-5°C by 2050 and 2100, respectively, in lower ground areas TAPP increase will be more intense (by ~+0.4°Cto +1°C) than in elevated regions. The city of Rome exhibits the largest increases, +2.6°C and +5.6°C by the middle and the end of the century.

The LIFE ASTI project significantly contributes to the overall objective of the EU Adaptation Strategy by developing policies to better adapt to the effects of UHI, especially during the summer heat waves. This is achieved by reducing the risk of heat waves in metropolitan areas, through the introduction of heat prevention services and the improved implementation of energy efficiency guidelines in European cities. The two Mediterranean cities (Thessaloniki and Rome) were selected to provide a representative geographical coverage of the UHI issue, to reflect different environmental conditions and to support one of the EU's most important political priorities for joint effort and transnational cooperation.

The implementation of operational UHI forecasting systems and the effective dissemination of focused information with the use of ICT tools successfully strengthen cities' adaptive capacity to climate change, and successfully address the issue of the UHI effect and its impacts. Within this context, atmospheric models can be a valuable tool for providing accurate spatiotemporal information with a high level of detail on UHI effect and assisting the application of heat health warning systems (HHWS).

The primary target of LIFE ASTI is the development, pilot operation, and validation of UHI forecasting systems, combined with HHWS. The information provided contains high resolution UHI-related forecasting products, including thermal bioclimatic indices and Heating/Cooling Degree Days (HDD/CDD) to estimate the energy demand of buildings, as well as heat health warnings in each involved city. This kind of information allows environmental protection, the prevention of heat-related deaths and sustainable urban development, in accordance with the LIFE Regulation (Regulation (EU) No. 1293/2013) and the objectives of EU Commission Communication EU Strategy on adaptation to climate change (COM/2013/0216).

Furthermore, the distribution of the information mentioned above is provided through open access ICT tools anticipating the implementation of EU Directive 2003/4/EC on public access to environmental information.

D.2. Other projects' results

A **list of projects relevant to the topic** is provided in Table 1 together with their short descriptions. Color "grey" is used to mark the projects, which are already completed, color "light blue" is used to mark the projects which are about to finish and color "light green" is used for projects with a longer deadline.

Table 1: List of Relevant Projects

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
1	LIFE HEATLAND	Innovative pavement solution for the mitigation of the urban heat island effect	LIFE16 CCA/ES/000077	- Resilient communities	https://heatlandlife.eu/	The LIFE HEATLAND project aims to demonstrate the mitigation of the UHI effect by using an innovative construction material for road surfaces, cool pavements using a mixture of lime aggregated, transparent synthetic binder and titanium oxide and iron oxides pigments. An innovative pavement will be installed along with four metering towers fitted with diverse sensors (e.g., a pavement surface temperature sensor, three air temperature sensors, an ozone meter, and a lux meter) in the city of Murcia.	02/10/2017 - 31/12/2021	1,359,221 € [EU Contribution: 730,898 €]
2	LIFE GREEN	Generate resilient	LIFE18 CCA/FR/0011	- Green infrastructure	https://www.toulouse-	The Green Heart project's overall aim is to increase the resilience of Toulouse Mtropoles	01/09/2019	3,852,000 €

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
	HEART	actions against the heat island effect on urban territory	50	- Urban Design - Resilient communities	metropole.fr/projets/grand-parc-garonne/life-green-heart/life-green-heart-en	territory to climate change. Specifically the main objective is to reduce the local temperature by 3°C on average during heatwave events on an area of 30 hectares located on the Ile du Ramier in Toulouse, by counteracting the Urban Heat Island (UHI) effect. Surrounding neighbourhoods will also benefit from this cooling effect.	- 01/09/2024	[EU Contribution: 2,107,600 €]
3	LIFE Tree Check	LIFE TreeCheck: Green Infrastructure Minimising the Urban Heat Island Effect	LIFE17 GIC/CZ/000107		https://www.lifetreecheck.eu/en/	The main objective of the LIFE TreeCheck project is to decrease adverse climate impacts, particularly the Urban Heat Island effect, in European cities by making green infrastructure planning and decision-making processes more efficient and effective. Climate governance tools will be developed and applied, increasing the capacities of local public authorities, improving stakeholder involvement and building public awareness.	01/09/2018 - 31/08/2022	1,557,091 € [EU Contribution: 924,053 €]
4	LIFE METRO ADAPT	METRO ADAPT: enhancing climate change adaptation strategies and measures in	LIFE17 CCA/IT/000080	- Resilient communities	https://www.lifemetroadapt.eu/en/	Metro Adapt aims at mainstreaming climate change adaptation strategies in the Metropolitan Area of Milan (CMM). More specifically, the project aims at fostering the creation of a common well-structured governance related to climate change adaptation among the local authorities and	03/09/2018 – 30/09/2021	1,306,010 € [EU Contribution: 670,417 €]

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
		the Metropolitan City of Milan				produce tools that allow local authorities to implement cost-effective climate change adaptation strategies and policies adapted to the local context.		
5	LIFE URBAN PROOF	Climate Proofing Urban Municipalities	LIFE15 CCA/CY/000086	- Resilient communities	http://urbanproof.eu/el/	The overall aim of the LIFE UrbanProof project is to increase the resilience of municipalities to climate change equipping them with a powerful tool for supporting better informed decision making on climate change adaptation planning. In the framework of this project, selected regional climate models and statistical downscaling techniques will be used for the assessment of climate change in the future at regional and local level. In addition, the existing and future vulnerabilities and available adaptation measures to climate change will be identified and evaluated.	01/10/2016 – 30/04/2021	1,854,000 € [EU Contribution: 1,104,599 €]
6	LIFE LOCAL	Integration of climate change adaptation	LIFE15 CCA/DE/0001	- Resilient communities	https://life-local-	The project aims to implement specific climate change adaptation measures in cooperation with municipalities, integrate climate change	01/07/2016 - 31/12/2021	3,070,065 € [EU

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
	ADAPT	into the work of local authorities	33		adapt.eu/en	adaptation into the administrative practice of local authorities, enhance municipalities' knowledge on climate change adaptation and improve the data and information base on climate change impacts.		Contribution: 1,841,581 €]
7	LIFE Veg-Gap	Vegetation for urban quality plans	LIFE18 /PRE/IT/003		https://www.lifeveggap.eu/	The VEG-GAP project works on developing a strategy for providing new reliable information in support of designing urban Air Quality Plans (AQPs) considering the urban vegetation ecosystems characteristics such as plant type and state, green area extension, etc. The multiple vegetation ecosystems services will be evaluated in an integrated way through multi-scale and multi pollutant approaches resembling the real-world as much as possible.	1/12/2018 – 31/05/2022	1,666,667 € [EU Contribution: 1,000,000 €]
8	EU - FP7: 2007/2013 - RAMSES	Reconciling Adaptation, Mitigation and Sustainable Development for cities supported biomass	Grant agreement ID: 308497		https://ramses-cities.eu/home/	The main aim of this research project was to deliver much needed quantified evidence of the impacts of climate change and the costs and benefits of a wide range of adaptation measures, focusing on cities. RAMSES engaged with stakeholders to ensure this information was policy relevant and ultimately to enable the design and implementation of adaptation strategies in the EU and beyond. The project	1/10/2012-30/09/2017	6,533,459.88 € [EU contribution: 5,200,000 €]

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
		growth				focused on climate impacts and adaptation strategies pertinent to urban areas due to their high social and economic importance.		
9	LIFE QUF	Quick urban forestation	LIFE12 ENV/ES/000092	- Urban design (urban-rural) - Resilient communities	http://www.iclaves.es	The main objective of the LIFE-QUF project was to promote the reforestation of southern European cities, through the design and development of a key demonstration project in the Spanish city of Valladolid.	01/07/2013 – 31/03/2017	1,356,782 € [EU Contribution: 620,750 €]
10	LIFE CLIVUT	Climate value of urban trees	LIFE18 GIC/IT/001217	- Resilient communities - Public and Stakeholders participation - Green infrastructure	https://www.lifeclivutspringames.education/	The main objective of the LIFE CLIVUT is to develop an urban green asset strategy for Mediterranean medium-size cities and implement it in four pilot cities: two in Italy, one in Greece and one in Portugal.	01/09/2019 - 28/02/2023	2,337,069 € [EU Contribution: 1,277,137 €]
11	LIFE DERRIS	DERRIS - Disaster risk reduction	LIFE14 CCA/IT/000650	- Market based instruments - Risk assessment	http://www.derris.eu/en/	Derris project aimed to provide SMEs with useful tools to reduce the risks deriving from extreme climate events such as floods, landslides,	01/09/2015 - 30/09/2018	1,317,166 € [EU Contribution:

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
		insurance		and monitoring - Resilient communities - Sectoral adaptation (industry-services)		tornadoes, heatwaves or frost.		790,299 €]
12	LIFE AdaptInGR	Boosting the implementation of adaptation policy across Greece	LIFE17 IPC/GR/000006		https://www.adaptivegreece.gr/el-gr/	The project aims to catalyse the implementation of the Greek National Adaptation Strategy and of the 13 Regional Adaptation Action Plans at the current 1st adaptation policy cycle (2016-2025) and to prepare the passage to the 2nd adaptation policy cycle (2026+), through appropriate action at national, regional and local levels.	21/1/2019 - 31/12/2026	14,200,000 € [EU Contribution: 8,300,000 €]
13	LIFE HEROTILE	High Energy savings in building cooling by roof tiles shape optimization toward a better above sheathing	LIFE 14 CCA/IT/000939	- Resilient communities - Sectoral adaptation (industry-services) - Building	https://www.lifeherotile.eu/	LIFE HEROTILE aimed to improve the energy behavior of the buildings through the development of innovative types of roof tiles able to increase their underlay ventilation. Thanks to technologies and systems suitable for being replicated, transferred or mainstreamed, the project aimed to contribute to the development and implementation of energy savings approaches, mainly at Mediterranean	01/08/2015 – 31/01/2019	2,476,158 [EU Contribution: 1,442,784 €]

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
		ventilation				Region, and to climate change mitigation.		
14	LIFE LUNGS	Towards a more resilient Lisbon urban green infrastructure as an adaptation to climate change	LIFE18 CCA/PT/001170	- Urban design (urban-rural) - Resilient communities - Green infrastructure - Soil and landscape protection	https://life-lungs.lisboa.pt/	LIFE LUNGs main objective is to implement the municipal climate adaptation strategy (EMAAC) by making use of urban green infrastructure as a tool for climate change adaptation. It will also promote and develop related ecosystem services. Its overall aim is to increase Lisbon's resilience and resistance to climate change.	16/09/2019 - 31/08/2024	2,739,725 € [EU Contribution: 1,506,384 €]
15	EU - Horizon 2020 - Heat Shield	Integrated inter-sector framework to increase the thermal resilience of European workers in the context of global	Grant agreement ID: 668786		https://www.heat-shield.eu/	The overall aim of HEAT-SHIELD project is to create a sustainable inter-sectoral framework to promote health and prevent heat-induced illnesses of European workers and improve quality and productivity of strategic European industries (i.e., manufacturing, construction, transportation, tourism and agriculture).	01/01/2016 – 31/12/2021	6,830,936.25 € [EU Contribution: 5,777,543.25 €]

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
		warming						
16	EU - Horizon 2020 - Grow Green project	Green Cities for Climate and Water Resilience, Sustainable Economic Growth, Healthy Citizens and Environments	Grant agreement ID: 730283		http://growgreenproject.eu/	GrowGreen aims to create climate and water resilient, healthy and livable cities by investing in nature-based solutions (NBS). Making nature part of the urban living environment improves quality of life for all citizens and will help business to prosper. High quality green spaces and waterways provide innovative and inspiring solutions to major urban challenges, such as flooding, heat stress, drought, poor air quality and unemployment and will help biodiversity to flourish.	01/06/2017 – 31/05/2022	11,519,299.50 € [EU Contribution: 11,224,058.25 €]
17	EU - Horizon 2020 - UNaLAB	Urban Nature Labs	Grant agreement ID: 730052		https://unalab.eu/en	UNaLab will develop, via co-creation with stakeholders and implementation of 'living lab' demonstration areas, a robust evidence base and European framework of innovative, replicable, and locally attuned nature-based solutions to enhance the climate and water resilience of cities. UNaLab focuses on urban ecological water management, accompanied with greening measures and innovative and inclusive urban design.	01/06/2017 – 30/11/2022	14,278,699.25 € [EU Contribution: 12,768,931.75 €]

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
18	EU - Horizon 2020 - Urban GreenUP	New Strategy for Re-Naturing Cities through Nature-Based Solutions	Grant agreement ID: 730426		https://www.urbangreenup.eu/	Urban GreenUP aims at obtaining a tailored methodology (1) to support the co-development of Renaturing Urban Plans focused on climate change mitigation and adaptation and efficient water management, and (2) to assist in the implementation of NBS in an effective way. NBS classification and parametrization will be addressed and some resources to support decision making will be established as part of the project activities.	01/06/2017 – 30/11/2022	14,791,003.09 € [EU Contribution: 13,970,642.25 €]
19	EU - Horizon 2020 - URBANFLUXES	Urban anthropogenic heat FLUX from Earth observation Satellites	Grant agreement ID: 637519		http://urbanfluxes.eu/	The main goal of the URBANFLUXES project is to investigate the potential of Earth Observation (EO) to retrieve anthropogenic heat fluxes. URBANFLUXES aimed to investigate the potential of EO to retrieve the anthropogenic heat flux, as a key component in the urban energy budget and by developing a method capable of deriving it from space. The objective was to develop a method that could be used operationally in the near future, when observations with adequate	01/01/2015 – 30/12/2017	2,687,446.25 € [EU Contribution: 2,346,193 €]

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
						temporal resolution become available		
20	EU - Horizon 2020 - MUSE GeoERA	Managing urban shallow geothermal energy	Grant agreement ID: 731166	- Geo-energy - Groundwater - Raw Materials - Information Platform	https://geoera.eu/projects/muse3/	MUSE investigates resources and possible conflicts of use associated with the use of shallow geothermal energy (SGE) in European urban areas and delivers key geoscientific subsurface data to stakeholders via a user-friendly web based GeoERA information platform (GIP)	01/07/2018 – 30/06/2021	1,313,260 € [EU Contribution: 393,978 €]
21	EU - Horizon 2020 - Climate-Fit City	Pan-European Urban Climate Services	Grant agreement ID: 730004		https://climate-fit.city/	The objective of the Pan-European Urban Climate Service (PUCS) project is to establish a service that translates the best available scientific urban climate data into relevant information for public and private end-users operating in cities.	01/06/2017 – 29/02/2020	3,514,416.25 € [EU Contribution: 2,936,600.63 €]
22	EU - Horizon 2020 - SOLOCLIM	Solutions for outdoor climate adaptation	Grant agreement ID: 861119		https://soloclim.eu/	The aim of SOLOCLIM is to develop a doctoral training programme that enables young researchers to generate solutions for urban outdoor environments. Projections show that urbanisation could add another 2.5 billion people to urban areas by 2050 and the cumulative effect of all the negative urban climate impacts of urbanisation such as the	01/10/2019 – 30/09/2023	1,626,994.80 € [EU Contribution: 1,626,994.80 €]

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
						occurrence of urban heat islands as well as distinctive wind patterns in cities create discomfort and health risks.		
23	URCLIM	Advance on Urban Climate Services	Project URCLIM is part of ERA4CS, an ERA-NET initiated by JPI Climate with co-funding of the European Union (Grant agreement ID: 690462)		http://urclim.prod.lamp.cnrs.fr/	URCLIM project aims at providing a concept, which is the realization of integrated Urban Climate Services (UCS), which will be of interest for urban planners and related stakeholders, to respond to user needs, but also to provide assistance in decision making. The consortium will do this using open urban data and regional climate data.	15/09/2017 – 14/09/2020	4,500,000 €
24	CLIMPACT	National network for climate change			https://climpact.gr/main/	The CLIMPACT network seeks cooperation with the National Commission for Climate Change, with the Climate Change Impact Study Committee of the Bank of Greece but also with	01/10/2019 - 17/10/2022	National Initiative funded by the Ministry of

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
		and its impact				other relevant initiatives and actions. CLIMPACT aims to be a pole of valid and multifaceted expertise and an advisory body of the State and Society.		Development and Investment
25	DUE - UHI	Urban Heat Island and Urban Thermography			http://due.esrin.esa.int/page_project122.php	The project aimed at developing a set of satellite/ airborne- based services to help municipalities to understand and predict Urban Heat Islands. That would contribute to a better prevention of UHI impacts during summer heat waves, a reduction of the heat wave risk in metropolitan areas and a better implementation of energy efficiency measures.	01/11/2008 – 30/09/2011	1,135,000 €
26	Green-Blue Infrastructure, Potsdamer Platz, Berlin, Germany - (Detailed Project Description below)							
27	Eco-Boulevard in Vallecas, Madrid, Spain - (Detailed Project Description below)							
28	Vertical Garden – Patrick Blanc, Madrid - (Detailed Project Description below)							
29	Green roofs Rotterdam, The Netherlands - (Detailed Project Description below)							
30	Green Infrastructure, Place de la République, Paris, France - (Detailed Project Description below)							

No.	Project Acronym	Full Project Title	Project Reference	Themes	Website/ Link	Short Description	Duration	Total Budget
31	Community gardens, Paris, France - (Detailed Project Description below)							
32	Water square in Benthemplein, Rotterdam, The Netherlands - (Detailed Project Description below)							

After the more detailed description of the last initiatives (No.26-No.32) of Table 1, that follows, the results or expected results of the rest of the above (No1.-No.25) are presented in Table 7 afterwards.

Project No.26: Green-Blue Infrastructure, Potsdamer Platz, Berlin, Germany

Table 2: Project (No.26) Information

Project information	
Location:	Potsdamer Platz, Berlin, Germany
Client:	City Berlin / Debis Immobilien
Urban design:	Renzo Piano, Christoph Kolhbecker
Designer/water concept:	Atelier Dreiseitl
Scale:	District
Realisation year:	1997-1998

Source: (Urban Green-Blue Grids, n.d.)

In an architecturally important area of Berlin, between the Berliner Philharmonie and the Berlin State Library and the construction on Potsdamer Platz, a series of urban pools have been created, covering an area of approximately 1.2 hectares. The scale, the inner-city location and the integration of ecological, aesthetic and civil-engineering functions are noteworthy (Urban Green-Blue Grids, n.d.).

The purpose of the water features in the highly urban context is two-fold: design and ecology. The large water surfaces are fed entirely by rainwater. The water features improve the urban climate: the water lowers the ambient temperature in summer, binds dust particles and humidifies the air. The rainwater from the roofs of the surrounding buildings is captured in large underground cisterns, which is used for topping up the pools, for toilets in offices and for irrigating green areas (Urban Green-Blue Grids, n.d.).

Image 1: © Atelier Dreiseitl

The temporary retention in cisterns and pools guarantees that larger volumes of rainwater only need to be discharged into the Landwehr Canal on an average of three times every ten years - similar to an unpaved surface. The five cisterns have a total volume of 2,600 m3, of which 900 m3 is reserved for extreme rainfall. The main pool has an additional 15 cm buffering height, which translates as 1,300 m3. From the cisterns the water is fed into the southern pool through seepage facilities. Once there, it runs directly through a biotope with vegetation, where it is treated. If necessary, filters can be added during summer months to filter suspended algae from the water. The water is aerated as it passes through a series of multi-layered structures and set in motion near the Piazza. The water features work without any chemical additives and consume little energy. The rainwater is buffered, less drinking water is used, and a pleasant outdoor space is created (Urban Green-Blue Grids, n.d.).

Project No.27: Eco-Boulevard in Vallecas, Madrid, Spain

Table 3: Project (No.27) Information

Project information	
Location:	Pau de Vallecas, Vial C-91, Madrid, Spain
Client:	Municipality of Madrid
Architect:	Belinda Tato, Lose Luis Vallejo, Diego Garcia-Setien

Scale:	District
Realisation year:	2004-2005, 2006-2007

Source: (Wikiarchitectura, n.d.)

The Eco-boulevard in Vallecas, built in 2007, is an urban recycling operation consisting of the insertion of an air tree-social dynamizer, over an existing urbanization area, densification of existing alignment trees, reduction, and asymmetric arrangement of wheeled traffic circulation. The project opted for supplied areas with higher climatic comfort, serving as the seed of a public space regenerating process (ArchDaily, 2007).

The air tree is a light structure that is self-sufficient in terms of energy and can be dismantled. It consumes only what it can produce through photovoltaic solar energy collection systems. Selling this energy to the power network generates a surplus on the annual balance sheet and this is reinvested in the maintenance of the structure (ArchDaily, 2007).

Image 2: The Eco-boulevard in Vallecas ©ArchDaily

Source: (ArchDaily, 2007)

The role technology plays in this project is critical and decisive, as it adapts to a specific context. In this case, climatic adaptation techniques normally employed in the farming industry are borrowed. A strong point of this project is that it may be re-installed in similar locations or in other types of situations requiring an urban activity regeneration process (new suburban, developments, degraded parks, squares) (ArchDaily, 2007).

The simple climatic adaptation systems installed in the trees of air are of the evapotranspirative type, often used in greenhouses. This artificial adaptation tries to undo the leisure - consumption binomial and reactivate the public space by creating climatically adapted environments: 8ºC-10ºC cooler than the rest of the street in summer (ArchDaily, 2007).

Project No.28: Vertical Garden – Patrick Blanc, Madrid

Table 4: Project (No.28) Information

Project information	
Location:	Madrid, Spain
Client:	Caixa Forum Museum
Designer:	Patrick Blank
Scale:	Building
Realisation year:	2001

Source: (WGIN, n.d.)

This project involved the transformation of the old Mediodia Power Station into the new headquarters of the Caixa Forum in Madrid. It is the work of Swiss architects Jacques Herzog and Pierre de Meuron. The rejuvenation and rehabilitation work considered the following action lines: (i) preservation of the building's appearance, while also maintaining its original geometry, and (ii) an increase of the surface area from its original 2,000 m^2 to a total of approximately 10,000 m^2 (Ferrovial, n.d.).

Image 3: Vertical garden by Patrick Blanc, in Madrid, Spain

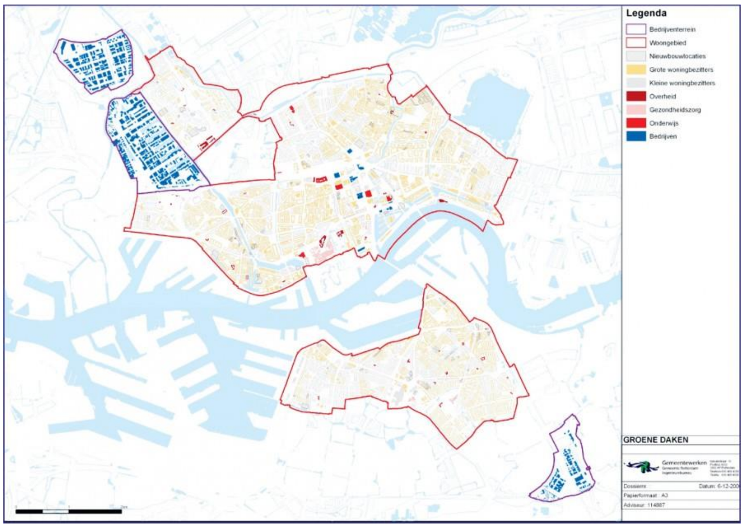
Source: (Ferrovial, n.d.)

Two fountains adorn the plaza, one of which is under the vertical garden designed by Patrick Blanc, the first to be built in Spain. This garden is 24 meters high, with 460m^2 of surface area, providing space for 15,000 plants of 250 different species. It is a wall of plants which can survive without any soil, only requiring water and nutrients. The wall of vegetation attracts people into the new building and is an important landmark. (Ferrovial, n.d.).

Project No.29: Green roofs Rotterdam, The Netherlands

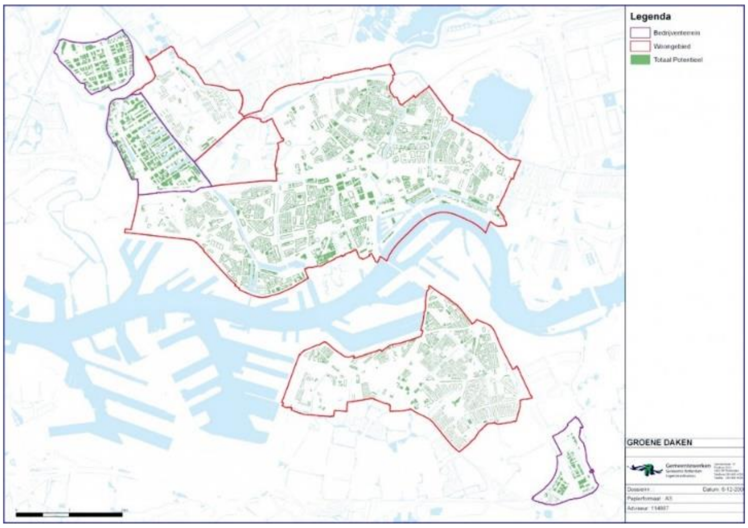
A case study was developed for the city of Rotterdam, where 25% of the roofs in Oud Mathenesse were replaced with green roof installations, with a retention capacity of 25 mm. As a result, the annual overflow volume was reduced by 19.5%, which in turn had a positive effect on the surface water quality (Urban Green-Blue Grids, n.d.).

Green roofs have a positive effect on water quality regarding pollution on rooftops. The rainwater retention capacity depends on many factors: the slope of the roof, the consistency of the layers, the thickness and type of substrate (Urban Green-Blue Grids, n.d.).



Map 2: Buildings in Rotterdam suitable for placing extensive green roofs divided per owner

Source: (Urban Green-Blue Grids, n.d.)



Map 3: Total potential

Source: (Urban Green-Blue Grids, n.d.)

The Municipality of Rotterdam is encouraging the construction of green roofs in the city, through a subsidy for roof owners. In 2019, there were 400,000m² of green roofs in Rotterdam (Urban Green-Blue Grids, n.d.).

Project No.30: Green Infrastructure, Place de la République, Paris, France

Table 5: Project (No.30) Information

Project information	
Location:	Paris, France
Client:	City of Paris
Designer:	VK Trévelo & Viger-Kohler Architectes Urbanistes
Scale:	District
Realisation year:	n.d.

Source: (Urban Green-Blue Grids, n.d.)

In Paris, the physics of urban planning play a major role in the design for the redevelopment of the Place de la Republique. With the goal to mitigate the UHI effect, the design that won the competition, submitted by TVK (Trévelo & Viger-Kohler Architectes Urbanistes), involves a partnership with the building physics consultants of Transsolar from Stuttgart (Urban Green-Blue Grids, n.d.).

The design maximises the proportion of trees and plants, and wind flow has been incorporated to offer maximum ventilation and cooling in summer. An area of 12,000 m^2 of the 20,000 m^2 square is designed as an urban garden with dense vegetation. The area available to pedestrians has been increased by 50%. The design also ensures that sunlight reaches the pedestrian routes (Urban Green-Blue Grids, n.d.).

Image 4: Impression of Place de la République © TVK

Source: (Urban Green-Blue Grids, n.d.)

Image 5: La Place de la République

Source: (C., 2018)

The main principles in the new design were for the area to become attractive in terms of connecting the metropolitan scale with the human scale, as well as creating a pleasant urban climate. Moreover, the approach adopted for the redesign of the square involved workshops with people living in and around the designated area (Urban Green-Blue Grids, n.d.).

Project No.31: Community gardens, Paris, France

Meeting an increasing demand from local citizens, the municipal program of Paris 'Main Verte' has been set up to formalize, support and encourage community gardening and education while fostering neighbourhood social connections (Green-Blue Grids, n.d.).

Image 6: Garden of the "Aqueduc", Paris © Michel Koenig

(Source: Green-Blue Grids, n.d.)

The Municipality of Paris makes available and cleans up plots which are disused or temporarily vacant, guarantees water supply and garden enclosing for a variable duration from one to five years, a period that can be extended depending on urban developments. Along with this commitment, gardeners adhere to specific environmental guidelines such as composting, harvesting rainwater for irrigation, organic gardening and material recycling. The 'Charte Main Verte' (Green Hand Pact), signed by the neighbourhood associations, puts in place guidelines regarding weekly openings, public events organization, management plan creation and communication. A community garden, despite the fence, remains a public space (Green-Blue Grids, n.d.).

Image 7: Villemin Square, Paris © Michel Koening

Source: (Green-Blue Grids, n.d.)

The community garden plots could be individual, collective or mixed where individual areas are next to collective ones. Some integrate social and professional inclusion programs. Moreover, some plots are reserved for schools, the neighbourhood children or therapeutic gardening activities. Community gardens involve a varied range of individuals, from different generations, social backgrounds, cultures and origins (Green-Blue Grids, n.d.).

Paris' inner walls (21,196 ha/km^2 density) indicate the 'Compact City' model, within which community gardens meet the expectations of citizens who seek to take ownership of an outdoor space. Beyond providing accessible green spaces in cities and improving urban environmental quality, community gardens provide new social and cultural hubs. Moreover, they generate effective participation; create a new sense of citizenship, and more flexible urban spaces. Furthermore, community gardens are a successful way of reinventing the city and showing such interventions are crucial for sustainable city planning (Green-Blue Grids, n.d.).

Project No.32: Water square in Benthemplein, Rotterdam, The Netherlands

Table 6: Project (No.32) Information

Project information	
Location:	Rotterdam, Netherlands
Client:	Rotterdam Climate Initiative, City of Rotterdam supported by the Water board Schieland & Krimpenerwaar

Designer:	De Urbanisten
Scale:	District
Realisation year:	2013

Source: (De Urbanisten, n.d)

A once-empty, monotonous square now holds three large rainwater collection ponds which, when the weather is dry, can be used as amphitheatres, basketball and volleyball courts, or skateboarding rinks (Public Space, 2013).

Image 8: Before the project

Source: (Public Space, 2013)

Image 9: After the project

Source: (Public Space, 2013)

The municipal administration of the city of Rotterdam has adopted a strategy where new water-storage systems have been located on the surface, contributing to the environmental quality of urban spaces, strengthening neighbourhood identities, and offering leisure spaces to citizens (Public Space, 2013).

Image 10: Design of the Water Square

Source: (Public Space, 2013)

Besides its hydraulic function, the project's aim was to add meaning to the space and endow it with attractive features that would appeal to users of the surrounding buildings. To this end, a participative process was devised, bringing together teachers and students from the Graphic Lyceum and Zadkine College, theatregoers, users of the gymnasium, members of the congregation of the nearby church and residents from the Agniesebuurt neighbourhood (Public Space, 2013).

Image 11: The Water Square

Source: (Public Space, 2013)

Now refurbished, Benthemplein is known as “Waterplein” (Water Square) because of the installation of three pools which fill up when it rains. However, for a significant part of the year the pools are dry and can be used as recreational spaces (playing area for football, basketball or volleyball, and it has two rows of tiered seating) (Public Space, 2013).

The “Water Square” is a good example of the benefits that can accrue when public facilities serve more than one use/function. As a result of their versatility and the variety of guises they take on over the year, the Benthemplein ponds bring dynamism, increase useability and add meaning to the space (Public Space, 2013).

Table 7: Relevant Projects' Results

No.	Project Acronym	Results/ Expected Results
1	LIFE HEATLAND	The project's results: - Increase in solar reflectance of 173%, decrease in the ambient temperature by around 2ºC and the asphalt temperature by up to 15ºC. Also, the ambient noise level in the area is 3 dB (A) lower. - Four measurement towers that, over these 3 years, have obtained 6.5 million data, recording the following parameters every 15 minutes, 24 hours/ day: surface temperature of the pavement, air temperature, humidity, wind speed, solar radiation, atmospheric pollutants, lighting level and noise. - After an agreement reached with the Barcelona City Council, the project will be replicated in one of the city's streets at the end of November 2021 with a total surface area of approximately 4,200 m2.
2	LIFE GREEN HEART	The project's expected results: - Air temperature reduced by 3oC on average in the areas with urban regreening implementation during intense heat periods. - Green space surface area in the city centre increased from 3 hectares to 19 hectares by 2024. - Surface area of the riverside vegetation increased by 50% between 2018 and 2024. - A continuity of 4 km of the green and blue infrastructure networks. - Biodiversity restoration across 30 hectares. - 800 parking spaces deleted (70%) compared to 2018. - Creation of walking and cycling routes on a total area of 5.6 hectares. - Reduction of noise pollution by 3 dbs.
3	LIFE Tree Check	The project's expected results: - Increased compliance and enforcement of the European Climate Change Adaptation Strategy in CEE by designing and implementing concrete

No.	Project Acronym	Results/ Expected Results
		governance steps in eight targeted cities with more than 100 000 citizens (regional capitals): Prague, Brno, Ostrava (all Czech Republic), Kosice (Slovakia), Prerov (Slovakia) and Walbrzych (Poland). - Activities and involvement planned for Plzen (Czech Republic) and Budapest (Hungary) and further disseminated to 100 cities with more than 40 000 inhabitants in the target countries and shared at EU level. - New easily replicable tools for decision-makers and professionals to strengthen the implementation, planning and management of urban green infrastructure as well as tools strengthening citizen involvement. - Increased participation and changed behaviour of CEE citizens with regards to urban green infrastructure to prevent the adverse impacts of the UHI effect on their health, their quality of life and the environment. - More than 250 municipal green infrastructure managers and 150 local politicians in the pilot cities reached (measured by questionnaires and structured interviews before and after project implementation). - Multiple pilot actions for climate change adaptation carried out in the pilot cities with tailored specificities and local actions. - A catalogue of 15-20 unique adaptation measures recommended for each pilot city with a detailed cost-benefit analysis, feasibility assessment and potential demonstration projects. - More than 100 towns involved in the replicability phase becoming familiar with the TreeCheck Pro software and manual, and citizens using the TreeCheck App. - Wide spread of project activities (more than 18 000 visitors to the project website and 3 000 people following the daily updates of the project on social media.) - More than a million people reached by communication actions and motivation tools to involve them in urban decision-making, including media actions, awareness-raising campaigns, the Adaptation Measure of the Year and Urban Tree of the Year contests, the TreeCheck App and a range of community actions developed within the LIFE TreeCheck project.

No.	Project Acronym	Results/ Expected Results
4	LIFE METRO ADAPT	The project's results: - Development of the Metro Adapt Platform, which is a dissemination tool, aimed at providing an overview of the main issues addressed by the project. The Platform offers access to all the tools, analyses and collected data of the project. Thus, information on climate vulnerabilities affecting the territory can be shared with local administrations and authorities within the Metropolitan Area of Milan (MetroAdapt, n.d.). - A climatological analysis and territorial vulnerability study were undertaken. Specifically, two potential runoff maps were produced, one for critical events, referring to a day of heavy rains, and one for annual figures that consider the maximum value of fallen rain per territorial unit. Data provision about the urban drainage network that registered recurrent issues in some municipalities and provision of data on the critical situations of the urban drainage network that occurred during the 2016 weather events (flood events). - A catalogue of 20 NBS has been produced to illustrate the solutions that can be implemented in urban and peri-urban areas, specifying their scale of application, describing their environmental and socio-economic benefits, the advantages and disadvantages and providing examples of good practices. - The Metropolitan City of Milan has therefore defined within its general planning tool, the Metropolitan Territorial Plan, an action strategy for its entire territory, improving the integration of adaptation policies within territorial planning and creating the necessary framework for the concrete implementation of initiatives that contribute to increasing the resilience and adaptability of the territory to the most appropriate scale.
5	LIFE URBAN PROOF	The project's results: - Development of the UrbanProof toolkit, a web-based platform and decision-support tool for urban adaptation planning and community-based participation. - Production of a toolkit administrator guide and tutorial video. - Evaluation of the technical and economic viability of the toolkit. - Identification and assessment of the likely impacts of climate change on the partner municipalities in Cyprus, Greece and Italy and development of local adaptation strategies for these municipalities. - Endorsement by the municipalities of these strategies (local council approval);

No.	Project Acronym	Results/ Expected Results
		- Implementation of green infrastructure projects in partner municipalities in Cyprus and Italy. The expected impact of these measures is quantified as follows: ▪ Green roofs: o runoff reduction of 38% o reduction of annual energy demand for heating/cooling by 7.9kW/m2/year o reduction of greenhouse gas emissions by 4.3kg CO2 equivalent o reduction of ambient air temperature by 1°C ▪ Permeable pavements: o runoff reduction of 20-30%, o reduction of ambient air temperature by 1.5°C ▪ Greening areas: o runoff reduction of 23-34% o urban agricultural gardens: ✓ runoff reduction of 10-50% - Dissemination activities throughout the project's lifespan to raise awareness of the project and its potential for replicability, including events, training seminars, a scientific conference, and technical and scientific publications.
6	LIFE LOCAL ADAPT	The project's expected results: - Local risk and vulnerability assessment, related to recent high impact events of heat, heavy rain and drought. - Climate adaptation factsheets for the participating municipalities (completed for Germany, Austria and Czech Republic) - An assessment of the benefits and co-benefits of particular urban adaptations measures.

No.	Project Acronym	Results/ Expected Results
		- Examination of resilience options, including best practice examples in the context of urban flooding, flash floods, soil erosion and heat waves. - Examination of funding programmes supporting climate change adaptation at municipal level. - Transfer knowledge on climate change, local climate risks and adaptation strategies in the fields of strategic regional planning, urban land-use planning, social infrastructure, technical infrastructure and disaster management, though 29 workshops/information events with the municipalities of the three project regions. - A concept for the implementation of a CCA advisory service. - Enhanced climate change adaptation knowledge and capacity amongst decisions-makers in at least 15 municipalities/counties and four other organisations. - Newly implemented features for Regional Climate Information Systems. - Policy improvement in at least 10 municipalities/ counties. - Implementation of at least five best practice measures in key vulnerable climate adaptation-related sectors in Saxony and Styria. - At least five municipal CCA strategies. - Contingency plans for severe heavy rain and heat waves. - Integration of the solutions identified during the project into existing climate services. These will be introduced to key multipliers at national level.
7	LIFE Veg-Gap	The project's expected results: - A Database with the inventory of projects and initiatives, so far - exploitation of lessons learnt related to urban ecosystems/vegetation and air pollution. - Critical analysis of different sources of information available to quantify the vegetation in urban areas. - References/methodologies for estimating vegetation characteristics relevant for air pollution. - Development of a methodology to map vegetation in target urban areas prone to O3 (Ozone) and PM (Particulate Matter) exceedances. This will support further analysis aimed at evaluating plant-atmosphere interactions (e.g., impact on natural ventilation patterns, adsorption, transformation, emission of air pollutants). - BVOC emission database for Bologna, Madrid and Milan prone to O3 exceedances using a consistent computation methodology for the different

No.	Project Acronym	Results/ Expected Results
		areas and vegetation scenarios. The database will contain information on time and space emission variability as a function of meteorological conditions and biological/ecosystem characteristics. - Assessment of the role of vegetation ecosystems in urban heating and cooling patterns and the relation with air pollution in three municipalities: Bologna, Madrid and Milan. - Establishing synergic interaction with other initiatives/projects such as JRC/FAIRMODE and Life PREPAIR in order to guarantee an added value of the project results in addressing O3 and PM exceedances in urban areas providing relevant data for urban AQPs (Air Quality Plans) and general public. - High resolution maps of relevant indexes for health and vegetation ecosystem risk assessments in terms of concentration changes (limit values, target values and critical levels) for each city (Bologna, Milan and Madrid) and scenario. - High resolution maps of relevant indexes for health and vegetation ecosystem risk assessments (exceedances, mortality, O3 fluxes, etc.) for each city and scenario. - Assessment report on the impact of urban ecosystems/vegetation on health and ecosystem risks due to their effect on air pollution for the selected reference cities. - Guidelines for estimating impact of urban ecosystems/ vegetation on health and ecosystem risks due to their effect on air pollution. - Provision of clear and simple as possible information about the status of urban ecosystems/vegetation and air quality in Europe at present, ecosystems characteristics, their emissions and their potential role in air quality maintenance and change, their impact on human health and ecosystems themselves, etc. Engagement with at least 25,000 people. - Transfer of knowledge about the link between vegetation ecosystem and air quality in cities, evaluate project's achievements and encourage other stakeholders for its replication. - Coordination with other LIFE and not LIFE projects, at local and at consortium level. - Three networking events, one in each of the cities participating in the project: Bologna, Madrid and Milan. - Networking with at least 20 projects.

No.	Project Acronym	Results/ Expected Results
8	LIFE RAMSES	The project's results: - Final publishable summary report. - RAMSES policy briefs. - Scientific reports (Political/ Institutional Assessment, Cost Assessment): ▪ A Transition model supporting cities in the selection of the best alternative of transition to climate change adaptation at short and long term. This model provides pathway alternatives guiding the cities translation into future resilient cities. ▪ Transition reports for selected case studies - Application of the transition model. The model (methodology) was validated in London, applied in the city of Antwerp and results were transferred to the city of Bilbao. ▪ Identification of factors influencing the transition dynamics. ▪ Identification of drivers of urban growth in the political and institutional context. ▪ Analytical framework of the decision-making process on adaptation. ▪ Stakeholder survey report. ▪ A cost assessment framework to help policy makers make adaptation decisions more effectively and efficiently. The framework follows a hierarchical approach for prioritising and financing adaptation. ▪ Adaptation Cost Curves ▪ Methods inventory for infrastructure assessment ▪ Economic costs of heat and flooding in cities: Cost and economic data for the European Clearinghouse databases ▪ Assessment tool to estimate the economic costs of health impacts of climate change at the local level. ▪ Review on economic assessment of damage or adaptation costs of health effects of climate change. ▪ Review of climate change losses and adaptation costs for case studies. - Journal articles, PhD theses, book chapters etc. - RAMSES Transition Handbook and Training Package ▪ A Transition Handbook which embeds the most important findings from the project in a process management cycle, using the Urban Adaptation Support Tool developed by the European Environment Agency, and synthetises the project results in a practical step-by-step fashion, presenting resources that cities can use to strengthen their knowledge of climate adaptation planning.

No.	Project Acronym	Results/ Expected Results
		▪ A Training Package which complements the Transition Handbook by taking stock of existing toolkits to support adaptation management in cities and proposes worksheets and exercises that city can use to progress on their adaptation endeavours. The worksheets complement the information contained in the Transition Handbook and offer cities a clear path towards becoming more climate adaptive. - Development of the RAMSES Common Platform. - An Audio-visual guidance tool - Over 100 short video interviews “On Urban Resilience” from 33 climate change adaptation and resilience experts. - RAMSES webinars and Stakeholder Dialogues Several workshops, conferences, and dissemination activities. - Newsletters
9	LIFE QUF	The project’s results: - 30,000 trees were planted in Valladolid, there was a combination of use of mycorrhizae and water retainers, and native species such as almond (Prunus dulcis), holm oak (Quercus ilex), stone pine (Pinus pinea), juniper (Juniperus thurifera) and field maple (Acer campestre) were used. - The evolution of the plantation and environmental indicators were monitored through new technologies. - The GSEC group (a network of Green Southern European Cities) was created to exchange experiences and best practices, and to act as a lobby group to promote urban plantations and support legislative and funding decisions to encourage reforestation techniques around arid cities. - The White Book was created, in which all the project’s information and results were collected. - The treatments increased the survival rate of trees by up to 30% when they included water retainers; the effect being lower (17%) using only mycorrhiza.a - Humidity increased.

No.	Project Acronym	Results/ Expected Results
10	LIFE CLIVUT	The project's expected results: - Reduced urban emissions (CO_2 equivalent: -18,200 tonnes/year; NO_x: -1,200 tonnes/year; SO_2: -2,300 tonnes/year) thanks to tree planting, new zero-emission strategies from companies joining the pilot actions, among other changes. - Carbon and PM10 sequestration from trees planted amounting to 230 tonnes of CO_2 and 2,600 tonnes of PM10 annually. - Energy savings of 82,000 MWh/year as a result of trees' micro-climatic benefits. - At least a 10% increase in the City Biodiversity Index (Singapore Index) score in the four cities. - Eradication of alien species and restoration of native species in about 100 ha of urban green spa.
11	LIFE DERRIS	The project's results: - The LIFE DERRIS project successfully tested an innovative model of public-private partnership between insurers, public administrations and SMEs to increase urban resilience to climate change, including through risk reduction tools for SMEs. Specific actions included: ▪ Risk assessment/risk management training for 296 people from SMEs and public authorities in Turin and 10 other cities in Italy. ▪ Development of a Climate Risk Assessment and Management (CRAM) Tool to help enterprises to identify adaptation measures that they should implement to enhance resilience. After trials with 30 companies in Turin, this was rolled out to more than 3 800 companies across Italy, of which more than 300 calculated their firm's risk index. ▪ Creation of 128 company adaptation action plans (CAAPs), which outlined a great number of specific steps the participating companies could take to cope with floods, drought, high temperatures, high winds and other extreme weather events. ▪ Development and implementation in part of Turin of a new governance model for climate risk management, the Integrated District Adaptation Plan. This public-private partnership was subsequently formalised through local and national after-LIFE agreements. ▪ Provision of access to credit (through Unipol) for companies that have a CAAP in place, to favour the implementation of resilience measures; and ▪ Guidance to enable other insurance and financial services companies to replicate the innovations proposed by the project. - The municipalities of Milan, Avigliana and Almese agreed to replicate the measures introduced by LIFE DERRIS in Turin. Most of the tools developed by the project will be shared on the Climate-ADAPT platform to facilitate uptake by cities and towns ready to produce their own Adaptation Strategy

No.	Project Acronym	Results/ Expected Results
		but also the cities already committed to the Mayors Adapt Initiative across Europe (European Commission, 2018). - The sustainability of project results and the continuation of initiatives after the end of LIFE funding will be guaranteed by the broad Unipol and partners network, which includes clients, associates and professionals with about 1 million SMEs, 10 000 local insurance agencies and 350 municipalities. Unipol will maintain its online adaptation platform and DERRIS Community, and together with CINEAS, it will continue to train companies to use the CRAM tool (European Commission, 2018).
12	LIFE AdaptInGR	The project's expected results: - Acceleration of the implementation of regional adaptation action plans in the 13 Greek regions. - Implementation of streamlined monitoring and evaluation adaptation methodologies and use of common thematic indicators across Greece. - A national adaptation hub for stakeholder groups and the general public, gathering all project resources, as well as additional good practice examples. - Increased resilience to climate change in priority sectors in 3 regions of Greece, achieved through the implementation of specific pilot projects, to befurther scaled up through complementary actions. - Implementation of climate resilience commitments through adaptation projects in 5 Greek municipalities; increased resilience of towns and cities to climate change (built environment, coastal zones, flood management) through the application of green infrastructure and ecosystem-based approaches. - Integration of adaptation and mitigation synergies, objectives and trade-offs within the framework of Greeces 2050 long-term low emission strategy of Greece and revised national adaptation strategy. - Pilot climate change impact assessments and guidelines for the selection of adaptation measures for landscapes and land use to guide the implementation of adaptation measures in regions/areas with similar characteristics and vulnerabilities (Greece and EU). - Guidelines and best practices for climate change adaptation for regions and municipalities.

No.	Project Acronym	Results/ Expected Results
		- Increased knowledge and experience-sharing on (a) adaptation options for implementing climate change adaptation in the EU and the Mediterranean, (b) quantification of the environmental output (benefits and impact) for specific adaptation actions, (c) good adaptation practices for priority sectors in the Mediterranean. - Enhanced public and stakeholder awareness on climate adaptation policy and action at national and regional level. - Refinement and coordination of funding priorities for implementing climate change adaptation in the current and post-2020 (new ESIF) period. - Review of the Greek national adaptation strategy, revised national adaptation strategy and regionally specific terms of reference for the 7-year review of the regional adaptation action plans. - Support the update of the regional adaptation action plans after 7 years. In addition to the IP budget itself, the project will mobilise up to approx. 446 million from EU, national and private sector funds.
13	LIFE HEROTILE	The project's results: - Development of innovative roof tiles that can passively remove heat, so reducing energy consumption for the cooling of buildings by up to 50%. The tiles were introduced into the market soon after the project ended (European Commission, 2019). - The project beneficiaries developed two new clay roof tile designs and demonstrated their improved performances in terms of energy consumption for summer cooling and greenhouse gas (GHG) emissions. Performance was evaluated under controlled conditions, and in real-world conditions by refurbishing the roofs of two demonstrative buildings in Cadelbosco (Italy) and Zaragosa (Spain). - Development of a software tool (SENSAPIRO) for the assessment of the cooling performances of roofs based on the results of the project demonstrations. - The main environmental benefits were: ▪ A reduction of about 10-50% in energy consumption for house cooling during the summer due to improved passive ventilation of the roof envelope, depending on the type of roof ▪ A related reduction (10-50%) in GHG emissions and air pollution. - Other benefits were: ▪ Reduced heating requirements in winter due to increased insulation (thicker air cushion) in the under-roof space, and

No.	Project Acronym	Results/ Expected Results
		▪ Reduced moisture in LIFE HEROTILE successfully developed innovative roof tiles that can passively remove heat, so reducing energy consumption for the cooling of buildings by up to 50%.
14	LIFE LUNGS	The project's expected results: - Better use of rainwater by trialling zero rainwater waste areas and implementing rain-fed ecosystems in an area of over 100 ha. - Over 100 ha of shaded areas thanks to tree planting, with improved microclimate conditions within the urban, green areas. - Improved flood resilience in over 100 ha of the urban green infrastructure areas. - Around 115 ha to benefit from increased resilience against soil erosion by using natural-based solutions. - Around 740 tonnes of CO_2 sequestered. - Replication of the project once at EU level during the project lifetime, and three times afterwards, two cases in Portugal and one at EU level. - Reproduction of project activities in five private green areas in Lisbon. - Share of technical knowhow with around 20 municipalities in the Lisbon metropolitan area and with five other Portuguese municipalities which are working on climate adaptation. - Encouragement of more local urban farmers to use more water-efficient and climate-adapted irrigation.
15	EU - Horizon 2020 - Heat Shield	The project's expected results: - Production of reports on: ▪ Defining appropriate heat stress indices to obtain from available atmospheric variables ▪ Solutions to mitigate heat stress of workers in the transportation sector ▪ The effects of climatic change on health and work productivity

No.	Project Acronym	Results/ Expected Results
		▪ Solutions to mitigate heat stress of workers in the construction sector, ▪ Accumulated evidence and final guidelines to mitigate heat stress of workers from each of the addressed industries ▪ Solutions to mitigate heat stress of workers in the agricultural sector, ▪ Solutions to mitigate heat stress of workers in the manufacturing sector, ▪ Solutions to mitigate heat stress of workers in the tourism sector, ▪ Existing/piloted early warning systems - Maps ▪ Vulnerability maps for health and productivity impact across Europe ▪ High-resolution maps identifying heat stress indices over Europe for the current climate conditions and for future conditions based on climate model simulations - Online access service to help industry and society anticipate threats to workers' health and to disseminate adaptation guidelines
16	EU - Horizon 2020 - Grow Green project	The project's expected results: - Development of the Green Cities Framework, which provides a step-by-step guide for cities to develop a successful strategy for nature-based solutions. - Development of the GrowGreen NBS co-design guide - a tool that guides the NBS co-design process through questions. It is structured similarly as the GCF (Green Cities Framework), based on three main pillars: Planning, Mobilising, and Evaluating. - Development of Nbs projects and strategies in Manchester (UK), Wroclaw (Poland), Valencia (Spain), Wuhan (China), Brest (France), Modena (Italy) and Zadar (Croatia). - Promotion of the project outputs to 4-5 replication cities in Latin America, Africa and India to encourage them to develop and implement NBS strategies and to 146 Chinese 'Sponge Cities'. These channels have been designed to create global demand for NBS and to promote European NBS products and services to meet this demand (CORDIS EUROPA, 2017).
17	EU - Horizon 2020 -	The project's expected results:

No.	Project Acronym	Results/ Expected Results
	UNaLAB	- Implementation of nature-based solutions towards climate change mitigation and adaptation, along with the sustainable management of water resources. - Collaboration of local stakeholders and citizens. Co-creation approach among cities. - Development of NBS roadmaps and global NBS marketplace. - Development of a European NBS Reference framework on cost-effectiveness, economic viability and replicability of nature-based solutions, which will guide cities across Europe and beyond in developing and implementing their own co-creative nature-based solutions.
18	EU - Horizon 2020 - Urban GreenUP	The project's expected results: - Implementation of nature-based solutions throughout the project, covering a variety of complementary yet interconnected aspects of urban life and infrastructures, grouped into four categories: re-naturing urbanization, water interventions, singular green infrastructures and non-technical interventions, aiming at achieving a variety of impacts related with both environmental and socio-economic aspects (i.e. reduction of CO2 emissions and temperature during summer time, storing rain water during storms, use sequestrate carbon from the atmosphere for self-fertilization use etc.). - Improvement of quality of life in urban areas. - Raise of awareness on the importance of environment preservation among citizens. - Creation of new market opportunities for European companies at international level. - Foster the creation of transnational networks and synergies. - Highlighting the Importance of active participation of local communities to activities that involve citizens towards the address of climate problems.
19	EU - Horizon 2020 -	The project's results:

No.	Project Acronym	Results/ Expected Results
	URBANFLUXES	- Development of new synergistic algorithms for analysis of EO data. - Implementation of new urban surface parameterization schemes. - EO-based estimation of UEB fluxes, validated in three case studies. - Successful estimation of anthropogenic heat flux relative spatial patterns. - Involvement of users via Community of Practice and organization of successful demonstrations. - Advancement of the current knowledge of the role of the different UEB fluxes on UHI and hence on urban climate and energy consumption. - Production of results capable of supporting the development of Sentinels-based downstream services towards informing policymaking.
20	EU - Horizon 2020 - MUSE GeoERA	The project's results: - Identification, summary and development of state-of-the-art methods including harmonized standards for: quantifying the potential of SGE use in urban areas, evaluating cost-efficient geophysical exploration and monitoring tools, assessing constraints of use associated with open- and closed-loop systems and evaluating the efficiency and impacts of SGE installations. - Development of strategies for efficient and sustainable use of SGE in European urban areas by means of: evaluating current legal regulation, identifying and promoting prospective technical concepts and summarising criteria, strategies and actions for planning, managing and monitoring of SGE use in cities. - Transfer and integration of these methods into strategies in urban pilot areas across Europe. - Dissemination of shared knowledge by displaying spatial output datasets via the web-hosted services integrated in the GeoERA Information Platform and other dissemination actions. - Contribution to the overall GeoERA objectives by knowledge exchange and interacting with other projects of GeoERA covering overlapping and cross-cutting aspects of SGE use in the urban areas as well as providing technical concepts and datasets for implementing geoscientific knowledge related to SGE use in the European Geological Data Infrastructure (EGDI) information platform.
21	EU - Horizon 2020 -	The project's results:

No.	Project Acronym	Results/ Expected Results
	Climate-Fit City	- Identification of the barriers preventing urban administrators, planners and coordinators from seizing the opportunities offered by climate services. - Transformation of high-calibre scientific data into highly usable tools to address specific local challenges. - Production of high-level spatial resolution urban climate data, as well as detailed, local-scale climate-change impact information, and very specific impact analyses, giving a clear insight into the best way to build sustainability and resilience. - Facilitation of clear communication between the climate community and sector specific experts. - Creation of urban climate service communities capable of integrating climate wisdom into the very fabric of their cities. - Involvement of end-users and climate service providers in the co-design/-development of six concrete sectoral cases, to be implemented in Antwerp, Barcelona, Bern, Prague, Rome, and Vienna. Implementation of a detailed socio-economic impact analysis in each case, quantifying the benefits of using urban climate information. - Upscaling and market replication, aiming at the extension with six new cases, involving new (non-financed) end-users.

22	EU - Horizon 2020 - SOLOCLIM	The project's expected results:
		- Investigation of the following three clusters of microclimatic interventions in the urban environment:
		  ▪ Vegetation-based interventions - green facades
		  ▪ Solutions using water - water vaporization
		  ▪ Climate-responsive flexible systems - movable systems that respond to weather or microclimate change
		- Development of such solutions on different scale levels from small scale around buildings to a larger neighbourhood/city scale and test their effects.
		- Training for advanced climate responsive design offered to experts, PhD students as well as some parts to a broader community and beyond the duration of the project (SoloCLIM, 2019).

No.	Project Acronym	Results/ Expected Results
23	URCLIM	Some of the project's results included publications on: - Publications on: ▪ Modeling the scaling of short-duration precipitation extremes with temperature, in Earth and Space Science Journal. ▪ Urban climate services: climate impact projections and their uncertainties at city scale, in FMI's Climate Bulletin. ▪ Heat related mortality in the two largest Belgian urban areas: A time series analysis, in Environmental Research journal. ▪ A statistical-dynamical methodology to downscale regional climate projections to urban scale, in Journal of Applied Meteorology and Climatology. ▪ Co-Visualization of Air Temperature and Urban Data for Visual Exploration, in IEEEVIS 2020. ▪ Visualizing 3D climate data in urban 3D models, in International Journal of Photogrammetry and Remote Sensing. ▪ City-descriptive input data for urban climate models: Model requirements, data sources and challenges, in Urban Climate, vol.31.
24	CLIMPACT	The project's expected results: - Immediate integration, harmonization, and optimization of existing climate services and early warning systems for climate change-related natural disasters in Greece, including supportive observations from relevant national infrastructures. - Creation of a scientific core of research excellence to generate new knowledge on climate change, by supporting innovative studies (computational and experimental) to reduce uncertainties in climate models, as there is currently a core of outstanding Greek scientists involved active in climate change issues. This action will also utilize the current infrastructure of the National Road Map (e.g., PANACEA, HIMIOFoTS) and will act in addition to projects already underway, (e.g., 'Life-IP Program' – Adaptation to climate change/Coordinator Ministry of Environment and Energy, Report of the Bank of Greece on Climate Change). - Establishment of an interdisciplinary consortium, which will act as the main advisory body for the State and the citizens on issues of climate change and its related effects. Through scientific excellence and innovative computer and measurement systems, the proposed flagship initiative aims to consolidate this consortium internationally as a scientific interlocutor equal to those of other countries. The initiative is anticipated to influence decision-making internationally both to climate change mitigation and to research-related topics on climate change.

No.	Project Acronym	Results/ Expected Results
25	DUE - UHI	The project's results: - Development of adequate and validated methodologies to assimilate satellite remote sensing observations (in particular of LST) with urban ground stations into urban meteorological and climate modeling (e.g., AT historical products). - Implementation of a user-tailored information system – based on a WebGIS and on the state-of-the- art EO algorithms – providing a standard methodology useful in different regions and cities and possibly transferred in other cities. - A deep analysis of needs and requirements of potential users involved into UHI and energy efficiency matters was performed. - A trade-off analysis to find high level mission scenarios able to respond adequately to different users' scenarios/needs. - Identification of two high level scenarios. For each scenario a set of high-level mission requirements, observations, and scenarios for a regular and efficient monitoring of surface and air temperature sensor were indicated. - Development of winter and summer thermography products using airborne and satellite data. Two use cases have been reported for Madrid and Brussels. Users of both cities expressed a high interest and willingness to use airborne-based products rather than satellite- based products considered too coarse for such application.

PART E: Financial tools for Green Infrastructure funding.

E.1. Private Bank funding

Banking sector provides specific tools for the support of Green Infrastructures, either with internal funds or with a funding scheme that combines private and public sources.

With regards to Greece, all four systemic Greek Banks support Green Infrastructure of business and residencies, through the development of specific products, i.e. Loans for “Green Purchases” or “Green Repairs”, as well as through investments and funding towards a sustainable environment. In Italy, SMEs financing is often based on banks and almost half of Italian businesses are "green-oriented", according to the Report “Programma per la Transizione alla Green Economy” published in November 2017 by Italy's Foundation for Sustainable Development.

Indicative supportive banking products in both countries:

- **National Bank of Greece (NBG)** together with the **European Investment Bank (EIB)**, have launched a new green and urban infrastructure investment scheme to support renewable energy, energy efficiency and urban development projects across Greece, through an agreement of an infrastructure investment Initiative **(IntraFoF)**. The National Bank of Greece and the European Investment Bank, which will manage the new fund, agreed the details of the first EUR 32 million components to be made available for investment.
  Also, the National Bank of Greece has created the following programs/products:
  - **“Eksoikonomo – Aftonomo” (save money – make autonomous) Programme:** NBG offers to energy inspectors and contractors / suppliers of the program, the possibility of receiving financing on preferential terms to cover the increased working capital needs that will arise -from the implementation of the projects under the program with special privileges.
  - **Green Loan:** addressed to individuals and finances houses’ energy upgrade with environmentally friendly products and services. The funding percentage can reach up to 100% of the expenditure up to 30,000 euros.
  - **Estia Green:** a pioneering housing loan, which offers solutions for the purchase or construction of an environmentally friendly, energy efficient home, as well as for energy home improvements. The loan amount (at a minimum of € 10,000) may finance up to 100% of the total cost of the investment (based on the purchase contract), or of the relevant project.
- **Piraeus Bank of Greece**, with a focus in the Sustainable Development, participates to the Infrastructural Fund of Funds **(IntraFoF)** supporting both Public and Private entities in their Green Infrastructure ventures. Piraeus Bank will finance "clean" energy projects through the Fund, such as wind farms, photovoltaic stations, biogas and biomass installations and hydropower plants. New investments to improve energy efficiency in public and private buildings will also be considered. This initiative will mobilize investments that are expected to have a significant impact on socio-economic development, such as industrial and craft

parks, facilities for educational or cultural use, construction, expansion, upgrading or renovation of hotels and other tourist accommodation and facilities (i.e., hot springs, marinas, conference rooms). Further, with the “**Eksoikonomo – Aftonomo”** Programme, Piraeus Bank can support residencies in low energy efficiency classification, to become “Greener”, by providing Loans with special privileges.

- **Eurobank**: continues to expand its “green” products range so as to contribute to a significant improvement in the living quality of households and in environmental protection in Greece. Specifically, Eurobank has created the ***Green Housing - Energy Saving Loan*** to finance home repair or renovation works, aimed at upgrading energy efficiency and enhancing energy conservation. Eurobank’s Green Housing - Energy Saving Loan offers real solutions, giving homeowners the opportunity to improve energy efficiency of their house and reap real economic benefits, to ensure a better quality of life, while also contributing to the protection of the environment. The Green Housing - Energy Saving Loan offers the following features:
    - Preferential floating interest rate in Euro;
    - 100% coverage of the cost of repairs;
    - may be issued with or without property underwriting;
    - technical support throughout the duration of works.

  Also, Eurobank supports the “**Eksoikonomo – Aftonomo”** Programme, through the provision of Loans with special privileges.
- **Alpha Bank**: In addition to the special financing for the **"Eksoikonomo – Aftonomo" Programme,** which ensures an eco-friendly and cost saving way of life by increasing home energy efficiency with premium financing, Alpha Bank has created a series of "***Green Solutions***", which finance the *energy upgrade of the house* (80% of the value of the property and up to 100% of the purchase contract, with minimum amount of 10,000 euros and lasting from 5 to 35 years). Also, the green solutions extend to ***consumer loans*** (duration from 6 to 96 months and amounts from 1,500 euros to 30,000 euros), but also for **purchases of *electric car and bicycle*** (also up to 30,000 euros and duration up to 96 months).
- **Bank of Italy:** The Bank of Italy (regulated by public-law) is committed to sustainable economic development, with a priority in its investment choices that respect the environment and work towards sustainable growth. To this extent, the Bank supports green activities, after examining the received applications. Further, the Bank is a member of the Network for Greening the Financial System, a global financial group which treats climate change as a threat to financial stability. In 2019, it has also purchased shares in an investment fund specialized in green bonds, financing projects with an interest in environmental sustainability managed by the Bank for International Settlements. It also decided to extend its sustainability criteria to its own corporate bond portfolio.

- **Fineco Bank:** One of the leading private banks in Italy, that supports Green Infrastructure, through specific products such as the provision of Green Mortgage / green Loans, with a fixed rate (from 0,60%) for the purchase of an A-class energy home, while the Bank's business model is focusing on the sustainable growing strategy and achievements of the 17 Sustainable Goals (SDGs) of the United Nations (UN) 2030 Agenda.
- **Mediobanca Group:** The financial and credit products of Mediobanca, are designed to support the social and environmental development of local areas and reward those who invest to sustainability. In this context, the Group has defined and implemented a Green and Sustainable Bond Framework, enabling it to complete its first green bond issue for institutional investors in a nominal amount of € 500 million (09/2020). Also, the digital bank launched by the Group in 2008 – CheBanca! – has launched green mortgages for people interested to buy or refurbished properties in energy class A or B, with a lower spread than mortgages for other properties. Also, an extensive catalogue of financial products and services with sustainable objectives are also offered by the Group, as well as funds that promote environmental and social characteristics, aiming to increase the value of the invested capital over time, by considering sustainable finance criteria, i.e. environmental, social and governance (ESG) factors, as well as the traditional financial ones.
- **Banco BPM:** Banco BPM has a focus in sustainability, aiming to contribute to the sustainable growth of Italy through initiatives that have an economic, social and environmental impact, providing finance sources to environmental projects with products in the following areas: Project Financing, mainly in the field of renewable energy sources; Investments in closed-end funds, supporting strategic projects for leading Italian companies in the renewable energy sector; Products for individuals and businesses, including leasing and personal loans at advantageous rates. Specific products to be noted: Ecology package: Online funding dedicated to consumers, business and condominiums) for green projects' Photovoltaic Loan (for Individuals, businesses or apartment buildings.
- **Intesa SanPaolo:** The Bank supports Green projects of retail customers through the **provision of Loans and mortgages for environmental purposes**. Such loans include the renovation of buildings with eco-friendly perspective, energy efficiency activities etc., also covering a wide range of financing such products for companies and non-profit companies that wish to invest in energy efficiency projects.
- **Banca Generali:** With a long-term strategy focused on sustainable development, promotes sustainable investments, with an approach based on the "Sustainable Development Goals" promoted by the United Nations, and supports its customers in pursuing environmental, social and good governance results. Thus, the Bank provides **financial advisory services** for investments that will effectuate green projects. **BG4Real** is a programme for investments solutions and instruments oriented to the real economy through dedicated services and innovative products. Also, a **new non-reserved AIF** (Alternative Investment Fund) — **8a+ Real Innovation** — dedicated to innovative Italian and European SMEs and targeted to private clients, with a minimum investment of €100 thousand.

E.2. NSRF funding

National Strategic Reference Framework (NSRF) 2014-2020, is the main pillar of development of Greece and the tool for funding programs implementation. The NSRF funds, aim at the development of entrepreneurship, the modernization of infrastructure, the human resources upgrading, the regional development stimulation and the society and economy adaptation to new technologies.

The objectives of the European Structural and Investment Funds of the EU, through which, the National Strategic Reference Framework (NSRF) 2014-2020 is funded, are implemented through Operational Programs that are either Sectoral or Regional. The ones that could support Green Infrastructure projects are:

- **OP Competitiveness, Entrepreneurship and Innovation:** This OP contributes to achieving the Europe 2020 targets for smart, sustainable, and inclusive growth.
  The OP will contribute to promote the following key priorities:
  - "Enhancing entrepreneurship with sectorial priorities" (ERDF –50,79% of EU allocation): increase research potential and private investments in research and development, promote innovation and outturn of SMEs, particularly in sectors with a competitive advantage (agri-food, energy, supply chain, cultural and creative industries, environment, tourism/culture, ICT, health, Material/Constructions).
  - "Adaptability of employees, enterprises and entrepreneurial environment to the new development requirements" (ESF –18,18% of EU allocation): aiming at matching the employees and enterprises skills to the development needs. In parallel, the effort will focus on the capacity of the public administration to facilitate the improvement of the entrepreneurial environment.
  - "Development of mechanisms to enhance entrepreneurship" (ERDF –29,19 % of EU allocation): invest in upgrading the country's infrastructures in the sectors enhancing the development of entrepreneurship, the innovation and the outturn of the enterprises (mainly research centers, broadband and NGA infrastructures and energy efficiency interventions).
  - "Technical Assistance" (ERDF - 1.50% and ESF 0.34% of EU allocation respectively): provision of technical assistance.

The total OP budget is 6,422,664,136.00 € while the total EU contribution amounts to 4,970,859,417.00 €.

- **OP Transport Infrastructure, Environment and Sustainable Development:** The program includes in total 16 priority axes, divided amongst transport and environment. It bases itself upon the following Thematic Objectives:
  - Supporting the shift towards a low carbon economy in all sectors

- Promoting climate change adaptation, risk prevention and management
- Preserving and protecting the environment and promoting resource efficiency
- Promoting sustainable transport and removing bottlenecks in key network infrastructures.

The Funding priorities of the OP, relating to transport are listed below:

- Promoting the completion of part of the infrastructures of the core TEN-T (road and rail) and developing/improving the comprehensive TEN-T (with emphasis on road and rail, but also with focused interventions on ports and airports).
- Promoting combined transportation and the modernization of the transport system.
- Improving the safety of transportation.
- Developing and expanding sustainable and ecological urban transportation (urban transportation of fixed trajectory and other clean modes of surface transportation).

The OP, relating to the environment priorities:

- Aims to implement important environmental projects and provides compliance to the European Environmental acquis mainly in the sectors of solid waste, waters and waste waters and biodiversity.
- Focuses on the tackling of climate change and flood risk prevention and management.
- Undertakes focused actions in reducing environmental pollution and in particular air pollution and noise.
- Promotes sustainable urban development and promotes smart energy efficiency projects in public buildings and broader use of tele-heating.

The whole Operational Programme aims to create, during its implementation, 82,000 jobs with more than 32,000 in the transport sector and around 50,000 in the environment sector. ***The total OP budget amounts to 5,186,665,146 € while the total EU contribution is 4,333,917,411 €.***

- Thirteen (13) Regional Operational Programmes (ROP), one for each of the 13 administrative regions of the country, including regional-scale activities:
  The Partnership Agreement 2014-2020, along with the sectoral programs, includes 13 multi-sectoral and multi-funded Regional Operational Programmes (ROP). Each one of the Greek regions is the subject of a Regional Programme that includes projects and regional scale actions, leverages local strengths, and is funded by the European Regional Development Fund (ERDF) and the European Social Fund (ESF). The thirteen Regional Operational Programmes are:
  - ROP Eastern Macedonia and Thrace
  - ROP Central Macedonia
  - ROP Western Macedonia
  - ROP Epirus

- ROP Thessaly
- ROP Ionian Islands
- ROP Western Greece
- ROP Sterea Ellada
- ROP Attica
- ROP Peloponnese
- ROP Northern Aegean
- ROP Southern Aegean
- ROP Crete

Their common ground is the aim to strengthen the capacity of regional and local authorities to implement a full range of actions that aim to serve the main priorities of the PA. Moreover, the regions will be assigned the management of important resources of the Cohesion Fund for the Environment and especially funds that will be directed to meeting the country's as well as the Regions' obligations relating to waste water. The 13 Regions will also be assigned the management of approximately 30% of the funds from the Rural Development Programme.

An indicative tool that can fund Green Infrastructures, under the above Regional Operational Programmes is the "**Eksoikonomo-Aftonomo" 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, as presented above.

As regards **Italy**, the National Strategy for Development reflects on specific Operational Programmes, whilst those that <u>could potentially support Green Infrastructure</u> initiatives are presented below.

- National Operational Programme on Enterprises and Competitiveness
- National Operational Programme on Infrastructures and Networks
- National Operational Programme on Metropolitan Cities
- National Operational Programme on Research and Innovation
- National operational programme SME Initiative
- ROP Abruzzo ERDF
- ROP Basilicata ERDF
- ROP Calabria ERDF ESF
- ROP Campania ERDF
- ROP Emilia Romagna ERDF
- ROP Friuli Venezia Giulia ERDF
- ROP Lazio ERDF
- ROP Liguria ERDF

- ROP Lombardia ERDF
- ROP Marche ERDF
- ROP Molise ERDF ESF
- ROP PA Bolzano ERDF
- ROP PA Trento ERDF
- ROP Piemonte ERDF
- ROP Puglia ERDF ESF
- ROP Sardegna ERDF
- ROP Sicilia ERDF
- ROP Toscana ERDF
- ROP Umbria ERDF
- ROP Valle d'Aosta ERDF
- ROP Veneto ERDF

E.3. EU funding

Member States currently have the opportunity to support Green Infrastructure through Programmes integrated into their development strategies and co-financed from the Structural Funds (the European Regional Development Fund and European Social Fund), the Cohesion Fund, the European Maritime and Fisheries Fund, the European Agricultural Fund for Rural Development, LIFE+ and the research funding programmes. Funding for climate change mitigation and adaptation could also provide significant co-benefits for Green Infrastructure, given the carbon storage, erosion and flood control services of many ecosystems. The new multi-annual financial framework for the period 2014-2020 proposes enlarged financing possibilities for Green Infrastructure projects.

Such **Co-Financing Opportunities** currently available are analyzed below.

- Structural Funds (European Regional Development Fund and European Social Fund)
  ERDF aims to strengthen economic and social cohesion in the EU, focusing -among others- to investments related to low carbon economy.
  Under this Tool, **European Territorial Cooperation Programmes** are planned, as the ERDF also gives particular attention to specific territorial characteristics and includes actions designed to reduce economic, environmental and social problems in **urban** areas, with a special focus on **sustainable urban development.**
  European Territorial Cooperation Programmes of Interest in the field of the Project: More "popular" as Interreg, the European Territorial Cooperation Programmes include a series of Programmes that foresee joint actions and policy exchange between national, regional and local actors from different Member States, and can be divided into three categories:
    - **Cross-Border:** IPA CBC Italy – Albania - Montenegro [IT] , Interreg V-A - France-Italy (ALCOTRA) [FR] [IT], Interreg V-A - Greece-Italy [EL] [IT], Interreg V-A - Italy-Austria [DE] [IT], Interreg V-A - Italy-Croatia [HR] [IT], Interreg V-A - Italy-France (Maritime) [FR] [IT], Interreg V-A - Italy-Malta [IT] [MT], Interreg V-A - Italy-Slovenia [IT] [SL], Interreg V-A - Italy-Switzerland [IT], IPA CBC Greece - Albania [EL], IPA CBC Greece – Republic of North Macedonia [EL], Interreg V-A - Greece-Bulgaria [BG] [EL], Interreg V-A - Greece-Cyprus [EL], Balkan-Mediterranean [BG] [EL], Black Sea Basin.
    - **Transnational** (covering larger areas of Cooperation): Mediterranean [EL] [ES] [FR] [HR] [IT] [MT] [PT] [SL], Adriatic-Ionian [EL] [HR] [IT] [SL], Alpine Space [DE] [FR] [IT] [SL], Central Europe [CS] [DE] [FR] [HR] [HU] [IT] [PL] [SK] [SL].
    - **Interregional** which provide a framework for exchanging experience between regional and local bodies in different countries: INTERREG Europe, Urbact III, Interact III, ESPON.

The fifth period of Interreg is based on 11 investment priorities laid down in the ERDF Regulation contributing to the delivery of the Europe 2020 strategy for smart, sustainable, and inclusive growth.

This budget also includes the ERDF allocation for Member States to participate in EU external border cooperation Programmes supported by other instruments, while at least 80% of the budget for each cooperation programme has to concentrate on a maximum of 4 thematic objectives among the eleven EU priorities:

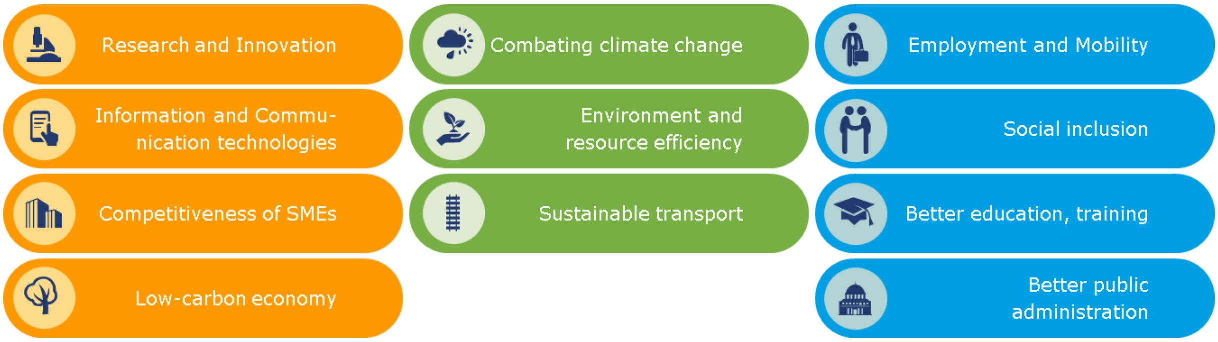


Image 1: EU Investment Priorities, https://ec.europa.eu

This budget also includes the ERDF allocation for Member States to participate in EU external border cooperation programmes supported by other instruments (**Instrument for Pre-Accession and European Neighborhood Instrument**):

- **12 Instrument for Pre-Accession Assistance (IPA) cross-border collaboration programmes.** EU allocation: EUR 11.7 billion, of which 242 million is earmarked for cross-border cooperation, which is based on partnerships with the EU candidate countries and potential candidate countries.
- **16 European Neighbourhood Instrument (ENI) cross-border collaboration programmes.** EU allocation: EUR 15.4 billion, of which 634 million is earmarked for cross-border cooperation, which promotes co-operation and economic integration between the EU and partner countries.

- **European Social Fund (ESF):** ESF Invests in people, with a focus on improving employment and education opportunities across the EU, with a focus on the following objectives: promoting employment and supporting labor mobility; promoting social inclusion and combating poverty; investing in education, skills and lifelong learning; enhancing institutional capacity and an efficient public administration.

- **Cohesion Fund:** This fund supports Members States with a Gross National Income (GNI) per inhabitant less than 90% of the EU average, aiming to promote sustainable development and reducing economic and social disparities. For the period 2014-2020, among the countries this opportunity concerns is Greece. The Fund allocates a total of € 63.4 billion to activities under the following categories:
  - trans-European transport networks, notably priority projects of European interest, under the **Connecting Europe Facility (CEF);**

- environment: projects related to energy or transport, as long as they clearly benefit the environment in terms of energy efficiency, use of renewable energy, developing rail transport, supporting intra-modality etc.

- **European Maritime and Fisheries Fund (EMFF):** This fund (**EMFF**) is used to co-finance projects, along with national resources, through the operational programme of each country. Among others, the Fund supports sustainable aquaculture developments.

- **European Agricultural Fund for Rural Development:** This Fund is the tool to strengthen the social, environmental and economic sustainability of rural areas, through a series of income supports and target measures, within Rural Development, 2nd pillar of the Common Agricultural Policy (CAP), which contributes to the following long-term objectives: fostering the competitiveness of agriculture and forestry; ensuring the sustainable management of natural resources, and climate action; achieving a balanced territorial development of rural economies and communities including the creation and maintenance of employment.

- **LIFE:** LIFE is a main EU funding Programme for the environment, further divided into two sub-Programmes, one for environment (representing 75% of the overall financial envelope) and one for climate action (representing 25% of the envelope). The first one funds project for nature conservation and biodiversity, environment and resource efficiency, environmental governance and information, while the 2nd one, supports projects for climate change adaptation and mitigation, climate governance and information.

- **European Fund for Strategic Investment (EFSI): EFSI** is an initiative launched by the EIB Group (European Investment Bank and European Investment Fund) and the European Commission. Aiming to boost European Economy with strategic investments, mobilizing both public and private resources, EFSI provides funding for economically viable projects with a focus in key sectors such as Strategic infrastructure, renewable energy and resource efficiency. It supports key factors by financing projects that make the continent fairer, **greener** and more modern and is one of the 3 pillars of the Investment Plan for Europe.

- **Horizon 2020:** Horizon 2020 is the biggest EU research and innovation programme, the financial instrument implementing the Innovation Union, a Europe 2020 Flagship initiative aiming at securing Europe's Global competitiveness. By coupling research and innovation, Horizon 2020 is helping to achieve this with its emphasis on excellent science, industrial leadership and tackling societal challenges. One of the topics addressed is the ability of the economy to adapt and become more climate change resilient, resource efficient and at the same time remain competitive depends on high levels of eco-innovation, of a societal, economic, organizational and technological nature.

The new multi-annual financial framework for the period 2014-2020 also proposes enlarged financing possibilities for green infrastructure projects.

In this context, the European Commission and the European Investment Bank (EIB) have established the **Natural Capital Financing Facility (NCFF).** Natural Capital Financing Facility (NCFF): The NCFF will finance investments in natural capital projects, including in green infrastructure, which generate revenues or save costs and contribute to nature, biodiversity and climate change adaptation objectives. The NCFF is open to public and private entities, where appropriate cooperating in partnerships. Investments could for example focus on ecosystem restoration projects as insurance against floods or draughts or to improve water quality.

Meanwhile, the European Bank for Reconstruction and Development (EBRD): EBRD is a climate finance leader that aims to become a majority green bank by 2025. The EBRD Green Cities programme builds a better and more sustainable future for cities and their residents. It identifies, prioritizes and connects environmental challenges with sustainable infrastructure and policies. EBRD provides financial products (direct financing) such as Loans, Equity Investments and Guarantees, as well as advisory services to SMEs.

E.4. Other means and policies contributing to GI's funding

Green Infrastructures can also be supported through Equity financing; this is when an investor provides money to a venture, in return for a share in business for a range of years, after which he will look for a return on the money through the sale of the company or by offering to sell shares in the company to the public. Apart from money, investors also provide valuable know-how and networking that support business in growth.

EquiFund is an initiative created by the Hellenic Republic in cooperation with the European Investment Fund (EIF), which is independently advised by the EIF and is co-funded by the EU and national funds, as well as funding from the EIF. The European Investment Bank has joined the existing cornerstone investors through the European Fund for Strategic Investments, the core of the so-called 'Juncker Plan.' Strategic Partners such as the Onassis Foundation and the National Bank of Greece have also committed to several of the EquiFund supported funds.

EquiFund offers three different types of equity financing to ensure access to the right financing, at the right stage for business or idea.

Funds available, related to **GI**:

Innovation Window Funds

- **BigPi Ventures:** BigPi Ventures focuses on technology transfer by assisting both research-based projects and companies, mostly active in the B2B segment. Targeted sectors include: Technology segments such as software, data analytics, machine learning, SaaS but also electronic-based hardware, including robotics, optics, sensors. The Fund can also invest in materials science, **energy-related technologies** and clean technologies (clean-tech).
- **Metavallon fund:** Metavallon is an accelerator fund that focuses on pre-seed and seed stage companies in Greece and targets technology and intellectual property (IP)-driven start-ups primarily in information and communications technology (ICT) and engineering products. Targeted sectors include: B2B solutions and products in technology, ICT, high tech in verticals such as robotics, microelectronics, artificial intelligence, data and machine learning, cyber security, energy, transportation and fintech.
- **Uni.Fund:** Uni.Fund targets pre-seed and seed investments in the broad technology sector, aiming to leverage the hidden potential that exists in the Greek university, R&D and technological space. Targeted sectors include: broad technology sector with focus on ICT, e-business, robotics, maritime, supply chain, Internet of Things (IoT), **energy informatics**, fintech and insurance technology.
- **Velocity.Partners:** Velocity.Partners Fund is a pre-seed and seed acceleration fund that focuses on technology companies in verticals where the Greek economy can provide global validation and real market traction. Targeted sectors include: ICT sector-oriented with a

horizontal focus on SaaS, IoT, B2B and a sub-vertical focus on tech entrepreneurs wishing to operate in tourism/travel, fintech, logistics, retail, shipping, maritime and e-health and wellness.

Early Stage Window Funds

- **Marathon VC:** Marathon VC brings together a team that combines investment, entrepreneurial, technical and operational skills in order to help the new generation of ambitious founders build world-class technology companies. The fund targets SMEs at the seed and Series A stages. Targeted sectors include: Generalist ICT with a preference for B2B.
- **VentureFriends 400W:** VentureFriends 400W brings together a strong and cohesive team able to provide substantial value to ICT SMEs in the seed and Series A stages. Targeted sectors include: Marketplaces and SaaS.

Growth Window Funds

- **Elikonos 2:** Elikonos 2 aspires to provide financing solutions to companies in sectors that offer the strongest growth opportunities within the context of the Greek economy. Targeted sectors include: All sectors.
- **EOS Capital Partners:** EOS Capital Partners aims to establish a premier Greek private equity group with a long-term perspective that will support Greek growth companies to achieve a real impact on the Greek economy. Targeted sectors include: All sectors with a particular focus on food & beverage, tourism, fintech, retail, **energy efficiency** and pharmaceuticals.
- **Synergia Hellenic Fund IV:** Synergia Hellenic Fund IV targets Greek SMEs in sectors that offer great growth opportunities, while also adding value through active, hands-on partnership with investee companies' management. Targeted sectors include: All sectors, with a special focus on the food, beverage and agri-business, tourism and hospitality, **environment and energy efficiency sectors**.

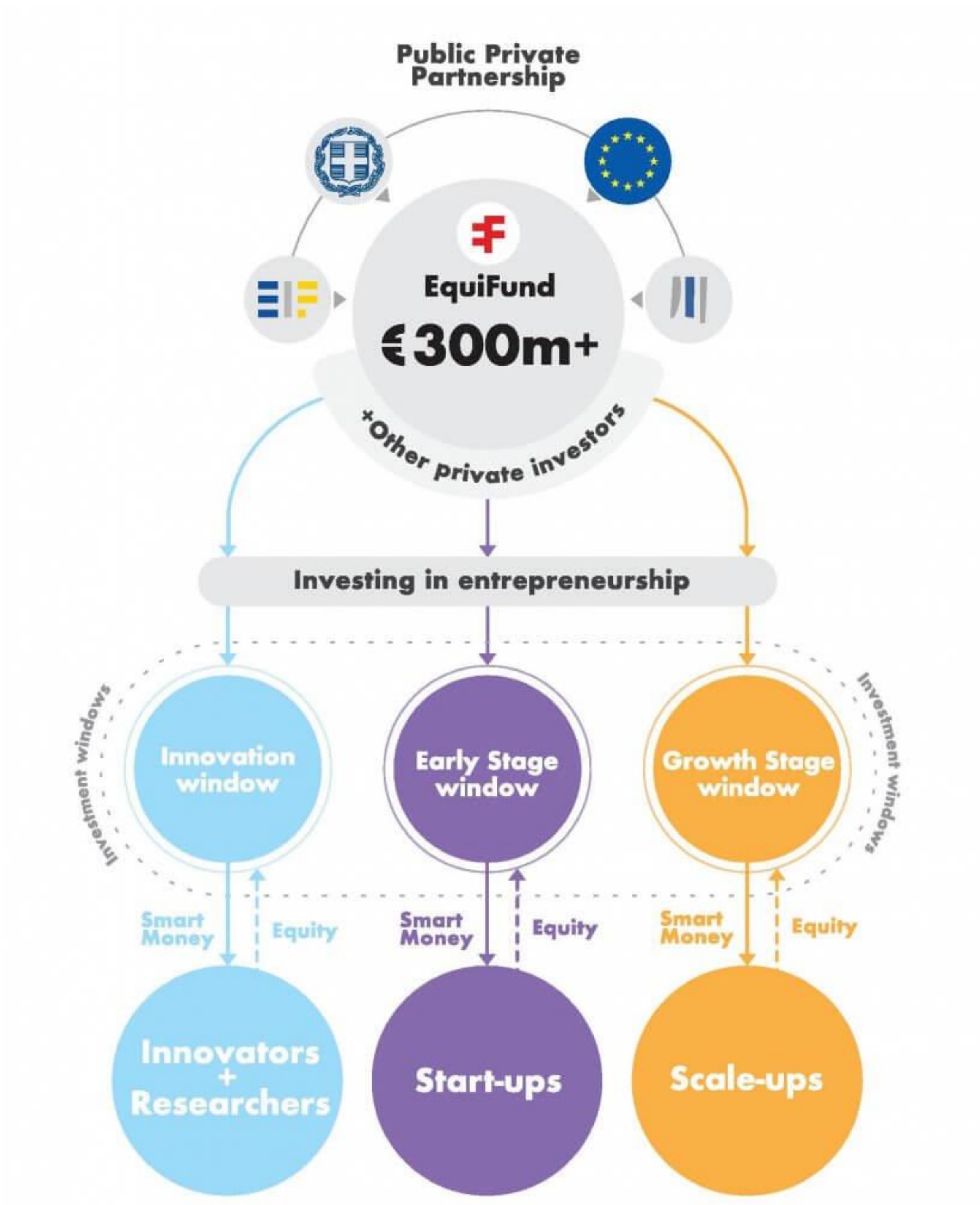


Image 2: EquiFund Structure, https://equifund.gr

- **Iren:** One of the most important multi-service companies in Italy, **Iren** has a focus in sustainability and foresees to allocate more than 50% of its **investments to sustainable cities, decarbonization, circular economy and water conservation**. To this extent, the company has issued **four Green Bond sets**, to be used to finance/ refinance a series of projects/ activities identified in compliance with the defined Green Bond Principles and cover a range of categories i.e. renewable energy, environmentally sustainable management, energy efficiency etc.
- **Alternative Capital Partners (ACP) SGR:** An asset management firm that invests in alternatives and applying ESG Principles to the spectrum of private assets. The first Italian debt thematic AIF, reserved to institutional investors, among which the EIB (European Investment Bank) and leading Italian banks and pension funds. ACP is launching two thematic AIFs, which will invest in infrastructures and in social real estate infrastructures, with the aim of supporting the energy transition and the educational growth of new generations, respectively. The strategies will be launched in the forms of both debt and equity instruments. It has been created with the mission of combining ESG principles and innovative alternative investments with a high impact on the environment and the real economy – announces the launch of **Sustainable Securities Fund (SSF), the first Italian thematic private debt fund that finances "Green" energy infrastructures** through a highly diversified, in terms of financial instruments, multi-strategy approach, and advanced digital technologies, thus offering medium-to-long term financial returns de-correlated from market trends, anti- cyclical, with reduced volatility and pretty stable cash-flows, in line with the current needs of institutional investors.
- **Foresight Italian Green Bond Fund:** The Foresight Italian Green Bond Fund is a closed-end Fund focused on direct lending for green infrastructure projects. The **Fund invests in Renewable Energy & Energy Efficiency Projects** with long-term contracted revenues and is focused on direct lending to renewable energy plants and energy efficiency projects in Italy. The Fund is exposed to: Energy efficiency, Public lighting, Solar energy, Co-generation and district heating, Waste to energy, is managed from the Rome office, focuses on direct lending to renewable energy plants and energy efficient projects in Italy through the use of Green-Bonds, which are: Directly originated, Fully amortising, Senior secured, Investment grade • 75% fixed; 25% floating rate.
- **VEI GREEN Italy:** VEI Green was incorporated in 2012 to act as investment platform fully dedicated to the renewables, with an initial capital allocation more than €130m. Its shareholders are primary Italian institutional investors and during the last years, VEI Green has invested in **both the wind and solar markets** and in parallel with the ForVEI and Whysol Investments joint ventures, it now has an interest in **operating production plants** with a total installed capacity of over 200 MW. The VEI Green team is responsible for portfolio management, along with identifying and evaluating new investment opportunities, mergers and acquisitions, capital and debt growth to support the ongoing pooling process.

- **Sovereign Green Bonds (SGB) Framework:** The new SGBs Framework will be used to finance public expenditure in a 'green' way in alignment with the "Green Bonds Principles" and, as much as possible, with the draft EU Green Bond Standard. For Italy, the project also includes support in identifying all eligible green sectors in alignment with the EU Sustainable Finance Taxonomy as well as with the 2030 Sustainable Development Goals (SDGs) as well as the investment gap for all key economic sectors in Italy against the target of climate-neutrality by the year 2050.

Besides, the **Investment Incentives Law** L.4399/2016 in Greece, consists a statutory framework for the establishment of Private Investments Aid Schemes for the regional and economic development of the country. The key objectives of the Law include:

- the creation of new jobs with emphasis in the employment of skilled human resources;
- the increase of extroversion and innovativeness of businesses;
- the increase in added value;
- the improvement of technological level and competitiveness;
- the creation of a new extrovert national image (branding);
- the reindustrialization of the country;
- the attraction of foreign direct investments;
- achieving a better placement of the country in the International Division of Labor;
- the promotion of a balanced and sustainable development with emphasis on regional convergence.

The Law foresees different aid schemes such as Equipment aid, General Entrepreneurship, New Independent SMEs, SME Innovation Investments, Large Investments, Networking & Clusters etc., with different types of support i.e. Grants, Subsidies, Tax Exemptions.

E.5. Presentation of funding tools in .XLS form

See attached

Abbreviations

ACP	Alternative Capital Partners
AIF	Alternative Investment Fund
AUHI	atmospheric UHI
B2B	Business to Business
BEM	building energy model
BEP	buildings effect parameterization
BLUHI	boundary-layer UHI
CAAPs	company adaptation action plans
CAP	Common Agricultural Policy
CBC	Cross Border Cooperation
CEF	Connecting Europe Facility
EBRD	European Bank for Reconstruction and Development
EFSI	European Fund for Strategic Investment
EIB	European Investment Bank
EIF	European Investment Fund
EMFF	European Maritime and Fisheries Fund
ENI	European Neighborhood Instrument
ERDF	European Regional Development Fund
ESF	European Social Fund

EU	European Union
GDAL	Geospatial Data Abstraction Library
GI	Green Infrastructure
GPG	Good Practice Handbook
HHWS	Heat Health Warning System
ICT	Information and Communications Technology
IntraFoF	Infrastructure Investment Initiative
IPA	Instrument for Pre-Accession Assistance
LCZs	Local Climate Zones
NBG	National Bank of Greece
NCFF	Natural Capital Financing Facility
NSRF	National Strategic Reference Framework
OP	Operational Programmes
POSD	Pilot Operational Simulations Database
PPD	Post-Processing Database
PPT	Post-Processing Tools
ROP	Regional Operational Programme
SBG	Sovereign Green Bonds
SDGs	Sustainable Development Goals

SLUCMs	single-layer urban canopy models
SMEs	Small Medium Enterprises
SSF	Sustainable Securities Fund
SUHI	surface UHI
SVR	Support Vector Regression
TEB	Town Energy Balance
UCL	urban canopy layer
UCM	urban canopy model
UCPs	urban canopy parameters
UHI	Urban Heat Island
UHII	Urban Heat Island Intensity
UHI-ASAR	UHI Adaptation Strategies Assessment Report
UHI-FCAR	UHI Future Climate Assessment Report
UHI-OFS	UHI forecasting system
UN	United Nations
USGS	U.S. Geological Survey
UTCI	Universal Thermal Comfort Index
WRF-SLUCM	Weather Research and Forecasting (weather forecast model) coupled with the Single Layer Urban Canopy Model

Table of Maps

Table of Figures

Table of Images

Table of Tables

References

© atelier GROENBLAUW. (n.d.). *Urban water channels.* Retrieved April 23, 2021, from Urban green blue grids: https://www.urbangreenbluegrids.com/measures/open-water-channels/

AdaptInGreece. (n.d.). *The Project*. Retrieved from Adaptive Greece Website: https://www.adaptivegreece.gr/en-us/the-project/overview-objectives

Agathangelidis, I., Cartalis, C., Santamouris, M., 2019. Integrating Urban Form, Function, and Energy Fluxes in a Heat Exposure Indicator in View of Intra-Urban Heat Island Assessment and Climate Change Adaptation. Clim. . https://doi.org/10.3390/cli7060075.

Agathangelidis, I., Cartalis, C., Santamouris, M., 2020. Urban morphological controls on surface thermal dynamics: A comparative assessment of major european cities with a focus on Athens, Greece. Climate 8, 1–33. https://doi.org/10.3390/cli8110131.

ArchDaily. (2007). *Eco-Boulevard in Vallecas / Ecosistema Urbano*. Retrieved from ArchDaily Website: https://www.archdaily.com/6303/eco-boulevard-in-vallecas-ecosistema-urbano

Arizona State University. (n.d.). *What is an Urban Heat Island?* Retrieved from Phoenix CubeSat: http://phxcubesat.asu.edu/science

Bokwa, A., Dobrovolny, P., Gál, T., Geletič, J., Gulyás, Á., Hajto, M. J., . . . Zuvela-Aloise, M. (2018). Urban climate in Central European cities and global climate change. *Acta Climatologica et Chronologica 51-52*, 7-35.

Brousse, O., Martilli, A., Foley, M., Mills, G., Bechtel, B., 2016. WUDAPT, an efficient land use producing data tool for mesoscale models? Integration of urban LCZ in WRF over Madrid. Urban Clim. 17, 116–134. https://doi.org/10.1016/j.uclim.2016.04.001.

C., M. (2018). *Histoire de la Place de la République*. Retrieved from Sortir a Paris Website: https://www.sortiraparis.com/arts-culture/balades/articles/172712-histoire-de-la-place-de-la-republique

Chen, F., Kusaka, H., Bornstein, R., Ching, J., Grimmond, C.S.B., Grossman-Clarke, S., Loridan, T., Manning, K.W., Martilli, A., Miao, S., Sailor, D., Salamanca, F.P., Taha, H., Tewari, M., Wang, X., Wyszogrodzki, A.A., Zhang, C., 2011. The integrated WRF/urban modeling system: Development, evaluation, and applications to urban environmental problems. Int. J. Climatol. 31, 273–288. https://doi.org/10.1002/joc.2158

Ching, J., Mills, G., Bechtel, B., See, L., Feddema, J., Wang, X., Ren, C., Brousse, O., Martilli, A., Neophytou, M., Mouzourides, P., Stewart, I., Hanna, A., Ng, E., Foley, M., Alexander, P., Aliaga, D., Niyogi, D., Shreevastava, A., Bhalachandran, P., Masson, V., Hidalgo, J., Fung, J., Andrade, M., Baklanov, A., Dai, W., Milcinski, G., Demuzere, M., Brunsell, N., Pesaresi, M., Miao, S., Mu, Q., Chen, F., Theeuwes, N., 2018. WUDAPT: An Urban Weather, Climate, and Environmental Modeling Infrastructure for the Anthropocene. Bull. Am. Meteorol. Soc. 99, 1907–1924. https://doi.org/10.1175/BAMS-D-16-0236.1.

Climate-Fit City. (2019). *About*. Retrieved from Climate-Fit City Website: https://climate-fit.city/about-climate-fit/

CLIMPACT. (2020). *Overview*. Retrieved from CLIMPACT Website: https://climpact.gr/about/overview

Conigliaro, E., Monti, P., Leuzzi, G., Cantelli, A., 2021. A three-dimensional urban canopy model for mesoscale atmospheric simulations and its comparison with a two-dimensional urban canopy model in an idealized case. Urban Clim. 37, 100831. https://doi.org/https://doi.org/10.1016/j.uclim.2021.100831

CORDIS EUROPA. (2017). *EU research results*. Retrieved from GROW GREEN:

https://cordis.europa.eu/project/id/730283

CORDIS EUROPA. (2017). *EU research results*. Retrieved from New Strategy for Re-Naturing Cities through Nature-Based Solutions: https://cordis.europa.eu/project/id/730426

CORDIS EUROPA. (2017). *EU research results*. Retrieved from Urban Nature Labs: https://cordis.europa.eu/project/id/730052

CORDIS EUROPA. (2017). *URBan ANthrpogenic heat FLUX from Earth observation Satellites*. Retrieved from EU research results: https://cordis.europa.eu/project/id/637519

CORDIS EUROPA. (2020). *Pan-European Urban Climate Services*. Retrieved from Eu research results: https://cordis.europa.eu/project/id/730004

Cutter, B. W., Griffin, J., & Hunt, L. (2018). A Description and Analysis of Mediterranean Cities and Regions Planning for Climate Impacts. *Cities and the Environment (CATE), 10*(2).

De Urbanisten. (n.d.). Water Square Benthemplein. Retrieved from De Urbanisten Website: http://www.urbanisten.nl/wp/?portfolio=waterplein-benthemplein

Dupont, S., Mestayer, P.G., 2006. Parameterization of the Urban Energy Budget with the Submesoscale Soil Model. J. Appl. Meteorol. Climatol. 45, 1744–1765. https://doi.org/10.1175/JAM2417.1.

Dupont, S., Otte, T.L., Ching, J.K.S., 2004. Simulation of Meteorological Fields Within and Above Urban and Rural Canopies with a Mesoscale Model (MM5). Boundary-Layer Meteorol. 111–158.

EEA. (2020, August 5). *Urban Head Island Summer Intensity*. Retrieved from European Environment Agency Website: https://www.eea.europa.eu/data-and-maps/data/external/urban-heat-island-summer-intensity

ESA. (n.d.). *Project*. Retrieved from DUE - UHI and UT: http://due.esrin.esa.int/page_project122.php

European Commission. (2017). *LIFE CLIVUT*. Retrieved from LIFE Public Database: https://webgate.ec.europa.eu/life/publicWebsite/project/details/5065

European Commission. (2017). *LIFE-IP AdaptInGR*. Retrieved from LIFE Public Database: https://webgate.ec.europa.eu/life/publicWebsite/project/details/4995

European Commission. (2017). *LIFE-QUF*. Retrieved from LIFE Public Database: https://webgate.ec.europa.eu/life/publicWebsite/project/details/3848

European Commission. (2018). *DERRIS - DisastEr Risk Reduction InSurance*. Retrieved from LIFE Public Database: https://webgate.ec.europa.eu/life/publicWebsite/project/details/4205

European Commission. (2018). *LIFE RAMSES*. Retrieved from LIFE Public Database: https://webgate.ec.europa.eu/life/publicWebsite/project/details/4187

European Commission. (2018, December 31). *Reporting*. Retrieved from CORDIS EU research results: https://cordis.europa.eu/project/id/668786/reporting

European Commission. (2019). *LIFE HEROTILE* . Retrieved from LIFE Public Database: https://webgate.ec.europa.eu/life/publicWebsite/project/details/4199

European Commission. (2019). *LIFE Public Database*. Retrieved from LIFE LUNGS: https://webgate.ec.europa.eu/life/publicWebsite/project/details/5070

European Commission. (n.d.). *LIFE Green Heart.* Retrieved from Project Description: https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=7138#RM

European Commission. (n.d.). *Project Description*. Retrieved from LIFE Lungs Project Page: https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=7122

Ferrovial. (n.d.). *Caixa Forum Madrid*. Retrieved from Ferrovial: https://www.ferrovial.com/en/business/projects/caixaforum-madrid/

GeoERA. (2020, October). *MUSE and the underground urban heat island effect*. Retrieved from GeoERA Website: https://geoera.eu/blog/muse-and-the-underground-urban-heat-island-effect/

GeoERA. (2021). *Managing Urban Shallow geothermal Energy (MUSE)*. Retrieved from GeoERA : https://geoera.eu/projects/muse3/

Giannaros, C., 2018. Sensitivity analysis and optimization of a mesoscale atmospheric model. PhD dissertation, Aristotle University of Thessaloniki.

Giannaros, T.M., 2013. Study of the urban heat island effect using a meso-scale atmospheric model and analyzing observational data. PhD dissertation, Aristotle University of Thessaloniki.

Giannaros, T.M., Melas, D., Daglis, I.A., Keramitsoglou, I., 2014. Development of an operational modeling system for urban heat islands: An application to Athens, Greece. Nat. Hazards Earth Syst. Sci. 14, 347–358. doi:10.5194/nhess-14-347-2014.

Green-Blue Grids. (n.d.). *Projects, Community gardens Paris*. Retrieved from Green-Blue Grids Website: https://www.urbangreenbluegrids.com/projects/community-gardens-paris/

Grimmond, C.S.B., Baklanov, A., Oleson, K., 2009. Meteorological and Air Quality Models for Urban Areas. doi:10.1007/978-3-642-00298-4.

GrowGreen . (2017). *About the project*. Retrieved from GrowGreen Website: http://growgreenproject.eu/about/project/

Hammerberg, K., Brousse, O., Martilli, A., Mahdavi, A., 2018. Implications of employing detailed urban canopy parameters for mesoscale climate modeling: a comparison between WUDAPT and GIS databases over Vienna, Austria. Int. J. Climatol. 38, e1241–e1257.

https://doi.org/https://doi.org/10.1002/joc.5447.

HeatandLIFE. (2018, January 24). *The LIFE HeatLand project tests a cold asphalt in Murcia that reduces pollution in cities*. Retrieved from HeatandLife: https://heatlandlife.eu/el-proyecto-life-heatland-prueba-en-murcia-un-asfalto-frio-que-reduce-la-contaminacion-en-las-ciudades/

HeatandLife. (2020, March). *Newsletter 5.* Retrieved from HeatLand LIFE: https://heatlandlife.eu/wp-content/uploads/2020/03/NEWSLETTERene-mar2020.pdf

HeatandLife. (2020, September). *Newsletter 6.* Retrieved from HeatLand Website: https://heatlandlife.eu/wp-content/uploads/2020/10/NEWSLETTER06ENG.pdf

HeatandLife. (n.d.). *First workshop of the LIFE HeatLand project*. Retrieved from HEATandLIFE Website: https://heatlandlife.eu/primer-workshop-del-proyecto-life-heatland/

HEATLAND Life. (n.d.). *The Project*. Retrieved from HEATLAND Life Website: https://heatlandlife.eu/objetivos/

HeatLand. (2018, September 11). *Newsletter 3.* Retrieved from HeatandLIFE: https://heatlandlife.eu/wp-content/uploads/2018/12/NEWSLETTER03.pdf

HeatShield. (2016). *About*. Retrieved from HeatShield Website: https://www.heat-shield.eu/

IPCC. (2013). Climate Change: The Physical Science Basis. UNEP & WMO.

Johnson, B.A., Jozdani, S.E., 2019. Local Climate Zone (LCZ) Map Accuracy Assessments Should Account for Land Cover Physical Characteristics that Affect the Local Thermal Environment. Remote Sens. . https://doi.org/10.3390/rs11202420

Kondo, H., Genchi, Y., Kikegawa, Y., Ohashi, Y., Yoshikado, H., Komiyama, H., 2005. Development of a multi-layer urban canopy model for the analysis of energy consumption in a big city: Structure of the urban canopy model and its basic performance. Boundary-Layer Meteorol. 116, 395–421. doi:10.1007/s10546-005-0905-5.

Krayenhoff, E.S., Christen, A., Martilli, A., Oke, T.R., 2014. A Multi-layer Radiation Model for Urban Neighbourhoods with Trees. Boundary-Layer Meteorol. 151, 139–178. doi:10.1007/s10546-013-9883-1.

Kusaka, H., Kondo, H., Kikegawa, Y., Kimura, F., 2001. A Simple Single-Layer Urban Canopy Model For Atmospheric Models: Comparison With Multi-Layer And Slab Models. Boundary-Layer Meteorol. 101, 329–358. doi:10.1023/A:1019207923078.

Lee, S.H., Kim, S.W., Angevine, W.M., Bianco, L., McKeen, S.A., Senff, C.J., Trainer, M., Tucker, S.C., Zamora, R.J., 2011. Evaluation of urban surface parameterizations in the WRF model using measurements during the Texas Air Quality Study 2006 field campaign. Atmos. Chem. Phys. 11, 2127–2143. doi:10.5194/acp-11-2127-2011.

Lee, S.H., Park, S.U., 2008. A vegetated urban canopy model for meteorological and environmental modeling. Boundary-Layer Meteorol. 126, 73–102. doi:10.1007/s10546-007-9221-6.

LIFE ASTI. (n.d.). *The Project*. Retrieved from LIFE ASTI Project Website: https://lifeasti.eu/

LIFE LocalAdapt. (2021). *Project*. Retrieved from LIFE LocalAdapt Website: https://life-local-adapt.eu/en/project/objectives

LIFE MetroAdapt. (2020, September 26). *Adapting European Metropolitan Areas to Climate Change: Join the workshop!* Retrieved from MetroAdapt Website: https://www.lifemetroadapt.eu/en/2020/09/26/adapting-european-metropolitan-areas-to-climate-change-join-the-workshop/

LIFE MetroAdapt. (n.d.). *The Project*. Retrieved from LIFE MetroAdapt Website: https://www.lifemetroadapt.eu/en/the-project/

LIFE TreeCheck. (2021). *About the Project*. Retrieved from LIFE TreeCheck Website: https://www.lifetreecheck.eu/en/About

LIFE UrbanProof. (n.d.). *LIFE UrbanProof Toolkit*. Retrieved from LIFE UrbanProof Website: https://tool.urbanproof.eu/

LIFE VegGap. (2019). *About*. Retrieved from LIFE VegGap Website: https://www.lifeveggap.eu/

LIFECLIVUT. (n.d.). *About us*. Retrieved from LIFE CLIVUT Website: https://www.lifeclivut.eu/LIFECLIVUT_ABOUT.aspx?ID_Canal=404&canal=About%20Us

Marinaccio, A., Scortichini, M., Gariazzo, C., Leva, A., Bonafede, M., De' Donato, Fr. and M., Stafoggia. 2019. Nationwide epidemiological study for estimating the effect of extreme outdoor temperature on occupational injuries in italy. Environment International, 133:105176.

Martilli, A., Clappier, A., Rotach, M.W., 2002. An Urban Surface Exchange Parameterization for Mesoscale Models. Boundary-Layer Meteorol. 104, 261–304. doi:10.1023/A:1016099921195.

Masson, V., 2000. A physically based scheme for the urban energy budget in atmospheric models. Bound. Layer Meteorol. 94, 357–397. doi:10.1023/A:1002463829265.

Masson, V., 2006. Urban surface modeling and the meso-scale impact of cities. Theor. Appl. Climatol. 84, 35–45. doi:10.1007/s00704-005-0142-3.

MetroAdapt. (2020, December 9). *Climate and Resilience: The MetroAdapt Webinars*. Retrieved from LIFE MetroAdapt: https://www.lifemetroadapt.eu/en/2020/12/09/climate-and-resilience-the-metro-adapt-webinars/

MetroAdapt. (2020, July 24). *The LIFE Metro Adapt project shares its achieved results and tools*. Retrieved from LIFE MetroAdapt: https://www.lifemetroadapt.eu/en/2020/07/24/the-life-metro-adapt-project-shares-its-achieved-results-and-tools/

MetroAdapt. (2021, April 14). *Strategies and measures to adapt to climate change in the Metropolitan City of Milan*. Retrieved from LIFE MetroAdapt: https://www.lifemetroadapt.eu/en/2021/04/14/metro-adapt-strategies-and-measures-to-adapt-to-climate-change-in-the-metropolitan-city-of-milan/

MetroAdapt. (n.d.). *MetroAdapt Platform*. Retrieved from LIFE MetroAdapt: http://www.lifemetroadapt.eu/en/metro-adapt-platform/

Molnár, G., Gyöngyösi, A.Z., Gá, T., 2016. Specification of urban canopy parameters for better understanding the thermal structure in case of Szeged, Hungary. Presented at 16th EMS Annual Meeting & 11th European Conference on Applied Climatology (ECAC), Trieste, Italy, September 12–16, 2016.

Molnár, G., Gyöngyösi, A.Z., Gál, T., 2019. Integration of an LCZ-based classification into WRF to assess the intra-urban temperature pattern under a heatwave period in Szeged, Hungary. Theor. Appl. Climatol. 138, 1139–1158. https://doi.org/10.1007/s00704-019-02881-1.

Oke, T. R. , Mills, G., Christen, A. and J. A. Voogt, 2017. Urban Climates. Cambridge University Press.

Papamanolis, N., Dimelli, D., & Ragia, L. (2015). The Urban Heat Island Intensities in Greek cities as a function of the characteristics of the built environment. Chania: Technical University of Crete.

Public Space. (2013). *"Water Square" in Benthemplein*. Retrieved from Public Space Website: https://www.publicspace.org/works/-/project/h034-water-square-in-benthemplein

QuickUrbanForestation. (n.d.). *The QUF Life + project*. Retrieved from QUF LIFE Website: http://www.quickurbanforest.eu/node/3

Ribeiro, I., Martilli, A., Falls, M., Zonato, A., Villalba, G., 2021. Highly resolved WRF-BEP/BEM simulations over Barcelona urban area with LCZ. Atmos. Res. 248. https://doi.org/10.1016/j.atmosres.2020.105220.

Royé, D., Sera, Fr., Tobías, A., Lowe, R., Gasparrini, A., Pascal, M., de'Donato, Fr., Nunes, B., Teixeira, J.P., 2021, Effects of hot nights on mortality in southern europe. Epidemiology., 32(4):487–498.

Sailor, D.J., Georgescu, M., Milne, J.M., Hart, M.A., 2015. Development of a national anthropogenic heating database with an extrapolation for international cities. Atmos. Environ. 118, 7–18. doi:10.1016/j.atmosenv.2015.07.016.

Salamanca, F., Krpo, A., Martilli, A., Clappier, A., 2010. A new building energy model coupled with an urban canopy parameterization for urban climate simulations-part I. formulation, verification, and sensitivity analysis of the model. Theor. Appl. Climatol. 99, 331–344. doi:10.1007/s00704-009-0142-9.

Salamanca, F., Martilli, A., 2010. A new Building Energy Model coupled with an Urban Canopy Parameterization for urban climate simulations-part II. Validation with one dimension off-line simulations. Theor. Appl. Climatol. 99, 345–356. doi:10.1007/s00704-009-0143-8.

Salvati, A., Coch Roura, H., & Cecere, C. (2017). Assessing the urban heat island and its energy impact on residential buildings in Mediterranean climate: Barcelona case study. *Energy and Buildings 146*, 38-54.

Santamouris, M. (2007). Heat Island Research in Europe: The State of the Art. *Advances in Building Energy Research*, 123-150.

Schatz, J. & Ch. Kucharik, 2015, Urban climate effects on extreme temperatures in Madison, Wisconsin, USA. Environmental Research Letters, 10:094024.

Shepherd, J. M. (2005). A review of current investigations of urban-induced rainfall and recommendations for the future. *Earth Interactions, 9*(1), 1-27.

Stankov, U., Marković, V., Savić, S., Dolinaj, D., Pantelić, M., & Arsenović, D. (2014). Tourism Resources in Urban Heat Island: A GIS Analysis of Novi Sad, Serbia. *5th International Conference on Carthography and GISAt: Volume: I.* Riviera, Bulgaria.

Stewart, I. D., & Oke, T. R. (2012). Local Climate Zones for Urban Temperature Studies. *Bulletin of the American Meteorological Society, 93*(12), 1879 - 1900.

Stewart, I.D., Oke, T.R., 2012. Local climate zones for urban temperature studies. Bull. Am. Meteorol. Soc. 93, 1879–1900. https://doi.org/10.1175/BAMS-D-11-00019.1.

Taha H. 2008. Meso-urban meteorological and photochemical modeling of heat island mitigation. Atmospheric Environment 42:8795–8809, DOI:10.1016/j.atmosenv.2008.06.036.

UnALab. (n.d.). *About us*. Retrieved from UnALab Website: https://unalab.eu/en/about-us

UNEP. (2004). Impacts of Summer 2003 Heat Wave in Europe. *European Environment Alert Bulletin 2*, 1-4.

Urban Green-Blue Grids. (n.d.). *Example projects, Place de la République, Paris*. Retrieved from Urban Green-Blue Grids Website: https://www.urbangreenbluegrids.com/projects/place-de-la-republique-paris/

Urban Green-Blue Grids. (n.d.). *Example projects: Potsdamer Plarz, Berlin, Germany*. Retrieved from Urban Gree-Blue Grids Website: https://www.urbangreenbluegrids.com/projects/potsdamer-platz-berlin-germany/

Urban Green-Blue Grids. (n.d.). *Projects, Green roofs - Rotterdam, Netherlands*. Retrieved from Urban Green-Blue Grids Website: https://www.urbangreenbluegrids.com/projects/rotterdam-the-netherlands/

Urban Heat Islands. (n.d.). *The Urban Heat Island (UHI) Effect* . Retrieved from UHIs: https://www.urbanheatislands.com/

UrbanGreenUp. (n.d.). *About*. Retrieved from UrbanGreenUp Website: https://www.urbangreenup.eu/about/about.kl

URCLIM. (n.d.). *About*. Retrieved from URCLIM: http://urclim.prod.lamp.cnrs.fr/about/

Vasiliadis, S. (2019). Project Monitorint Performance Guide. Sympraxis.

Verdonck, M.L., Demuzere, M., Hooyberghs, H., Beck, C., Cyrys, J., Schneider, A., Dewulf, R., Van Coillie, F., 2018. The potential of local climate zones maps as a heat stress assessment tool, supported by simulated air temperature data. Landsc. Urban Plan. 178, 183–197. https://doi.org/10.1016/j.landurbplan.2018.06.004

Viel, M., Ceriola, G., & de Ridder, K. (2011). *Final Report - Volume 1.* Bari: Planetek Italia.

Wang, Z.H., Bou-Zeid, E., Smith, J.A., 2011. A Spatially-Analytical Scheme for Surface Temperatures and Conductive Heat Fluxes in Urban Canopy Models. Boundary-Layer Meteorol. 138, 171–193. doi:10.1007/s10546-010-9552-6.

Wang, Z.-H., Bou-Zeid, E., Smith, J.A., 2013. A coupled energy transport and hydrological model for urban canopies evaluated using a wireless sensor network. Q. J. R. Meteorol. Soc. 139, 1643–1657. doi:10.1002/qj.2032.

WGIN. (n.d.). Caixa Forum Museum Vertical Garden. Retrieved from WGIN Website: https://worldgreeninfrastructurenetwork.org/caixa-forum-museum-vertical-garden/

Wikiarchitectura. (n.d.). *Eco Boulevard in Vallecas.* Retrieved from Wikiarchitectura Website: https://en.wikiarquitectura.com/building/eco-boulevard-in-vallecas/

World Bank Group. (2020). Analysis of Heat Waves and Urban Heat Island Effects in Central European Cities and Implications for Urban Planning. Washington DC: World Bank.

ZAMG, World Bank Group, & GFDRR. (2020). Analysis of Heat Waves and Urban Heat Island Effects in Central European Cities and Implications for Urban Planning. Washington: The World Bank.

ZAMG. (2018). *Urban Heat Island Strategy.* Vienna: Municipality of Vienna.

Zhou, D., J. Xiao, S. Bonafoni, C. Berger, K. Deilami, Y. Zhou, S. Frolking, R. Yao, Z. Qiao, and J. A. Sobrino, 2019, Satellite remote sensing of surface urban heat islands: Progress, challenges, and perspectives. Remote Sensing, 11(1).

Zonato, A., 2016. Evaluating the Urban Heat Island for Cities of Emilia-Romagna Region through Numerical Simulations. University of Bologna.

forecAsting System for urban heaT Island effect

The project Implementation of a forecAsting System for urban heat Island effect for the development of urban adaptation strategies- LIFE ASTI has received funding from the LIFE Programme of the European Union".

D/EP/Lazio
Dipartimento di Epidemiologia
Servizio Sanitario Regionale
Regione Lazio

ARISTOTLE UNIVERSITY OF THESSALONIKI

GET GEOSPATIAL ENABLING TECHNOLOGIES
making location matter

ISAC

CITY OF THESSALONIKI

TEAM sympraxis