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NEXT Black Sea Basin

Green Urban Resilience

Pathway Planning GUIDE

Climate Change Adaptation Through Green Infrastructure in the Urban Areas

LANDLAB

Pathway Planning GUIDE

Climate Change Adaptation Through Green Infrastructure in the Urban Areas

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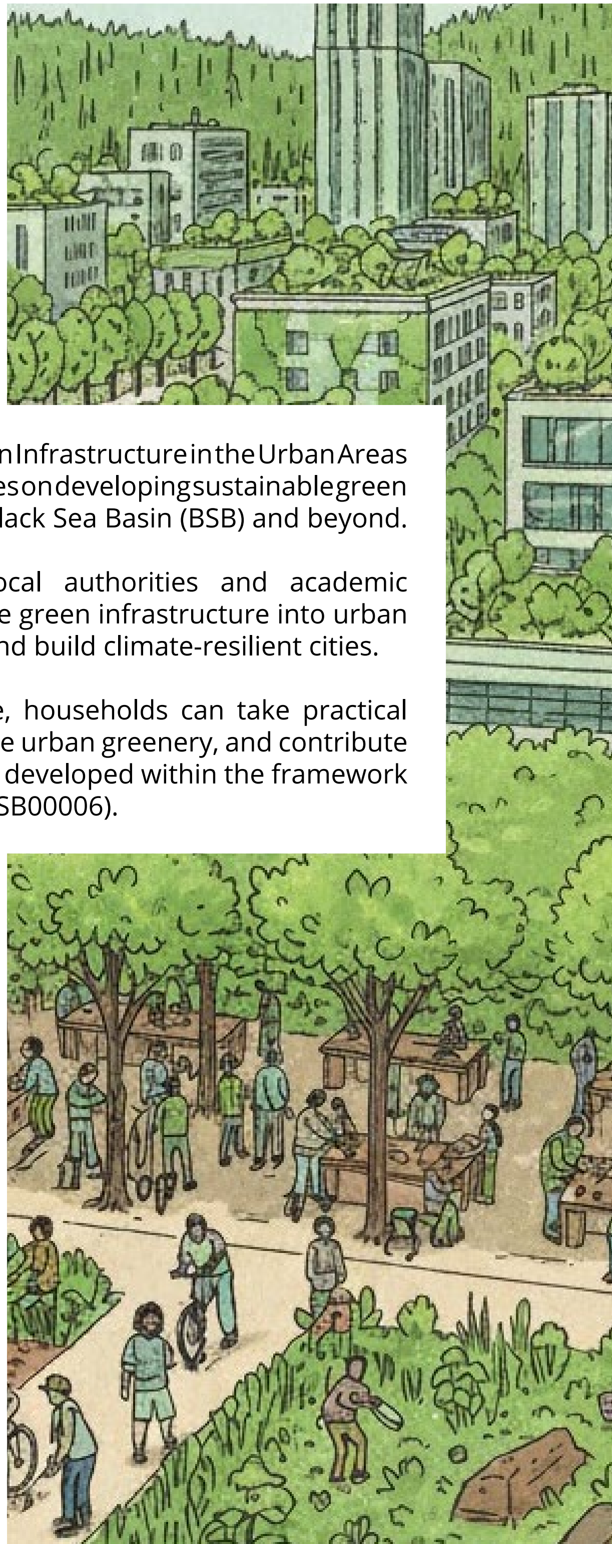

Climate Change Adaptation Through Green Infrastructure in the Urban Areas Pathway Planning Guide The project focuses on developing sustainable green solutions for climate adaptation in the Black Sea Basin (BSB) and beyond.

Through cross-border cooperation, local authorities and academic experts are working together to integrate green infrastructure into urban planning, aiming to reduce heat stress and build climate-resilient cities.

By following the methods in this guide, households can take practical steps to adapt to climate change, enhance urban greenery, and contribute to a greener and cooler future. has been developed within the framework of the Green Urban Resilience Project (BSB00006).

Assoc.Prof.Dr. Nilüfer Kart Aktaş
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Introduction

1. Introduction

1.1 Purpose of the Guidelines

This guide aims to support the development of adaptation pathways to climate change for BSB countries using nature-based solutions and to develop a transnational tool for green urban solutions that contribute to climate change adaptation and are integrated into local and regional plans for urban resilience.

While the principles and methodologies presented are applicable to pilot regions and other BSB countries, the guides highlight the unique challenges and opportunities faced by cities and their inhabitants, including climate change-related indicators:

Urban heat island effect (UHI): The warming of cities significantly impacts urban ecosystems and urban health. This situation impacts virtually all activities, including ecological, economic, social, cultural, and tourism activities.

Thermal comfort: To evaluate the level of thermal discomfort experienced by participants in open spaces during summer months and to obtain quantitative and qualitative data on urban temperature perception by analyzing it together with meteorological data. Threatens the health of people, especially vulnerable populations (elderly, disabled, children, and women).

Nature based solutions: When challenges are properly analyzed and appropriate solutions are developed, new opportunities emerge for cities, such as the rehabilitation of green spaces, the implemantation of new green spaces, the reduction of hard surfaces, the creation of roof gardens, and water management.

Recognizing the vulnerabilities and opportunities in this region, the guide focus on the following issues:

Creating climate awareness: To enable municipalities to effectively engage with stakeholders and understand the perceptions, knowledge and concerns of local people, NGOs and policy makers in order to support policies they will develop regarding the impacts of climate change.

Providing key information to the public and decision-makers: Guiding municipalities in accessing and using information such as climate change causes and effects in order to develop climate adaptation and compliance strategies and guide decision-making processes.

1.1 Purpose of the Guidelines

Sharing and explaining good practice examples: Explaining successful projects that offer nature-based solutions to the effects of climate change

Sharing pilot regions and analysis results: Introduction of sample areas determined by project partners and analysis of climate parameters.

Developing effective climate adaptation strategies and explaining possible solutions: Providing practical methodologies and nature based solutions for the development and implementation of effective adaptation and mitigation strategies to the impacts of climate change.

1. Introduction

1.2 Scope

This guide focuses on development of cross-border tool for green urban solutions, contributing to climate change adaptation and their integration into the local and regional plans for urban resilience through application of European standardized assessment for mapping of the heat–stress, knowledge exchange, capacity building, restoration of green spaces and international cooperation in Black Sea Basin.

Measuring climate awareness: Assessment of topics such as individual awareness of climate change, perception, approach to local environmental issues, and policy preferences.

Mapping of Heat Stress: Creating urban heat maps of the project partner cities and performing heat island measurements in pilot areas via thermal cameras/drone.

Measuring Thermal Comfort: Thermal comfort refers to the level of comfort experienced by city dwellers in terms of climate conditions such as temperature, humidity and air flow, enabling them to carry out both physical and mental activities. Urban heat islands disrupt this comfort and have a significant impact on human health. In order to evaluate thermal comfort, environmental and personal factors must be taken into account in addition to air temperature and humidity.

Developing green infrastructure: Restoration of pilot urban green spaces, implementation of new green spaces and integration into urban green infrastructure.

Developing climate adaptation strategies based on heat stress analysis results: Developing strategies that implement green solutions based on knowledge of the impacts of climate change and the assessment of cities' heat stress and thermal comfort levels.

1.3 Framework and Audience

This guide is designed to be a valuable resource for all stakeholders, especially municipalities and local authorities, in the process of informing, mitigating and adapting to climate change and its impacts:

Municipalities and local authorities: Local government officials, landscape architects, planners and decision-makers responsible for developing and implementing adaptation strategies.

Local people: Urban dwellers living in urban areas and facing the effects of climate change.

Community organisations: Non-Governmental Organisations (NGOs), and community based organisations, actively engaged in environmental awareness, the protection and development of green infrastructure, adaptation to climate change, and community development.

Researchers and academics: Institutions and individuals conducting research on climate change impacts, BSB.

Professionals and practitioners: Professionals involved in climate change adaptation planning, risk assessment and community engagement.

Using this guide, stakeholders can engage effectively, develop informed adaptation plans and implement strategies that enhance urban resilience to the climate crisis.

02

Background

2.Background

2.1 Climate change, urbanization and urban heat island effect

It's now a well-known fact that one of the biggest problems of this century and the future is the climate crisis. The effects of changes that are occurring at a much faster pace than normal, particularly due to human activities, are most pronounced in cities. The Intergovernmental Panel on Climate Change (IPCC), in its latest assessment report, emphasizes that urbanization and climate change create "compounding" risks and that cities are at the center of these risks (IPCC, 2022).

Urbanization, climate change, and the urban heat island (UHI) effect form a complex network connecting today's most critical environmental challenges. With more than half of the world's population living in cities, the relationship between these three phenomena is becoming increasingly evident.

Urbanization is the process by which natural surfaces (vegetation, soil) are replaced by concrete, asphalt, and buildings. These artificial surfaces absorb solar energy and release it slowly throughout the night, causing cities to be significantly warmer than their surrounding rural areas (the UHI effect). Climate change, in turn, combines this local problem with a global threat. The rise in global temperatures increases the frequency and intensity of heatwaves.

Urbanization, climate change, and the Urban Heat Island (UHI) effect are critically interlinked. Urbanization, the process of replacing natural landscapes with impervious surfaces like concrete, is the primary driver of the UHI, causing cities to be significantly warmer than rural areas. Climate change exacerbates this local phenomenon. Global warming increases the frequency and intensity of heatwaves, and research demonstrates that these heatwaves interact with the UHI, amplifying ambient temperatures and posing severe risks to urban populations (Luo et al., 2023).

This relationship creates a dangerous feedback loop. Higher temperatures from the combined UHI and climate change effects increase the demand for energy-intensive air conditioning. This increased energy consumption, often reliant on fossil fuels, releases more greenhouse gases (GHGs). These GHGs, in turn, accelerate global climate change, which further intensifies the UHI effect, trapping cities in a worsening cycle of heat and emissions (Sattar et al., 2024).

Cities worldwide are under this dual pressure. The solution lies in increasing green infrastructure (green roofs, parks), using reflective materials, and prior¬itizing climate resilience in urban planning.

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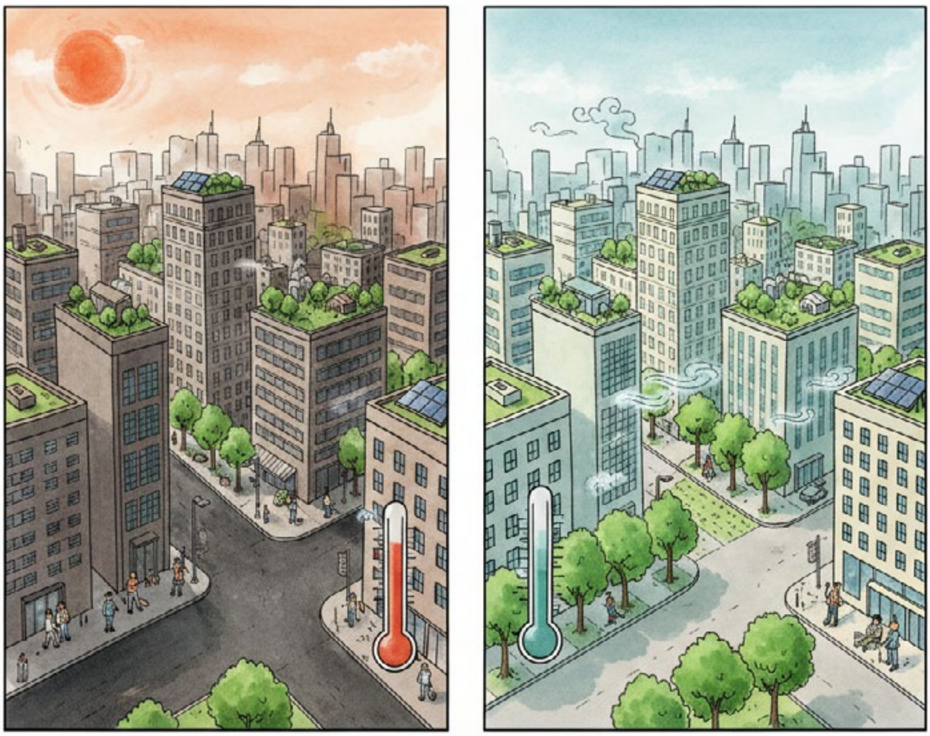


2.Background

2.2. Climate-resilient city

A climate-resilient city is an urban area prepared for the acute shocks (floods, storms, heatwaves) and chronic stresses (drought, sea-level rise) caused by climate change. It possesses the ability to adapt, absorb impacts, recover quickly, and maintain essential functions during these events. This approach aims not only for survival during a crisis but also to “bounce back better” by learning from the experience.

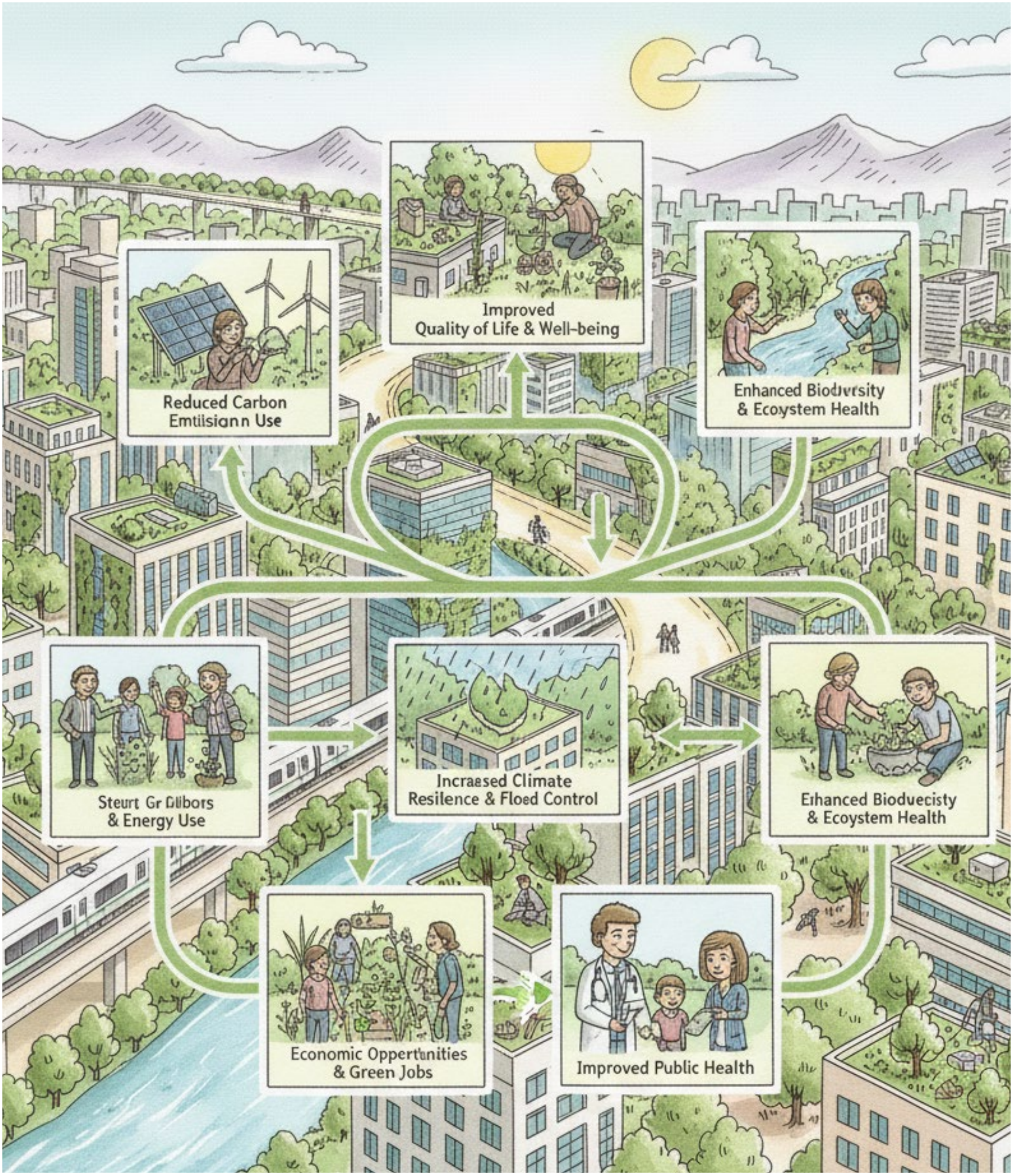
Although the ecological origins of the “resilience” concept trace back to the work of C.S. Holling in the 1970s (Holling, 1973), its application within the context of urban planning and climate change became prominent in the 2000s. Intergovernmental Panel on Climate Change (IPCC) reports, in particular, emphasized the need for resilience alongside adaptation (IPCC, 2014).

A resilient city is the sustainable coexistence of human communities and physical systems. Resilience requires that the physical structure of the city and the communities living within it be considered together to ensure immunity against two distinct threats.

The first is the ability of all systems derived from the city’s physical identity to maintain their functionality and continuity in the face of any danger.

The second is the resilience of the human communities living in the city, which can be described as ensuring that any activity taking place in a city does not profoundly affect the daily life practices of these communities, and if it does, that their existence is protected in such a way that they can return to their previous state as quickly as possible.

Resilient cities prioritize nature-based solutions and “green-blue infrastructure” (rain gardens, green roofs, permeable surfaces) over traditional “gray infrastructure” (concrete levees, channels) (Meerow et al., 2016). Prominent global examples include Rotterdam’s “living with water” strategy (floating homes, water plazas) and Copenhagen’s “Cloudburst Management Plan” developed to counter flash floods.


Improved
Quality of Life & Well-being
Reduced Carbon
Emtiisiann Use
Enhanced Biodıversity
& Ecoystem Health
Steurt Gr Dlibors
& Energy Use
Incraesed Climate
Resilence & Floed Control
Ehanced Bioduecisty
& Ecoystem Health
Economic Oppertunities
& Green Jobs
Improved Public Health

2.Background

2.3. Nature-based solutions, Blue-Green Infrastructure and Components

Increasing population density poses numerous environmental, economic, and social challenges to cities. Nature-based solutions, strategies and approaches are being adopted to combat environmental problems such as pollution, biodiversity loss and natural resource depletion, to protect the environment and to ensure that people in cities live a safe, peaceful and prosperous life with a high quality of life. One of these is "green infrastructure" (Grimm et al., 2008; Kalnay and Cai, 2003; Fedele et al., 2018; Monteiro and Ferreira, 2020; Monteiro et al., 2020; Kart Aktaş, 2021).

Blue-green infrastructure can be defined as a strategic approach that addresses fundamental urban services such as mobility, recreation, and biodiversity, creating long-term flexibility and economic sustainability. Blue-green infrastructure represents the interconnectedness of all types of urban green spaces that support local species, maintain natural ecological processes, protect air and water resources, and contribute to health and quality of life (Benedict and Mc Mahon 2006, Hansen et al., 2017; Pauleit et al., 2017; Parlak and Atik, 2020). Blue and green infrastructure always complement and support each other within the ecosystem. Blue-green infrastructure is a strategic planning approach that aims to create, design, and manage a network for green and blue spaces within cities in terms of ecosystem services (European Commission, 2017).

Green infrastructure is the integration of various natural and restored ecosystems and landscapes on a connection or a central axis. The content of green infrastructure is the synthesis of environmental management and ecological conservation thinking within a holistic landscape planning approach (Benedict and McMahon 2002; Benedict and McMahon 2006; Sarıarmağan and Var, 2019).

Blue-green infrastructure, based on strategically planned networks of natural and semi-natural areas, provides a wide range of ecosystem services such as water purification, improved air quality, and climate change adaptation

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(European Commission, 2013; European Commission, 2019; Parlak and Atik, 2020). All urban open and green spaces (city parks, neighborhood parks, cemeteries, groves, nature parks, green spaces within residential areas, etc.) are components of the green infrastructure system. The purpose of green infrastructure is to increase the quality and diversity of existing green spaces, prevent ecological loss, and ensure their continuity and sustainability. Blue infrastructure aims to create the water cycle and ensure the efficient use of water through the collection and storage of water, flood protection, and minimization of water consumption. Blue-green infrastructure is the green space and water environment that is indispensable for quality of life and the ecosystem.

One of the most important components of blue-green infrastructure is water and water management. Water, which is a fundamental input in agriculture, industry, energy, and transportation, and a key element of healthy ecosystems, is an important factor in landscape planning approaches (Grey and Sadoff, 2008). Today, as the world's population grows rapidly, the need for water and water consumption are also increasing exponentially. Globally, water demand is constantly increasing, particularly in the areas of agriculture, energy, and industry (WWAP, 2017). In the current situation, it is possible for cities, which disrupt the natural balance, to become agents of preserving this balance through the sustainable management of water within the city.

Green infrastructure applications aim to protect ecosystems by connecting ecologically important centers through natural corridors, creating integrated natural systems across the landscape, and balancing functional losses caused by habitat fragmentation (Weber et al. 2006; Sarıarmağan and Var, 2019). Green infrastructure refers to the life support system that plays a vital role in improving the functioning of the city and other city infrastructure. A network of public and private areas with natural, agricultural, and man-made landscape areas provides many ecological, environmental, social, and even economic services.

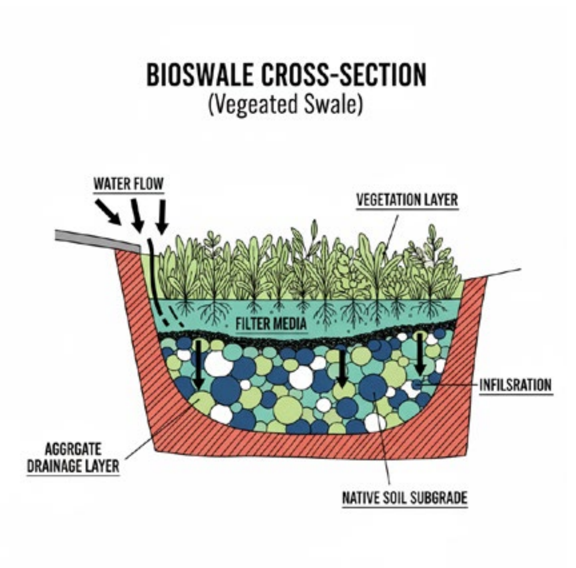
2.Background

This section focuses on practical and easy solutions that are resilient to climate change. However, the main and most important green infrastructure components are all natural green spaces and urban open and green spaces.

2.3.1.Bioswale

Bioswales (or vegetated swales) are linear, bio-engineered, open-channel conveyance systems. They are a fundamental component of Green Infrastructure (GI) and Low Impact Development (LID) strategies (U.S. EPA, 2021). These systems are strategically designed and sited adjacent to impervious or semi-pervious surfaces, such as transportation corridors and parking lots, to intercept and manage storm-generated surface runoff.

The primary hydrological function of a bioswale is the conveyance of stormwater. However, unlike conventional concrete drains, this conveyance is coupled with hydraulic attenuation and biogeochemical treatment (Davis etS al., 2012). As runoff flows longitudinally through the vegetated channel, flow velocities are reduced, dissipating hydraulic energy and thereby mitigating channel erosion and downstream scour. This reduction in velocity facilitates several key treatment processes:



Sedimentation: Heavier particulates, such as total suspended solids (TSS), settle out of the water column.
Filtration: The dense vegetation physically filters finer solids and associated pollutants.

Adsorption & Bioremediation: An engineered bio-filtration media, in conjunction with the plant rhizosphere, facilitates the adsorption of dissolved pollutants (notably heavy metals like zinc and copper) and the microbial degradation of organic compounds (Winston et al., 2012).

Although conveyance is often the primary objective, bioswales are frequently designed to promote infiltration, allowing a portion of the flow to percolate into the native subgrade. This process contributes to the localized recharge of groundwater aquifers (Stagge et al., 2012).

By integrating these functions, bioswales offer a multifunctional and ecological alternative to traditional "gray" infrastructure. They embody a source-control approach to water management while simultaneously providing significant ancillary ecosystem services, including the aesthetic enhancement of the urban landscape and the creation of habitat corridors that support local biodiversity (U.S. EPA, 2021).

2.3.2 Rain Garden

Rain gardens, technically referred to as bioretention systems, are a principal component of Low Impact Development (LID) and Green Infrastructure (GI) strategies. They are defined as shallow, engineered depressions in the landscape specifically designed to intercept, temporarily detain, and treat stormwater runoff (U.S. Environmental Protection Agency [EPA], 2021). These systems are engineered to manage runoff generated by proximal impervious surfaces, such as rooftops, driveways, and other transportation corridors.

Functionally, bioretention systems are distinct from bioswales; whereas bioswales are primarily designed for the conveyance of water, rain gardens are designed for retention and infiltration (University of Maryland Extension, n.d.). Hydraulic design criteria typically specify a maximum drawdown time of 24 to 48 hours for the captured water to infiltrate the soil media. This specification is critical for two reasons: it restores storage capacity for subsequent precipitation events and inhibits the breeding cycles of mosquito vectors (Hunt et al., 2012).

During this infiltration process, a combination of physical, chemical, and biological mechanisms—including filtration, adsorption, and microbial action—effectively removes a

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significant load of urban pollutants. These contaminants include suspended solids, nutrients (nitrogen and phosphorus), pesticides, and heavy metals (Davis, 2008). This process mitigates the non-point source pollution load entering local water bodies. Beyond these hydrological and water quality benefits, bioretention systems serve as valuable urban habitats (Holm & Clausen, 2017). Rain gardens consist of several layers which are described below.

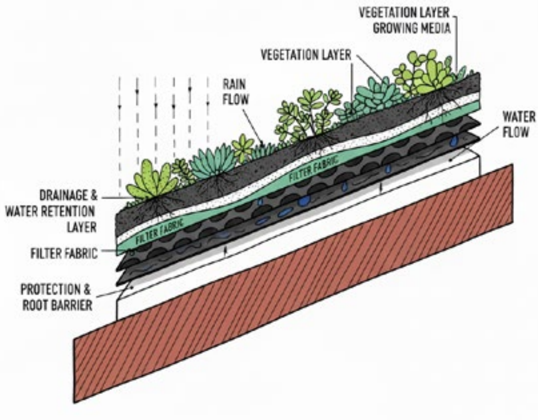
- Surface Vegetation: This layer consists of specifically selected perennial plants, grasses, and shrubs. The vegetation must be tolerant of periodic inundation (hydrophytic) as well as subsequent xeric (dry) conditions. The plant root systems (the rhizosphere) are critical for stabilizing the media, enhancing infiltration, and facilitating phytoremediation and microbial degradation of pollutants (EPA, 2021).
- Mulch Layer: A 5–8 cm (2–3 inch) layer of organic material, such as shredded hardwood mulch, is applied to the surface. This layer serves to retain soil moisture, suppress weed proliferation, mitigate soil erosion, and provide preliminary filtration by trapping fine sediments (University of Maryland Extension, n.d.).
- Planting Media / Growing Mix: This is the primary treatment layer, typically 45–90 cm (18–36 inches) deep. It is an engineered soil mixture, distinct from standard topsoil. The composition—commonly a blend of high-porosity sand (for drainage), compost (for water retention and nutrient cycling), and topsoil—is optimized to support robust plant growth while maximizing pollutant removal and ensuring adequate hydraulic conductivity (Davis, 2008).
- Geotextile Fabric (Optional): In some designs, a permeable, non-woven geotextile fabric is placed between the planting media and the underlying aggregate. Its function is to prevent the downward migration of fine soil particles (piping), which could otherwise clog the aggregate layer and reduce hydraulic function.
- Gravel Drainage Layer / Storage Reservoir: This layer consists of clean, washed aggregate (gravel or crushed stone). Its depth varies based on infiltration goals and hydraulic loading. It functions as a temporary storage reservoir, providing void space to hold water as it percolates, thereby maximizing detention time and allowing for controlled infiltration into the subgrade.
- Perforated Underdrain (Optional): In applications where the native subgrade has a low infiltration capacity (e.g., hydrologic soil group C or D, typically heavy clays) or where high groundwater tables are present, a perforated underdrain is installed within the gravel layer. This pipe

collects excess water that cannot infiltrate and conveys it to a storm drain or other safe outlet, preventing systemic waterlogging (EPA, 2021).

- Native Soil (Subgrade): The existing, unexcavated soil at the base of the system. The hydraulic conductivity of the subgrade is a critical design parameter, as it dictates the rate of exfiltration from the system and the potential for recharging local groundwater aquifers.

2.3.3. Green Roof

Green roofs, are engineered, multi-layered assemblies that integrate vegetation and a specialized growing medium atop a building's primary waterproofing membrane. These systems are an established Green Infrastructure (GI) and Low Impact Development (LID) technology designed to provide a suite of ecosystem services in dense urban environments (Oberndorfer et al., 2007; Ekşi, 2021).



Green roof systems are broadly classified into two distinct typologies based on substrate depth, plant selection, and maintenance requirements:

Extensive Systems: Characterized by a shallow substrate depth (typically 5–15 cm), these systems are lightweight and require minimal maintenance. They are generally planted with drought-tolerant, hardy vegetation, such as Sedum species, which can withstand harsh rooftop microclimates (Snodgrass & Snodgrass, 2006).

Intensive Systems: These systems resemble at-grade parks, featuring a significantly deeper substrate depth (often >20 cm) capable of supporting a diverse range of plant morphologies, including shrubs and small trees. Intensive systems necessitate greater structural load-bearing capacity and require active irrigation and horticultural maintenance (Oberndorfer et al., 2007).
Green roof systems provide numerous, well-documented benefits by restoring ecological functions to the built environment.

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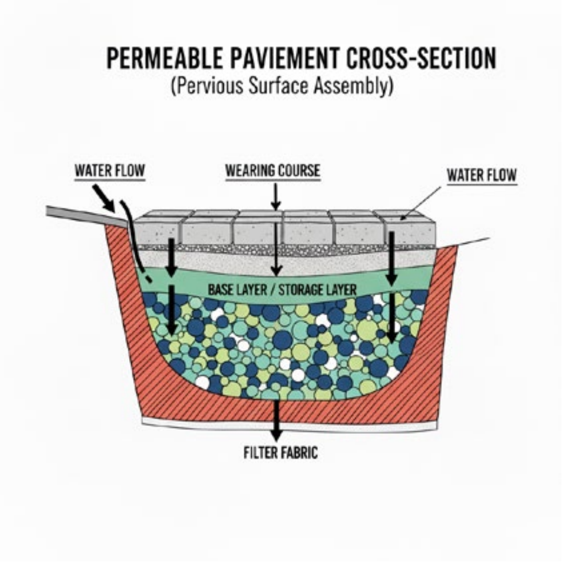
- Hydrological Performance A primary function of green roofs is stormwater management. The substrate and vegetation layers intercept, absorb, and store precipitation, a process defined as stormwater retention. This mechanism attenuates peak runoff flow rates and delays the time of concentration (the "lag time") for runoff, thereby reducing the hydraulic load on municipal sewer systems and mitigating the risk of urban flooding and combined sewer overflows (CSOs) (Berndtsson, 2010).
- Thermal and Energy Performance Green roofs enhance building energy efficiency by providing significant thermal insulation. The composite layers (substrate, vegetation, and trapped air) increase the thermal resistance (R-value) of the roof assembly, reducing heat flux. This effect lowers building energy consumption by decreasing interior heating demands in winter and, more significantly, reducing cooling demands in summer through shading and evapotranspiration (Castleton et al., 2010; Liu & Baskaran, 2003).
- Macro- and Micro-Climatic Regulation On a building and urban scale, green roofs are a critical strategy for mitigating the Urban Heat Island (UHI) effect—the phenomenon of elevated temperatures in cities compared to adjacent rural areas. The process of evapotranspiration (the evaporation of water from the substrate and transpiration from plants) actively cools the ambient air, while the vegetated surface replaces heat-absorbing hardscapes (Takebayashi & Moriyama, 2007).
- Air Quality and Biodiversity The vegetated canopy improves local air quality by filtering and trapping atmospheric particulates (such as PM10) and absorbing gaseous pollutants (Getter et al., 2009). Furthermore, these systems create novel, often essential, habitats for urban wildlife, particularly for invertebrates, insects, and birds, thereby contributing to the enhancement of urban biodiversity (Brenneisen, 2006).

2.3.4. Permeable Pavements (Pervious Surfaces)

Permeable Pavement Systems (PPS) are a foundational component of Low Impact Development (LID) and Green Infrastructure (GI) frameworks, serving as an engineered alternative to conventional impervious surfaces (U.S. EPA, 2021). These systems are designed as load-bearing surfaces for sidewalks, parking lots, and low-traffic roads, which possess a high degree of hydraulic conductivity. This allows for the infiltration of precipitation, facilitating the "source control" of stormwater, in direct contrast to the runoff-generating nature of traditional concrete or asphalt (Fassman & Blackbourn, 2010).

The primary function of PPS is the management of urban stormwater. By capturing and infiltrating precipitation at the point of incidence, these systems fundamentally alter the local hydrograph. This results in the significant attenuation of peak flow rates and a reduction in total runoff volume, which directly mitigates localized flood risk and alleviates the hydraulic load on municipal storm sewer systems (SSS), thereby reducing the frequency of combined sewer overflow (CSO) events (Brown & Borst, 2014).



Furthermore, PPS function as effective water quality treatment systems. As stormwater percolates through the pavement's aggregate sub-layers, various physical, chemical, and biological processes occur. These processes—including filtration, sedimentation, and adsorption—are highly effective at removing pollutants such as total suspended solids (TSS), heavy metals (e.g., zinc, copper), and hydrocarbons (Bratieres et al., 2008; Collins et al., 2010). This passive treatment process facilitates the recharge of local groundwater aquifers with water of improved quality.In addition to stormwater management, PPS provide significant thermal benefits. Conventional dark, impervious surfaces are a primary contributor to the Urban Heat Island (UHI) effect due to their low albedo (high heat absorption) and lack of moisture for evaporation. Permeable pavements, particularly lighter-colored pervious concrete, exhibit a higher albedo. Moreover, their ability to retain moisture within their pore structure allows for evaporative cooling following precipitation events, resulting in demonstrably lower surface temperatures compared to traditional asphalt (Li et al., 2013; Haselbach, 2010).

2.3.5. Sustainable Drainage Systems (SuDS)

Sustainable Drainage Systems (SuDS) represent a paradigm shift in hydrological design, moving from conventional, conveyance-based infrastructure to a holistic philosophy for managing surface water (Woods Ballard et al., 2015).

2.Background

Traditional urban drainage is characterized by "gray" infrastructure (e.g., concrete pipes, channels) designed for the rapid collection and conveyance of stormwater. This approach is widely recognized for exacerbating hydrological problems, including increased peak flow rates (leading to fluvial and pluvial flooding), degradation of receiving water bodies due to non-point source pollution, and diminished groundwater recharge (Fletcher et al., 2015).

In contrast, SuDS (also known internationally as Low Impact Development or Water Sensitive Urban Design) aim to replicate the natural hydrological cycle by managing precipitation at or near its source (Woods Ballard et al., 2015). The core strategy involves utilizing a "management train"—a sequence of techniques—to control runoff. These techniques, which include bioretention systems (rain gardens), vegetated swales (bioswales), permeable pavements, and green roofs, are designed to detain (slow), retain (store), filter, and facilitate the infiltration of stormwater. The fundamental objective of SuDS is not singular; rather, it is a multi-functional approach built upon four key pillars, as codified by the UK's Construction Industry Research and Information Association (CIRIA):

Water Quantity: To attenuate peak runoff flows and reduce runoff volume, thereby mitigating flood risk.

Water Quality: To improve the quality of receiving water bodies by removing pollutants (e.g., suspended solids, heavy metals, hydrocarbons) through sedimentation, filtration, adsorption, and biological processes.

Amenity: To enhance the aesthetic, social, and recreational value of the urban landscape, contributing to public well-being.

Biodiversity: To create and sustain diverse, ecologically resilient habitats for urban wildlife.

2.3.6. Water harvesting

Water Harvesting (WH) is an established engineering and adaptation strategy for managing scarce water resources, defined by the collection, storage, and conservation of precipitation-derived runoff (primarily rainwater and floodwater) (Oweis et al., 1999). This practice is based on the principle of capturing water before it is lost to evaporation, deep percolation, or contamination, thereby maximizing water use efficiency. Water harvesting techniques are particularly vital in Arid and Semi-Arid Regions (ASARs), where precipitation is characterized by high spatio-temporal variability (Falkenmark & Rockström, 2006). Systems are generally classified into two principal categories:

Rainwater Harvesting (RWH): This occurs at the micro-catchment level and typically involves the collection of runoff from rooftop surfaces or small land areas. The collected water is stored primarily for domestic use (potable or non-potable) or small-scale subsistence agriculture (Gould & Nissen-Petersen, 1999).

Floodwater Harvesting (FWH): This is a macro-catchment approach involving the diversion, slowing, and storage of runoff from ephemeral or seasonal streambeds during flood events. This water is generally utilized for agricultural irrigation or managed aquifer recharge (MAR) (Oweis et al., 1999).

Water harvesting mitigates soil erosion by reducing the velocity of surface runoff and contributes to the replenishment of local groundwater tables (Boers & Ben-Asher, 1982). From an agricultural perspective, it enhances food security by stabilizing and increasing crop yields in rain-fed farming systems. Ecologically, it restores local water cycles and serves as a localized adaptation mechanism to climate variability and change (Li et al., 2018).

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2.4. Ecosystem Services

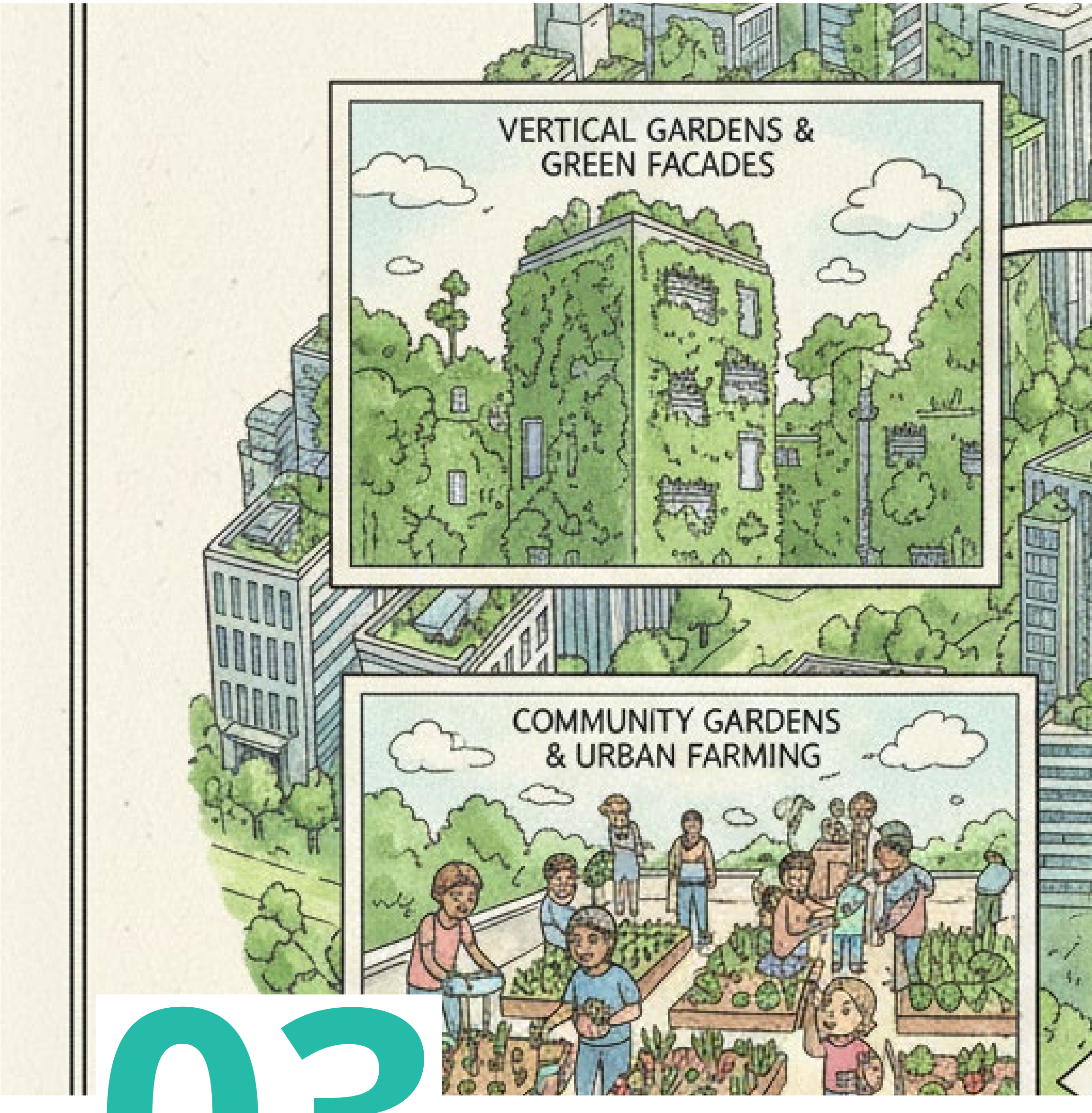
Green infrastructure is defined by the European Commission as "a strategically planned network of natural and semi-natural areas designed and managed to provide a wide range of ecosystem services, along with other environmental features. It includes green spaces (or blue spaces in the case of aquatic ecosystems) and other physical features in terrestrial (including coastal) and marine areas (https://www.dogavesehirler.org/uploads/yayinlar/yesilaltyapi_web_04.pdf).

Ecosystem services are the entirety of the direct and indirect contributions and benefits that natural ecosystem provide to human well-being. They refer to the natural processes that sustain our lives, ranging from the air we breathe and the water we drink to the food we eat and flood control.
While the concept has roots in the 1970s, the term "ecosystem services" began to gain widespread traction in scientific literature in the 1990s (Costanza et al., 1997). However, the concept's global recognition and its integration into policy-making processes were largely catalyzed by the United Nations Millennium Ecosystem Assessment (MEA), published in 2005. This assessment classified these services and established their critical link to human well-being (MEA, 2005).

Ecosystem services are classified into four main categories (MEA, 2005):
1.Provisioning Services: The tangible products obtained directly from ecosystems, such as food, clean water, firewood, fiber, and genetic resources.
2.Regulating Services: The benefits derived from the regulation of ecosystem processes, including climate regulation, water purification, pollination, and disease control.
3.Cultural Services: The non-material benefits people obtain from nature, such as recreational activities, aesthetic pleasure, spiritual fulfillment, and scientific inspiration.
4.Supporting Services: The fundamental ecological processes necessary for the production of all other ecosystem services, such as soil formation, photosynthesis, and nutrient cycling.

These services form the foundation of human life and the global economy. However, they are often overlooked in conventional economic systems be¬cause they are typically not assigned a monetary value (Costanza et al., 1997).

Source: WWF Living Planet Report 2016



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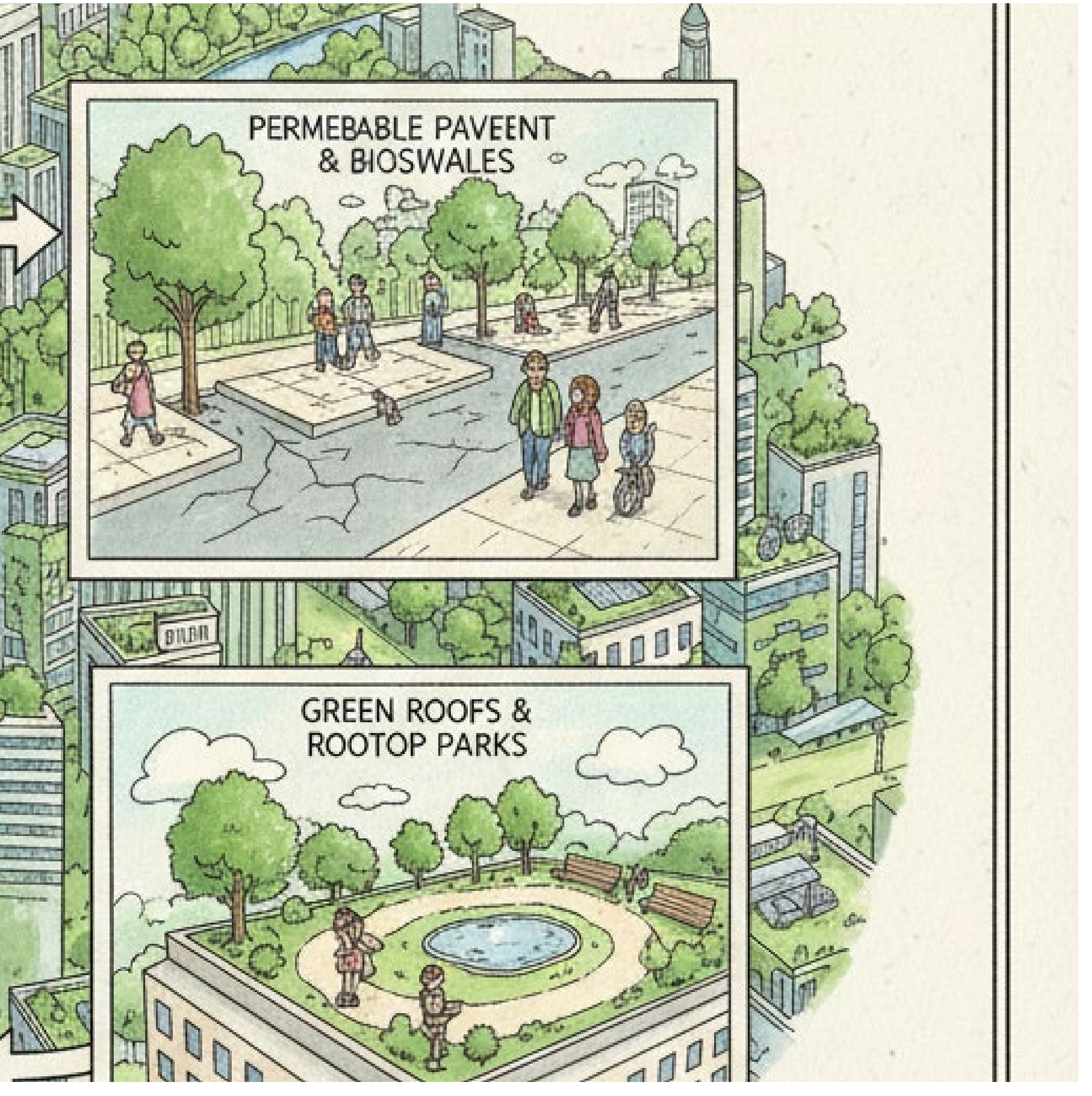
Best Practice Examples


PERMEBABLE PAVEENT
& BIOSWALES
GREEN ROOFS &
ROOTOP PARKS

3. Best Examples

3.1 Research and applications

3.1.1 UNaLab (Urban Nature Labs)

UNaLab was a practical, demonstration-focused project. Its primary goal was to develop, implement, and test innovative Nature-Based Solutions in specific cities to address climate and water-related challenges.

Main objective is to demonstrate how NBS can help cities become more climate-resilient and water-wise. It focused on mitigating problems like flooding (stormwater management) and the urban heat island effect (cooling).

The project used a "Front-Runner" and "Follower" city approach. Front-Runner Cities (Tampere, Finland; Eindhoven, Netherlands; Genoa, Italy): These cities had existing experience with NBS and served as "living laboratories" (the "Urban Nature Labs") to co-create and test new solutions. Follower Cities: This group of cities learned from the experiences of the Front-Runners to replicate and adapt the successful solutions to their own local contexts.

UNaLab produced practical guidelines, tools, and real-world evidence showing how to successfully plan and implement NBS in diverse urban settings.

3.1.2 ThinkNature

ThinkNature was a platform-based, support-oriented project. Its goal was not to implement solutions itself, but rather to create a central hub to consolidate knowledge and build a community around Nature-Based Solutions.

Main objective is to support the mainstreaming and scaling-up of NBS in Europe and globally. It aimed to bridge the gap between research, policy, and practice.

Methodology: Knowledge Platform: It created a multi-stakeholder online platform (the "ThinkNature Platform") to gather and share information, best practices, case studies, and tools related to NBS.

Community Building: It worked to connect scientists, policymakers, businesses, and citizens to foster dialogue and collaboration.

NBS Handbook: One of its most significant outputs was the EU-wide handbook on Nature-Based Solutions, providing a comprehensive guide for practitioners.

3. Best Examples

Key Outcome: ThinkNature acted as an "enabler," providing the resources, network, and consolidated knowledge base that cities and project developers (like those in UNaLab) need to implement NBS effectively.

Cities are "hotspots" for climate change impacts. Both UNaLab and ThinkNature were created to solve the problems in cities which they suffer from following problems.

- Urban Heat Island Effect: Concrete and asphalt absorb heat, making cities significantly warmer than surrounding rural areas.
- Intense Flooding: Impermeable surfaces (like roads and roofs) prevent rainwater from soaking into the ground, overwhelming drainage systems during heavy storms.
- Air Pollution & Biodiversity Loss: Lack of green space contributes to poor air quality and loss of natural habitats.

UNaLab and ThinkNature highligts the Nature-Based Solutions (NBS) as the answer. Instead of relying purely on "grey" infrastructure (pipes, concrete, air conditioning), NBS uses natural systems to solve these problems. Examples of NBS include:

- Green Roofs & Walls: Insulate buildings, cool the air, and absorb rainwater.
- Urban Parks & Forests: Provide cooling, clean the air, and offer recreational space.
- Raingardens & Bioswales: Manage stormwater naturally, filtering pollutants and preventing floods.
- Permeable Pavements: Allow water to soak into the ground.

UNaLab and ThinkNature together, they represented a key part of the EU's strategy to build more sustainable, resilient, and liveable cities in the face of climate change.

thinknature

3. Best Examples

3.2. Case studies from European cities

These solutions are often multi-functional: they manage water, cool the city, enhance biodiversity, and provide recreational spaces for people.

3.2.1 Copenhagen, Denmark: Climate Resilient Neighborhoods (Klimakvarter)[1]

Following a major cloudburst event (a severe flood) in 2011, Copenhagen developed a radical plan to manage stormwater. Implementation: The "Klimakvarter" (Climate Quarter) project, which started in areas like Østerbro, aims to manage rainwater as a resource rather than as a problem to be diverted into the sewer system

Water Plazas (Tåsinge Plads): This space functions as a dry public square most of the time but is designed to transform into a basin that can temporarily detain water during heavy rainfall.
Green Streets: Streets are designed with permeable surfaces and "bioswales" (vegetated channels) instead of traditional curbs. Water is guided through these channels to parks or the harbor.
Benefits: Reduced flood risk, less strain on the sewer system, creation of new green spaces, and more aesthetically pleasing streets.

3.2.2 Freiburg, Germany: The Vauban & Rieselfeld Districts[2]

Freiburg has long been known as “Europe’s eco-capital” and provides one of the earliest and most comprehensive examples of sustainable urban planning. The Vauban district, built on a former French military base, was redeveloped in the 1990s as a fully sustainable neighborhood.

Passive House Standard: Most homes are built to the “Passivhaus” standard, which requires very little energy for heating or cooling.
Car-Free Living: The neighborhood is designed to be “car-free,” prioritizing pedestrians and cyclists. Car ownership is discouraged, and vehicles are kept in parking garages on the district’s periphery.

SUDS (Sustainable Urban Drainage): Rainwater is managed on the surface. It is collected in open, vegetated channels (bioswales) along the streets, allowing it to be filtered and to soak slowly back into the ground (infiltration).
Benefits: A low carbon footprint, high air quality, a strong sense of community, and respect for the natural water cycle.

3. Best Examples

3.2.3 Barcelona, Spain: Superblocks (Superilles)[3]

Barcelona devised an ingenious solution to combat the urban heat island effect, air pollution, and a lack of public space. "Superblocks" (or Superilles in Catalan) are created by grouping together nine standard city blocks (in a 3x3 grid). The streets inside this block are closed to through-traffic, or speeds are limited to 10 km/h.

Intersections and roads reclaimed from cars are converted into "citizen spaces" with benches, planters, play areas, and small parks.

The Poblenou and Sant Antoni neighborhoods are early, successful models of this concept.

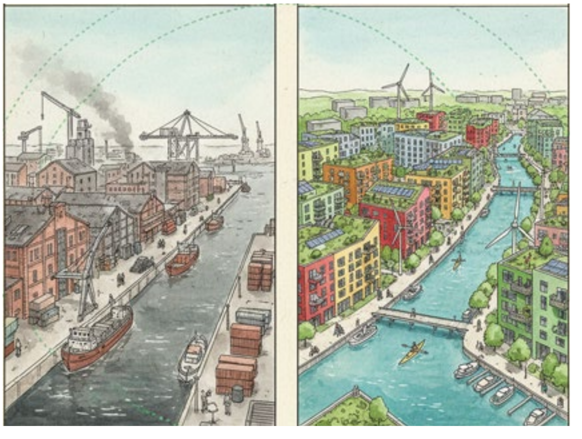
Benefits: Encourages walking and cycling, significantly reduces noise and air pollution, increases social interaction, and cools the city by adding new green spaces.

3 https://www.escofet.com/en/blog/superblocks-phenomenon-filling-streets-life

3.2.4. Malmö, Sweden: The Bo01 District (Western Harbour)[4]
Malmö transformed a derelict industrial port area into one of Europe's most sustainable and innovative residential districts. The Bo01 district (from "Bo," the Swedish word "to live") was designed as a housing exposition in 2001 and became a permanent neighborhood.

100% Renewable Energy: All energy for the district is supplied by local wind turbines, solar panels, and geothermal power.

Extensive Green Roofs: The majority of buildings are covered with green roofs to manage rainwater, provide insulation, and support biodiversity.



Open Drainage Systems: Stormwater is collected and filtered through a beautiful, visible system of open channels and ponds before being discharged into the sea.

Benefits: An energy-positive neighborhood, climate resilience, and local systems for turning food waste into biogas.

3. Best Examples

3.2.5 Vitoria-Gasteiz, Spain: The Green Belt (Anillo Verde)[5]

Often overshadowed by larger cities, Vitoria-Gasteiz was named the "European Green Capital" in 2012 and has one of the most successful large-scale green infrastructure examples.
Implementation: In the 1990s, the city decided to restore the degraded, fragmented areas on its periphery (such as old gravel pits and marshlands).

The "Anillo Verde" (Green Belt): This is an uninterrupted ring of parks, wetlands, forests, and river corridors that encircles the entire city.

Restored wetlands, like Salburua Park, have become critical habitats for endangered species, including the European mink.

Benefits: Acts as the city's "lungs," provides flood control, creates a sanctuary for biodiversity, and ensures all citizens have easy access (by foot or bike) to nature.

5 https://www.europarc.org/case-studies/vitoria-gasteiz-green-belt-actions-conservation-biodiversity/

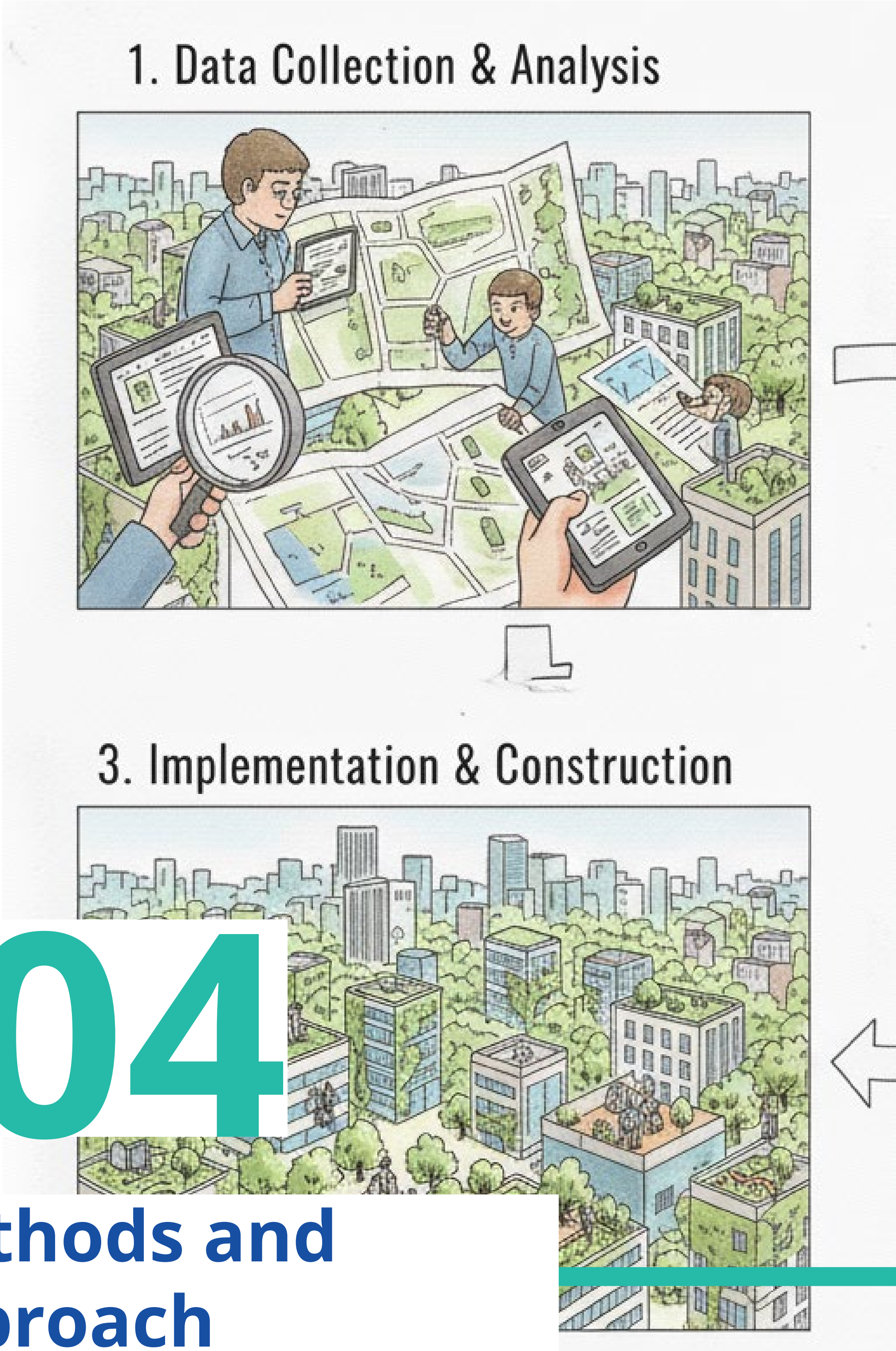
3.2.6 Rotterdam, Netherlands: Water Plazas (Waterpleinen)[6]

Embracing the philosophy of "live with water, don't fight it," Rotterdam is one of the world's most innovative cities in flood management. The city creates "dual-function" spaces to store water in densely populated urban areas.

Benthemplein Water Plaza: Most of the year, this is a basketball court, skate park, and open-air theater. When it rains heavily, these areas are designed to gradually fill with water, acting as giant temporary reservoirs and preventing the surrounding streets from flooding.

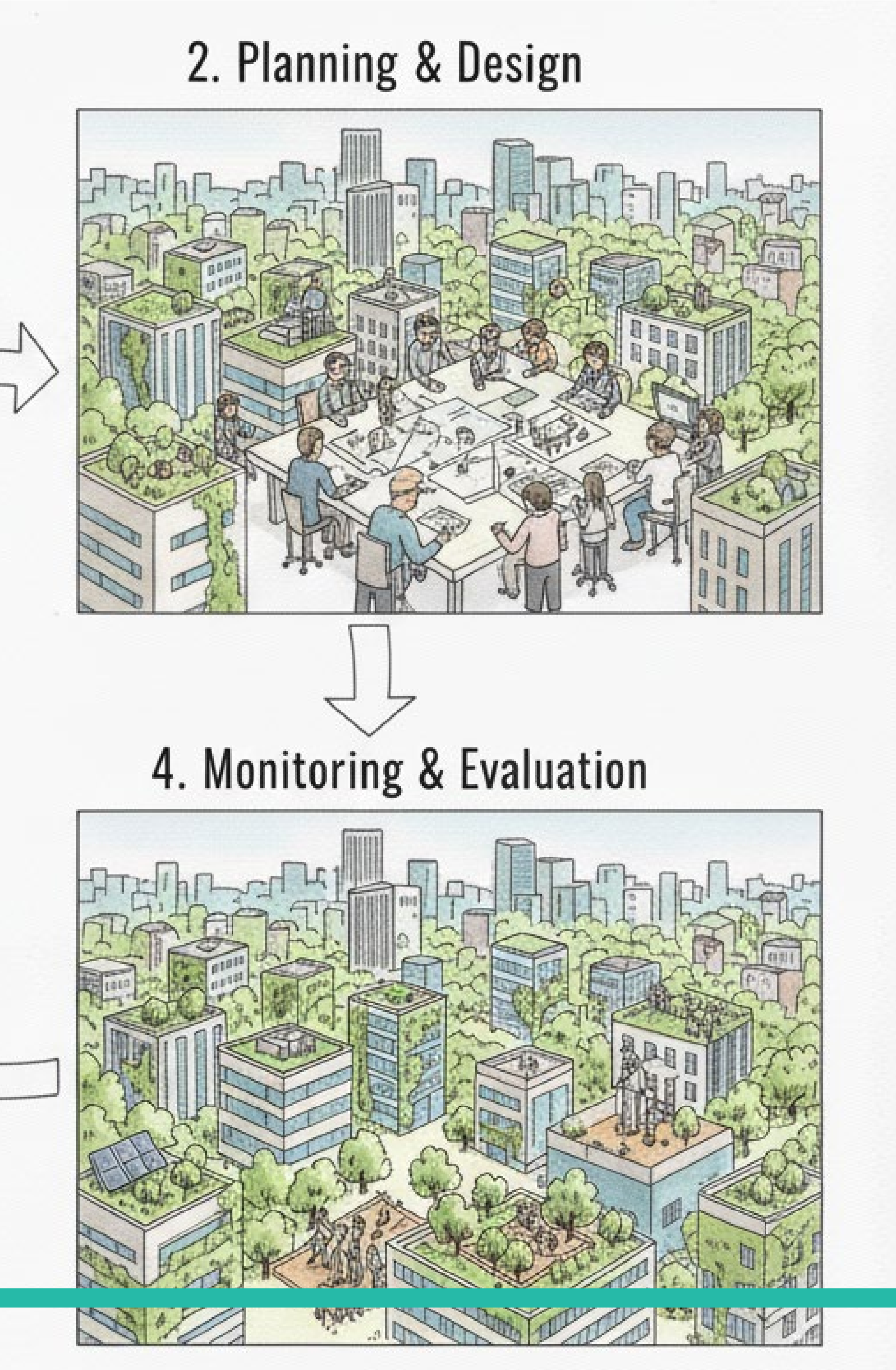
Benefits: Provides water security while simultaneously offering valuable public space for residents.

6 https://www.urbanisten.nl/work/benthemplein



04

Methods and Approach


2. Planning & Design
4. Monitoring & Evaluation

4.Methods and approach

The guide focuses on the integration of green infrastructure solutions into local policies, strategies and practices aimed at analysing, assessing and mitigating the increasing urban heat island (UHI) effects in the context of climate change in four target cities located in the Black Sea Basin (Uzunköprü, Kavala, Batum and Sozopol). The guide adopts an interdisciplinary and participatory approach to enhance the existing capacity of municipalities in the climate change adaptation process, improve thermal comfort and promote sustainable green space management.

1. **Analysis of Current Policies and Strategies:**

- Review of existing plans, strategies and policies for combating climate change in the four target cities.
- Assessment of the degree of integration of green planning and green infrastructure into these strategies.
- Analysis of the need to develop a heat resilience strategy.

2. **Development of a Common Methodology:**

- Collection of data through 'initiative groups' to be established in each country, consisting of local stakeholders, NGO representatives and citizens.
- Preparing and implementing common surveys, organising meetings with these groups, and identifying local needs.
- Implementing field-based methods that assess thermal comfort/ discomfort perception.

3. **Preparation and Analysis of Survey**

- Academics from Istanbul University-Cerrahpaşa Faculty of Forestry LANDLAB will seek answers to the questions: "Do local policymakers prioritise green infrastructure, and what is the rate of integration of Green Planning into the climate adaptation strategies of target cities/regions?". Preparation of survey questions for two different groups to obtain answers to the questions: 'What measures are target cities taking to reduce UHI in cities?
- Preparation of survey questions for two different groups: internal stakeholders (policy makers) and external stakeholders (NGOs, local communities, etc.)
- Analysis and reporting of survey responses

4. **Development of a Joint Measurement Methodology:**

- Preparation of a joint measurement protocol for assessing the Urban Heat Island (UHI) effect, in collaboration with a team of experts.
- Provision of a standard methodology for studies to be conducted in

collaboration with local measurement groups in other countries.

5. **Thermal Comfort Measurement and Mapping Activities:**

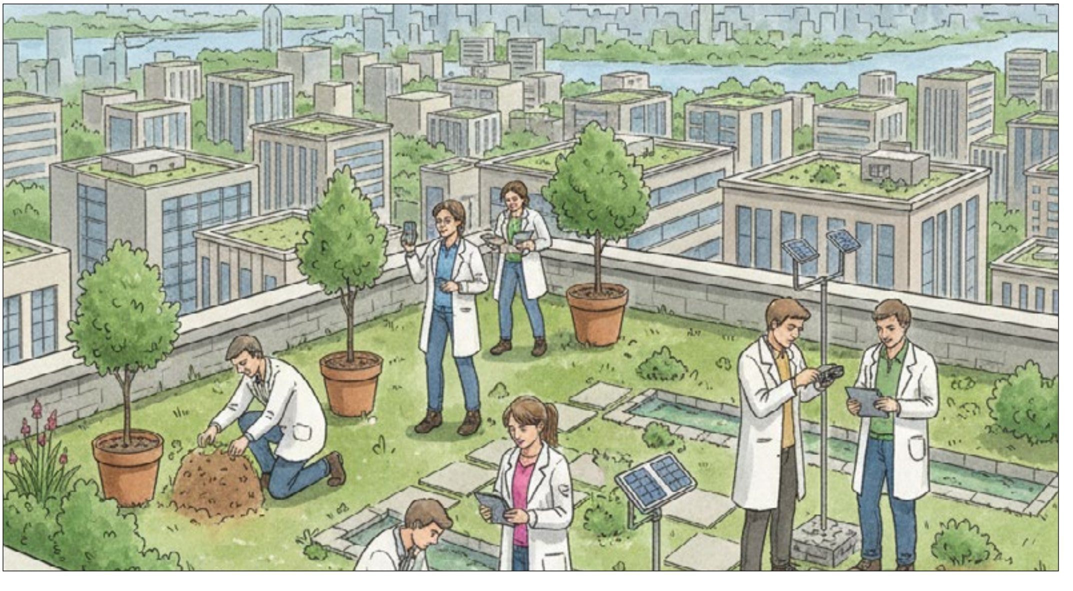
- Conducting field studies in the cities of Uzunköprü, Sozopol, Batum and Kavala, performing thermal measurements both at ground level and from the air.
- Creating and analysing digital thermal maps based on measurement data.

6. **Climate Data Analysis and UHI Detection:**

- Identifying areas affected by the UHI effect by analysing climate data (temperature, humidity, wind speed) from previous years.
- Determining heatwave periods and preparing special measurement plans for these periods.

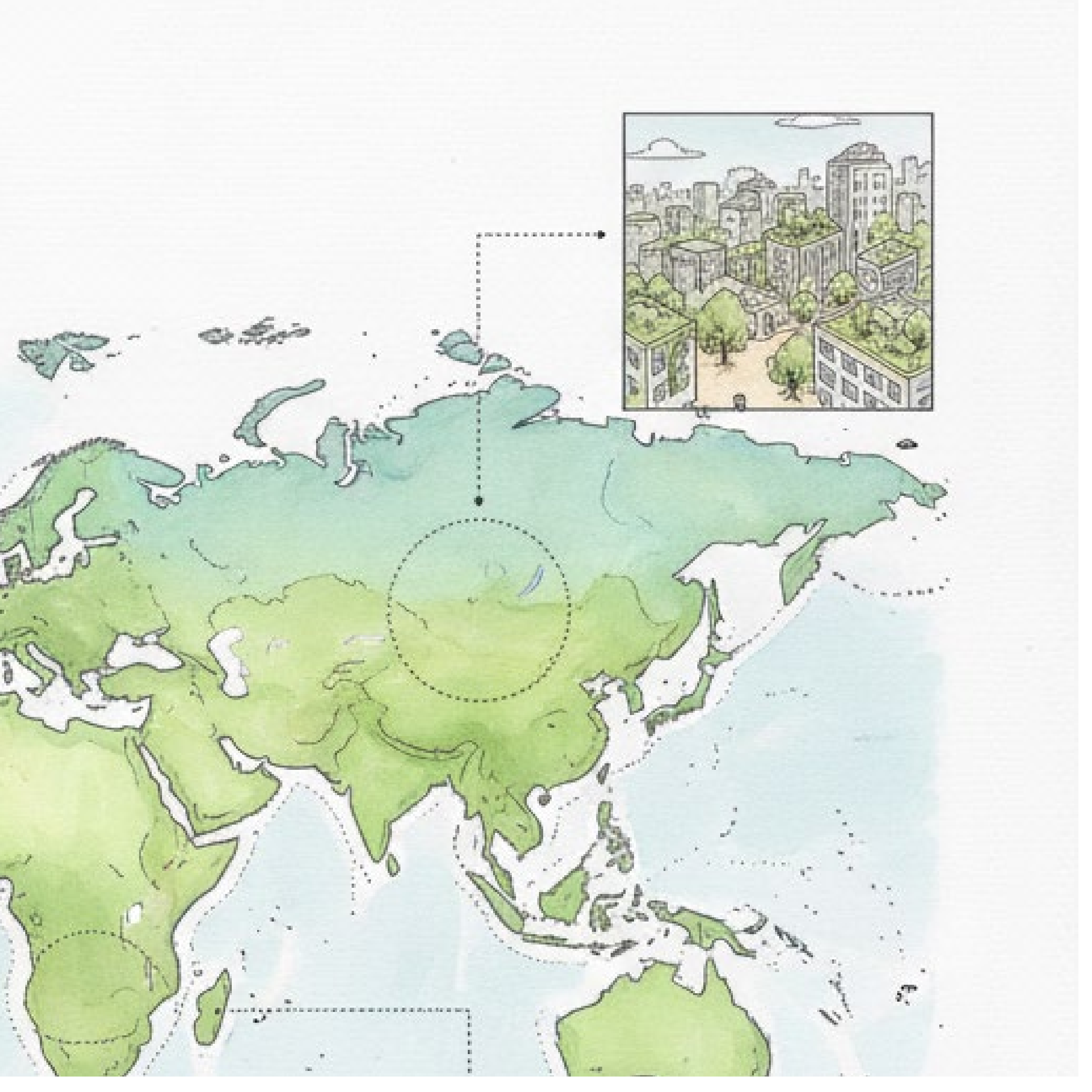
7. **Identification of Green Intervention Areas:**

- Identification of areas where pilot green infrastructure applications will be implemented based on measurement results.
- Analysis of the effects of interventions through comparative measurements before and after implementation.



05

Application Areas and Pilot Regions



5. Application Areas and Pilot Regions

5.1 Climate assessment

The long-term climate normals of *Batumi, Kavala, Uzunköprü* and *Sozopol* reveal four distinct climatic profiles, primarily dictated by their geographical position, topographical setting (coastal vs. inland), and the influence of different maritime bodies (Black Sea vs. Aegean Sea).

Batumi exhibits a hyper-humid Cfa (Humid Subtropical) climate, characterized by exceptionally high annual precipitation. This extreme rainfall is a result of persistent orographic lift as moist air from the Black Sea encounters the adjacent Lesser Caucasus Mountains. Its climate is highly temperate, with very mild winters (7.8°C) due to the shielding effect of the mountains, and warm, humid summers. Topographical sheltering also results in the lowest average wind speeds among the group.

Kavala is a definitive example of a Csa (Hot-summer Mediterranean) climate. Its regime is defined by a pronounced summer xerothermia (drought) and a winter precipitation maximum. It experiences the highest annual (15.6°C) and summer (24.7°C) mean temperatures of the four cities. The climate is also subject to strong, seasonal northerly (Etesian/Meltemi) winds.

As an inland location in the Thrace region, **Uzunköprü** is classified as a Csa (Hot-summer Mediterranean) climate, though it features strong continental influences. It meets the Csa criteria with its hot, distinctly dry summers (24.1°C) and wet winters. However, its inland position results in the highest seasonal thermal amplitude and significantly colder winters (4.3°C) than a typical coastal Csa. It is also, by a substantial margin, the windiest location.

Sozopol represents a cooler, temperate Cfa (Humid Subtropical) climate on the western Black Sea coast. While coastal, it is exposed to Balkan cold air masses, resulting in cold winters (4.1°C) similar to inland Uzunköprü. Its annual mean temperature (12.9°C) is the lowest of the group, and its summers are moderated by the Black Sea, making them the mildest (22.0°C).

4.1.1.Comparative Precipitation Regimes

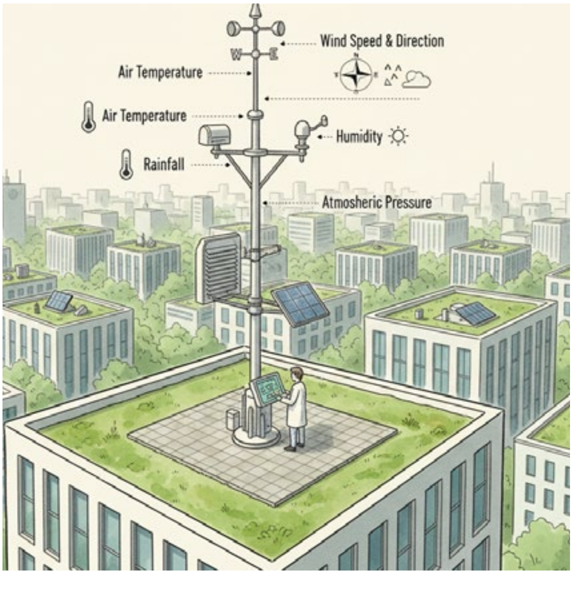
The analyzed cities exhibit extreme divergence in annual precipitation, reflecting their distinct geographic and orographic contexts.

Hyper-Humid (Batumi) Batumi (≈2,450 mm) is characterized by an exceptionally high mean annual precipitation, classifying it among Europe's most humid cities. Its location at the foothills of the Lesser Caucasus results in significant orographic lift, trapping moist maritime air from the Black Sea and ensuring year-round, substantial rainfall that exceeds the combined total of the other three cities.

Moderate (Uzunköprü) Uzunköprü (≈647 mm), despite its inland location, receives moderate precipitation. Its position in the Thrace region exposes it to weather systems from both the Balkans and the Black Sea.

Low (Kavala & Sozopol) Conversely, the coastal cities of Kavala (≈522 mm) and Sozopol (≈548 mm) record the lowest precipitation totals. Kavala's location is partially in a rain shadow. Both cities exhibit a distinct, if not severe, period of summer xerothermia (dryness).

4.1.2. Comparative Thermal Regimes



The thermal regimes are defined by the interplay between maritime moderation and continental influences.

Annual Mean Temperatures The annual mean temperatures for the cohort fall within a narrow range, from 12.9°C (Sozopol) to 15.6°C (Kavala).

Winter Mean Temperatures The divergence between maritime and continental influences is most evident in winter.

- *Mild Winters (Maritime):* Batumi (7.8°C) and Kavala (6.9°C)) exhibit high thermal moderation. Batumi benefits from the Black Sea and orographic shielding by the Caucasus, while Kavala is tempered by the Aegean Sea.

- *Cold Winters (Continental/Balkan):* In contrast, Sozopol (4.1°C) and Uzunköprü (4.3°C) are exposed to cold air advection from the Balkans, resulting in significantly lower temperatures and regular frost.

Summer Mean Temperatures Summer regimes are differentiated by continental heating versus maritime moderation.

- *Hot Summers (Continental/Mediterranean):* Kavala (≈24.7°C) and Uzunköprü (≈24.1°C) record the highest summer temperatures, reflecting Kavala's Csa (Hot-summer Mediterranean) climate and Uzunköprü's continental heating.
- *Cooler Summers (Maritime):* Sozopol (≈22.0°C) and Batumi (≈22.6°C) experience moderated summers due to the influence of the Black Sea. In Batumi, high humidity and cloud cover also tend to suppress extreme temperature peaks.

4.1.3.Comparative Wind Regimes

Wind speed and direction show significant variation, driven by exposure to large-scale systems versus localized topographical control.

Uzunköprü (High Velocity / Bimodal): Exhibiting the highest mean wind speed (21–23 km/h), Uzunköprü is situated in the Thrace wind corridor. Its wind regime is characterized by a variable, often bimodal pattern, subject to strong northerly and southerly air currents.

Kavala (High Velocity / Northerly): Kavala also maintains a high mean wind speed (17.7 km/h). Its regime is dominated by the seasonal Etesian (Meltemi) winds, which are strong, dry, northerly currents prevalent in the Aegean summer.

Sozopol (Moderate Velocity / Northerly): Sozopol presents a moderate wind climate (13.3 km/h). Dominant winds are primarily northerly (N/NW), originating from Eastern European/Balkan pressure systems.

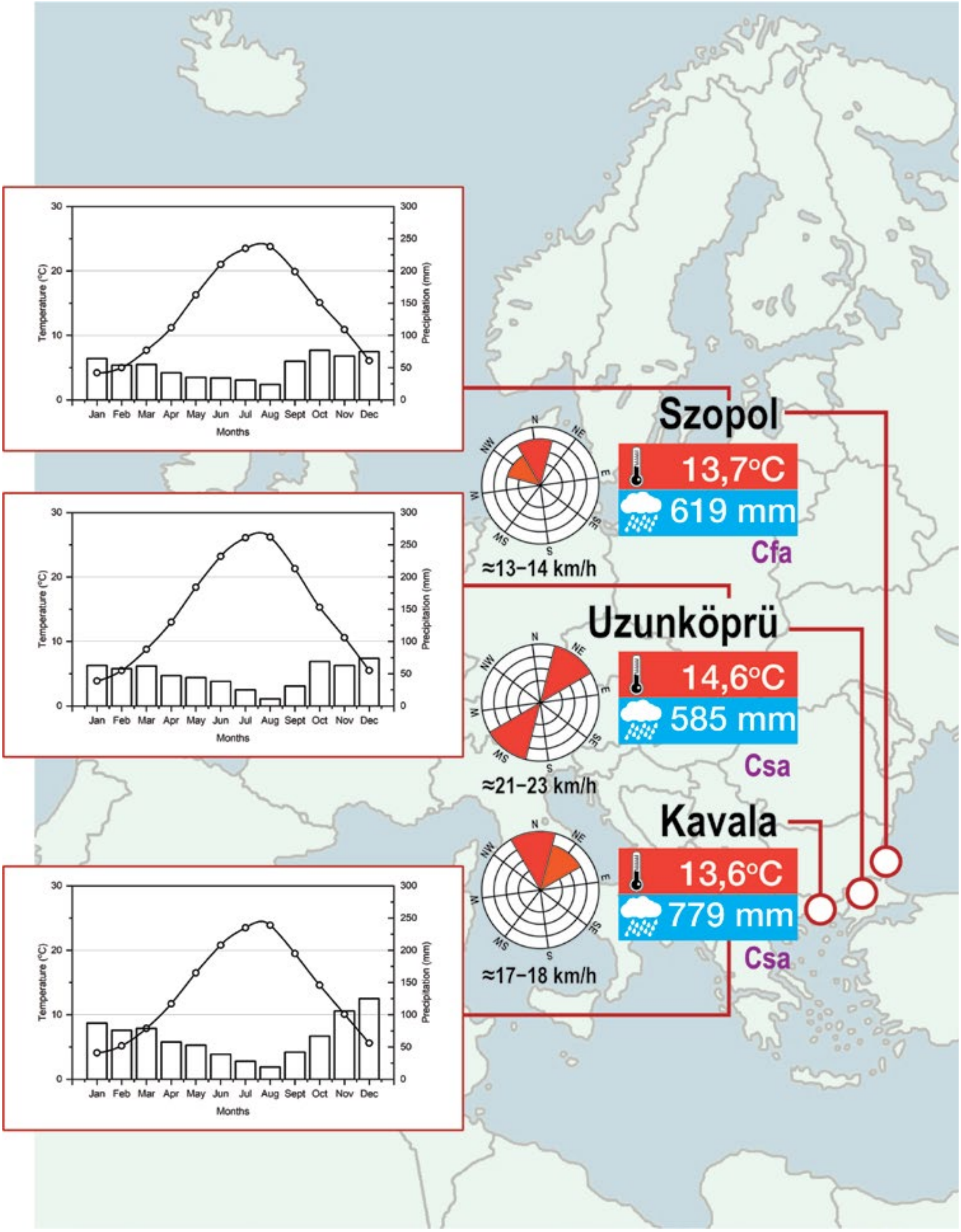
Batumi (Low Velocity / Topographically Controlled): Batumi (8.8 km/h) is the calmest location. Its unique topography provides significant orographic sheltering from large-scale synoptic systems. The dominant wind is often a light, topographically-controlled southeasterly wind.

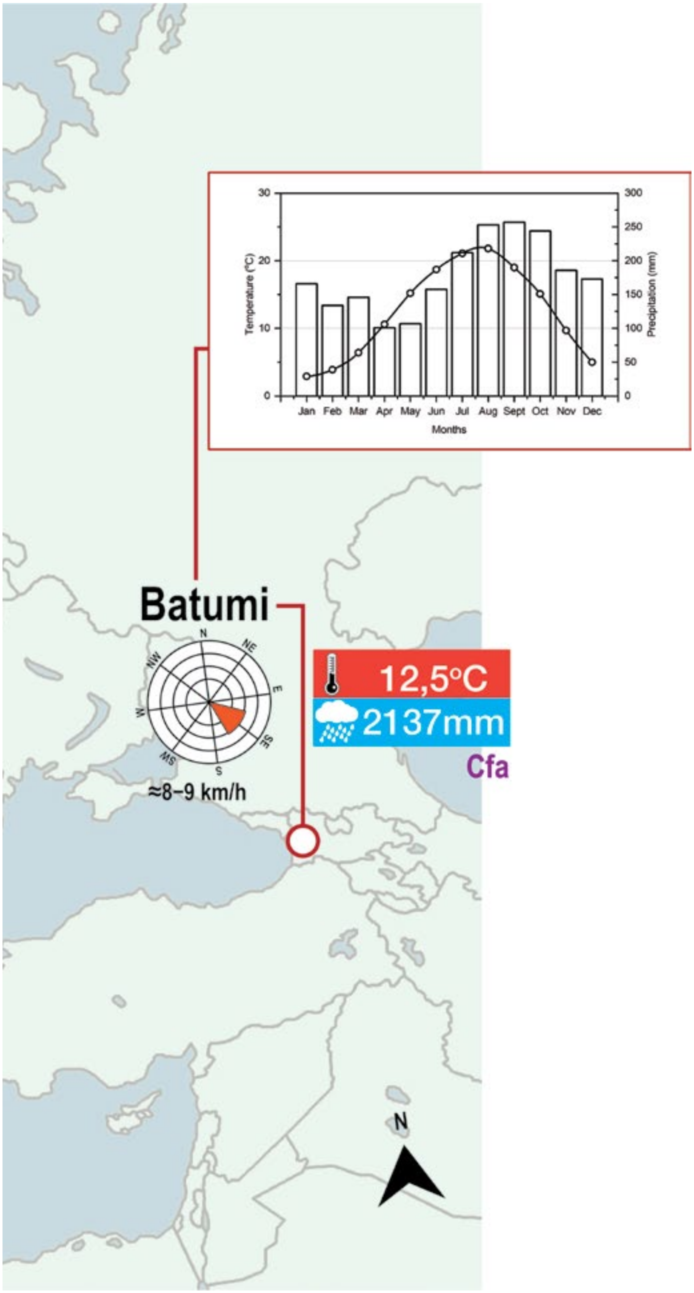
5. Application Areas and Pilot Regions

Table -1 Prominent climatic factors of selected cities.

Parameter	Kavala	Sozopol	Batumi	Uzunköprü
Annual Avg, Temperature (°C)	15,6	12,9	14,9	14,1
Summer Avg, Temperature (°C)	24,7	22	22,6	24,1
Winter Avg, Temperature (°C)	6,9	4,1	7,8	4,3
Total Annual Precipitation (mm)	522	548	2,45	647
Annual Avg, Rel, Humidity (%)	70%	77%	76%	72%
Avg, Annual Wind Speed (km/h)	17,7 km/h (High)	13,3 km/h (Medium)	8,8 km/h (Very Low)	22 km/h (Very High)
Dominant Wind Direction	North / Northeast	North / Northwest	Southeast	Southwest & Northeast

5. Application Areas and Pilot Regions





Temperature (°C)
Precipitation (mm)
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
Months
Batumi
≈8-9 km/h
12,5°C
2137mm
Cfa
N

5. Application Areas and Pilot Regions

5.2 Urbanization status

Batumi is one of the fastest-growing and urbanizing cities in Georgia.. The city is built on a narrow coastal strip, squeezed between the Black Sea on one side and mountains rising immediately behind it on the other. This geographical constraint has forced urban land use toward vertical development. Nearly all new developments are high-rise buildings within the existing urban fabric or along the coastal strip.

• **Rapid Population Growth:** According to the latest data from the National Statistics Office of Georgia (GeoStat), the city's official resident population has grown significantly (from 152,839 in the 2014 census to 183,181 in 2024). This figure is widely considered an undercount, as it doesn't include the large influx of non-resident investors, remote workers, and migrants post-2022.
• **High Urbanization Rate and Urban Area Pressure:** The Autonomous Republic of Adjara, of which Batumi is the capital, has the highest urbanization rate in Georgia (excluding Tbilisi), largely driven by Batumi's dense population. It is widely observed that rapid construction has placed immense pressure on existing green spaces and the historic urban fabric. Academic studies note that this rapid transformation threatens the city's "human scale" and "urban heritage."

• **Tourism and Construction-Led Growth:** In the post-2007 era, Batumi was positioned to attract international investment, sometimes nicknamed the "Dubai of the Black Sea" or the "Las Vegas of Georgia." This led to the rapid rise of high-rise hotels, residences, and casinos, especially along the coastline.

• **Challenges:** This rapid and often unregulated growth has brought classic urban problems, including traffic congestion, parking shortages, and infrastructure strain.

5. Application Areas and Pilot Regions

Table -2 Urbanization status of Batumi

Parameter	Value / Status
Administrative Area	64.9 km² (A compact urban area)
Official Resident Population	183,181 (National Statistics Office of Georgia - GeoStat, as of Jan 1, 2024)
Population (Tourist Season)	Can reach an estimated 750,000+ in peak summer months (regional estimate)
Population Density	~ 2,822 people/km² (Based on 2024 resident population)

5. Application Areas and Pilot Regions

Kavala is a historic port city, squeezed in an amphitheater shape between the sea and the mountain (Simvolo Mountain). Its urbanization model is dense and "cumulative" (built up over time) rather than vertically sprawling.

• **Population and Urbanization Status:** Kavala is a stable and mature administrative, commercial, and educational center for the Eastern Macedonia-Thrace region. Its population has remained relatively stable over the last decade. The urbanization model consists of dense, attached, medium-rise (4-7 story) apartment buildings, forced to conform to the topography.

• **Area and Land Use:** The 351.3 km^2 municipal (Dimos) area includes large rural areas and villages in addition to the urban center. The "city" itself is confined to a narrow strip between the mountain and the sea. This geographical constraint has largely prevented urban sprawl, forcing the city into a more compact and dense structure. Main urban activities are concentrated around the port and the coastal strip expanding west.

• **Green Space Presence:** Kavala's green infrastructure has a different character than the Batumi Boulevard.

• **Urban Parks:** The city has a large central park (Faliro Park) and various smaller squares.

• **Peri-Urban Forest:** The city's main green infrastructure is the forests and olive groves on the slopes of Simvolo Mountain, which rises immediately behind the city. This area serves as the city's "visual backdrop" and also functions as a recreational and climate-cooling asset. While the green-to-urban ratio in the center is low due to the dense fabric, the entire city is enveloped by a green landscape.

5. Application Areas and Pilot Regions

Table -3 Urbanization status of Kavala

Parameter	Value / Status
Administrative Area	351.3 km² (Entire Municipality - Dimos)
Population (Urban Center)	~ 52,000 (2021 Census)
Population (Total Municipality)	~ 66,000 (2021 Census)
Population Density (Municipality)	~ 188 people/km²

5. Application Areas and Pilot Regions

Sozopol is a small tourist town with a distinct "dual character": a historic peninsula (Old Town) with high levels of protection, and a new town area developing rapidly under intense tourism pressure.

• **Population and Urbanization Status:** Sozopol is a typical tourist resort town with a very low year-round resident population (approx. 5,800) but a population that can increase by up to 20 times in the summer. The pressure for urbanization comes not from permanent residents but from seasonal tourism demand. This demand manifests as the construction of new hotels, aparthotels, and holiday complexes outside the historic peninsula, especially to the south (Kavatsite, Dyuni areas).

• **Area and Land Use:** The 527 km² municipal area is much larger than the town of Sozopol itself and includes many villages, beaches, and protected nature areas (e.g., Ropotamo Reserve) along the coast. Urban land use is completely restricted in the "Old Town" (peninsula) due to architectural preservation, while in the "New Town" (Harmanite area) and along the coast, tourism-focused development is rapidly increasing.

• **Green Space Presence:** Sozopol's urban green space is limited; the town's identity comes from its historic streetscapes and beaches, not parks.

• **Urban Area Pressure:** In the newly developing hotel zones, the green space ratio is often kept to the legal minimum to maximize the buildable area.

• **Natural Green Infrastructure:** The city's true "green" value lies in its surrounding protected areas. The greatest threat from urban sprawl is its encroachment into natural assets like the Ropotamo wetlands, forests, and especially the coastal sand dunes (which are protected under the EU Natura 2000 network). The sustainability debate here is less about creating urban parks and more about preventing urban development from destroying this natural green infrastructure.

Table-4 Urbanization status of Sozopol

Parameter	Value / Status
Administrative Area	527 km² (Entire Municipality - Obshtina)
Population (Town Center)	~ 5,800 (NSI, 2022 data)
Population (Total Municipality)	~ 14,500 (NSI, 2022 data)
Tourist Season Population	100,000+ (Estimate)

5. Application Areas and Pilot Regions

Uzunköprü is an inland city, and its identity is defined not by tourism or port trade, but by agriculture. It is one of the agricultural hubs of the Thrace region.

• **Population and Urbanization Status:** Uzunköprü is a district center in the Edirne province. Its population is stable, showing no major increases or decreases. Its urbanization model is that of a "service town" for the surrounding agricultural activities. The city's growth is horizontal (sprawl), not vertical. New development typically takes the form of 2-5 story apartment buildings or detached houses, spreading into the farmland surrounding the town center.

• **Area and Land Use:** The 1,185 km² district area is vast, and a very large portion of it (approx. 80-85%) is agricultural land (mainly sunflower and wheat). The urban settlement area (the footprint of the town center) constitutes a very small percentage of this total area. Uzunköprü's urban form developed linearly along the historic stone bridge and the Ergene River.

• **Green Space Presence:** The concept of "green space" for Uzunköprü is entirely different from the other cities.

• **Agricultural Infrastructure:** The town itself is located in the middle of a vast "green infrastructure" of farmland. The primary sustainability issue here is not a lack of urban parks, but urban sprawl encroaching on fertile agricultural soil.

•**Blue Infrastructure (Ergene River):** The city's main geographical feature is the Ergene River. However, this is less of a healthy blue infrastructure and more of an ecological problem due to industrial pollution in the Thrace region. The restoration of the river and the protection of its floodplain is the city's most critical SITES/Green Infrastructure challenge.

•**Urban Parks:** The town center has standard municipal parks and recreational areas, particularly around the historic bridge and Cumhuriyet Square.

5. Application Areas and Pilot Regions

Table-5 Urbanization status of Uzunköprü

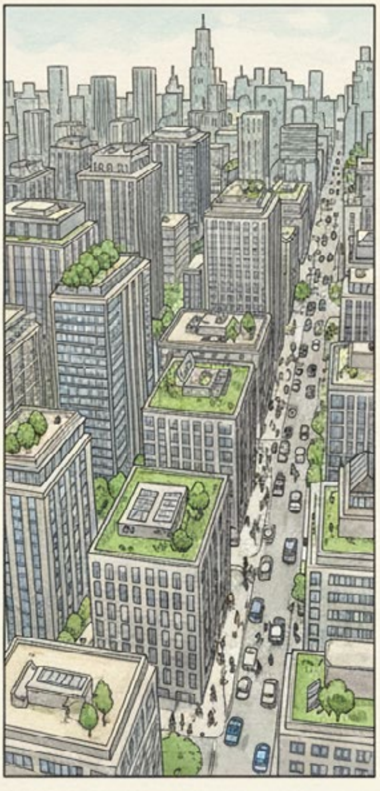
Parameter	Value / Status
Administrative Area	1,185 km² (Entire District - İlçe)
Population (Urban Center)	39,944 (TurkStat, 2023 data)
Population (Total District)	59,350 (TurkStat, 2023 data)
Population Density (District)	~ 50 people/km² (Very low, dominated by farm-land)

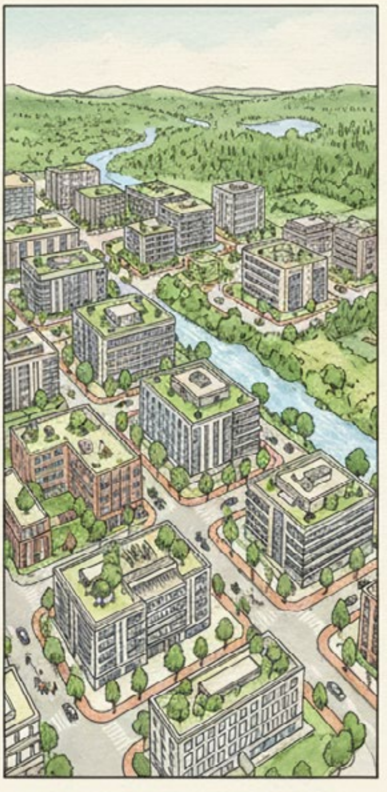
5. Application Areas and Pilot Regions

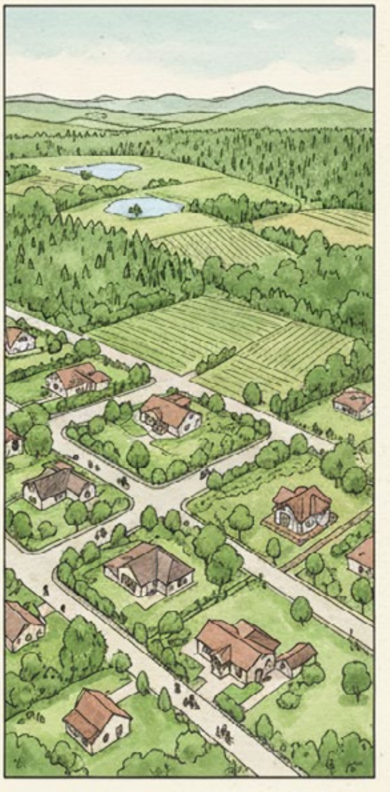
Table-6 Summary of urbanization pattterns of study areas

City	Urban Area (Impervious surfaces)	Urban Green Space Ratio	Visual Analysis Notes
Kavala	HIGH	MEDIUM	Geographical Constraint: The city is "squeezed" between the mountain and the sea in an amphitheater shape. The urban fabric is very dense, with attached buildings. Green Space: There is little integrated park space within the urban core (except Faliro Park). However, where the urban area ends, the very high-ratio forested mountain begins immediately.
Batumi	VERY HIGH	LOW (Integrated) / MEDIUM (Linear)	Vertical Densification: The new, high-rise development (hotels, residences), especially along the coast, has created an almost 100% impervious zone. The old town fabric is also dense. Green Space: The most prominent green space is the linear Batumi Boulevard along the coast. Integrated Park space (like May 6 Park) is low relative to the density.
Sozopol	HIGH	LOW	Tourism-Driven Density: Both the historic peninsula (Old Town) and the new hotel zone (New Town) have very dense development. Green space between buildings is minimal. Green Space: Parks/green spaces within the urban fabric are almost non-existent. However, as soon as the town ends (especially to the south), very high-ratio natural/coastal green space (dunes, scrubland) begins.
Uzunköprü	MEDIUM / LOW	MEDIUM	Horizontal Sprawl: Agricultural town. Unlike the others, development is horizontal and more "sparse," not vertical. Gardens, empty lots, and dirt areas are visible between buildings. Green Space: Green space is distributed throughout the urban fabric (gardens, small parks, medians). The most prominent green/blue infrastructure is the Ergene River and its surrounding floodplain/trees, which bisects the town.

Pathway Planning GUIDE







5. Application Areas and Pilot Regions

5.3 Evaluation of the cities based on SITES

The SITES (Sustainable Sites Initiative) criteria measure how a site's design and management contribute to ecosystem services (water, soil, plants) and human well-being. Based on the climate data (precipitation, temperature, wind), these four cities will have different priorities when applying the SITES criteria.

Table-7 Examination of cities' sustainability characteristics according to site criteria

SITES Category	Kavala (Greece)	Sozopol (Bulgaria)	Batumi (Georgia)	Uzunköprü (Turkey)
1. WATER (Water Management)	Challenge: Summer drought, water scarcity.	Challenge: Summer drought.	Challenge: Extreme precipitation, flood risk.	Challenge: Severe summer drought.
	Approach: Water conservation, winter rainwater harvesting (cisterns, green roofs, blue roofs), drought-tolerant native plants.	Approach: Water conservation, efficient irrigation, drought-tolerant native plants.	Approach: Large-scale stormwater management, rain gardens, bioswales, permeable surfaces.	Approach: Water conservation, harvesting of winter rain (cisterns, green roofs, blue roofs), preventing evaporation (mulching).
2. SOIL (Soil Health)	Challenge: Summer desiccation, loss of organic matter.	Challenge: Desiccation, frost effects.	Challenge: Severe soil erosion, nutrient leaching.	Challenge: Extreme summer desiccation, soil hardening, frost effects.
	Approach: Preserving soil moisture (mulching), increasing water retention with compost.	Approach: Mulching, adding organic matter.	Approach: Erosion control (terracing, vegetation), soil retention, increasing permeability of soil.	Approach: Increasing soil water-holding capacity (compost, mulch).
3. VEGETATION (Plant Use)	Challenge: Hot and dry summers.	Challenge: Dry summers and cold winters.	Challenge: Constantly saturated soil, high humidity.	Challenge: Most extreme scenario: Scorching/dry summers AND severe winter frosts.
	Approach: Use of drought-tolerant, native Mediterranean plants (maquis, lavender, etc.).	Approach: Selecting plants resistant to both drought and frost.	Approach: Using native Colchic flora (hydrophytic plants) that tolerate water-logged soil.	Approach: Selecting native Thracian steppe (grassland) plants resistant to both extreme drought and deep frost.

5. Application Areas and Pilot Regions

4. MATERIALS	Challenge: High UV radiation.	Challenge: UV radiation and freeze-thaw cycles.	Challenge: Constant high humidity, rain, moss/algae growth.	Challenge: High UV, severe freeze-thaw cycles.
	Approach: UV-resistant, light-colored (high albedo) materials to reduce heat island effect.	Approach: Selecting materials resistant to UV and frost.	Approach: Materials resistant to rot, mold, and corrosion (rust) (e.g., stone, composites, treated hardwood).	Approach: Materials highly resistant to cracking from frost, light-colored (albedo) surfaces.
5. HUMAN HEALTH (Comfort & Well-being)	Challenge: Scorching summer heat.	Challenge: Summer heat and cold winter winds.	Challenge: Constant rain, oppressive humidity.	Challenge: Scorching summer heat AND very high wind.
	Approach: Creating shade (strategic tree planting, pergolas) and using cooling water elements.	Approach: Shading for summer, windbreak designs for winter.	Approach: Rain-sheltered public spaces (wide eaves, gazebos) and designs that promote air circulation.	Approach: Two main priorities: Creating shade (for heat) and windbreaks (for wind comfort).

5. Application Areas and Pilot Regions

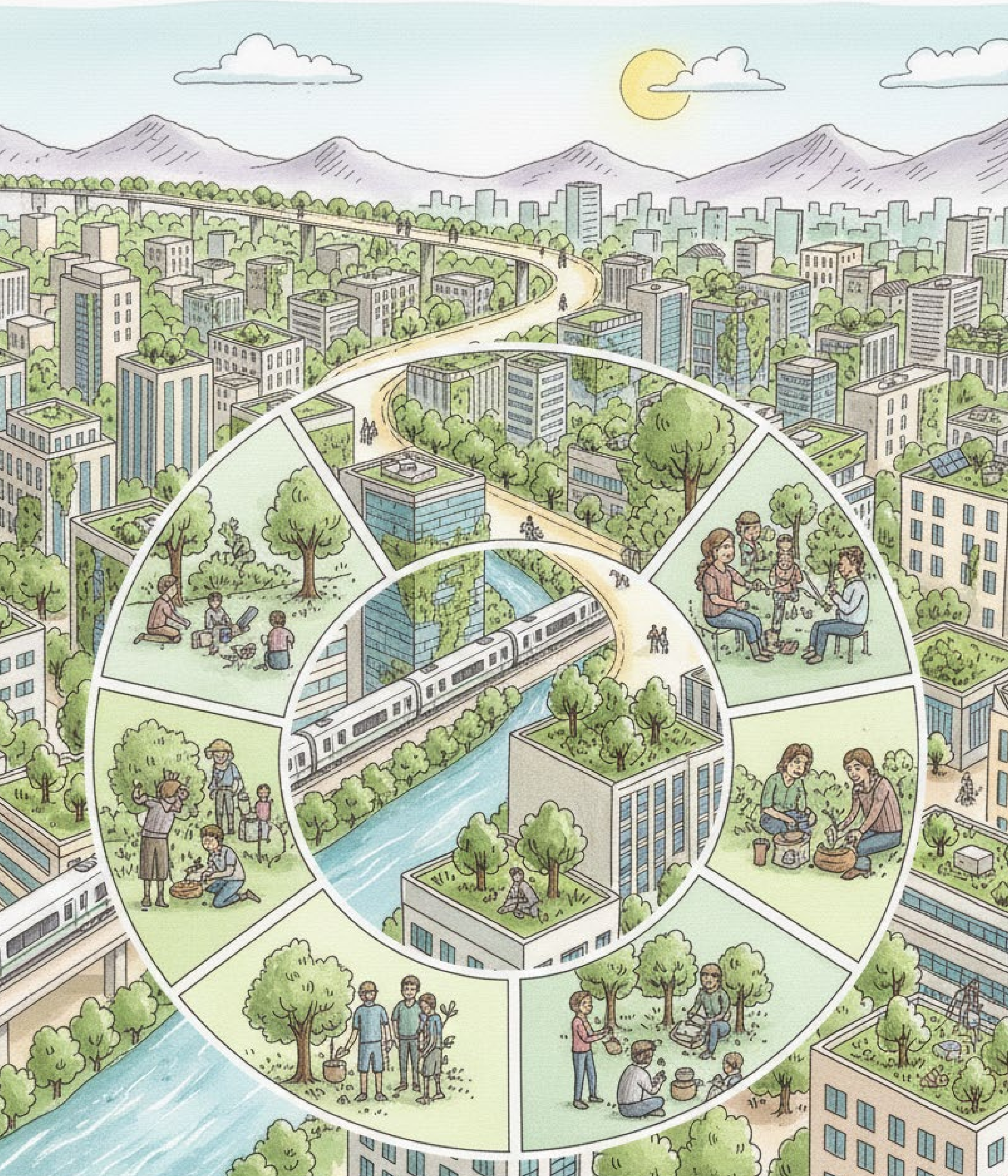
5.4.Suggestions on Green and Blue Infrastructure

Another sustainable approach which mostly common in EU is green infrastructure (GI). This was also enriched by blue infrastructure approach which is mostly focus on sustainable water management. The EU Green Infrastructure Strategy which was published by EU Comission aims to preserve, restore and enhance green infrastructure to help stop the loss of biodiversity and enable ecosystems to deliver their services to people. In the light of this policy, an assessment regarding green and blue infrastructure was shown below.

Table 8 – Assessment of cities regarding EU Green and Blue Infrastructure Strategy

City	Climate Challenge	EU GI Strategy Priority	Recommended Green Infrastructure (GI) Components	Recommended Blue Infrastructure (BI) Components
Batumi	extreme precipitation flooding erosion high humidity dense urbanization	1. Climate Adaptation (Flood Management) 2. Water Quality 3. Biodiversity (Erosion Control)	1. Green roofs (To absorb rainfall) 2. Slope stabilization (Erosion control with roots) 3. Dense urban forests (For humidity & airflow)	1. Sustainable Urban Drainage (SuDS) (Main priority) 2. Rain gardens, bioswales (Filtering/slowing water) 3. Constructed Wetlands (Storing & treating water) 4. Permeable pavements (reducing the effect of dense urbanization)
Kavala	summer drought water scarcity urban heat island	1. Climate Adaptation (Heat & Drought) 2. Human Health & Well-being 3. Water Conservation	1. Urban canopy (Dense tree planting, pergolas) 2. Xeriscaping (Native plants to eliminate irrigation) 3. Green walls (To cool buildings)	1. Rainwater harvesting (Cisterns, underground storage) 2. Water-efficient irrigation systems 3. Cooling water features (fountains) for microclimate. 4. Urban trees and vegetation
Uzunköprü	extreme temperatures (hot summer/ cold winter) summer drought very high wind speed.	1. Climate Adaptation (Climate Extremes) 2. Human Health (Wind comfort) 3. Agricultural Area Protection	1. Windbreaks (Strategic tree/shrub lines) 2. Parks and shaded pathways to reduce UHI. 3. Ecological corridors (For agricultural biodiversity)	1. Rainwater harvesting 2. Water-efficient irrigation systems 3. River (Ergene) restoration and floodplain protection (A critical BI component).

Pathway Planning GUIDE



5. Application Areas and Pilot Regions

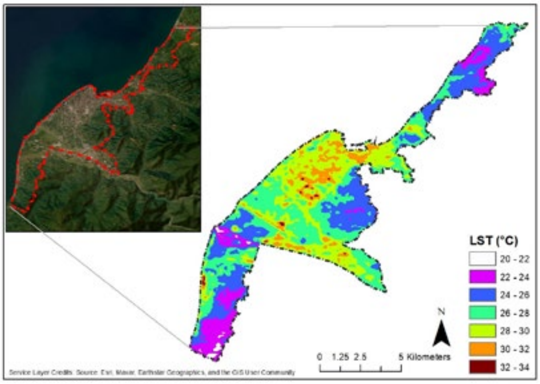
5.5 Heat map

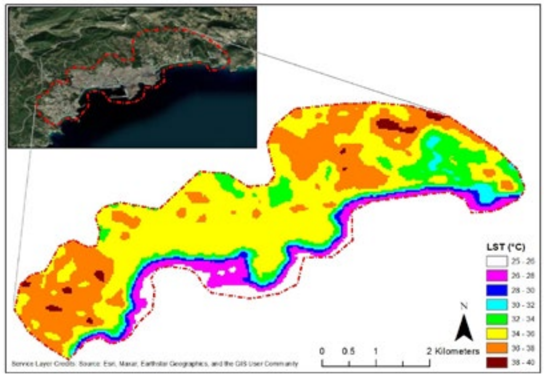
Surface temperatures are generally high across the settlement areas of Kavala, and, as shown in Figures, they exceed 36 °C particularly in the southwest of the settlement areas and in the agricultural zones located to the northeast of Kavala.

In Batumi, surface temperatures range between 20 and 26 °C in natural areas, whereas they reach up to 34 °C in settlement areas.

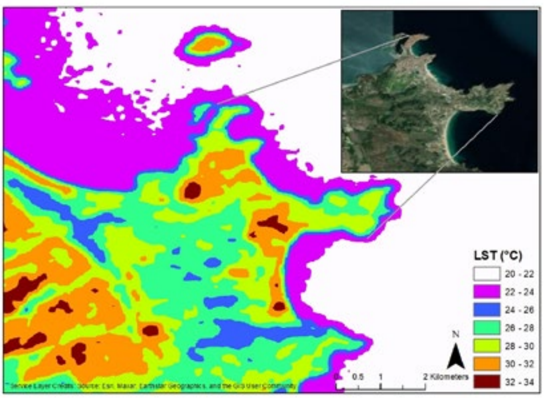
In Sozopol, surface temperatures range between 26 and 32 °C in settlement areas, while they reach up to 34 °C in the agricultural zones located to the southwest.

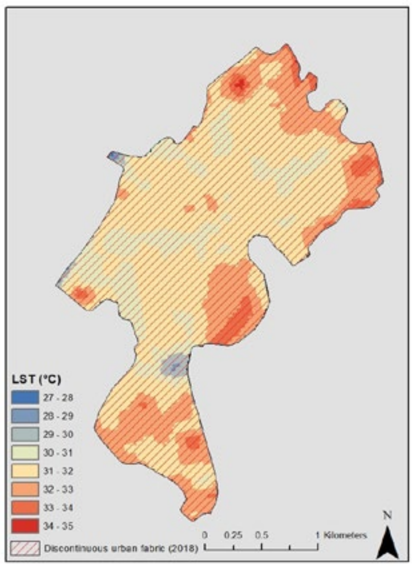
In Uzunköprü thermal analysis based on LST values derived from August 2025 Landsat imagery shows that the newly urbanized southern section exhibits the highest surface temperatures, reaching approximately 34-35 °C.





Heat map of Batumi (left) and Kavala (right)





Heat map of Sozopol (left) and Uzunköprü (right)

06

Activities and Action Plan

6. Activities and Action Plan

6.1 Analysis of Survey

1.1 Analysis of External Stakeholders' Perspective

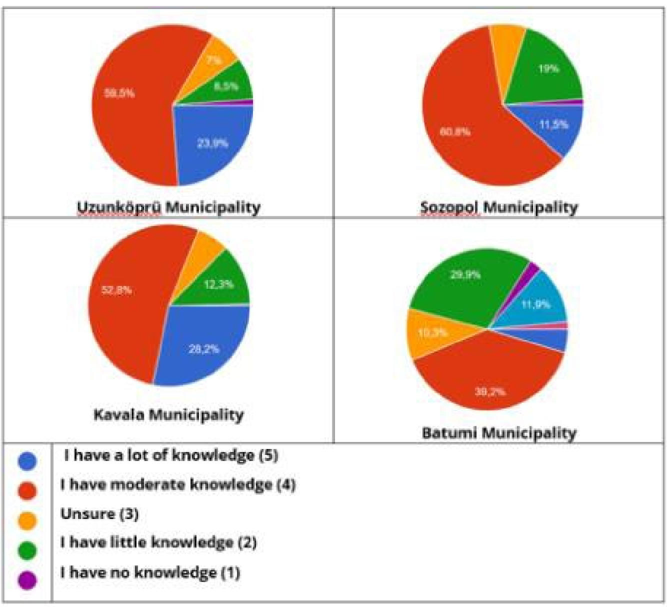
Section 1. Measuring Climate Perception

The full results are provided in the report web site, and answers to some questions are given below.

Q1. How much do you know about climate change?

- In Uzunköprü Municipality, 59.5% of the participants reported having a moderate level of knowledge, while 23% were considered to have a high level of knowledge.
- In Sozopol Municipality, 60.8% of participants indicated a moderate level of knowledge whereas 19.0 mentioned having a low level of knowledge
- In Kavala, 52.8% respondents identified their knowledge level as moderate and 28.2% rated as high.
- Among the participants from Batumi, 39.2% rated their knowledge as moderate, while 29.9% stated that they have little knowledge

These findings highlight variations in climate change awareness across municipalities, with a predominant trend of moderate knowledge levels among respondent. Overall, the level of knowledge regarding climate change is at a moderate level at all partner municipalities.



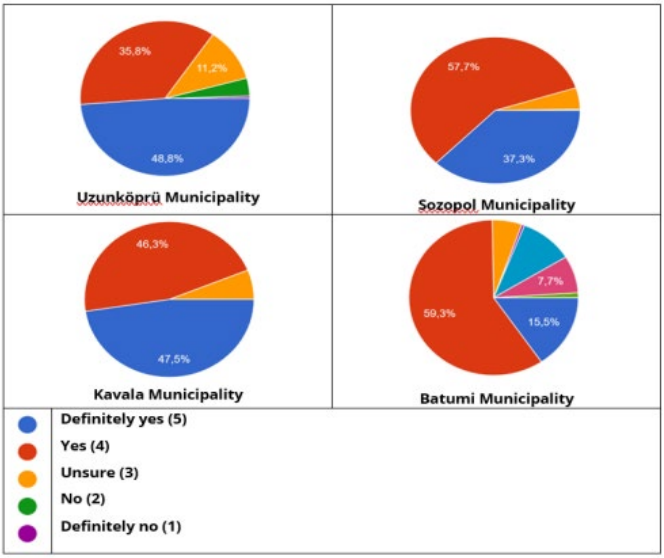
Q2. What comes to mind first when you think of climate change? (select up to 3 options)

- In Uzunköprü, the majority of the participants (61.9%) primarily associated climate change with rising temperatures, followed by the seasonal changes (49%) and the melting of glaciers (48%).
- In Sozopol, the most frequently mentioned climate change indicators were rising temperatures (68.3%), followed by seasonal changes (42.8%) and melting glaciers (42.5%).
- For Kavala, the related ranking was rising temperatures (78.5%), melting of glaciers (42.5%) and drought /water scarcity (35.6%).
- In Batumi, the most commonly cited factor was raising temperatures (76.8%) followed by melting glaciers (53.6%) and seasonal changes (37.1%).
- Rising temperatures was the most recognized factor across all the partner municipalities. Glacial melting, seasonal schanges and drought/water scarcity were the other highlighted factors.

Q3. Do you think climate change affects your region?

- In Uzunköprü Municipality, 48% of the participants stated that they believe climate change has definitely affected their region, while 35.8% reported that it has had an impact.
- In Sozopol, 57.7% of the participants indicated that their region has been affected by climate change, while 37.3 % mentioned that it has definitely been impacted.
- In Kavala, 47.5% of respondents believed that climate change has definitely affected their region and 46% thought that it has had an impact.
- In Batumi, 15% of participants claimed that their region has definitely been affected by climate change, while 59.3% reported that it has been affected.

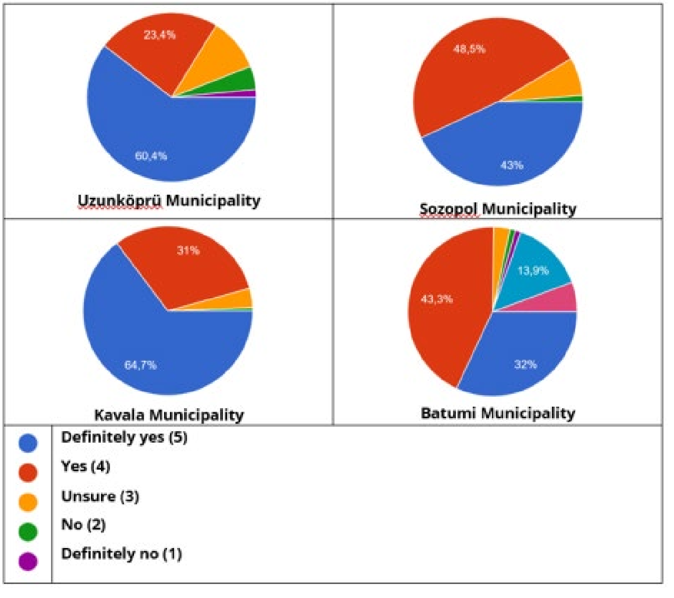
The perceived impact of climate change varies between municipalities, with the highest levels of certainty observed in Kavala and Sozopol, and a lower percentage of respondents in Batumi and Uzunköprü reporting a definite impact. The majority of the respondents in all municipalities considered the impact of climate change in their region to be very high or high.



Q4. Do you think climate change has negative consequences?

- In Uzunköprü Municipality, 60% of participants believe that climate change definitely has negative consequences, while 23.4% stated that it has negative consequences.
- In Sozopol Municipality, 48.5% of the participants indicated that climate change has negative effects, and 43% claimed that it definitely has negative effects.
- In Kavala Municipality, 64.7% of participants mentioned that climate change definitely has negative effects, while 31% believe that there are negative effects.
- In Batumi Mnicipality, 32% of participants staeted thet there are definitely negative effects, and 43.3% believed that there are negative effects

The responses from participants across these municipalities showed a general recognition of the negative impacts of climate change, with varying degrees of certainty. Participants from Kavala and Uzunköprü expressed a stronger conviction that climate change has definite negative consequences, while those from Batumi and Sozopol acknowledged the negative impacts but with slightly less certainty.

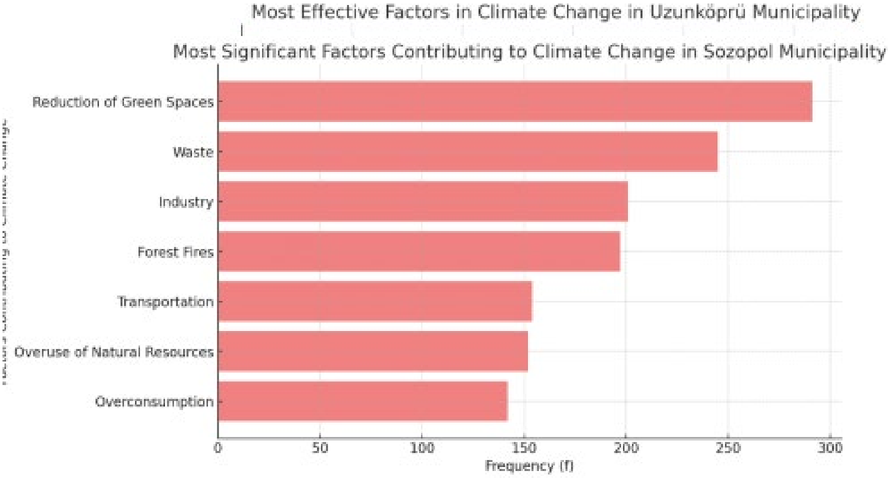


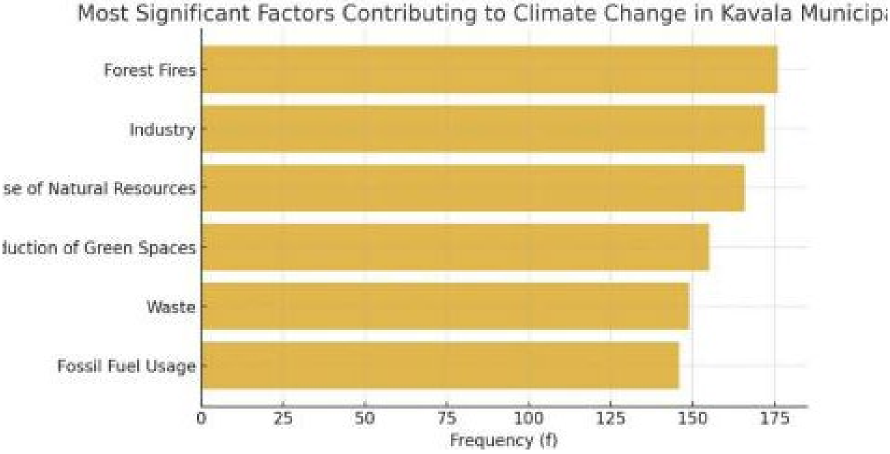
Q5. How would you rate the impact levels of the factors that cause climate change? (5 is most impactful, 1 is least impactful)

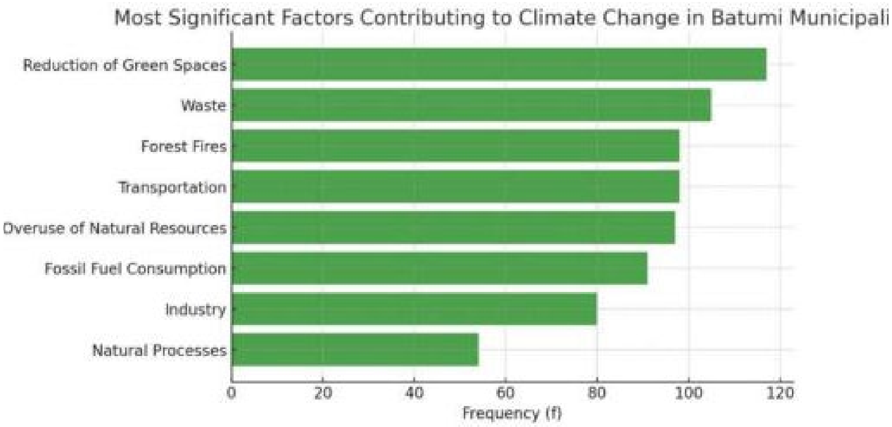
- In Uzunköprü Municipality, the most effective factors in climate change are reduction of green spaces (f=271), waste (f=234), overuse of natural resources (f=228), forest fires (f=228), industry (f=225), overpopulation (f=219), rapid urbanization (f=205), fossil fuel usage (f=189), and overconsumption (f=189).
- In Sozopol Municipality, the most significant factors contributing to climate change are the reduction of green spaces (f=291), waste (f=245), industry (f=201), forest fires (f=197), transportation (f=154), overuse of natural resources (f=152), and overconsumption (f=142).
- In Kavala Municipality, the leading factors influencing climate change are forest fires (f=176), industry (f=172), overuse of natural resources (f=166), reduction of green spaces (f=155), waste (f=149), and fossil fuel usage (f=146).
- In Batumi Municipality, the most effective factors in climate change are the reduction in green spaces (f=117), waste (f=105), forest fires (f=98), transportation (f=98), overuse of natural resources (f=97), fossil fuel consumption (f=91), industry (f=80), and natural processes (f=54).

6. Activities and Action Plan

Across all municipalities, the decrease in green spaces and waste management emerge as critical concerns in climate change. Additionally, the excessive use of natural resources and forest fires are consistently perceived as major contributors. While industrial activities are highlighted in most municipalities, transportation is particularly emphasized in Sozopol and Batumi.







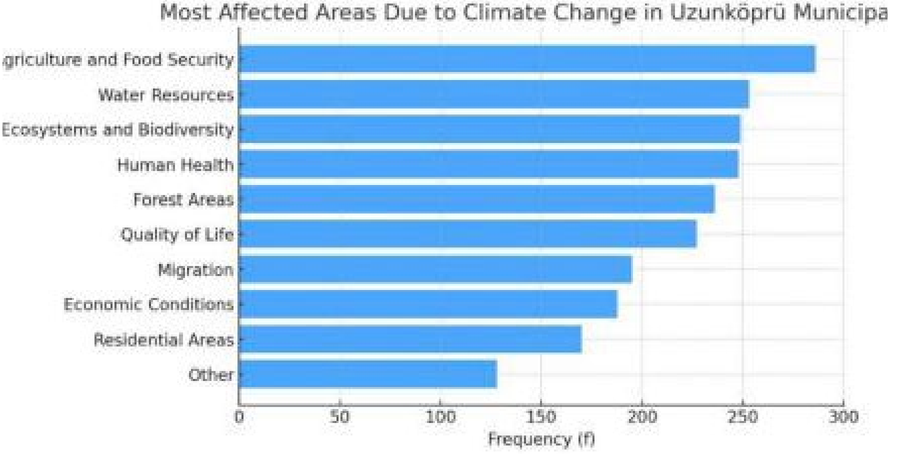
Q6. How do you think the issues listed below will be affected by the possible consequences of climate change

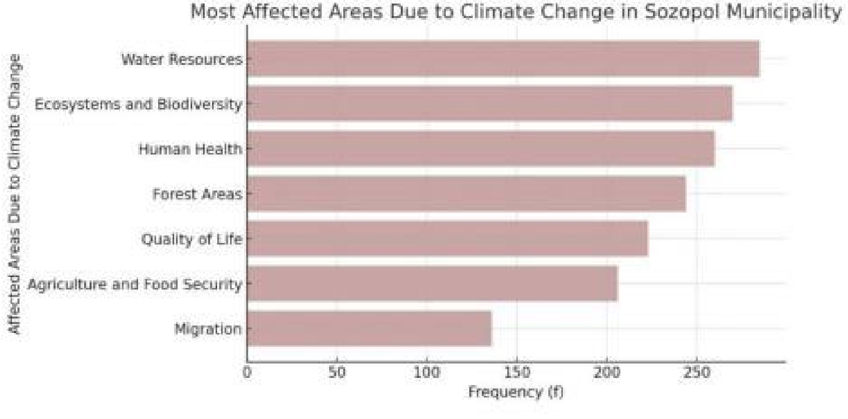
- In Uzunköprü Municipality, the most affected areas due to climate change are expected to be agriculture and food security (f=286), water resources (f=253), ecosystems and biodiversity (f=249), human health (f=248), forest areas (f=236), quality of life (f=227), migration (f=195), economic conditions (f=188), residential areas (f=170), and other (f=128) respectively.
- In Sozopol Municipality, the most significant areas expected to be affected by climate change include water resources (f=285), ecosystems and biodiversity (f=270), human health (f=260), forest areas (f=244), quality of life (f=223), agriculture and food security (f=206), and migration (f=136) respectively.
- In Kavala Municipality, the key areas estimated to be affected by climate change are water resources (f=210), ecosystems and biodiversity (f=205), forest areas (f=183), quality of life (f=165), agriculture and food security (f=164), migration (f=162), and other (f=106).
- In Batumi Municipality, the most vulnerable areas to climate change impacts are human health (f=111), ecosystems and biodiversity (f=103), agriculture and food security (f=96), water resources (f=95), quality of life (f=87), forest areas (f=85), economic conditions (f=64), residential areas (f=60), and other (f=52).

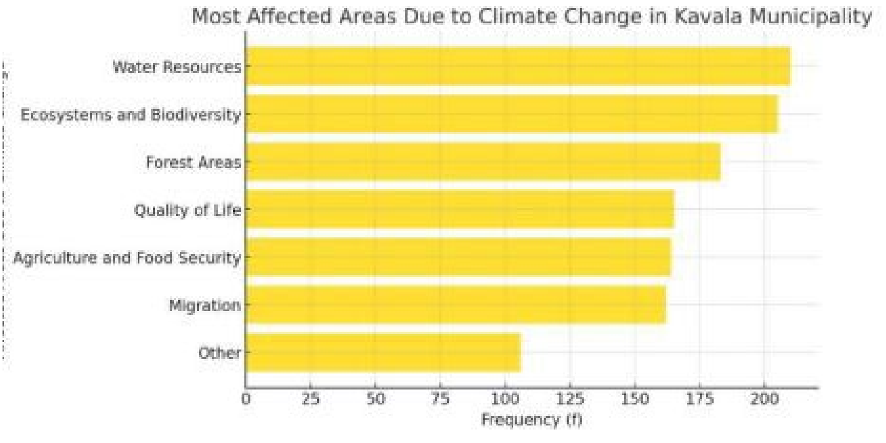
The most frequently identified issues across all municipalities are water resources, ecosystems and biodiversity, and agriculture and food security.

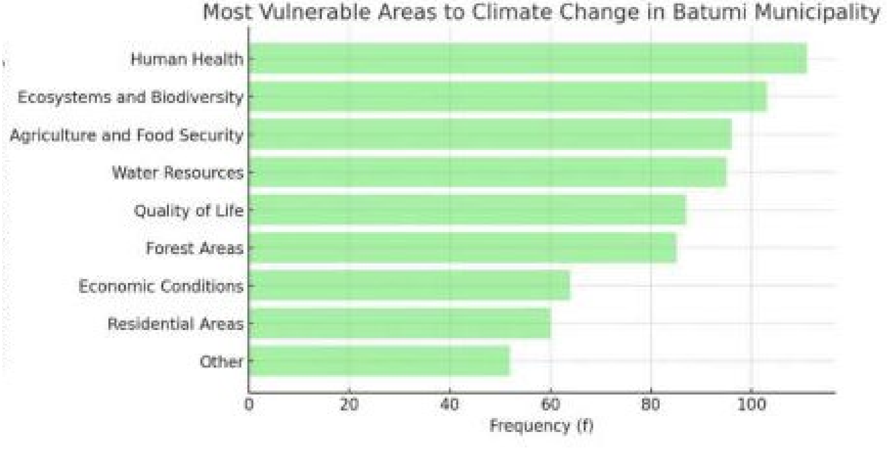
6. Activities and Action Plan

Human health is particularly emphasised in Batumi and Sozopol, while forest areas are identified as a significant factor in all locations. Additionally, quality of life and migration are identified as concerns, indicating the socio-economic









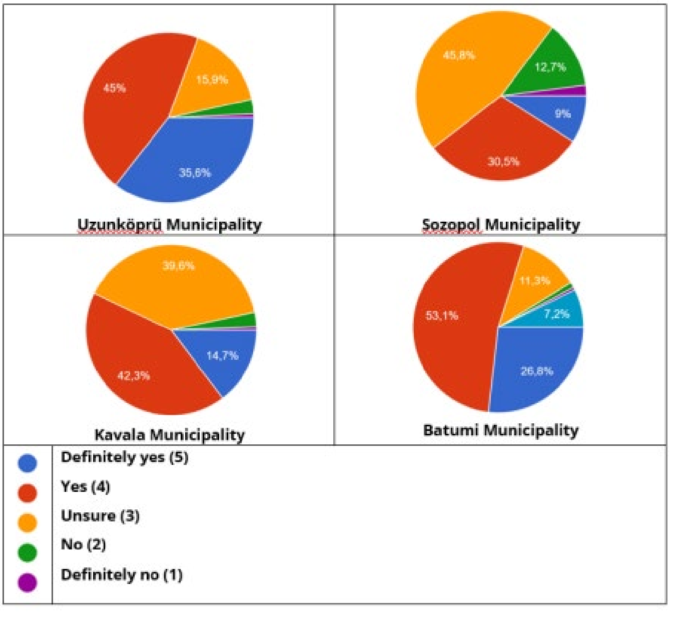
Q7. Can climate change be combated?

- In Uzunköprü Municipality, 45% of participants believed that climate change can be conbated, while 35.6% stated that it can definitely be combated.

6. Activities and Action Plan

- In Sozopol Municipality, 30.5% of participants thought that climate change can be combated, whereas 45.8% remained undecided on the aspect.
- In Kavala Municipality, 42.3% of participants believed that climate change can be combated, while 39.6% are uncertain about this possibility.
- In Batumi Municipality, 26.8% of participants stated that climate change can definitely be mitigated, while 53.1% believed that it can be mitigated.

Although the participants' views on climate change mitigation vary between municipalities, a significant percentage of respondents in Uzunköprü and Batumi believe that mitigation is possible. However a higher rate of indecision was observed in Sozopol and Kavala.



Q8. Which organizations are most effective in combating climate change? (Select up to 3 options)

In this section, the three most preferred items are evaluated.

- In Uzunköprü, participants identified National Authorities (85.6%)

and Local Authorities (76.9%) as the most effective organizations, followed by Civil Society Organizations(48%).

- In Szopol, participants identified National Authorities (64.3%) and International Collaborations (60.3%) as the most effective organizations, followed by Local Authorities (44.5%).
- In Kavala, participants identified International Collaborations (74.2%) and National Authorities (71.5%) as the most effective organizations, followed by Local Authorities (42.3%).
- In Batumi, participants identified International Collaborations (63.4%) and National Authorities (57.7%) as the most effective organizations, followed by Local Authorities (53.6%).

National and Local Authorities, along with International Collaborations, were consistently identified as the most effective organizations in combating climate change across all locations. The three most preferred factors for the participants from the partner municipalities can be found in the table below:

Municipality	1st effective organization	2nd effective organization	3rd effective organization
Uzunköprü	National Authorities (85.6%)	Local Authorities (76.9%)	Civil Society Orgs. (48%)
Sozoppol	National Authorities (64.3%)	International Collab. (60.3%)	Local Authorities (44.5%)
Kavala	International Collab. (74.2%)	National Authorities (71.5%)	Local Authorities (42.3%)
Batumi	International Collab. (63.4%)	National Authorities (57.7%)	Local Authorities (53.6%)

Q9. Please evaluate the impact level of measures (precautions) against climate change (5 is most effective, 1 is the least effective)

- In Uzunköprü, the most impactful measures against climate change were identified as renewable energy usage (f=296), increasing green spaces (f=256), and natüre conservation projects (f=249).
- In Szopol, the most impactful measures against climate change were identified as increasing green spaces (f=303), waste management (f=262), and recycling (f=231).
- In Kavala, the most impactful measures against climate change were identified as waste management (f=193), increasing green spaces (f=168), and nature conservation projects (f=166).
- In Batumi, the most impactful measures against climate change were identified as increasing green spaces (f=122), education and awareness campaigns (f=117), and waste management (f=114).

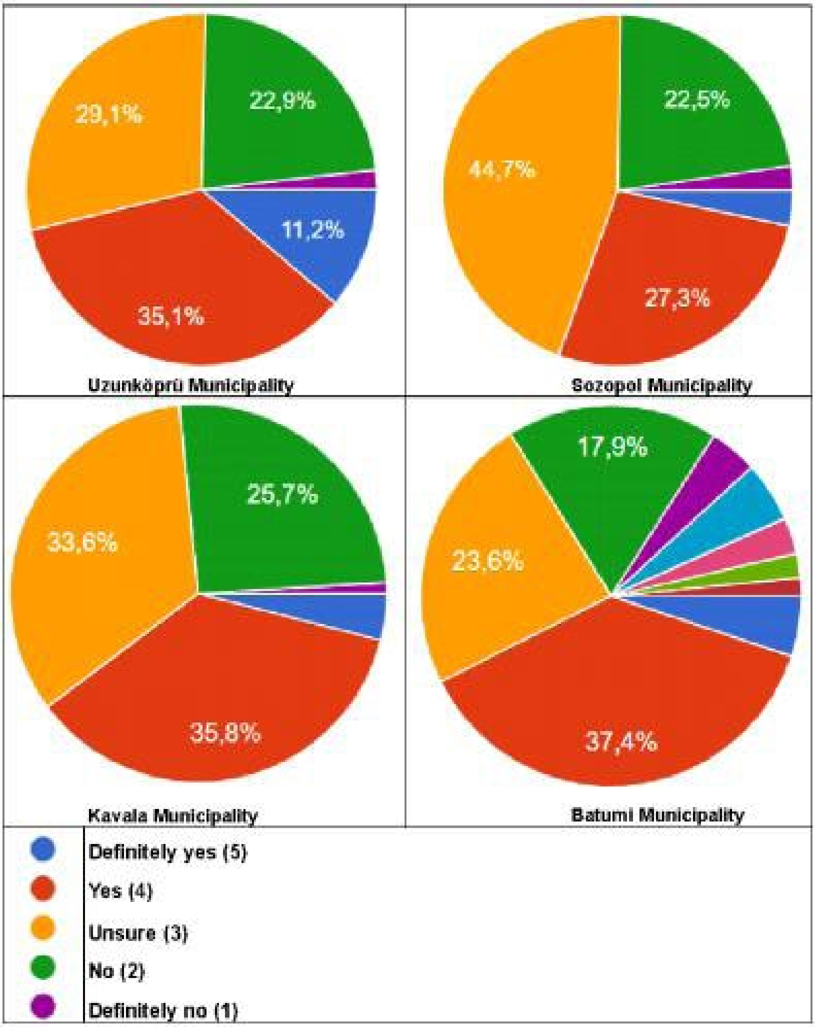
Across all municipalities, increasing green spaces and waste management emerge as critical measures perceived to have a high impact in combating climate change. Additionally, natüre conservation projects are consistently perceived as impactful. While renewable energy usage is highlighted in Uzunköprü, education and awareness campaigns are particularly emphasized in Batumi.

Municipality	1st impactful measure	2nd impactful measure	3rd impactful measure
Uzunköprü	Renewable Energy Usage (f=296)	Increasing Green Spaces (f=256)	Nature Conservation Projects (f=249)
Sozoppol	Increasing Green Spaces (f=303)	Waste Management (f=262)	Recycling (f=231)
Kavala	Waste Management (f=193)	Increasing Green Spaces (f=168)	Nature Conservation Projects (f=166)
Batumi	Increasing Green Spaces (f=122)	Education/Awareness Campaigns (f=117)	Waste Management (f=114)

Q10. Are you aware of the measures taken by public authorities regarding climate change?

- Uzunköprü Municipality: 35.1% of participants reported moderate awareness, with 11.2% feeling highly knowledgeable. A significant portion (29.1%) remained unsure, and 22.9% rated their awareness as slightly knowledgeable.
- Sozopol Municipality: 44.7% of participants were unsure, the highest uncertainty among the municipalities. Only 3.3% felt highly knowledgeable, and 27.3% reported moderate awareness.
- Kavala Municipality: 35.9% of participants had moderate awareness, with 33.4% unsure. A small percentage (4%) felt highly knowledgeable, but 25.8% rated themselves as slightly knowledgeable.
- Batumi Municipality: 37.4% had moderate awareness, with 23.6% unsure. 5.1% felt highly knowledgeable, while 17.9% rated their awareness as slightly knowledgeable.

Sozopol had the highest uncertainty, with many participants unsure about the measures. Kavala also showed considerable uncertainty, while Uzunköprü exhibited better awareness levels. Batumi participants had moderate awareness but lacked deep knowledge. These findings highlight the need for better communication and education on climate change measures, especially in Sozopol and Kavala.


22,9%
29,1%
11,2%
35,1%
Uzunköprü Municipality
22,5%
44,7%
27,3%
Sozopol Municipality
25,7%
33,6%
35,8%
Kavala Municipality
17,9%
23,6%
37,4%
Batumi Municipality
Definitely yes (5)
Yes (4)
Unsure (3)
No (2)
Definitely no (1)

6. Activities and Action Plan

Section 2. Climate Change And Green Space Impact

Q15. Do you believe urban green spaces can mitigate the effects of climate change?

- In Uzunköprü Municipality, 30.3% of participants stated that they definitely believe urban green spaces can reduce the effects of climate change, while 46.3% reported that they believe so.
- In Sozopol, 36.8% of participants responded “definitely yes” and 45.3% answered “yes” to the role of green spaces in mitigating climate change. In total, 82.1% of respondents expressed belief in this effect.
- In Kavala, 79.2% of participants stated that they believe in the role of green spaces in reducing climate change impacts, while 18.4% were undecided and 2.4% did not believe in this effect.
- In Batumi, 70.3% of respondents expressed belief in the role of green spaces in mitigating climate change, while 1.5% did not believe so.

The results show that, in all municipalities, a large majority of participants believe that urban green spaces play an important role in mitigating the effects of climate change. Among these, participants from Kavala stand out with the highest level of belief in the effectiveness of green spaces.

	5(%)	4(%)	3 (%)	2 (%)	1 (%)
Uzunköprü	30.3	46.3	15.4	6.7	1.2
Sozopol	36.8	45.3	13.8	4.2	-
Kavala	29.8	49.4	18.4	1.8	0.6
Batumi	28.2	42.1	11.8	1	0.5

5. Definitely yes
4. Yes
3. Unsure
2. No
1. Definitely no

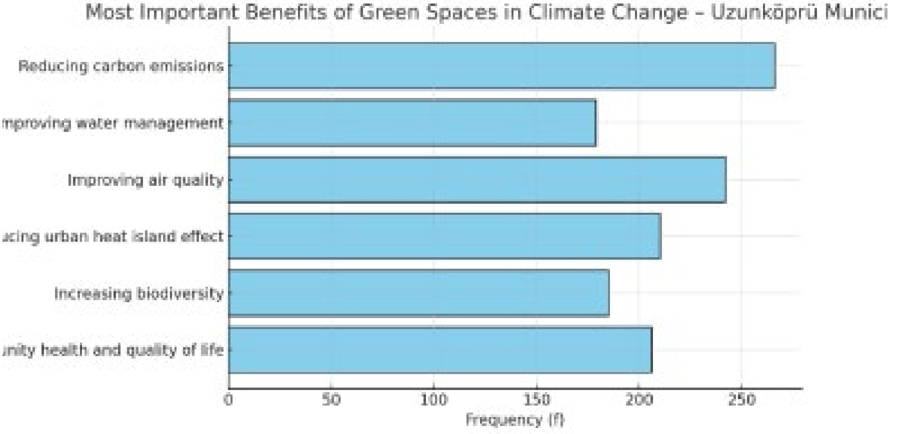
Q17. In your opinion, what is the most important benefit of green spaces against climate change? (5 is the most important, 1 is the least important)

- In Uzunköprü Municipality, the most important benefit of green spaces is considered to be reducing carbon emissions (f=266), followed by improving air quality (f=242) and reducing the urban heat island effect (f=210).
- In Sozopol, improving air quality (f=280) was identified as the most important benefit, followed by community health and quality of life (f=261) and reducing carbon emissions (f=242).
- In Kavala, improving air quality (f=184) was the most frequently selected factor, followed by community health and quality of life

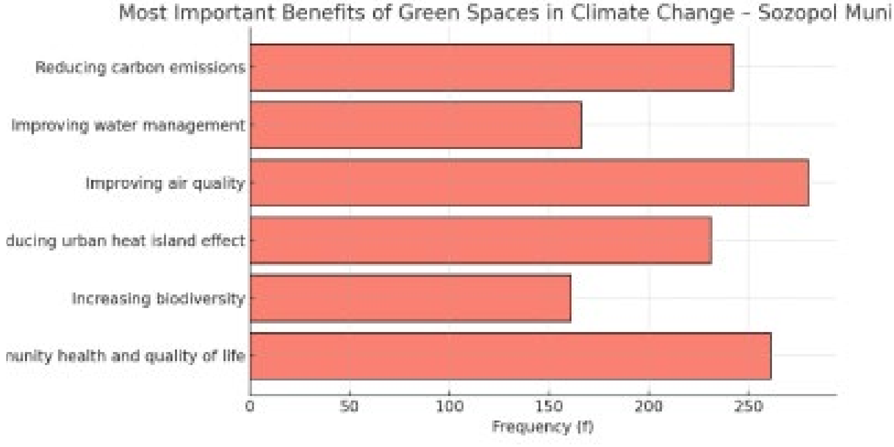
(f=182) and reducing the urban heat island effect (f=178).

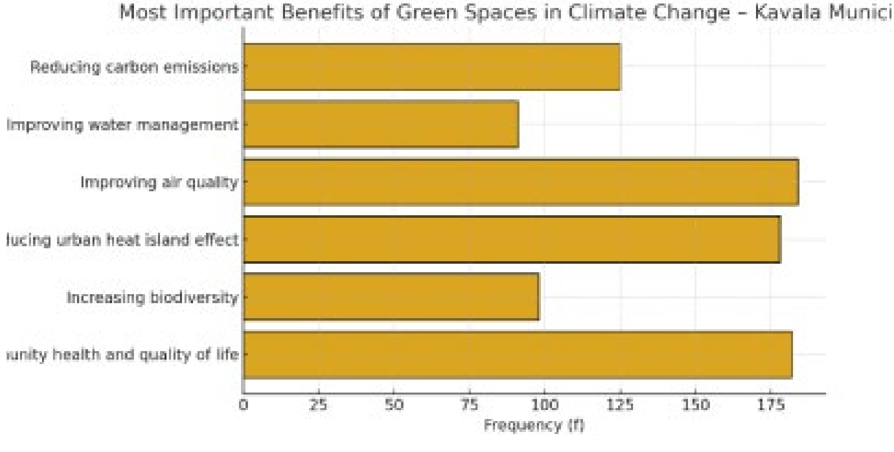
- In Batumi, participants most frequently emphasized improving air quality (f=133), followed by reducing carbon emissions (f=116) and community health and quality of life (f=110).

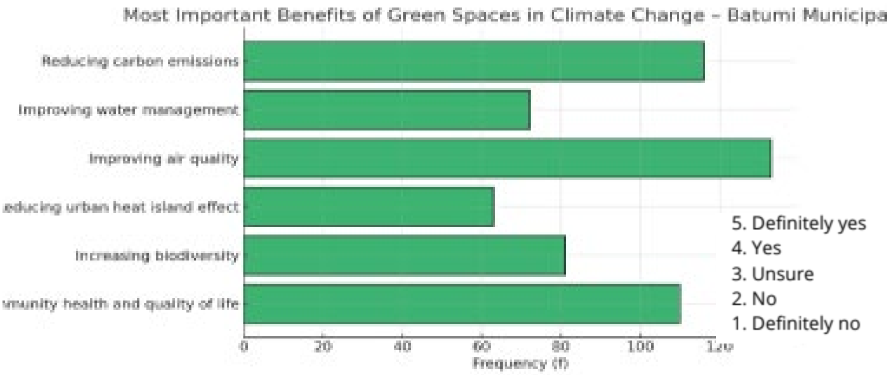
The results show that across all municipalities, improving air quality and reducing carbon emissions are seen as the most important benefits of green spaces in combating climate change. Additionally, community health and the reduction of the urban heat island effect are also highlighted. The comparison of the most important factors according to participants from each municipality is presented in the table below.



6. Activities and Action Plan







Q18. Do you think the green spaces in your city are sufficient/enough to combat climate change?

- In Uzunköprü Municipality, 22.4% of participants believe that green spaces are sufficient to combat climate change, while 53.2% do not believe so. Additionally, 24.4% of respondents are unsure.
- In Sozopol, 7.5% of respondents believe that the green spaces in their city are sufficient, while 63.2% think they are not. A total of 29.3% of participants are undecided.
- In Kavala, 4.2% of participants believe that green spaces are sufficient, whereas 81.4% do not believe so. Meanwhile, 14.4% of respondents remain unsure.
- In Batumi, 16.9% of respondents believe that green spaces are sufficient to combat climate change, while 40.5% think they are not. Additionally, 30.3% are unsure.

The results show that in all municipalities, the majority of participants do not consider the current green spaces in their city sufficient to combat climate change. The highest level of dissatisfaction is observed in Kavala, while Uzunköprü and Batumi display relatively higher positive responses.

6. Activities and Action Plan

	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)
Uzunköprü	8	14.4	24.4	37.3	15.9
Sozopol	1	6.5	29.3	50.2	13
Kavala	0.3	3.9	14.4	46.8	34.6
Batumi	1.5	15.4	30.3	37.9	2.6

5. Definitely yes
4. Yes
3. Unsure
2. No
1. Definitely no

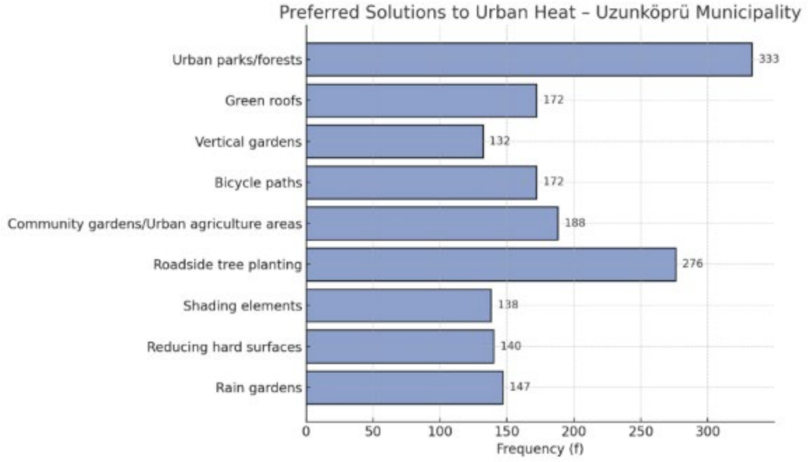
Section 3: Urban Heat Island Effect

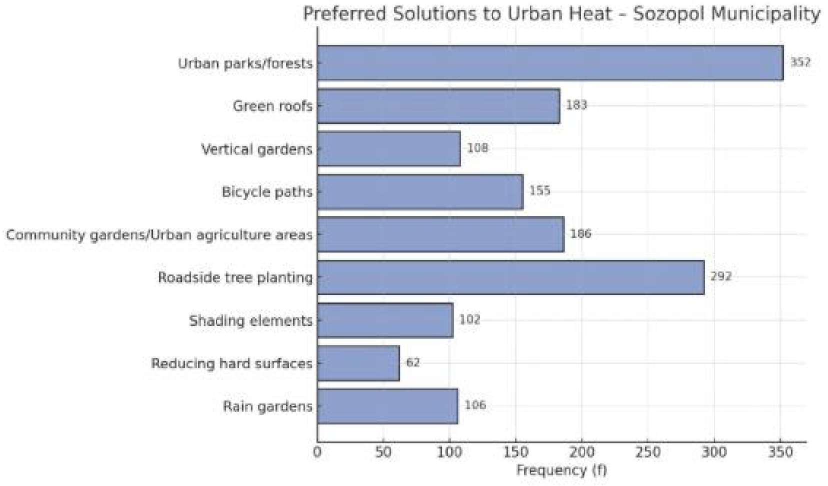
Q21. What solutions can be applied to regulate heat in urban areas? (You can select multiple options)

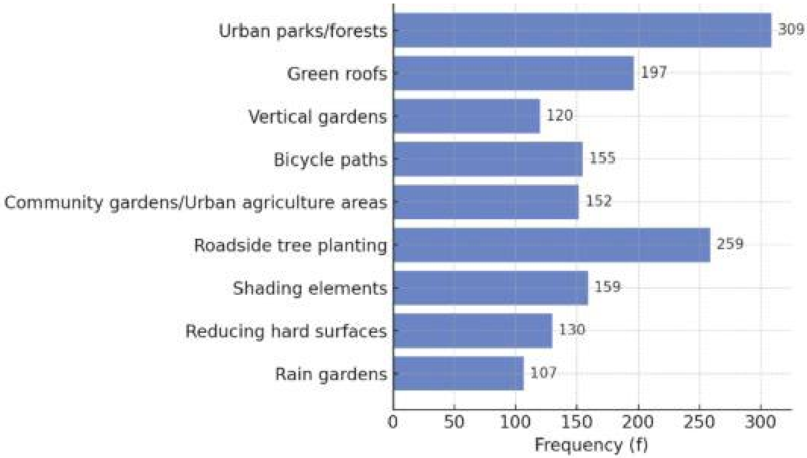
- In Uzunköprü Municipality, the most frequently selected solution was urban parks/forests (82.8%), followed by roadside tree planting (68.7%), community gardens/urban agriculture areas (46.8%), green roofs (42.8%), and bicycle paths (42.8%). Other selected solutions included rain gardens (36.6%), reducing hard surfaces (34.8%), shading elements (34.3%), and vertical gardens (32.8%).
- In Sozopol, urban parks/forests were also the most preferred solution (88%), followed by roadside tree planting (73%), community gardens/urban agriculture areas (46.5%), green roofs (45.8%), and bicycle paths (38.8%). Vertical gardens (27%), rain gardens (26.5%), shading elements (25.5%), and reducing hard surfaces (15.5%) were selected to a lesser extent.
- In Kavala, the highest percentage was again for urban parks/forests (94.5%), followed by roadside tree planting (79.1%), green roofs (60.1%), bicycle paths (47.5%), and shading elements (48.8%). Community gardens/urban agriculture areas (46.6%), reducing hard surfaces (39.9%), vertical gardens (36.8%), and rain gardens (32.8%) were also mentioned.
- In Batumi, urban parks/forests (86.7%) and roadside tree planting (71.3%) were t
- he leading solutions. These were followed by community gardens/urban agriculture areas (37.9%), green roofs (41.5%), bicycle paths (36.4%), vertical gardens (32.8%), rain gardens (29.7%), shading elements (31.8%), and reducing hard surfaces (20%).

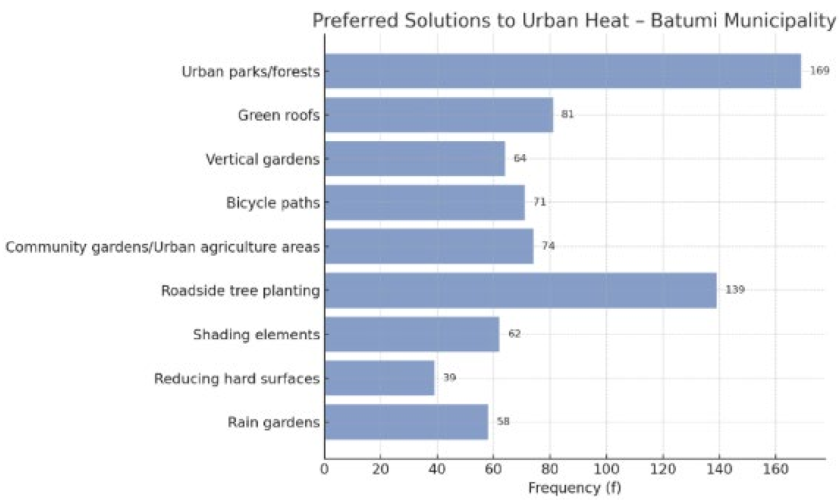
The results show that, across all municipalities, urban parks/forests and roadside tree planting are the most commonly preferred solutions to regulate heat in urban areas. The comparison of municipalities is presented in the table below.

6. Activities and Action Plan






Urban parks/forests
309
Green roofs
197
Vertical gardens
120
Bicycle paths
155
Community gardens/Urban agriculture areas
152
Roadside tree planting
259
Shading elements
159
Reducing hard surfaces
130
Rain gardens
107
0
50
100
150
200
250
300
Frequency (f)


Preferred Solutions to Urban Heat – Batumi Municipality
Urban parks/forests
169
Green roofs
81
Vertical gardens
64
Bicycle paths
71
Community gardens/Urban agriculture areas
74
Roadside tree planting
139
Shading elements
62
Reducing hard surfaces
39
Rain gardens
58
0
20
40
60
80
100
120
140
160
Frequency (f)

6. Activities and Action Plan

1.1 Analysis of Internal Stakeholders' Perspective

Section 1: Climate Perception and Solution Mechanisms

Q1. How would you assess the level of impact of the following factors contributing to climate change? (5 is the most effective, 1 is the least effective)

- In Uzunköprü, 85% of the participants thought that the most influential factors contributing to climate change are Decrease in green spaces,

	1st influential factor	2nd influential factor	3rd influential factor
Uzunköprü	Decrease in green spaces (f=34)	Forest fires (f=26) Overuse of natural resources (f=26) Fossil fuel usage (f=26)	Waste (f=25) Overconsumption (f=25)
Sozopol	Decrease in green spaces (f=29)	Waste (f=25)	Forest fires (f=19)
Kavala	Forest fires (f=26)	Fossil fuel usage (f=22)	Decrease in green spaces (f=21)
Batumi	Fossil fuel usage (f=22)	Tranportation (f=19)	Tourism (f=14)

Q2. How much do you think the following topics will be affected by the possible consequences of climate change? (5 is the most affected, 1 is the least affected)

In this section, the three most preferred items are evaluated.

- In Uzunköprü, 90% of the participants thought that the most affected topics by the possible consequences of climate change are Water resources and Ecosystems and biodiversity; Quality of life and Human health with 80% and Forest areas 75%.
- In Sozopol, 60% of the participants thought that the most affected topics by the possible consequences of climate change are Human health; Quality of life and Water resources with 52,5 and Forest areas and Ecosystems and biodiversity with 45%.
- In Kavala, 57,5% of the participants thought that the most affected topics by the possible consequences of climate change are Forest areas; Agriculture and food security, Water resources and Quality of life with 55% and Ecosystems and biodiversity with 47,5%.
- In Batumi, 37,5% of the participants thought that the most affected topics by the possible consequences of climate change are Human health and Ecosystems and biodiversity; Agriculture and food security and Water resources with 35% and Residential areas and Economic

situation with 32,5%.

The three most preferred factors for the participants from the partner municipalities can be found in the table below:

	1st affected topic	2nd affected topic	3rd affected topic
Uzunköprü	Water resources (f=36) Ecosystems and biodiversity (f=36)	Quality of life (f=32) Human health (f=32)	Forest areas (f=30)
Sozopol	Human health (f=24)	Quality of life (f=21) Water resources (f=21)	Forest areas (f=18) Ecosystems and biodiversity (f=18)
Kavala	Forest areas (f=23)	Agriculture and food security (f=22) Water resources (f=22) Quality of life (f=22)	Ecosystems and biodiversity (f=19)
Batumi	Human health (f=15) Ecosystems and biodiversity (f=15)	Agriculture and food security (f=14) Water resources (f=14)	Residential areas (f=13) Economic situation (f=13)

Q3. Please assess the impact level of the following measures against climate change (5 is the most effective, 1 is the least effective)

- In Uzunköprü, 80% of the participants stated that the most effective factors against climate change are Increase in green spaces, Waste management with 72,5% and Use of renewable energy, Nature conservation projects and Education and awareness campaigns with 70%.
- In Sozopol, 92,5% of the participants mentioned that the most effective factors against climate change are Increase in green spaces, Strategical planning with 72,5% and Waste management with 52,5%.
- In Kavala, 50% of the participants mentioned that the most effective factors against climate change are Increase in green spaces, Use of renewable energy and Waste management; Recycling with 47,5% and Nature conservation projects and Carbon emission reduction policies with 35%.
- In Batumi, 60% of participants claimed that the most effective factors against climate change are Increase in green spaces, Nature conservation projects with 52,5% and Waste management with 50%.

6. Activities and Action Plan

All countries have expressed a common opinion that the most effective factor in combating climate change is to increase green spaces.

The three most preferred factors for the participants from the partner municipalities can be found in the table below:

	1st effective factor	2nd effective factor	3rd effective factor
Uzunköprü	Increase in green spaces (f=32)	Waste management (f=29)	Use of renewable energy (f=28) Nature conservation projects (f=28) Education and awareness campaigns (f=28)
Sozopol	Increase in green spaces (f=37)	Strategical planning (f=29)	Waste management (f=21)
Kavala	Increase in green spaces (f=20) Use of renewable energy (f=20) Waste management (f=20)	Recycling (19%)	Nature conservation projects (f=14) Carbon emission reduction policies (f=14)
Batumi	Increase in green spaces (f=24)	Nature conservation projects (f=21)	Waste management (f=20)

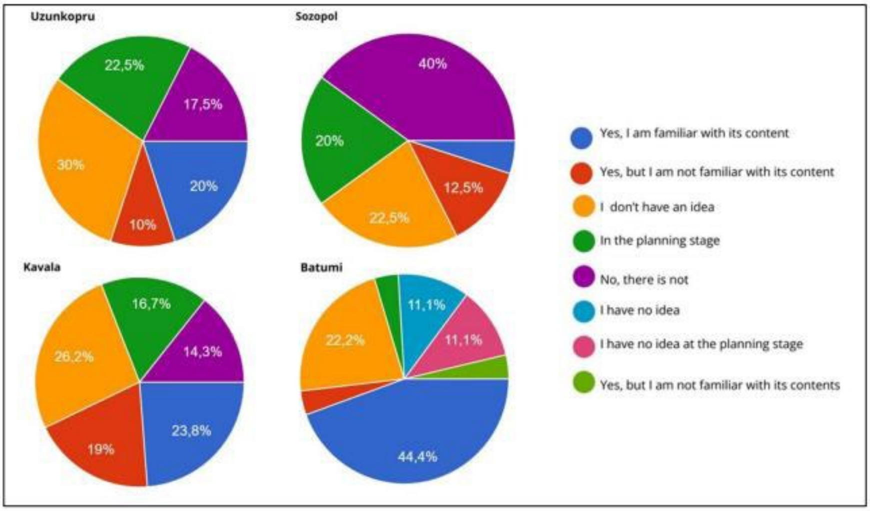
Q8. Does your municipality/institution have an official climate change action plan?

• In Uzunköprü Municipality, 30.00% of the participants reported having no knowledge, while 23.00% stated that there is an action plan, but they are not familiar with its content.

• In Sozopol Municipality, 40.00% of participants indicated that there is no action plan, whereas 5.00% stated that an action plan exists and they are familiar with its content.

• In Kavala, 26.20% respondents reported having no knowledge, while 14.30% stated that there is no action plan.

• Among the participants from Batumi, 44.40% stated that an action plan exists and they are familiar with its content. Additionally, 7.40% reported that an action plan exists but they are not familiar with its content.



Q9. To what extent are the following strategies implemented in your institution for climate change adaptation and mitigation?

In this section, the three most preferred items are evaluated.

- In Uzunköprü, climate-resilient agricultural practices and sustainable transportation solutions (public transport, bike paths) received moderate support, with a score of 3 from a significant portion of participants. Coastal management and protection of marine ecosystems received high positive feedback, with 45% rating it a score of 5.
- In Szopol, participants mostly rated areas low, with a score of 1, indicating dissatisfaction with spatial and action planning, disaster infrastructure, biodiversity conservation, climate change awareness campaigns, and climate-resilient agricultural practices.
- For Kavala, moderate assessments (scores of 2 and 3) were common, especially for forest and natural area protection and biodiversity conservation. Sustainable transportation solutions, however, were rated 1 by 33.33% of participants, showing dissatisfaction in this area.
- In Batumi, overall, participants gave moderate ratings (score of 3) in most areas, including water resource management, waste management, disaster infrastructure, forest protection, biodiversity conservation, and climate change awareness campaigns.

6. Activities and Action Plan

Section 2: Green Infrastructure and Climate Resilience

Q16. What are the perceived benefits of green spaces in combating climate change?

- In Uzunköprü Municipality, the most strongly rated benefit was carbon emission reduction (f=35), followed by improved air quality (f=32), and public health and quality of life (f=30). Other prominent areas were improved water management (f=29) and urban heat island effect reduction (f=26). The benefit of increased biodiversity was slightly less emphasized (f=25), and few selected “other” (f=1).
- In Sozopol Municipality, carbon emission reduction was again rated highest (f=23), followed closely by public health and quality of life (f=26) and urban heat island effect reduction (f=22). Other frequently noted benefits included improved air quality (f=21) and increased biodiversity (f=21). Three respondents provided an additional benefit under “other” (f=3).
- In Kavala Municipality, responses were more balanced. The highest scores went to carbon emission reduction (f=29), improved water management (f=26), air quality (f=26), and biodiversity (f=26). Public health and quality of life was also strongly endorsed (f=27), with lower emphasis placed on the “other” category (f=1).
- In Batumi Municipality, air quality improvement (f=25), carbon emission reduction (f=21), and urban heat island reduction (f=23) stood out. Water management (f=22), biodiversity (f=23), and public health and quality of life (f=24) followed closely, showing a well-rounded distribution. Only one person indicated an additional benefit (f=1).

Across the four municipalities, the most commonly recognised benefits of green spaces in relation to climate change were carbon emission reduction, air quality improvement, and public health. In Uzunköprü, these three benefits received the highest number of top scores, indicating strong awareness of both environmental and social functions. Kavala also showed high recognition of these areas, with a more balanced distribution across all categories. In Sozopol, public health and urban heat island reduction stood out slightly more, while ecological benefits were less prominent. In Batumi, the responses were well distributed, with high ratings given to nearly all benefits. These results suggest that while green spaces are valued in all cities, the focus areas vary. This shows the need for better communication and capacity building to raise awareness of the full range of climate-related benefits.

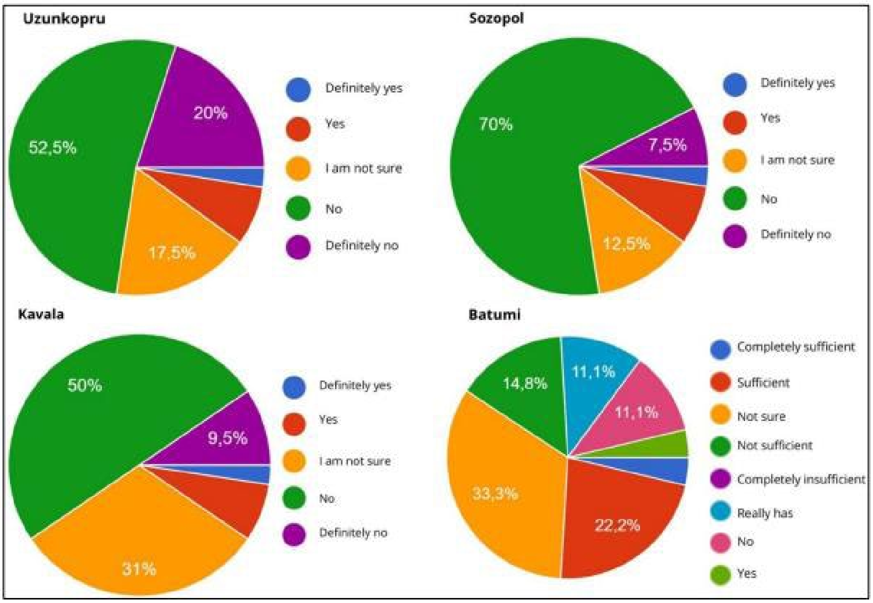
	1st Most Cited Benefit	2nd Most Cited Benefit	3rd Most Cited Benefit
Uzunköprü	Carbon emission reduction (f=35)	Air quality improvement (f=32)	Public health and quality of life (f=30)
Sozopol	Public health and quality of life (f=26)	Carbon emission reduction (f=23)	Urban heat island effect reduction (f=22)
Kavala	Air quality improvement (f=26)	Carbon emission reduction (f=29)	Public health and quality of life (f=27)
Batumi	Air quality improvement (f=25)	Public health and quality of life (f=24)	Urban heat island effect reduction (f=23)

Q17. Do you think your city has enough green spaces?

- In Uzunköprü Municipality, a majority of respondents expressed dissatisfaction with the current green space provision. Most answered either “No” or “Definitely no,” indicating a strong perception of insufficiency. Only a small portion responded positively, suggesting that green spaces are largely seen as inadequate in meeting community or environmental needs.
- In Sozopol Municipality, perceptions were similarly negative. Most participants stated “No” or “Definitely no,” while only a few believed that green spaces were sufficient. The prevalence of “Not sure” responses also suggests some uncertainty or lack of awareness regarding green space coverage.
- In Kavala Municipality, the responses reflected a clear concern. Most participants answered “No” or “Definitely no,” with a significant number also selecting “Not sure.” Positive responses were limited, indicating that the issue of green space sufficiency is perceived as problematic by many stakeholders.
- In Batumi Municipality, the responses were more varied but still leaned toward a perception of insufficiency. While some participants answered “Yes” or “Definitely yes,” many others were either uncertain or believed there were not enough green areas. The distribution suggests a mixed perception, potentially shaped by uneven spatial distribution or quality of green spaces across the city.

In all four cities, internal stakeholders do not believe their green spaces are sufficient. The concern is strongest in Uzunköprü and Sozopol. Kavala shows more uncertainty, and Batumi has a more balanced view. These results indicate the need for further green space development and clearer communication on planned improvements.

6. Activities and Action Plan

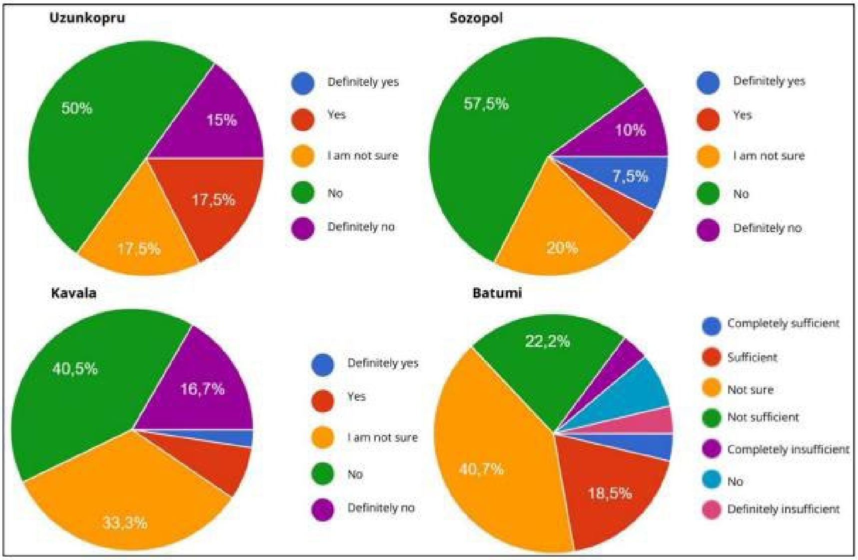


Q18. Do you think the current green infrastructure (parks, green roofs, vertical gardens, etc.) planning and implementation in your city is sufficient to fight climate change?

- In Uzunköprü Municipality, the majority of respondents (f=25) stated that the current efforts were insufficient or definitely insufficient. Only a few participants (f=6) considered them sufficient, while a smaller group (f=9) were unsure. This reflects a general perception of inadequacy regarding green infrastructure development.
- In Sozopol Municipality, responses showed a similar pattern. Most participants (f=29) reported that existing efforts were not sufficient, with only a few (f=4) seeing them as adequate. Uncertainty was also notable (f=7), suggesting the need for clearer planning and better communication of existing actions.
- In Kavala Municipality, the sense of inadequacy was even more pronounced. A significant number of respondents (f=30) answered "no" or "definitely no," while only a small group (f=3) found the efforts sufficient. Notably, many participants (f=9) were unsure, pointing to potential gaps in information or visibility of green projects.
- In Batumi Municipality, responses were more balanced. While 7

participants (f=7) believed current efforts were sufficient or definitely sufficient, a similar number (f=7) considered them insufficient or definitely insufficient. However, the largest group (f=11) was unsure, indicating mixed perceptions or low awareness about green infrastructure initiatives.

Overall, across all municipalities, there is a clear trend of dissatisfaction or uncertainty regarding the adequacy of current green infrastructure initiatives. The findings highlight a need for both stronger action and more transparent communication on green planning and implementation to build confidence and clarity among stakeholders.



Q19. Which green infrastructure practices should be prioritised in your municipality to fight climate change?

- In Uzunköprü Municipality, afforestation received the highest number of top ratings (f=35), followed by water management practices (f=33) and new park creation (f=31). Other practices such as native planting, drought-resistant solutions, and permeable surfaces were also mentioned as priorities but to lesser extent. This shows a clear emphasis on large-scale and nature-based interventions.
- In Sozopol Municipality, the most frequently prioritised practices were afforestation (f=32), new parks (f=31), and drought-resistant solutions

(f=30). Native planting and water management also received strong support. This distribution reflects a preference for both traditional green space expansion and climate-resilient planting strategies.

- In Kavala Municipality, the top-rated practices included afforestation (f=35), new park creation (f=33), and water management (f=31). Native planting and drought resistant strategies also featured prominently. The results suggest a broad agreement on integrating green space development with urban water and vegetation strategies.
- In Batumi Municipality, new park creation was the top priority (f=22), followed by local/native planting (f=19), afforestation (f=16), and water management (f=16). Permeable surfaces (f=15) also received strong support. These results indicate a well-balanced preference between expanding green areas and improving ecological functions.

Across all four cities, afforestation, new park creation, and water management were the most commonly prioritised green practices. Uzunköprü and Kavala gave the highest number of top ratings to these three areas, showing strong support for large-scale and nature-based actions. In Sozopol, drought-resistant solutions were also highly valued, along with afforestation and new parks. Batumi showed a slightly different trend, where new parks and native planting were most preferred, and more practices received similar levels of support. Overall, the results suggest that all cities agree on the importance of expanding green areas and using climate-adapted planting and water strategies, but each city has its own focus based on local needs.

	Uzunköprü	Sozopol	Kavala	Batumi
Afforestation	35	32	35	16
New park creation	31	31	33	22
Water management	33	28	31	16
Permeable surfaces	29	23	28	15
Vertical gardens/green roofs	28	23	26	14
Native planting	30	28	32	19
Drought-resistant solutions	31	30	31	13
Other	7	9	11	10

6.2. Thermal Comfort Measurement

As part of this activity, field measurements were conducted to examine the spatial and temporal variability of thermal comfort conditions along pedestrian routes. The study took place on typical summer days in urban streets with high pedestrian activity. In selected pilot areas across four Black Sea countries (Bulgaria, Georgia, Greece, Türkiye), air temperature, relative humidity, wind speed, and shortwave and longwave radiation were systematically recorded. The measurement data were analyzed to assess how different urban morphologies influence accumulated thermal load and heat stress during walking. The results provide evidence-based input to support planning and design strategies aimed at enhancing thermal comfort and promoting walkability in urban environments.

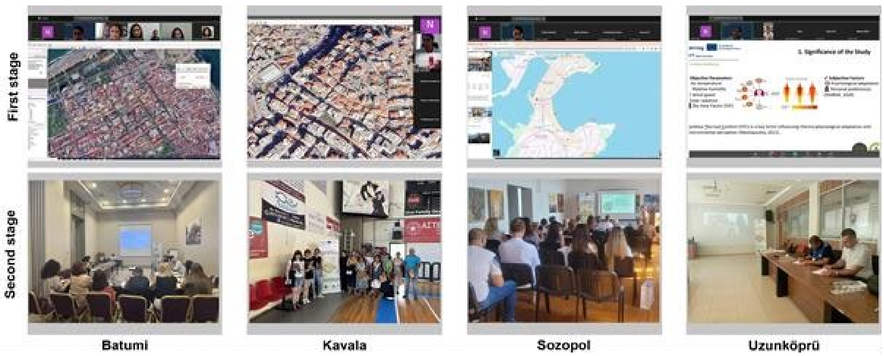


Figure 1. Training and orientation activities conducted in four partner countries

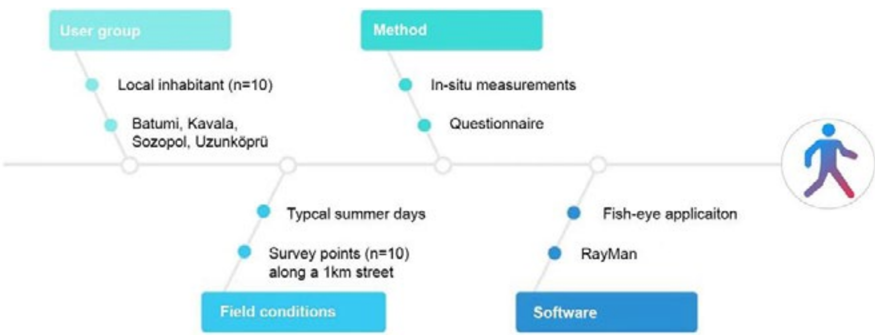


Figure 2 Research design integrating user group, field conditions,

methodology and software

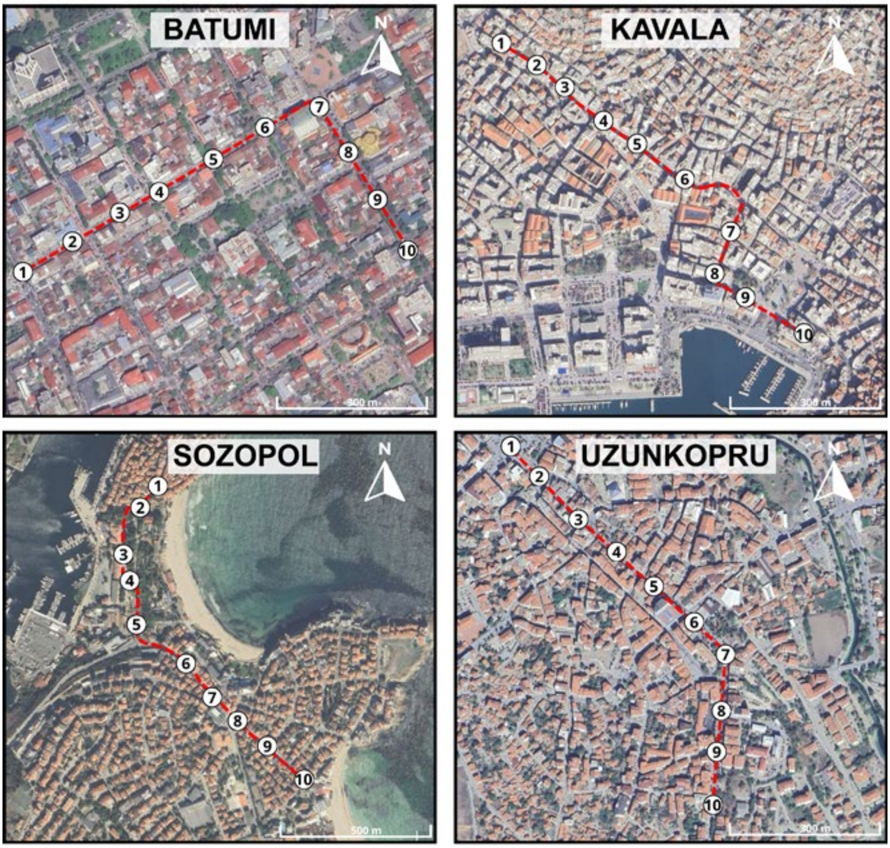


Figure 3 Measurement routes within the study areas of Batumi, Kavala, Sozopol, and Uzunköprü.

In each city, a measurement route was established along heavily used urban streets characterized by high pedestrian activity, mixed land-use patterns, and varying levels of shading and vegetation density. The measurement points were selected to represent microclimatic variations between open, sun-exposed streets and shaded urban areas. A total of 10 fixed measurement points were identified in each city, following a standardized measurement protocol to ensure comparability between sites. Approximately equal distances were maintained between consecutive measurement points.

During fieldwork, microclimatic measurements and questionnaire surveys were conducted simultaneously at each point. This approach enabled the integration of objective environmental data with subjective thermal perception and comfort assessments provided by local participants.

Measurement Protocol

The field measurements were conducted to capture the microclimatic conditions and corresponding human thermal perception under typical summer conditions. The protocol was designed to ensure consistency across all measurement points and time intervals, allowing the integration of physical and subjective data.

- **Measuring period:** 3 typical summer day
- **Measuring time:** 11:00 – 15:00
- **Measurement point:** 10 points on heavily used streets
- **Measurement parameters**:Air temperature, Globe temperature (°C); Relative Humidity (%); Wind speed (m/s)
- **Sampling period:** At least 4 minutes per point/measurements
- **Sensor placement:** 1.1 m above the ground
- **Interview location:** Conducted simultaneously with measurements
- **Interview numbers:** 10 inhabitants per measurement day

Calculation of PET

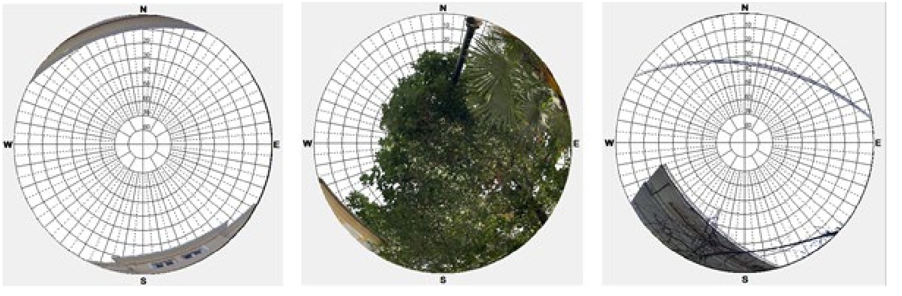


Figure 4 Sample fisheye photographs taken at measurement points

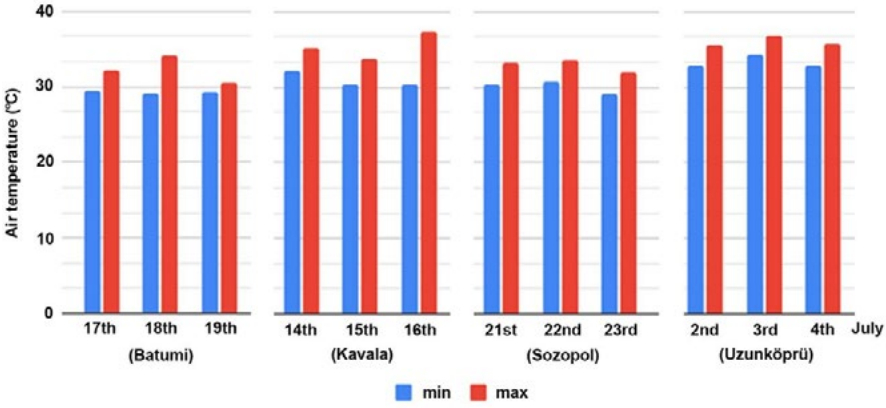
Questionnaire

The following form presents the questionnaire applied to participants to record their demographic details and subjective assessment of thermal comfort during on-site measurements (Table 2). The structure and content of the questionnaire were developed based on previous studies (Huang et al., 2021; Lai et al., 2020; Lam et al., 2020; Litman, 2023; Tian et al., 2022) , ensuring that the collected data align with established approaches in thermal comfort research.

Overall results

In this section, the variations in thermal conditions and pedestrian thermal perception were examined along the walking routes in four cities located in the Black Sea region. The analysis focused on air temperature, PET classification levels, mean thermal sensation votes at each stop, and the overall changes in thermal perception during movement. The results were evaluated comparatively to identify differences in thermal comfort conditions across Batumi, Kavala, Sozopol, and Uzunköprü.

The analysis of in-situ measurements conducted on typical summer days revealed distinct temperature patterns among the study areas. Minimum air temperatures remained below 30 °C in Batumi and Sozopol, while in Kavala, only one day exceeded this threshold. In Uzunköprü, however, minimum temperatures surpassed 30 °C on all three measurement days. Regarding maximum temperatures, Uzunköprü exhibited the highest values among the four cities, indicating higher air temperature conditions. By contrast, Batumi and Kavala recorded comparatively lower maximum temperatures, reflecting less severe daytime heating (Figure 5).



The selection of three typical summer days provided an opportunity to evaluate PET under different micro-meteorological conditions. When the cities were analyzed, it was observed that in Batumi, the most stressful thermal conditions occurred on 18 July. On that day, heat stress levels of HS4 or higher were recorded at every 200 meters, while HS3 conditions prevailed during the rest of the day. On the other two days, HS3 conditions generally dominated. In Kavala, the PET evaluation indicated that on 15 July, when the mildest thermal conditions were recorded, HS3 levels were observed only at stops 7, 8, and 9. At other stops and on the remaining days, thermal stress levels of HS4 or higher were predominant. In Sozopol, the overall climatic conditions remained relatively stable, and HS3 levels prevailed along the street during all three days. On 21 July, HS4 or higher stress levels were recorded at stops 6 and 8, but this did not result in a consistent increase in overall thermal stress along the route. In Uzunköprü, PET values exceeded 41 °C on all three days, consistently indicating HS4 or higher conditions throughout the measurement period. These results showed that the thermal conditions in the area exceeded comfort thresholds and that immediate measures are needed to improve walking conditions for pedestrians (Figure 6).

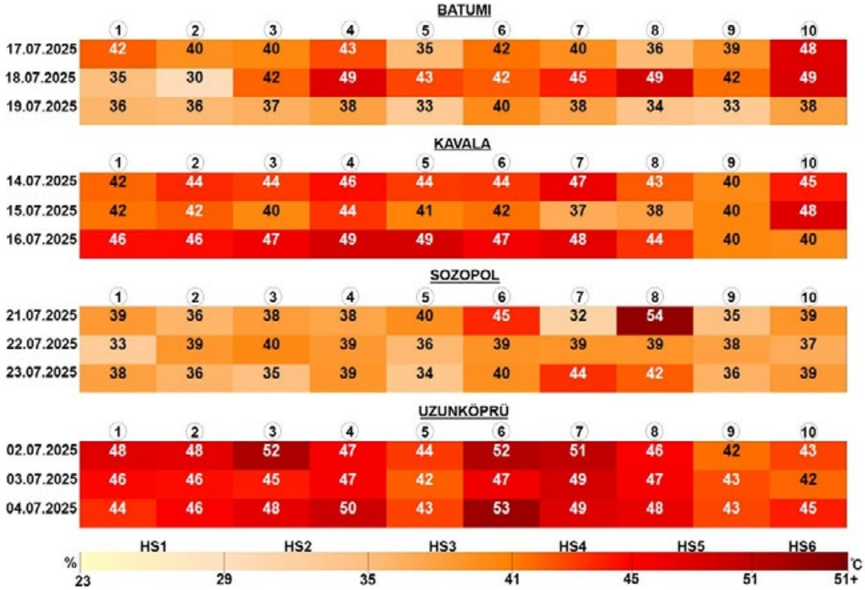


Figure 6 PET-based thermal stress levels across four cities on three typical summer days

The TSV (Thermal Sensation Vote) results clearly reveal the differences in perceived thermal conditions across the four study cities (Figure 7). In Batumi, most participants reported feeling “cool” or “slightly cool,” reflecting low thermal stress conditions due to the city’s coastal location and climatic characteristics. In Kavala, “neutral” and “slightly warm” sensations were predominant, with an observable increase in warmth from coastal zones toward inner urban areas, indicating the influence of microclimatic transitions. Sozopol generally exhibited “neutral” conditions; however, at certain points, “warm” and “hot” sensations became more pronounced, emphasizing the impact of shading and vegetation on thermal comfort. Uzunköprü showed the highest level of thermal stress, as the majority of participants reported feeling “warm” or “hot.” This outcome is associated with the city’s inland position and continental climatic conditions. Overall, the results highlight the decisive role of climatic context, shading conditions, and urban morphology in shaping users’ thermal perception within urban environments.

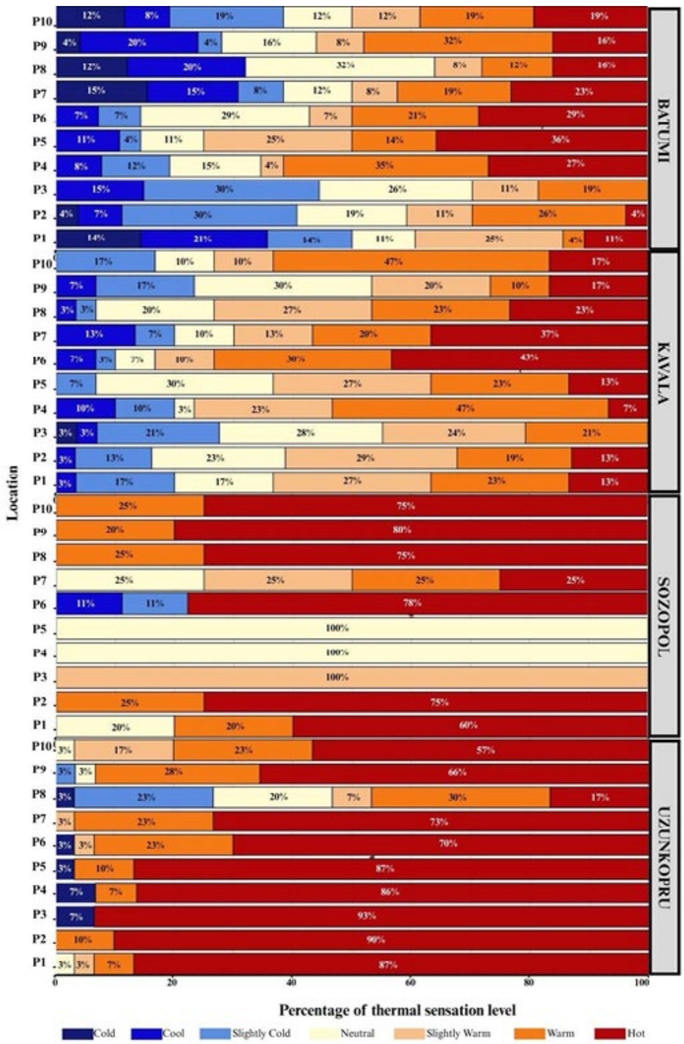


Figure 7 TSV-based thermal sensation levels across four cities on three typical summer days

6. Activities and Action Plan

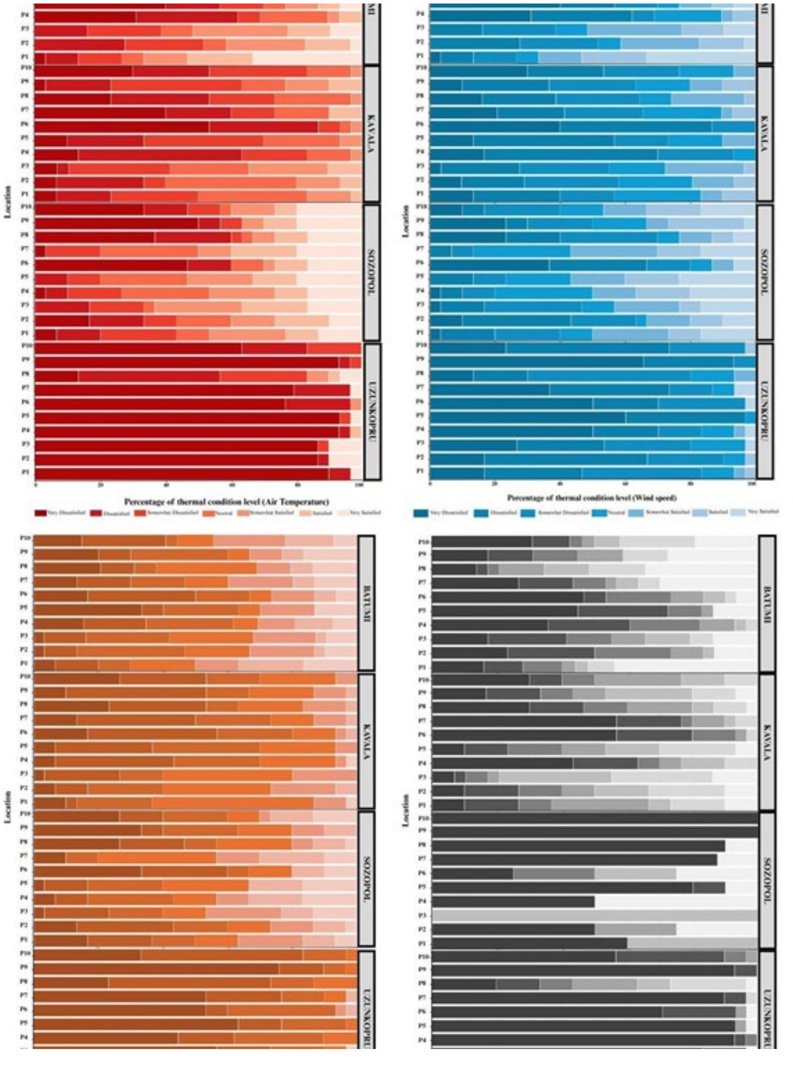
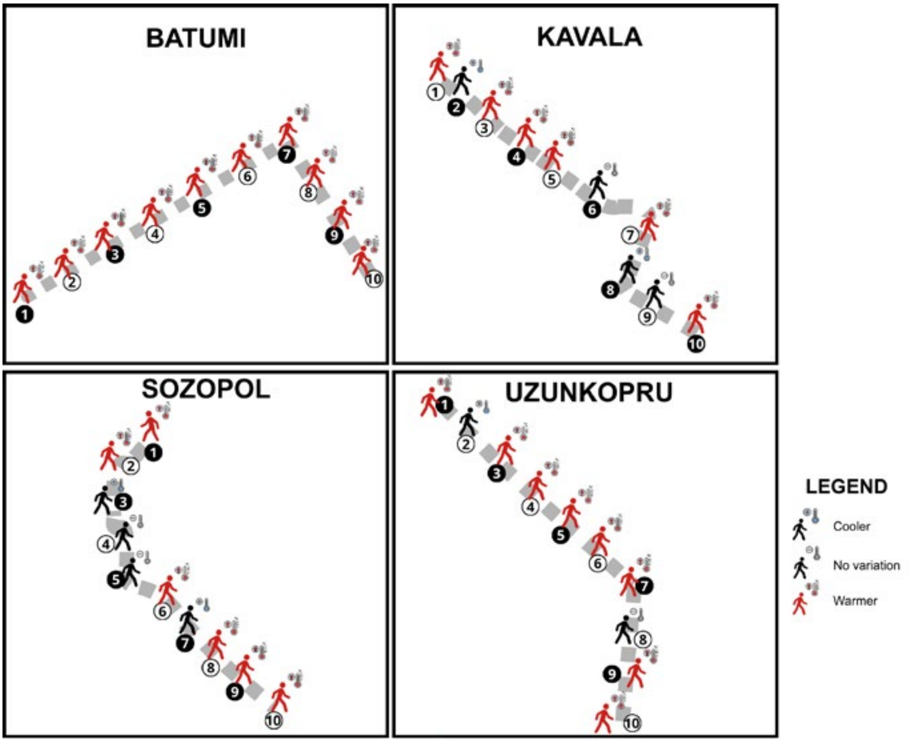


Figure 8 Percentage distribution of participants' assessments of thermal conditions related to air temperature, wind speed, relative humidity, and shading in Batumi, Kavala, Sozopol, and Uzunköprü

The percentage distribution of participants' perceptions of thermal conditions regarding air temperature, wind speed, relative humidity, and shading in Batumi, Kavala, Sozopol, and Uzunköprü is presented in Figure 8. The data are based on survey results conducted at ten measurement points (P1–P10) in each city.

According to the survey findings, air temperature conditions varied significantly among the cities. "Neutral" and "somewhat satisfied" responses were predominant in Batumi and Sozopol, whereas "dissatisfied" and "very dissatisfied" responses were more frequent in Kavala and especially in Uzunköprü. The results indicate that the most unfavorable air temperature conditions were perceived in Uzunköprü, while Sozopol recorded the most favorable conditions, reflecting the influence of local climatic characteristics.



6. Activities and Action Plan

6.3. Climate Data Analysis and UHI Detection:

In terms of wind speed conditions, higher satisfaction levels were recorded in Batumi and Sozopol, while lower satisfaction levels were observed in Uzunköprü and Kavala. The predominance of "satisfied" and "somewhat satisfied" responses in Batumi and Sozopol suggests that street morphology along the measurement routes positively influenced perceived thermal conditions. Conversely, lower satisfaction levels in Uzunköprü and Kavala can be attributed to limited wind circulation, which increases heat accumulation and perceived warmth, thereby deteriorating overall thermal conditions.

For relative humidity, differing tendencies were observed among the cities. Despite relatively high humidity levels, participants in Batumi and Sozopol mostly reported "neutral" or "somewhat satisfied" responses, indicating adaptation to humid environments. In contrast, Uzunköprü and Kavala showed higher proportions of "dissatisfied" responses. Particularly in Uzunköprü, the combination of high temperature and humidity intensified thermal discomfort.

The findings regarding shading conditions reveal that shading plays a critical role in shaping users' perception of thermal environments. "Satisfied" responses were dominant in Batumi and Kavala, while Sozopol and especially Uzunköprü exhibited higher levels of dissatisfaction. This indicates that insufficient shading in urban areas contributes to increased heat stress and negatively affects overall thermal conditions.

All walking routes consisted of 10 measurement points. At each point, participants were asked how they felt compared to the previous location, allowing for the evaluation of their thermal perception throughout the route. In Batumi, participants reported feeling warmer than at the previous stop. Interestingly, their reported satisfaction levels with TSV and meteorological factors varied across different locations but did not correspond to more comfortable segments of the walk. In Kavala, stops 2, 3, 5, and 9 were perceived as cooler; however, these sensations did not align with PET values. In Sozopol, cooler sensations were reported at stops 3, 4, 5, and 7, which, similar to Kavala, did not correspond to PET variations but were consistent with TSV patterns. In Uzunköprü, cooler sensations were recorded at stops 2 and 8, though only stop 8 showed consistency with TSV. These results demonstrate the critical need for a holistic evaluation of all influencing variables to inform effective design and planning interventions that improve thermal comfort during walking activities.

6. Activities and Action Plan

Within the scope of the project, fi**eld-based microclimate measurements were carried out in four cities Batumi, Sozopol, Edirne-Uzunköprü and Kavala** with the overarching aim of enabling a robust and comparable assessment of urban heat island behaviour in settlements with distinct urban morphologies and climatic settings. In Sozopol, Batumi and Kavala, measurements were conducted by operating a Kestrel 5400 portable weather station and ground-based thermal cameras simultaneously, while in Uzunköprü this setup was complemented by a drone-mounted thermal camera used to acquire high-resolution thermal and RGB orthophoto mosaics over the selected urban sites. Through this combined approach, both point-based microclimate parameters and the spatial distribution of land surface temperature were captured in considerable detail, providing a rich basis for subsequent spatial and statistical analyses.

The timing and design of the field campaigns were planned to represent the "before" situation, i.e., current conditions prior to the implementation of any landscape-based mitigation or improvement measures. For this reason, all measurements were scheduled during the hottest days of the summer period, when thermal stress and heat exposure are expected to peak. In the following year, after partners introduce targeted interventions such as additional vegetation, shading elements or surface material changes in the same areas, "after" measurements will be repeated using the same devices, protocols and survey geometry. This before–after design will allow the project team to quantify the impact of these interventions on urban heat island intensity and outdoor thermal comfort in a consistent and reproducible manner.

6. Activities and Action Plan

Using the Kestrel 5400, a comprehensive set of parameters was recorded at each measurement location, including Globe Temperature, Heat Index, Natural Wet Bulb (NWB) Temperature, Relative Humidity, Wet Bulb Temperature, Thermal Work Limit and Air Temperature. These variables jointly describe both the physical state of the atmosphere and human-perceived heat stress. To ensure that all observations were spatially explicit and directly usable in a GIS environment, GNSS-based location data were logged in parallel via personal smartphones at each measurement point. Thus, for every study area a harmonised dataset combining thermal comfort indices, classical meteorological variables and precise geographic coordinates was obtained. In each city (except Batumi, where a single site was selected), two study sites were identified in consultation with local partners, considering the structure of the urban fabric, the presence and distribution of green spaces, dominant surface cover types and local usage patterns.

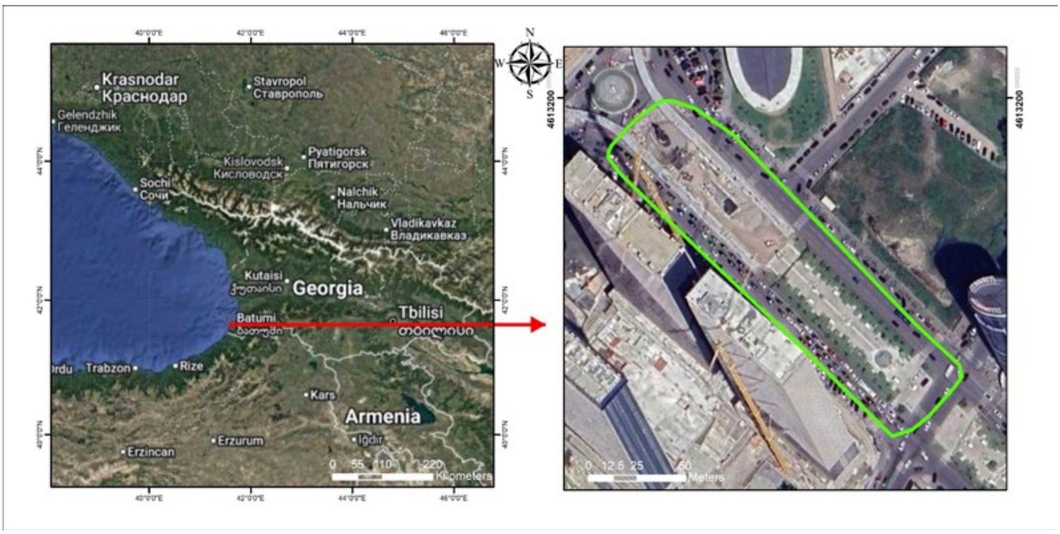
The raw data collected in the field were subsequently transferred into the GIS environment for processing and map production. For each parameter, the discrete point measurements were converted into continuous spatial surfaces using spline interpolation, which is well suited to representing smoothly varying environmental fields at the local scale. Polygons delineating the study areas were then used in an “extract by mask” step to clip the interpolated surfaces, and thus to focus the analysis on the specific urban zones of interest.

The resulting thermal, thermal comfort and humidity/temperature distribution maps, together with the high-resolution thermal and RGB orthophoto mosaics, clearly illustrate pronounced differences between densely built-up, hard-surfaced zones and shaded or vegetated areas, both in terms of surface temperature and comfort conditions. The workflow diagram created in ArcGIS ModelBuilder documents the entire processing chain—from data import and georeferencing to interpolation and masking—as a standard, semi-automated procedure. This not only ensures transparency and traceability of the analyses, but also provides a solid, repeatable framework for generating the future “after” maps and for conducting rigorous temporal comparisons across all partner cities.

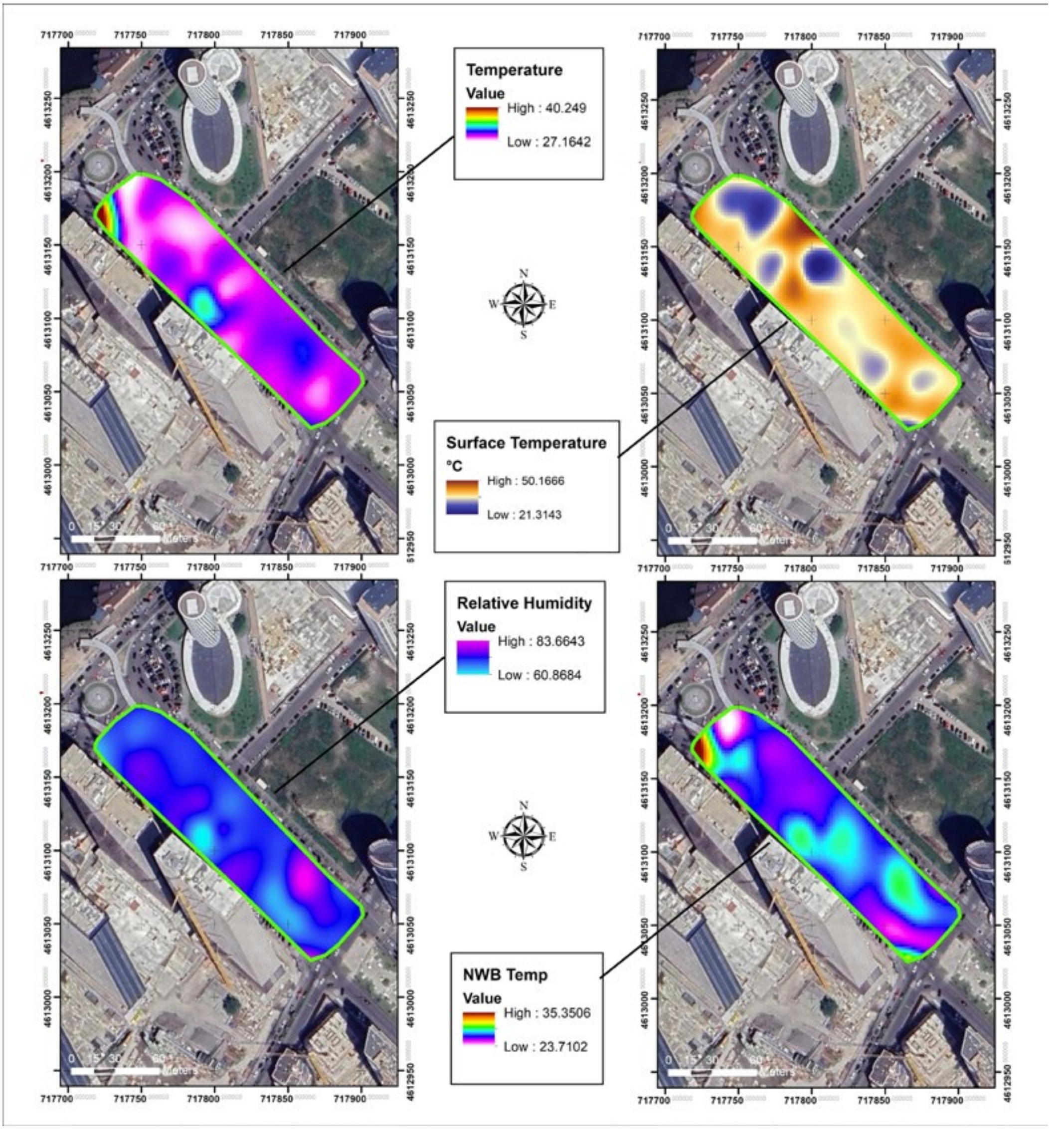
ArcGIS Interpolation Routine

6. Activities and Action Plan

Batumi



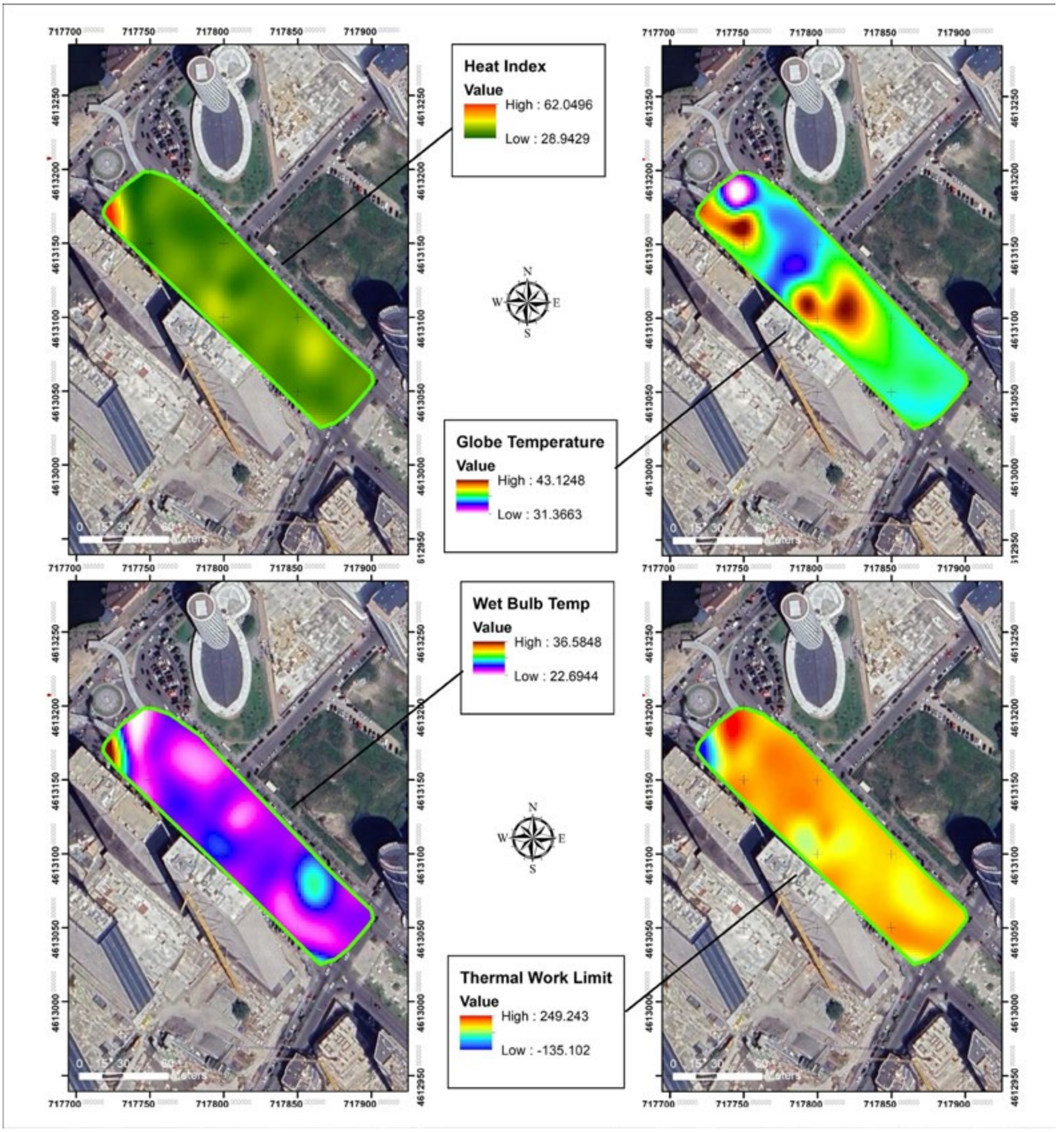
Batumi


Temperature
Value
High : 40.249
Low : 27.1642
Surface Temperature
°C
High : 50.1666
Low : 21.3143
Relative Humidity
Value
High : 83.6643
Low : 60.8684
NWB Temp
Value
High : 35.3506
Low : 23.7102

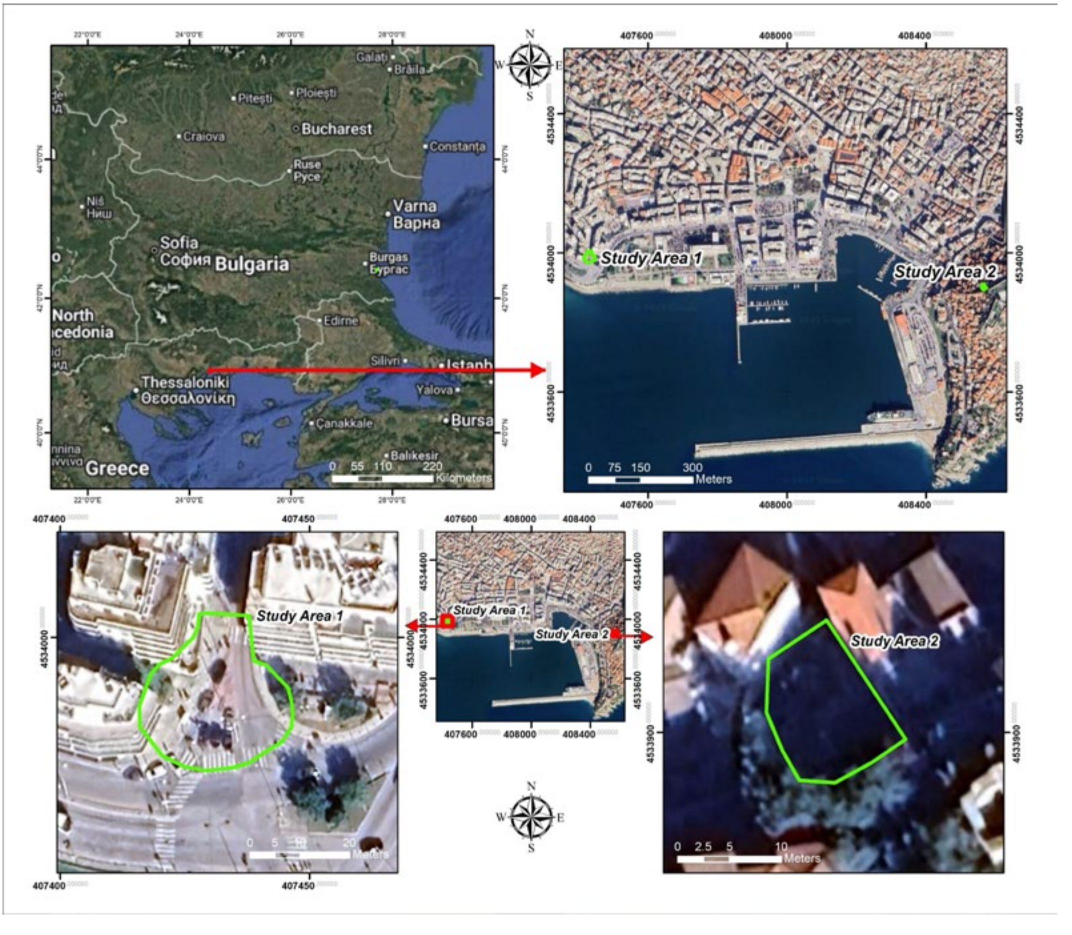
Pathway Planning GUIDE

6. Activities and Action Plan

Batumi

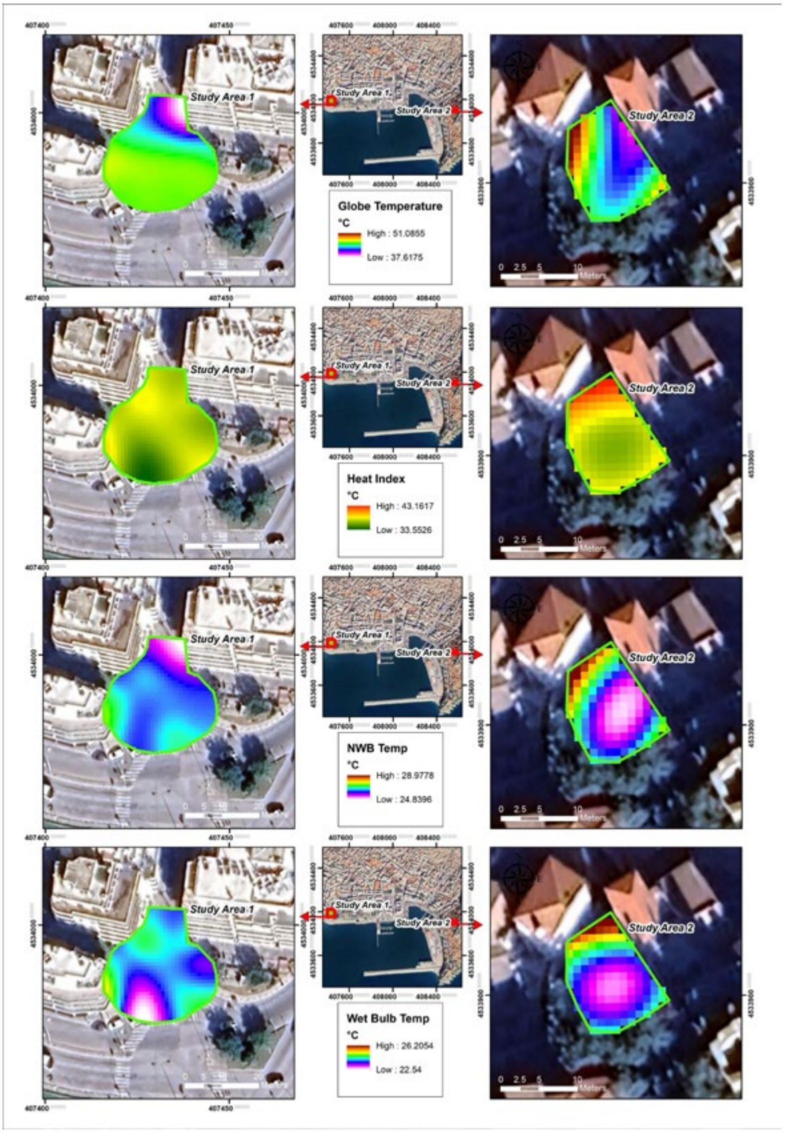


Kavala

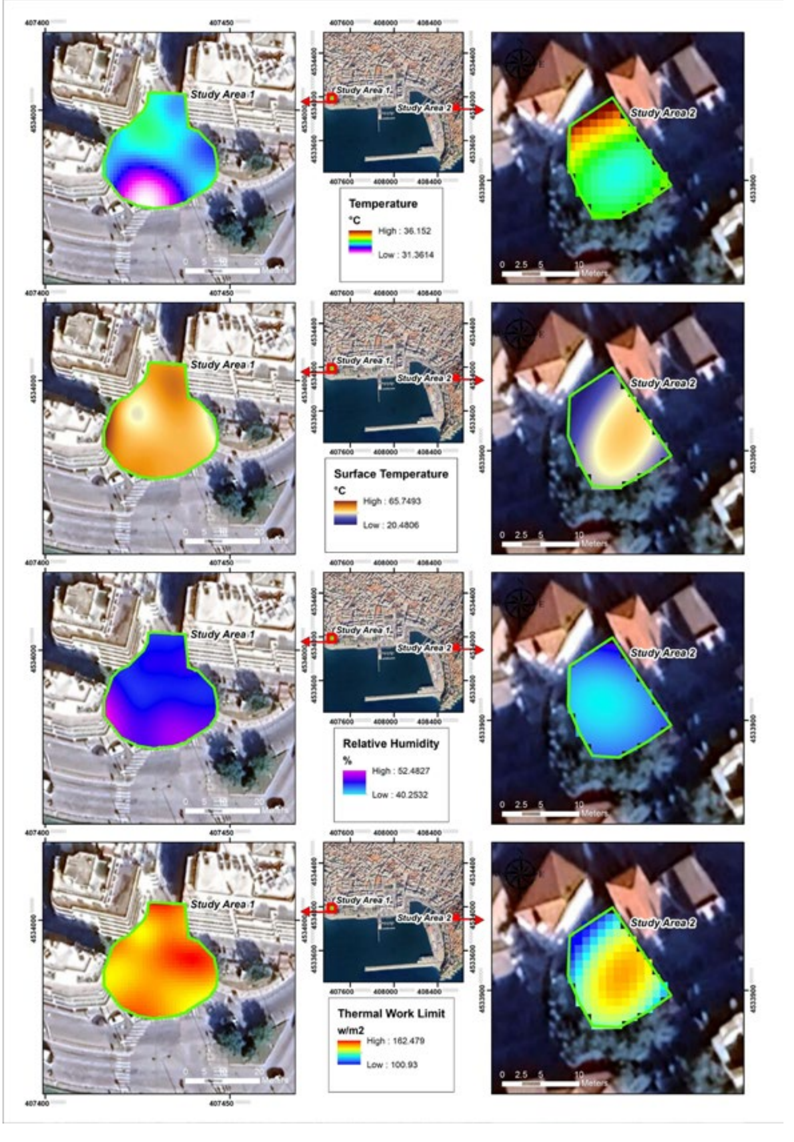

Study Area 1
Study Area 2
Bucharest
Varna
Варна
Sofia
София
Bulgaria
Thessaloniki
Θεσσαλονίκη
Greece
Edirne
Bursa
Çanakkale
Constanța
Meters
Kilometers

6. Activities and Action Plan

Kavala

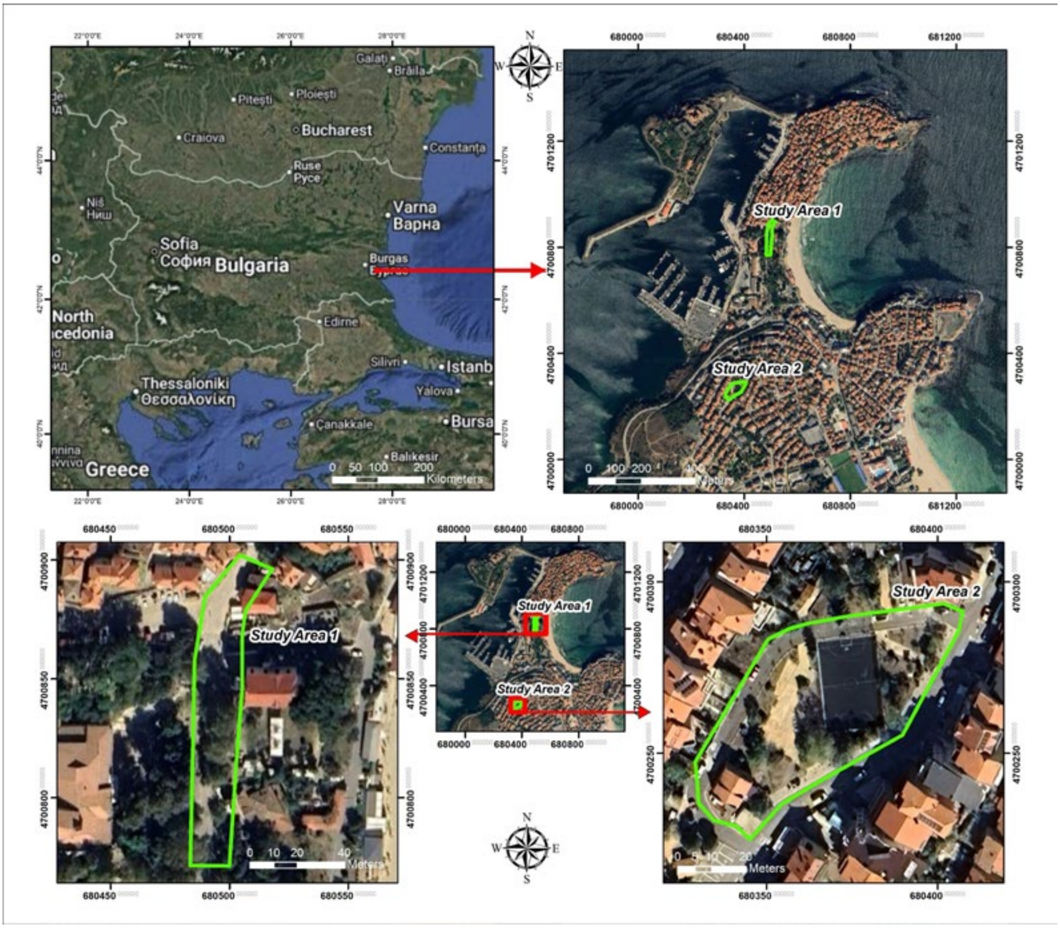


Kavala

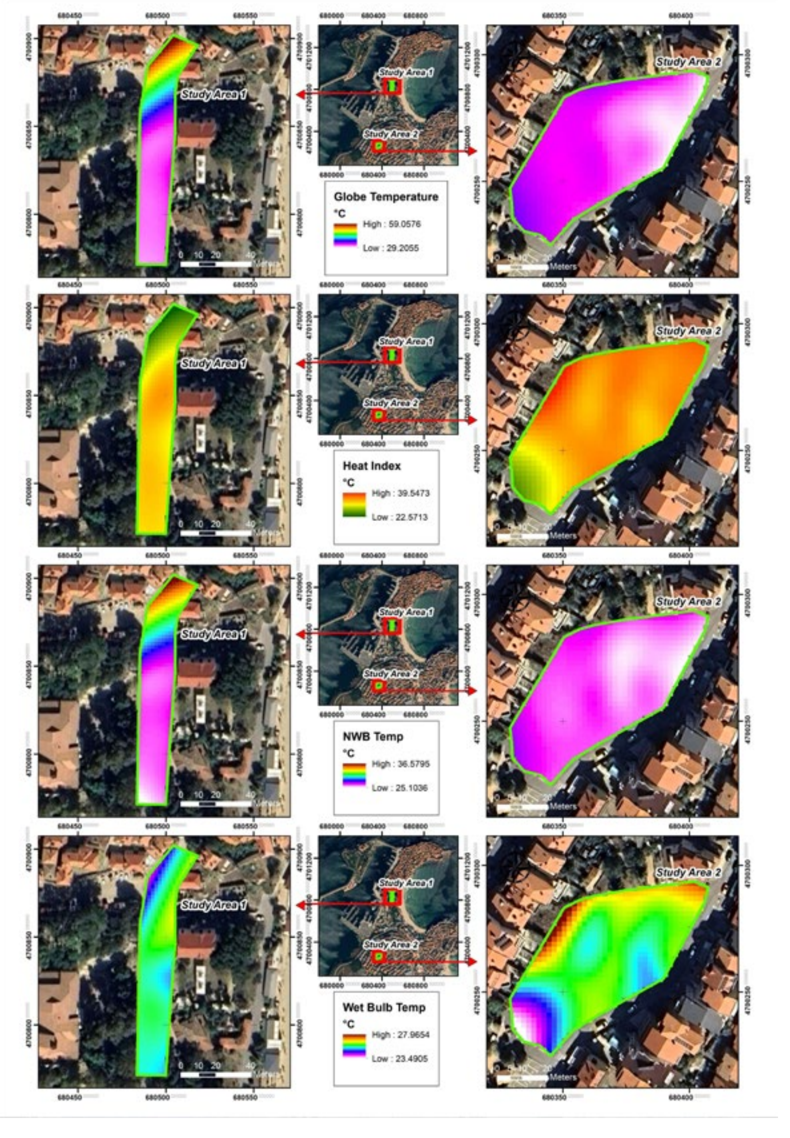

Study Area 1
Study Area 2
Temperature
°C
High : 36.152
Low : 31.3614
Surface Temperature
°C
High : 65.7493
Low : 20.4806
Relative Humidity
%
High : 52.4827
Low : 40.2532
Thermal Work Limit
w/m2
High : 162.479
Low : 100.93
Meters

6. Activities and Action Plan

Sozopol

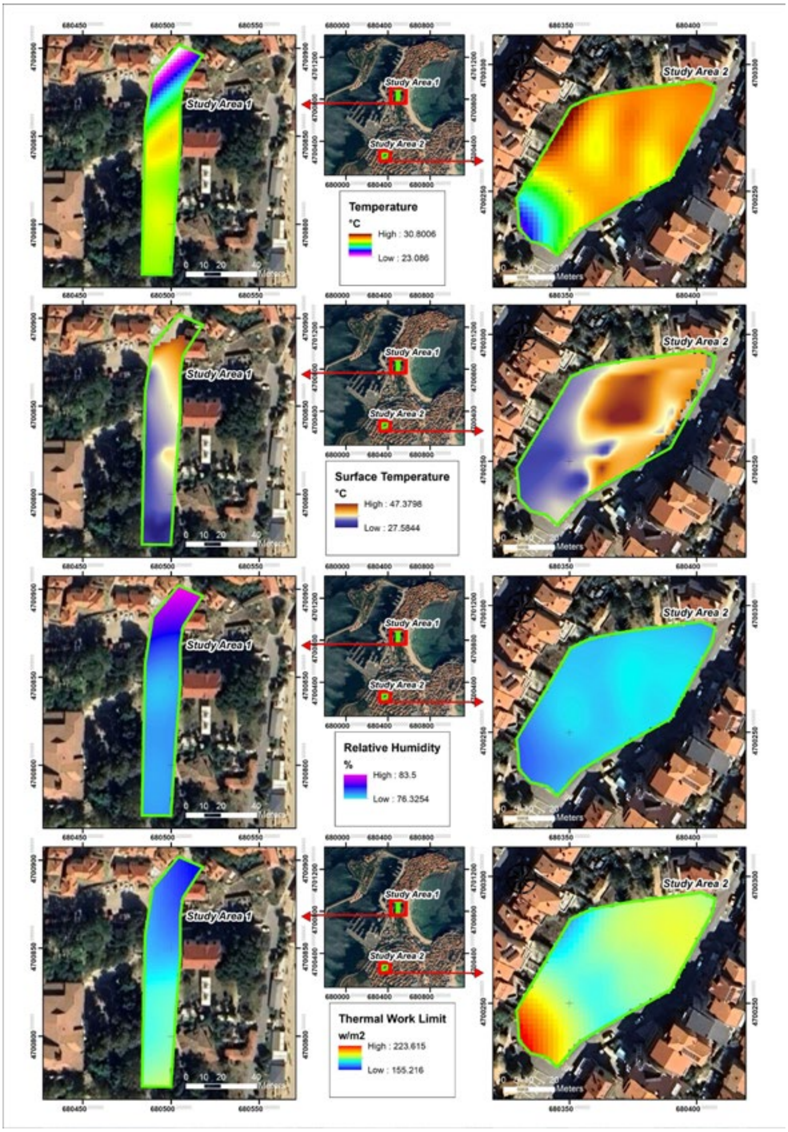


Sozopol

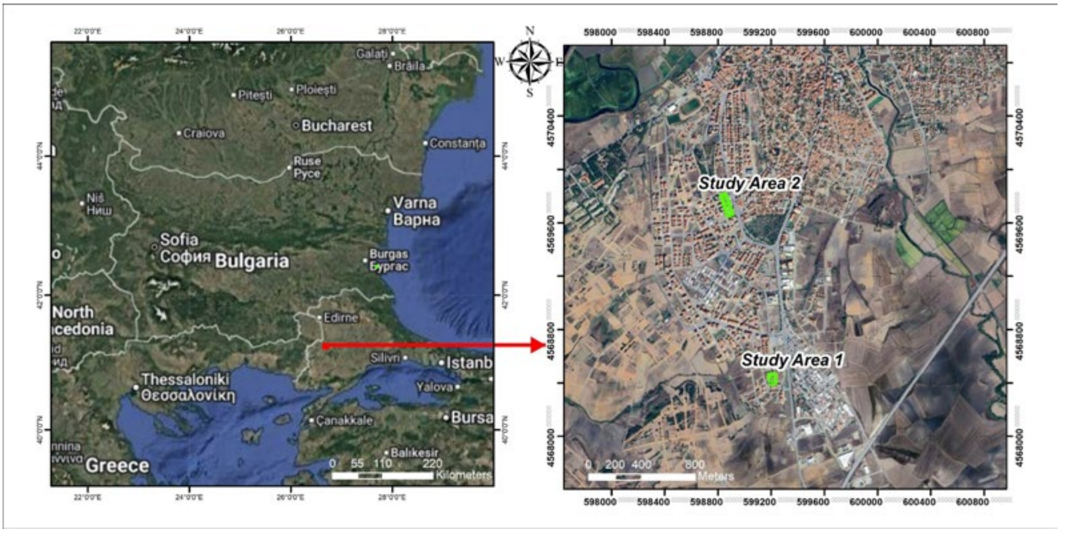

Study Area 1
Study Area 2
Globe Temperature
°C
High : 59.0576
Low : 29.2055
Heat Index
°C
High : 39.5473
Low : 22.5713
NWB Temp
°C
High : 36.5795
Low : 25.1036
Wet Bulb Temp
°C
High : 27.9654
Low : 23.4905

6. Activities and Action Plan

Sozopol

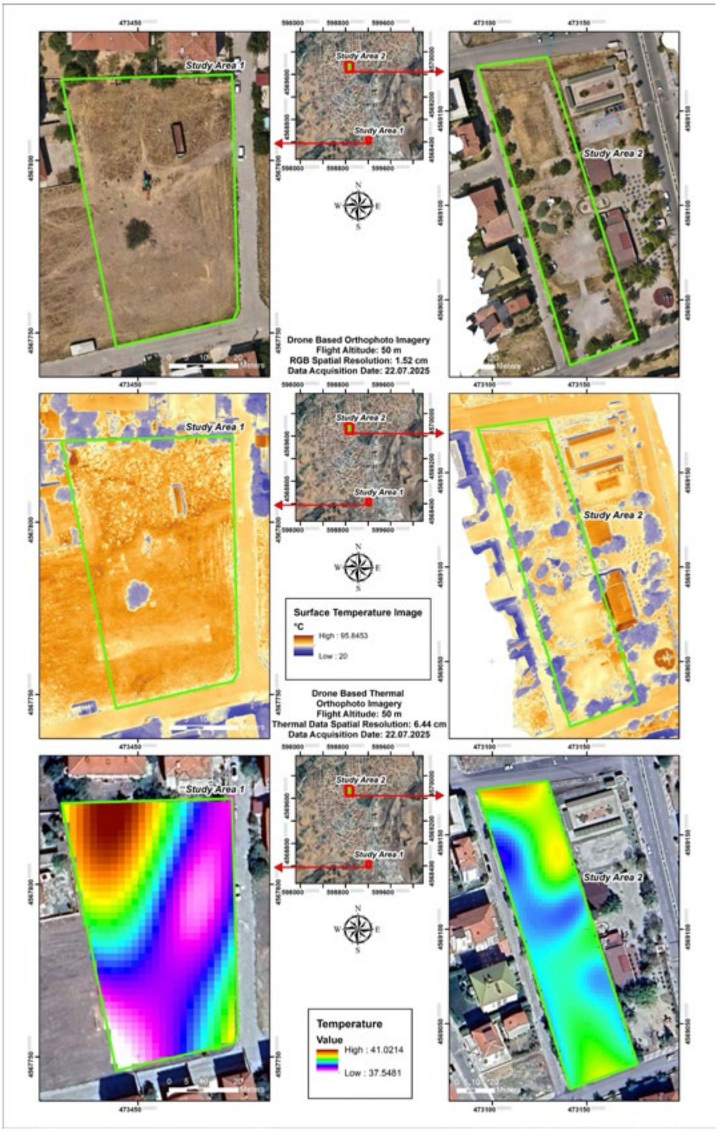


Uzunköprü

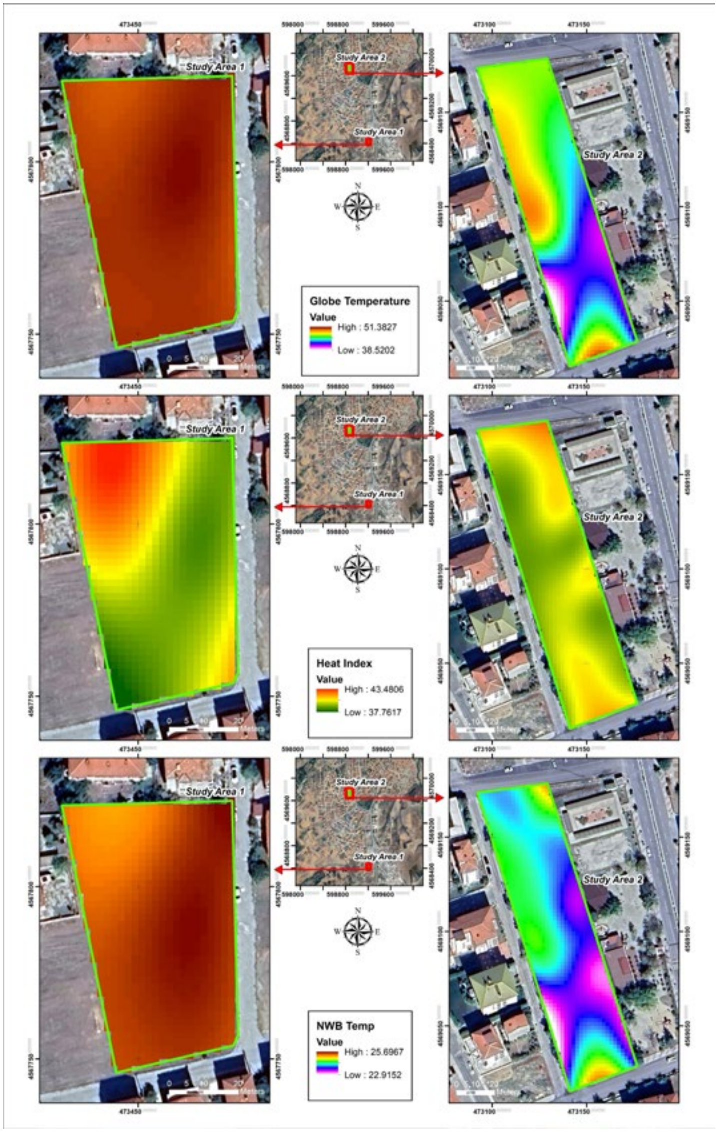

Bucharest
Bulgaria
Sofia
Varna
Edirne
Istanb
Greece
Thessaloniki
Bursa
Study Area 2
Study Area 1

6. Activities and Action Plan

Uzunköprü

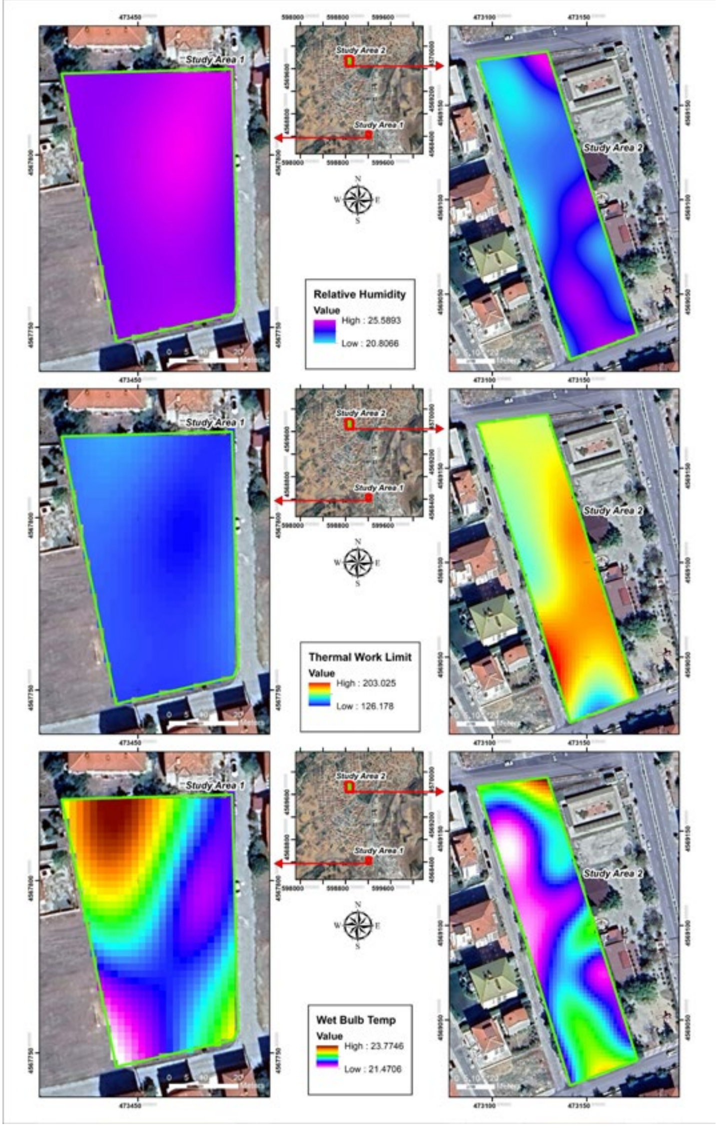


Uzunköprü


Study Area 1
Study Area 2
Globe Temperature
Value
High : 51.3827
Low : 38.5202
Heat Index
Value
High : 43.4806
Low : 37.7617
NWB Temp
Value
High : 25.6967
Low : 22.9152

6. Activities and Action Plan

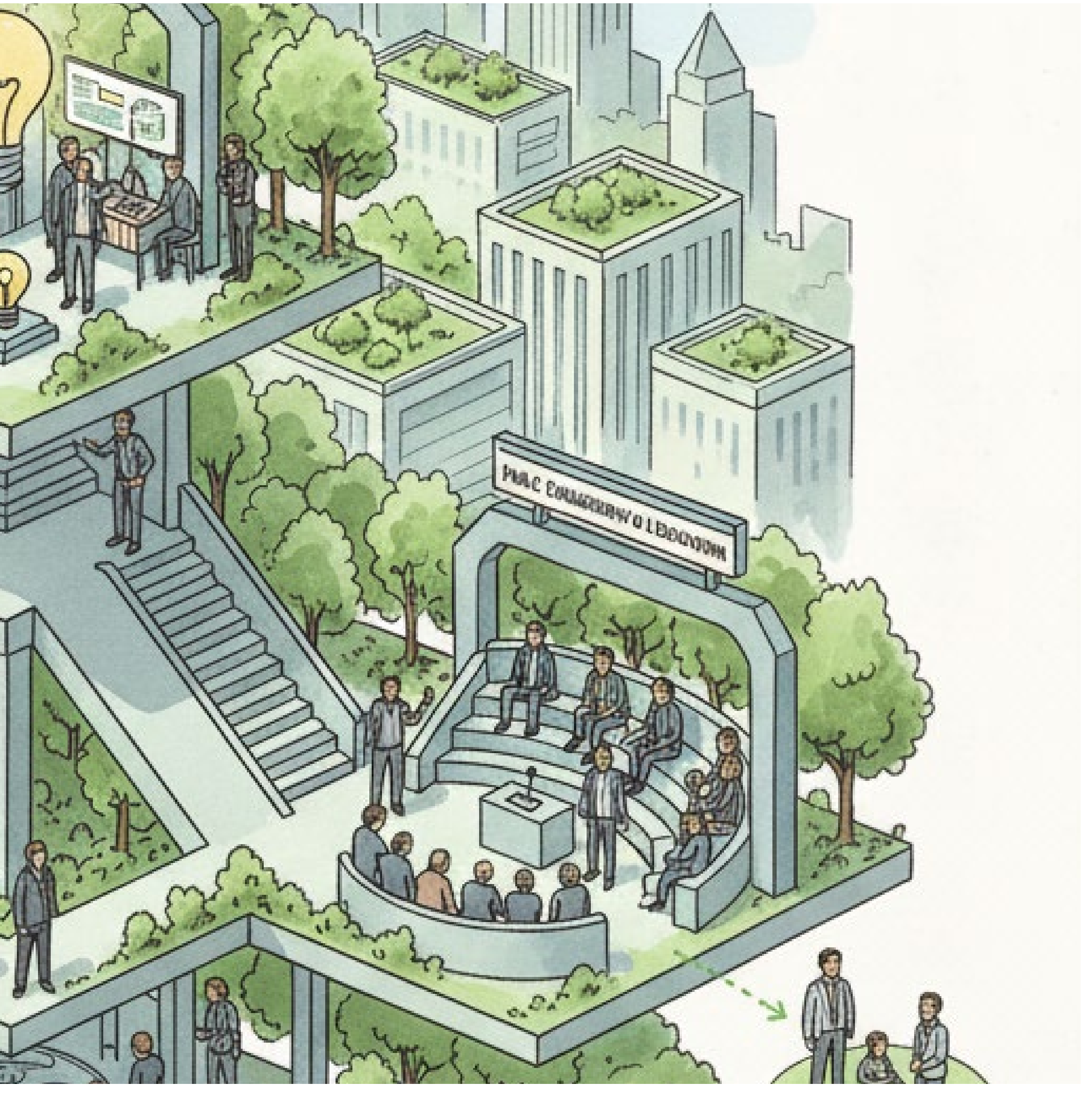
Uzunköprü




Sample thermal image

07

Policy Recommendations and Strategies



7. Policy Recommendations and Strategies

Climate and Green Spaces Awareness and Education Policy

Objective: To raise awareness about climate change in society, improve knowledge about the impact of green spaces in cities, and encourage individual efforts.

Strategies for the Public:

- Organising educational programmes in schools and locally on the impact of climate change and green spaces
- Provide information via social media, the internet and television channels and organise wide-ranging awareness/sensitisation programmes
- Inform the public about climate change and green spaces using visual and interactive materials appropriate for the target audience
- Ensure public participation by organising local events, seminars and cultural programmes

Objective: To increase awareness of climate change within municipal institutions and to support climate-sensitive decision-making processes.

Strategies for Municipalities:

- Supporting institutional capacity by organising regular training sessions, seminars and meetings for employees
- Informing employees working in relevant departments within the municipality about best practices and outcomes, and developing their implementation capacity through in-service training methods

Energy Use and Transport Policy

Objective: To reduce carbon footprint by decreasing fossil fuel consumption, ensuring municipalities play a leading role in this regard.

Strategies for the Public:

- Launching/increasing local campaigns that promote the use of renewable energy (solar energy, wind energy, biomass, etc.)
- Promoting the use of sustainable transport modes such as public transport and cycling

Strategies for Municipalities:

- Developing public transport and sustainable transport solutions (cycling, electric vehicles, etc.)
- Raising awareness about energy saving and efficiency
- Promoting energy efficiency and saving practices in municipalities and institutions and sharing these practices with the public.

Disaster and Emergency Preparedness Policy

Objective: To be prepared for the potential impacts of climate change and to increase the preparedness level of municipalities.

Strategies for the Public:

- Raise awareness about climate-related risks such as floods, droughts, and forest fires, and inform the public about personal precautions they can take.
- Organise disaster and emergency drills.

Strategies for Municipalities:

- Train municipal employees on disaster and emergency management and strengthen institutional capacity
- Develop coordinated emergency plans with municipalities, public institutions and NGOs, update them regularly and monitor them
- Prepare early warning systems and emergency plans

Participatory Management Policy

Objective: To develop international, national and local cooperation within the scope of climate change measures and to increase the effectiveness of climate policies through participatory mechanisms.

Strategies for the Public:

- Encourage the participation of NGOs and local stakeholders in projects
- Develop mechanisms to incorporate public opinion into policy-making and decision-making processes
- Conduct awareness-raising activities to ensure the public is informed about projects

Strategies for Municipalities:

- Developing collaborations and undertaking/increasing joint projects with the central government, international and national organisations, universities and NGOs
- Establishing an evaluation process and feedback system by holding regular meetings with stakeholders
- Encourage the active participation of local actors in municipal decision-making processes
- Effectively utilise international and national funds and municipal budgets for project financing
- Define the roles and responsibilities of relevant authorities without overlap and ensure inter-agency coordination

7. Policy Recommendations and Strategies

Environmental Protection and Green Space Development Policy

Objective: To increase environmental protection activities and green spaces in cities, and to enhance the role of municipalities in these processes

Strategies for the Public:

- Raising awareness about waste management in residential and communal areas
- Ensuring public participation in tree planting and green space initiatives
- Rewarding environmentally conscious collective or individual initiatives and using tools to promote their widespread adoptio

Strategies for Municipalities:

- Undertake planning initiatives to protect and increase environmental and green spaces in cities
- Develop and promote waste management and recycling projects, supporting them with corporate initiatives
- Develop practices to increase the proportion of green spaces in cities, enhancing tree planting/greening initiatives and green space arrangements

Urban Green Infrastructure Policy

Objective: To increase resilience to climate-related disasters and develop green infrastructure for this purpose

Strategies for the Public:

- Organising events and cultural programmes about the benefits of green spaces (air quality, carbon reduction, health, etc.), encouraging public participation
- Developing mechanisms to gather public feedback on green infrastructure applications such as parks and gardens
- Rewarding and publicising applications that promote the widespread adoption of green infrastructure applications

Strategies for Municipalities:

- Implementing projects and initiatives such as urban parks, green spaces, and urban forests
- Expanding roadside tree planting initiatives
- Increasing community gardens and urban farming areas/hobby gardens
- Promote urban green infrastructure applications such as cycle paths, rain gardens, and roof gardens
- Design urban layouts that reduce hard surfaces
- Prioritise drought-resistant and locally appropriate plant and landscape applications
- Integrate a green space-focused approach into planning and development

work
- Design new urban projects to incorporate climate-sensitive and green infrastructure elements
- Support initiatives developed by public institutions, NGOs, and the private sector engaged in green infrastructure activities outside of municipalities

Financial Support Policy

Objective: To ensure sustainable financing for green infrastructure and climate-resilient projects

Strategies:

- Allocate funds from international funds, national and local budgets to green infrastructure projects
- Strengthen financial capacity by increasing cooperation with the private sector
- Prioritise green infrastructure and climate-sensitive projects when planning budgets and resources

Monitoring and Evaluation Policy

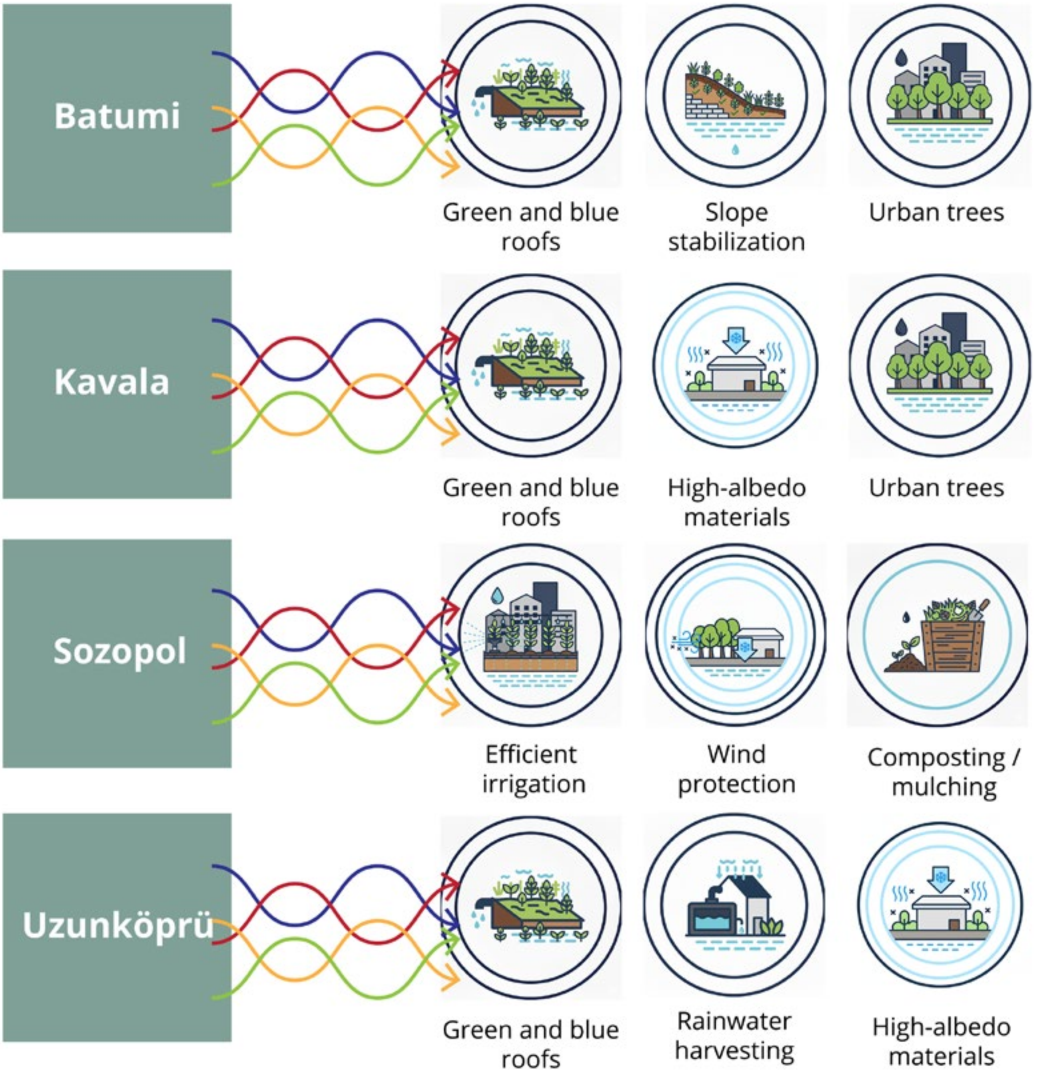
Objective: To evaluate the effectiveness of green space and infrastructure works and ensure their sustainability

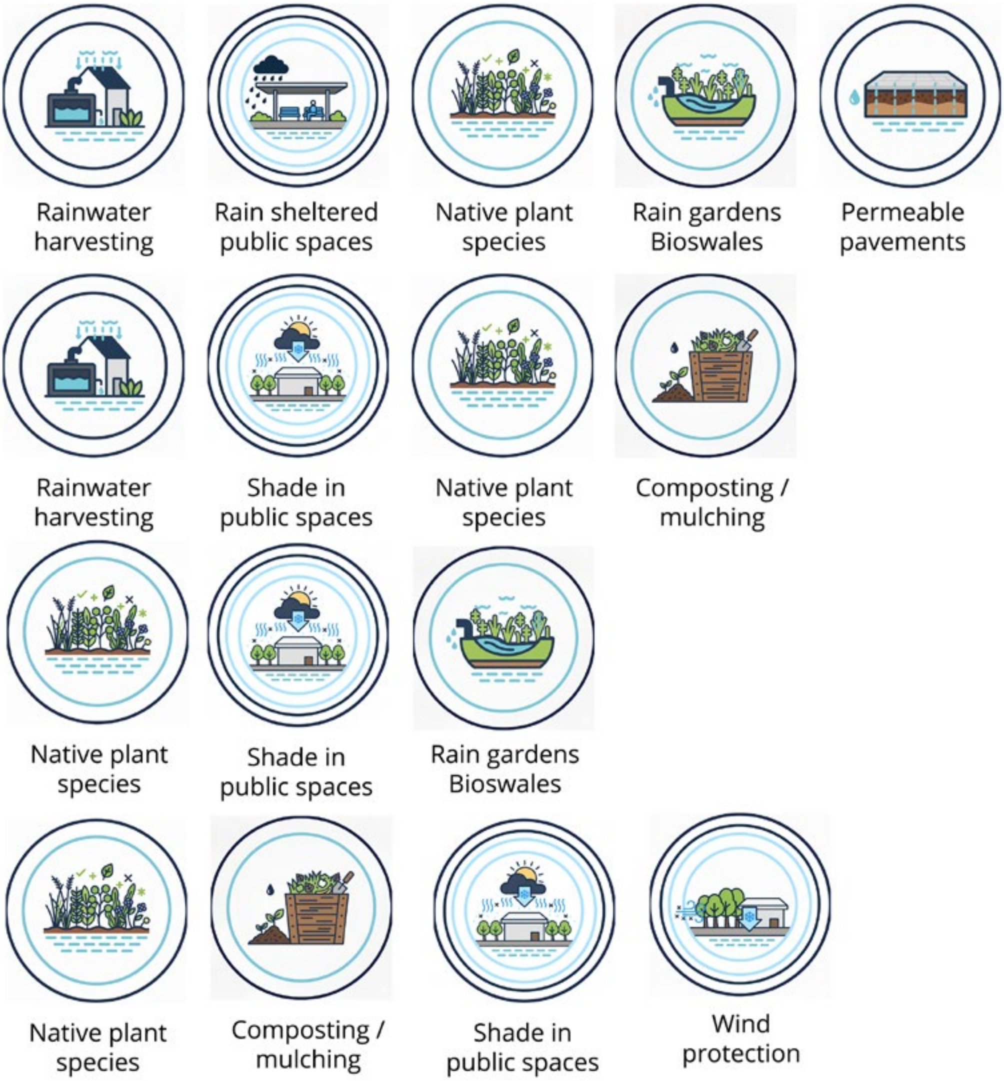
Strategies:

- Establish monitoring systems for each city that track indicators such as green space, urban heat island effect, and carbon levels
- Prepare heat island maps and ensure they are updated to regularly assess the current situation and monitor urban temperature indicators
- Publish information reports for the public and other stakeholders on this subject
- Ensure inter-institutional coordination in local data tracking
- Regularly measure public perception, expectations and demands
- Evaluate the effectiveness of policies and strategies related to climate, green infrastructure and urban heat effects
- Update policies and strategies through feedback and data analysis
- Share implementation results regularly to facilitate inter-city knowledge sharing and disseminate best practices accordingly

7. Policy Recommendations and Strategies

Proposed Green and Blue Infrastructure Practices for the study areas




Rainwater harvesting
Rain sheltered public spaces
Native plant species
Rain gardens Bioswales
Permeable pavements
Rainwater harvesting
Shade in public spaces
Native plant species
Composting / mulching
Native plant species
Shade in public spaces
Rain gardens Bioswales
Native plant species
Composting / mulching
Shade in public spaces
Wind protection

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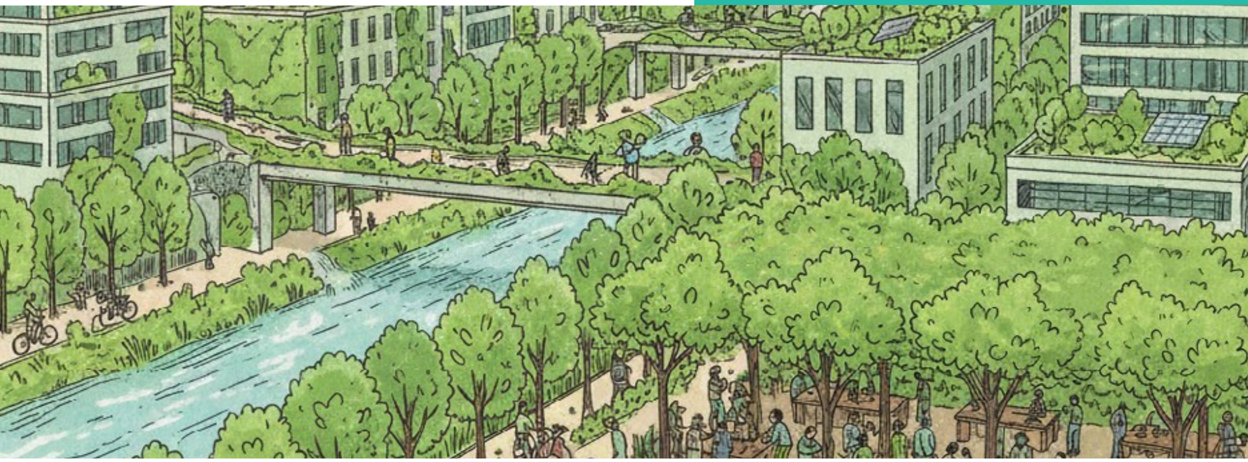

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Pathway Planning GUIDE

Climate Change Adaptation
Through Green Infrastructure
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