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Urban Green Infrastructure Management: A Key Strategy for Climate Change Adaptation in Mediterranean Cities

Harnessing effective practices to mitigate climate impacts and enhance urban resilience

Greek cities face rising temperatures and dry conditions, making effective urban green infrastructure management essential for climate change adaptation. Integrated strategies with specific guidelines improve resilience to extreme weather while promoting community sustainability.

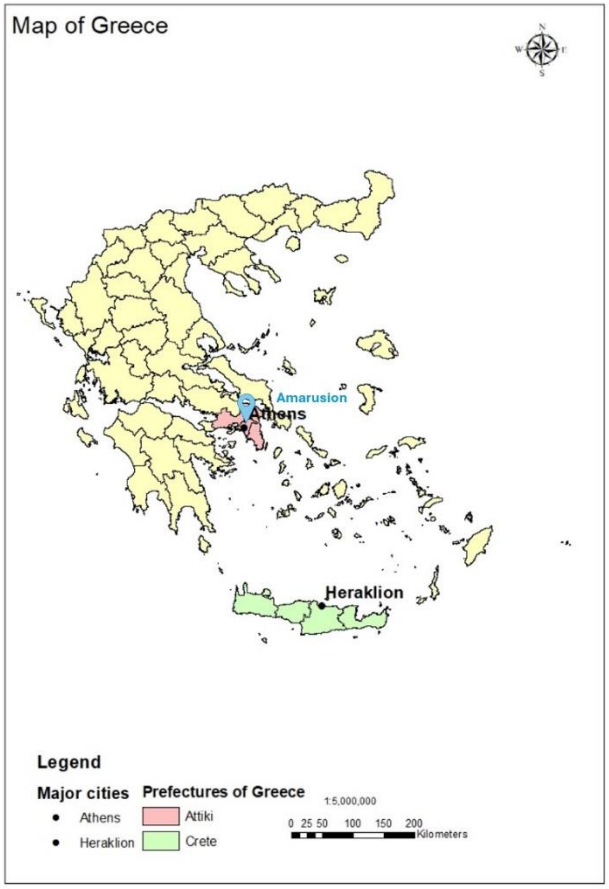
Key Learnings

- **Embrace Urban Green Infrastructure:** Prioritizing urban green areas unlocks nature's potential and supports combatting climate change and enhancing urban resilience.
- **Adopt Integrated Management and enhance collaboration:** Using a coordinated management strategy, involving stakeholders and community members ensures effective design and maintenance of green areas.
- **Invest in Data-Driven Decision Making:** Implement robust data collection and monitoring systems to assess the impact of urban green areas. Standardised indicators help make informed decisions for sustainable management.
- **Leverage Multi-Benefit Solutions:** Urban green areas provide a range of benefits. Therefore, promoting urban green infrastructure as essential assets can significantly improve the quality of life while also tackling climate challenges.

About the region

Amarousion (Marousi) is a municipality of the prefecture of Attiki, located 12 km northeast of **Athens**. It has a population of 71,830 inhabitants. Whilst Amarousion has the largest urban forest of Athens, the Alsos Syngrou, most of its urban green infrastructure, including parks and other open areas, roadsides, islet sections and unused public spaces, is sparse.

Heraklion is the largest city of Crete and the capital of the region. It is the island's trading, economic and scientific centre with a municipal population of 179,302 inhabitants and 211,370 in its wider metropolitan area. The municipality of Heraklion is the fourth largest city in Greece. Urban green infrastructure comprises sparse and small-sized areas. For example, only two green spaces cover more than one hectare each.



Climate Hazards

Extreme Temperatures, Flooding, Water Scarcity

Sector

Biodiversity, Urban

Key system

Critical Infrastructure, Ecosystems and Nature Based Solutions, Health and Wellbeing

Climate Threats

The climate in Greek cities is characterised by extremely warm and dry summers. Cities experience almost zero precipitation, enhancing the water stress of natural ecosystems and urban vegetation. Compared with previous decades, annual temperatures continue to increase, and dry conditions prevail across the country. While coastal areas and high-altitude mountainous regions are affected, the greatest impact is felt in urban areas. Cities are warmer compared to their surroundings and this is called the urban heat island effect. This phenomenon is recognised worldwide, but citizens in the Mediterranean, such as in Greece, are particularly suffering from its effects. Urban green spaces and their vegetation offer promising solutions to adapt cities to these impacts of climate change. Green spaces are the most effective tool to regulate urban climate, providing multiple benefits and important ecological services to local communities.

Urban Green Area Management

There are many ways in which cities can tackle climate change, including greening public spaces. Increasing the vegetation in urban areas can help reduce the urban heat island effect and its associated

impacts, providing natural cooling. Trees and plants provide shade, reduce surface temperatures through evapotranspiration, and improve air quality by absorbing pollutants. Additionally, urban green spaces contribute to flood prevention during heavy rain due to their water infiltration capacity. By incorporating vegetation into urban planning and development, cities can improve their overall climate resilience and enhance the well-being of their residents.

Therefore, specific urban adaptation strategies are needed to make cities more resilient. In this context, **experts see green areas and green infrastructure as the most broadly applicable, economically viable and practical tools to adapt to the effects of climate change**. However, when the greening of cities is not coordinated/ managed in an integrated way, this can cause problems in effectively supporting climate change adaptation. This issue has led to messy vegetation establishment, unsuitable species selection, treatments and measures without standards, resulting in inadequate ecosystem services provision and costly maintenance.

In Greece, the LIFE GrIn project addresses these challenges, and the project team developed tools to facilitate climate change adaptation in the Greek pilot regions of Amarousion and Heraklion. As managing urban green areas is necessary for applying sustainable and climate-effective short-, mid-, and long-term resilience to cities, the project team integrated strategic management plans for urban green areas into adaptation plans. To do so, the LIFE GrIn project team proposed to follow the steps of the Urban Adaptation Support Tool (UAST):

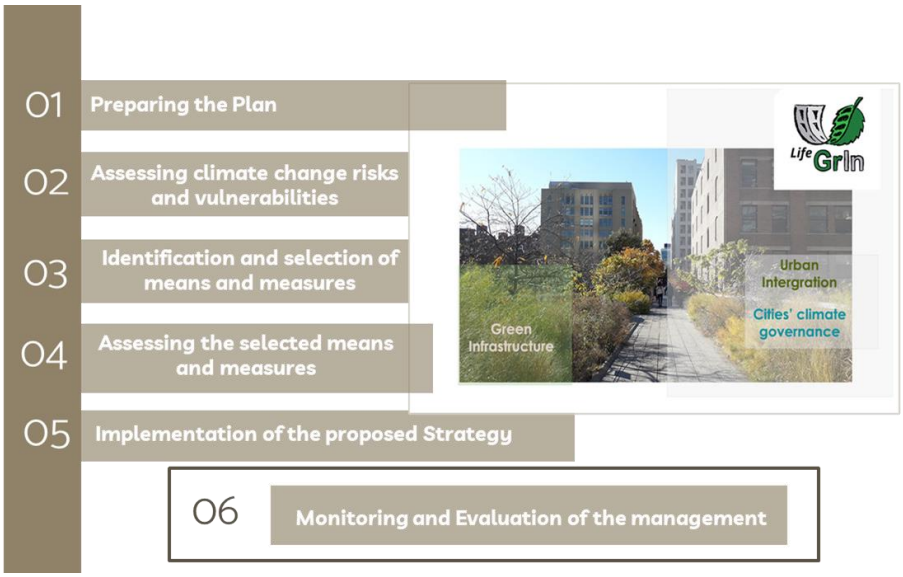


Figure 1: Steps for Strategic Management Plans for Urban Green Areas according to the Urban Adaptation Support Tool. Image Credit: LIFE GrIn project.

Monitoring and Evaluation of Urban Green Areas

Limited information exists on how to use urban green areas for climate adaptation in cities due to a lack of data on their amount and quality. To address this, better data collection, evaluation, and monitoring methods on urban green areas are needed, and more information about their impact on the urban ecosystem is required.

The LIFE GrIn project team developed criteria and an indicator system that addresses the needs of urban ecosystems. This system supports the governance, decision-making, and management of urban green spaces in a comprehensive and standardised manner.

The indicators are grouped by categories, including:

- **Urban green typology**: The typology and the analysis of the urban green areas provide the required information to assess the city's adaptation level to ecological and environmental conditions.

Share of Green Urban Areas	The proportion of the total surface of vegetated areas of any type in the total territory of the city
Distribution of Green Urban Areas	The density of urban green areas in the territory of the city
Effective Green Infrastructure	Efficiency zones around an urban green area
Peri-Urban Forest	The proportion of peri-urban forest that its functionality is connected with the relative one of city's urban green areas
Degree of soil sealing	The proportion of permeable surfaces in relation to impervious ones

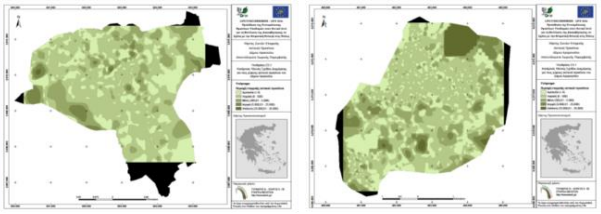


Figure 2: Urban Green Analysis. Image Credit: LIFE GrIn project.

- **Urban green composition and structure**: Urban green spaces form a mosaic of different-sized areas with distinctive vegetation and structure. These characteristics reflect historical changes in urban development and urban green areas management policies and methods. Additionally, the benefits urban green areas provide are directly or indirectly related to these features.

Tree Number Indicator	Total number of the urban trees in the territory of the Municipality
Species Number Indicator	Total number of the **woody species** in the territory of the Municipality
Tree Canopy Cover Indicator	The proportion of the area covered by the vertical projection of urban tree canopies
Ratio of total urban green area per citizen	The proportion of the total urban green areas surface per resident
Ratio of municipal urban green area per citizen	The proportion of the total municipal urban green areas surface per resident

Figure 3: Indicators of Urban Green Composition and Structure. Image Credit: LIFE GrIn project.

- **Urban green phenotype**: This summarises the observable characteristics and traits of the vegetation within the urban ecosystem, focusing on its unique features and adaptations shaped by urban conditions.

Health Indicator	1 : Healthy 2 : Stressed 3 : In decline 4 : Dead
Mortality Index	The proportion of dead individuals in relation to the total number of urban trees

Figure 4: Vegetation Phenotype-Indicators. Image Credit: LIFE GrIn project.

- **Biodiversity and alien species occurrence** are crucial for providing information on the ecological balance, stability and functionality of the ecosystem mechanisms.

Species Richness	The total number of species in a specific area (An urban green area or the entire city)
Abundance	The total number of the individuals of one species in a specific area (An urban green area or the entire city)
Relative Abundance	The proportion of individuals of a species to the total number of individuals of all species in a specific area (An urban green area or the entire city)
Evenness	The differences between the relative abundances of the species of an ecosystem
Diversity	The relationship between the species richness and their evenness
Shannon diversity index - H'	The proportion of individuals of one particular species found divided by the total number of individuals found
Alien Species Number	The total number of **alien species** that participate in the total population

Figure 5: Indicators on Biodiversity and Alien Species reflecting ecosystem health. Image Credit: LIFE GrIn project.

- **Landscape analysis indicators** show the degree of fragmentation of the urban green areas, their dispersion, connectivity and general spatial distribution within the city.

AREA - Patch Area Index	It indicates landscape composition
Landscape composition index PD - Patch Density	It indicates the pixels density of parcels of each landscape class
CONNECT - Connectance Index	It indicates the degree of facilitation of ecological flows
DIVISION - Division index	It indicates the degree of landscape coherence

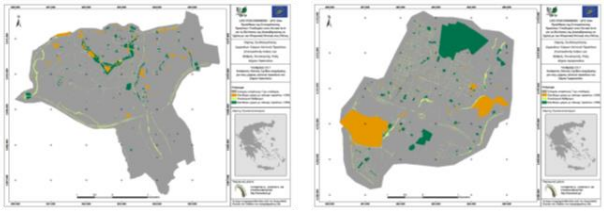


Figure 6: Fragmentation, dispersion, connectivity and spatial distribution indicators. Image Credit: LFE GrIn project.

- **Carbon storage** by the vegetation of urban green areas is crucial for climate change adaptation as it helps reduce CO_2 levels. It is calculated through allometric equations, according to the plant species and the climate zone.
- **Bioindicators** from systematic sampling enable the evaluation of lepidoptera-occurrence.
- **Bioclimatic indicators** allow the evaluation of a person's thermal comfort (or discomfort).

Physiological Equivalent Temperature - PET	It is a thermal indicator that evaluates the thermal comfort of human body. It is defined as the air temperature at which the energy balance of the human body is in equilibrium with its thermal environment.
Predicted Mean Vote - PMV	It indicates the average thermal comfort vote given by a large number of people using a 7-point rating scale. The indicator values show the feeling of most people in a space as their '*vote*' will determine the average value of the '*vote*'.

Figure 7: Indicators for thermal comfort evaluation. Image Credit: LIFE GrIn project.

- **Socio-economic indicators** represent metrics used to gauge the level of well-being or quality of life within urban areas.

Citizens' Welfare indicator because of the presence of Urban Green Infrastructure - URB_Wel_Ratio	The indicator compares the corresponding urban green area per citizen using as a measure of comparison the value of **9m² of accessible urban green** (optimal ratio area per citizen) per citizen proposed by **the WHO**.
Citizens' Socio-Economic prosperity indicator because of the presence of Urban Green Infrastructure - SOC_URB_Wel_Index	The Citizens' Welfare indicator is multiplied by **€10**, and then by the total population of the Municipality

Figure 8: Human wellbeing and quality of life. Image Credit: LIFE GrIn project.

- **Evaluation and self-evaluation indicators** primarily set a reference point and monitor the success of implementing the management plan.

Criterion Category	Weight	Scoreboard for Urban Greening Evaluation			
		Low	Moderate	Good	Excellent
Ecology and Planning (8 criteria)	5.5	0.25	0.5	0.75	1
Organization - Implemented Management (7 criteria)	2.75	0.25	0.5	0.75	1
Public relations (5 criteria)	2.0	0.25	0.5	0.75	1

Figure 9: Reference and monitoring indicators for implementation success. Image Credit: LIFE GrIn project.

Development of a cooperation platform and registry of urban green infrastructure

Effective management is essential to optimising the benefits of urban green infrastructure. This requires comprehensive information and data about urban green areas, which are currently lacking or disorganised

in Greece. As part of the LIFE Grin project, a national registry of urban green areas was established to systematically collect and organise this information in each municipality. The pilot phase of this registry was implemented in Maroussi and Heraklion.

Managed by the Ministry of Environment and Energy, the information collected concerns:

- Quantity and type of urban green areas
- Quantity and quality of woody vegetation
- Use and mapping of urban green areas
- Management and maintenance practices
- Ecological and social value of urban green infrastructure

This tool helps municipalities gather and organise data while aiding central services in monitoring, optimising existing infrastructure, assessing trends, identifying data gaps, budgeting, and raising citizen awareness.

"Programmes like LIFE GrIn enhance the role of municipalities and cities in addressing climate change by fostering cohesive green projects that are integrated within a broader strategic framework, rather than isolated interventions.",

Nikos Gialitakis, Deputy Mayor of the Municipality of Heraklion (2024)

Summary

The LIFE GrIn project integrates urban green areas into the urban ecosystem, recognising their role in climate change mitigation and adaptation. It aims to streamline local climate governance with a sustainable policy for managing, monitoring, and evaluating these areas through collaborative planning and best practices. Aligning with EU climate goals, the project enhances urban resilience and public values. Strategic management plans were developed for pilot regions in Amarousion and Heraklion, resulting in two new model green areas per municipality. The project's key achievement is the upcoming enactment of the policy as state law by the Ministry of Environment and Energy.

Further information

The work presented in this adaptation story is part of the LIFE GrIn project.

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