



ASSESSMENT OF SUSTAINABLE GREEN URBAN DEVELOPMENT STRATEGIES IN THE CITY OF SKOPJE

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Abstract. *Cities nowadays are facing a number of sustainability challenges in the context of climate change. Cities are vulnerable to the impacts of climate change and the need to connect climate change adaptation and mitigation with broader assessment of sustainability is becoming increasingly important. Urban planners need to plan and create more sustainable and resilient communities, make a plan for climate adaptation, preserve and create green space, adopt green building policies, engage the community in climate change planning process, approach climate change planning on a regional level. The methodology approach in this scientific paper focuses on defining the urban climate adaptation, overcoming urban adaptive capacity aspects and creating urban climate adaptation planning that will be factor for sustainable development in the cities.*

Keywords: *sustainability, urban adaptation, climate change, sustainable development.*

1 CLIMATE CHANGE EFFECTS IN THE CITIES

By 2030 nearly 60 percent of the global population is projected to be urban. Urban centers are drivers of global warming because they concentrate industries, transportation, households and many of the emitters of greenhouse gases (GHG); they are affected by climate change; and they are a resources of responses., of initiatives, policies and actions aimed at reducing emissions and adapting to climate change.

Urban areas occupy less than 2% of the Earth's land surface. Urban activities release greenhouse gases (GHGs) that drive global climate change directly (e.g. fossil fuel-based transport) and indirectly (e.g. electricity use and consumption of industrial and agricultural products). 80% of global GHG emissions are estimated to be attributable to urban areas. Cities are also potential hot spots of vulnerability to climate change impacts by virtue of their high concentration of people and assets. Urban areas concentrate population, economic activities and built environments, thus increasing their risk from floods, heat waves, and other climate and weather hazards. Urban centers are drivers of global warming and from the existing data there are three factors as relevant determinants of carbon emissions: a) population, b) affluence as measured by GDP per capita, and c) technology.

Sustainability and resilience can be promoted through a combination of strategies such as integrated urban planning adaptation, building efficiency of urban service quality and promoting green buildings and sustainable transport.

Climate impacts in urban areas and the most pressing issues of relevance to engineers seeking to adapt cities from the following urban climate effects:

- Urban heat islands are caused by the storage of solar energy in the urban fabric during the day and release of this energy into the atmosphere at night: the process of urbanization replaces the cooling effect of vegetated surfaces by imperviously engineered surfaces with different thermal properties.
- Air pollution may increase as warm, still days reduce air quality because high temperatures and ultraviolet light stimulate the production of photochemical smog, ozone and other compounds from traffic and industrial emissions and plants.
- Infrastructure damage from extremes, such as wind storms including hail and storm surges, floods from heavy precipitation events, landslides, tropical cyclones and heat extremes including fires and droughts,

- Biodiversity and urban ecology have already been affected by changes to temperature and precipitation that have resulted in exotic
- Water availability will decrease in many areas, with implications for water resources in terms of both quality and availability for human consumption, industry and agricultural areas.
- Health impacts may include changes to heat- and cold related mortality, food- and water-borne disease from higher average temperatures and/or extreme events.
- The urban economy may be affected in a diversity of ways. Extreme weather-related disasters can be impacted in multiple and complex ways and can take a long time to recover fully. The impacts can lead to direct damage to infrastructure and other urban assets.

2 THE EFFECT OF URBAN HEAT ISLAND IN THE CITIES

The Urban Heat Island mitigation strategies need to provide expertise in various specialized fields, such as urban planning, land use planning, architecture, civil engineering, building engineering, transportation and energy-saving technologies. There are many urban heat island mitigation strategies and they draw on the expertise of various professional fields, including urban planning, architecture, natural resources management and transportation. These mitigation strategies have a positive impact on both local and global climate.

The term Urban Heat Island refers to the observed temperature difference between urban environments and the surrounding rural areas. Urban Heat Island effect is shown on Fig.1, where the day surface temperatures vary widely by surface type and the day air temperatures vary much less. The night surface temperatures are hotter over urban surfaces and the night air temperatures follow the same pattern as surface temperatures.

The Urban Heat Island can have impacts on the environment, such as: deterioration of outdoor air quality, deterioration of indoor air quality, increase in energy demand, increase in demand for potable water; impacts on health, food availability, social impacts, thermal comfort, air conditioning etc.

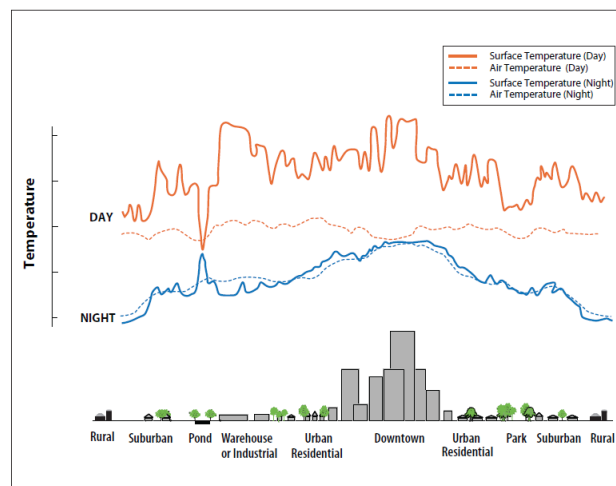


Figure 1. Urban Heat Island – Variations of Surface and Atmospheric Temperatures (Source: Urban Heat Island Basics, 2008, Reducing Urban Heat Islands: Compendium of Strategies, U.S.EPA. p.4)

An urban heat island mitigation strategy must be based on an integrated and multidisciplinary approach, (Fig.2) to urban development and requires the participation of various actors, as well as various sectors, for example public health, urban planning, architecture, transportation and natural resources.

Urban heat island effect in the City Skopje has been analyzed by the Meteorological Center, where the temperature differences in Skopje are within the limits of 1.2 °C to 5.7 °C (Fig 2).

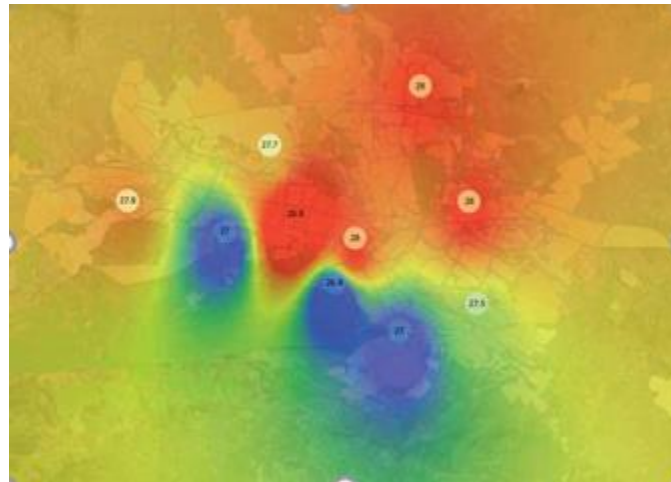


Figure 2. Urban Heat Island in Skopje with interpolation of temperature maps based on temperature measuring in Skopje, Source Resilient Skopje, Climate Change Strategy, 2017

The strategies for reducing Urban Heat Island have benefits for reducing energy demand and source reduction of water and air pollution, including greenhouse gas emissions.

The mitigation measures for reducing urban heat islands can be grouped into three categories (Fig 3):

- Greening measures;
- Urban infrastructure-related measures (architecture and land use planning);
- Anthropogenic heat reduction measures.

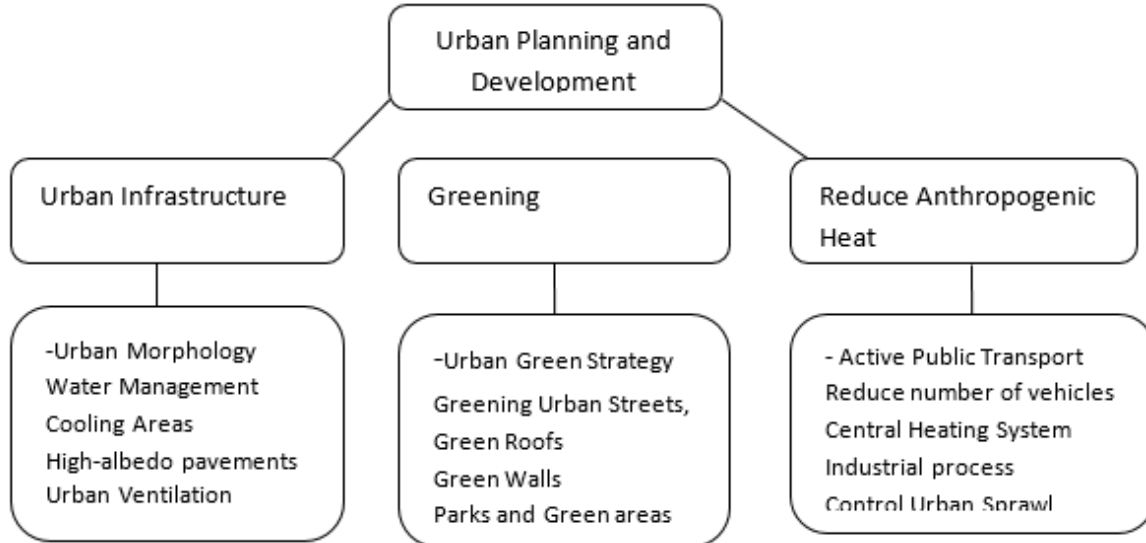


Figure 3. Sustainable organization of Urban Planning and Development in reducing Urban Heat Island

Indicators of environmental quality in the urban green areas in an urban environment, quality of life can be assessed, through indicators that relate to open green areas. Urban environment and the quality of the environment depend on physical conditions and social life. The basic attributes of the physical environment in the city are clean air and the availability of quality water, and it is equally important that the city has provided space and land for green and open spaces. Green areas are considered to be significant indicators of the environmental quality of a city.

- a) Environmental functions and benefits for the environment:

- create conditions for protection of natural resources,
 - provide habitats and positively affect the diversity of species,
 - mitigate the impacts of the urban climate with their regulatory environmental effects,
 - emission absorption, noise reduction, reduction of air pollution, and others.
- b) Social functions:
- provide a range of recreational activities,
 - enhance the quality of life,
 - contribute to promote a healthy lifestyle,
 - contribute to social integration in the development of communities and provide opportunities for cultural and social events,
 - understand the processes in the environment.
- c) Economic functions:
- open new businesses,
 - strengthen local businesses and economies attracting tourists and investment,
 - provide jobs for those who develop, manage and maintain these sites.
- d) Functions arising from the planning, development and management of green areas:
- define the urban structure,
 - ensure the identity of urban areas,
 - contribute to the aesthetic, historical and cultural identity of the city,
 - provide balance with the built space and can be developed as a green network that provides contact with nature.

Urban greening strategy and urban climate adaptation planning (Fig.4) provide complementary benefits in urban areas, including:

- Improving air quality through oxygen production, CO₂ capture, filtration of suspended particulate matter and reducing energy demand for air conditioning;
- Improving water quality through retention of rainwater in the ground and soil erosion control;
- Health benefits for the population, including protection from ultraviolet (UV) radiation, reducing heat stress and providing spaces for outdoor exercise
- Seasonal shading of infrastructure;
- Evapotranspiration; cooling provided by vegetation (Highly developed urban areas have less surface moisture available for evapotranspiration than natural ground cover. Fig.4)
- Minimizing ground temperature differences.

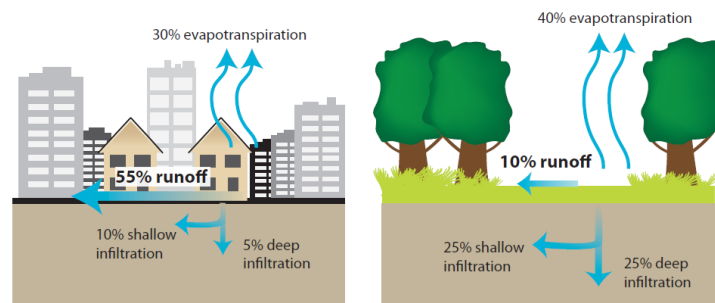


Figure 4. Evapotranspiration on different surfaces of intense urban built environment and vegetation (Source: Urban Heat Island Basics, 2008, Reducing Urban Heat Islands: Compendium of Strategies, U.S.EPA. p.4)

Urban planners and policy decision makers need to plan for sustainable urban development. They need to have holistic approach and integrated urban planning that will focus specifically in reducing urban heat island and climate changes in the cities. Simultaneous use of several urban heat island mitigation measures can have greater impact in lowering

urban temperatures. For example, using a combination of complementary measures provides better overall protection of the building envelope from *solar radiation*, which improves thermal comfort in the building.

3 URBAN CLIMATE ADAPTION STRATEGIES IN REPUBLIC OF N. MACEDONIA

Assessments and tools of adaptation strategies need to be predicated on a regional and local level data and assessments. Particularly important are the availability of regional climate change scenarios, risk assessments and modeling, impact Integrated urban planning requires holistic, systems-based analysis that takes into account the quantitative and qualitative costs and benefits of integration compared to stand-alone adaptation and mitigation policies. Analysis should be explicitly framed within local priorities and provide the foundation for evidence-based decision support tools. Plans should clarify short, medium and long-term goals, implementation opportunities, budgets, and concrete measures for assessing progress.

Integrated city climate action plans should include a variety of mitigation actions: Including energy, transport, waste management, and water policies, and more urban adaptation actions with infrastructure, natural resources, health, and consumption policies in synergistic ways.

The Strategy for sustainable development in Republic of Macedonia includes the following sectors:

- Climate change and clean energy – mitigating climate change and its negative effects on society and the environment through the use of renewable sources of energy and structural change in industry, benefiting facilities that do not have large energy and electricity needs and which have a cumulatively lower impact on the environment;
- Sustainable transport – ensuring that our transport system meets society’s economic, social and environmental needs whilst minimizing its undesirable impacts on the economy, society and the environment;
- Sustainable consumption and production – decoupling economic growth from environmental degradation;
- Conservation and management of natural resources – improving management and avoiding the over exploitation of natural resources, while recognizing the value of ecosystem services.

In the Strategy for sustainable development of the Republic of Macedonia, specific resources have been identified as priorities:

- the natural environment and bio-diversity– improving management and avoiding excessive natural resource exploitation, recognizing the value of ecosystem services, and developing international corridors that secure economic, social and environmental needs;
- Renewable sources of energy– increasing the share of renewable energy use from water, sun, wind and biomass;
- Diversity in traditional high-quality agricultural and forest products– emphasizing organic farming and agriculture, production of healthy food and traditional products such as cheese, wine, honey and spices, and integrated management of agriculture and forestry based on a sustainable economic and environmental approach.

The Green gas emissions scenario in Macedonia is that the total GHG emissions shall increase from 9,030 kt in 2012 to 18,340 kt in 2035, or by 100% (Figure 5).

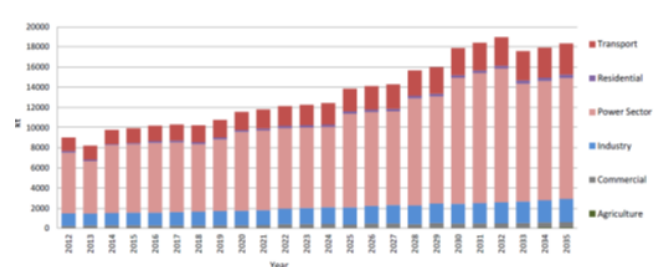


Figure 5. GHG emissions according to WOM scenario Macedonia, (Source: Climate Change Mitigation in Buildings, Transport and Energy Supply Sectors, First Biennial Update Report on Climate Change, Research Center for Energy and Sustainable Development, Macedonian Academy of Sciences and Arts, 2014)

The cumulative CO₂ emissions savings scenario in Macedonia until 2020 amount from 11,000 kt, and by 2030 will increase for five times and amount to 55,000 kt Cumulative emissions, compared to the WOM scenario, by 2020 shall decrease by 12%, while by 2030 they decrease approximately by 22% (Figure 6). The highest reduction is achieved by introducing CO₂ tax and electricity import which generates 34%, and next is the Rulebook on Energy Performance of Buildings with 27%, higher participation of RES with 10% and decreasing losses in distribution with about 6%.

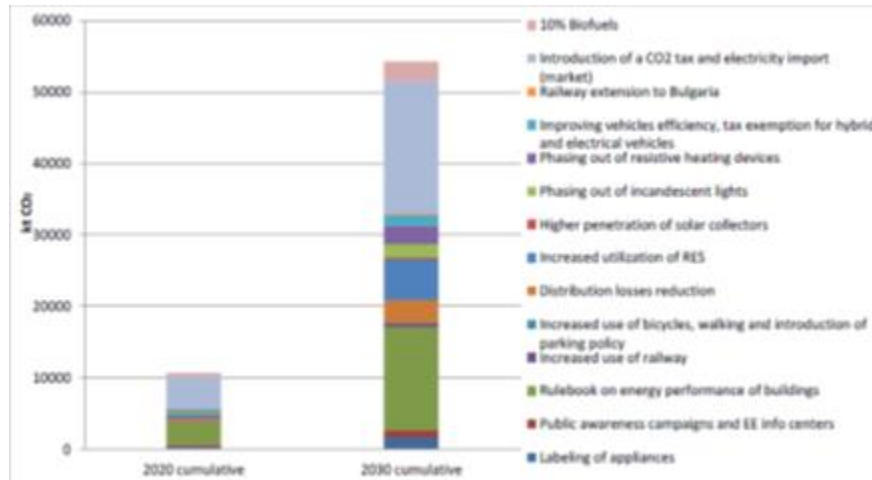


Figure 6. Cumulative savings of CO₂ by 2020 and 2030 to WOM scenario Macedonia, (Source: Climate Change Mitigation in Buildings, Transport and Energy Supply Sectors, First Biennial Update Report on Climate Change, Research Center for Energy and Sustainable Development, Macedonian Academy of Sciences and Arts, 2014)

4 GREENING STRATEGIES AND GREEN INFRASTRUCTURE OF THE CITY OF SKOPJE

The methodology and assessment for establishing an integrated green space system is the urban plan. The General Urban Plan provides an integrated system of green spaces, as well as interconnection of the larger urban complexes.

Strategies of development of green spaces in the City of Skopje are defined with the following concepts: defining public open urban space, analysis of the development of the City of Skopje, quantity and quality of urban green area, urban green spaces area in the City of Skopje, defining the green identity of the City of Skopje and planning, development and management of urban green areas.

Greening strategies and Green infrastructure create several benefits in the city such as: social aspects in urban areas, recreational activities, nature and biodiversity, economic aspects: regulation of the solar distribution in buildings, reduction of cooling costs, increasing the economic value of real estate and reducing health costs, aesthetic, historical and cultural identity of the city and defining the green infrastructure in the city.

Greening strategies in the City of Skopje define creating livable green network of streets by planting footpath locations with authentic trees, landscape urban design with greener streets, replacing paving with trees and landscape planting. In the Strategy for greening the region of the City of Skopje, is defined by urban greenery parks, gardens, squares, greenery in residential areas, forests and areas of protected natural landscape, as an integral part of the urban structure. Recommendations for creating a connected network system of urban green spaces and green corridors in the city of Skopje and its surroundings.

Urban Development of the City of Skopje with specific elements of city growth and development of green spaces can be analyzed with the urbanistic plans from 1965 and 1985, but strategies of green spaces are defined more specifically in the general urbanistic plans from 2002 and 2012 year, where recreation green areas and protected green forests in the City of Skopje are defined.

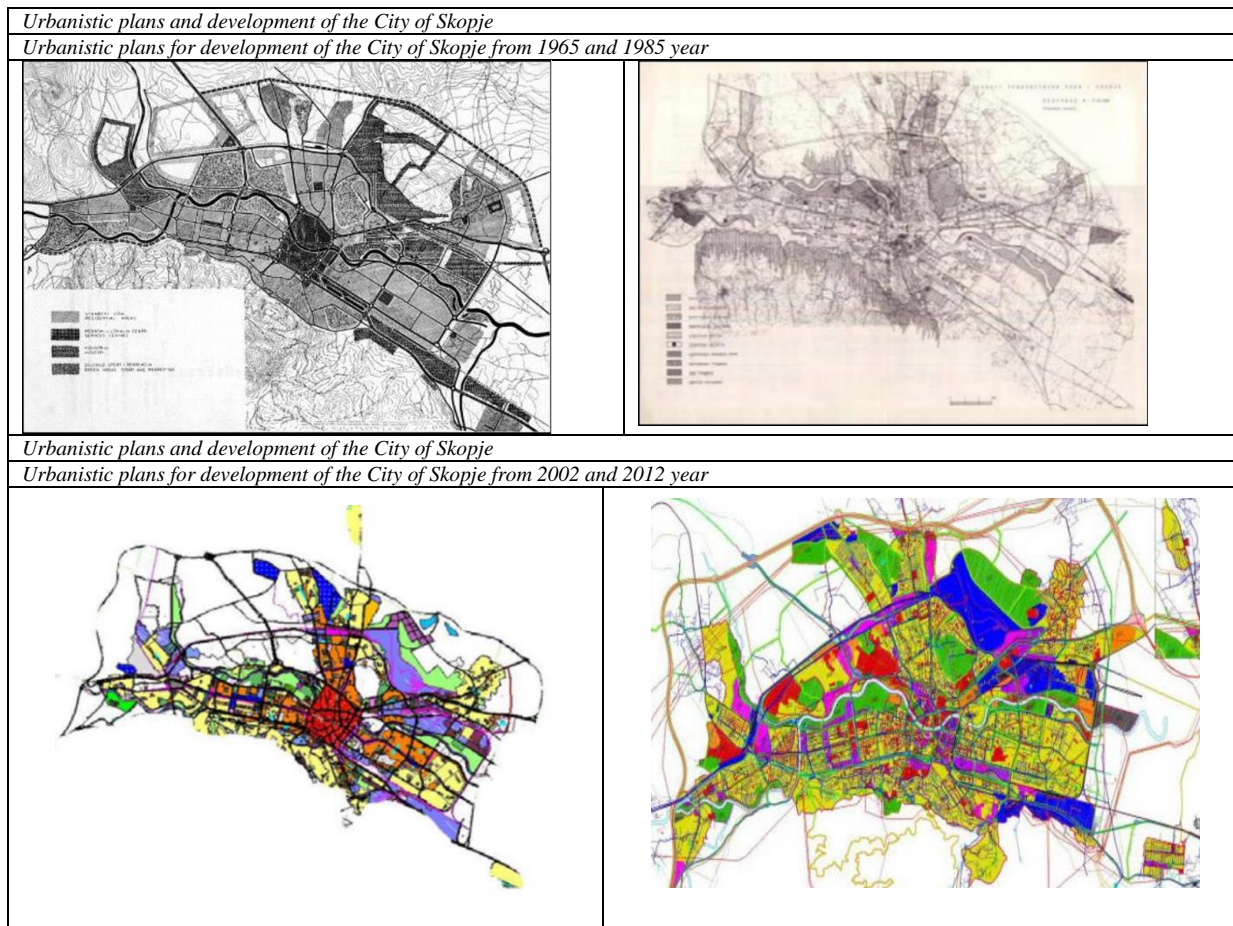


Table 1. Public Green Spaces in City of Skopje (Source:Студија за озеленување и пошумување на подрачјето на град Скопје, Град Скопје, 2015)

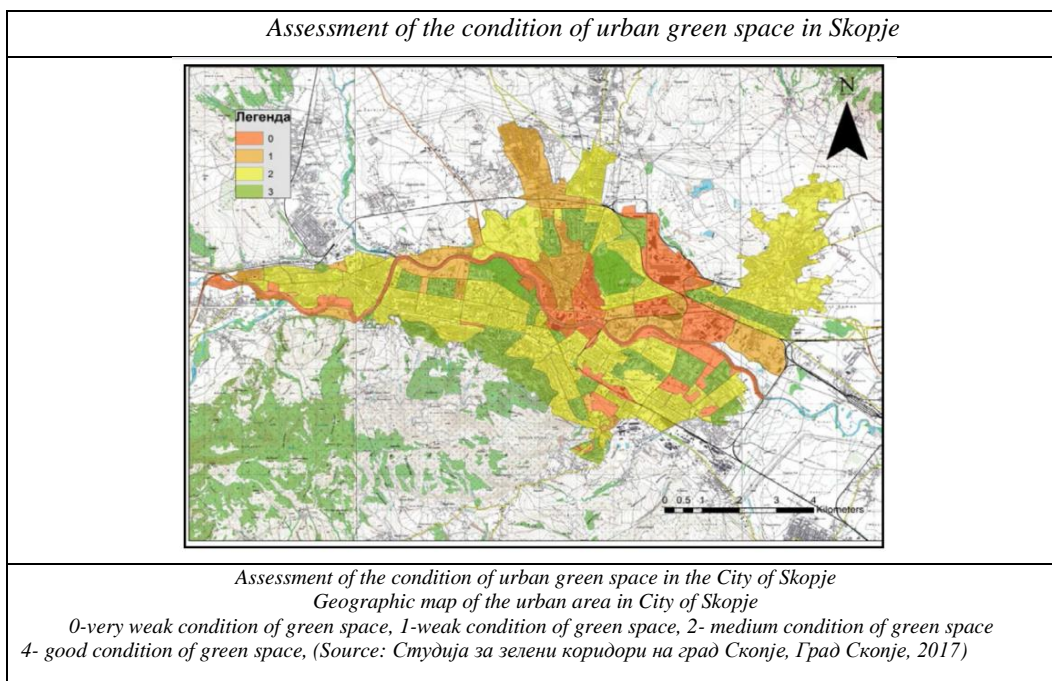
<i>Assessment and condition of green spaces in City of Skopje</i>				
	1964	1985	1998	2011
City green area according to analysis from General Urban Plan in ha	211	426.2	392.9	388
Green spaces in urbanistic scale, maintained by “Parks and Greenery” in city surroundings area in ha	No data	No data	183.2	141
Summary			576.1	529

Public Green Spaces in City of Skopje	Area ha
City Park	38.8
Park Zena Borec	0.9
Characteristic Landscape Gazi Baba	105.0
Zajcev Rid	5.0
Sport-recreation centers	Area ha
Lake Treska	18.6
Saray	24.0
Green space in the city surrounding area	Area ha
Park-Forest Vodno	4537

Analysis of residential green space in the Municipalities in the City of Skopje from 2017 year, show that summary green residential space in 248,5 ha, and Municipality Aerodrom has the most green residential area with 80,4 ha (Table 2).

Table 2. Residential green space in the Municipalities in the City Skopje (Source:Студија за зелени коридори на град Скопје, Град Скопје, 2017)

Residential green space in the Municipalities in the City of Skopje	
Municipality	Area ha
Municipality Centar	19.5
Municipality Karposh	61.0
Municipality Gorce Petrov	9.2
Municipality Kisela Voda	20.8
Municipality Aerodrom	80.4
Municipality Gazi Baba	18.6
Municipality Cair	29.7
Municipality Butel	7.4
Municipality Suto Orizari	1.6
Summary	248.5



Sustainable Green Development of public green spaces in the City of Skopje



Specific organization and development of the greening strategies of the City of Skopje can be analyzed by creating green infrastructure of the roads and central and side medians that perform a functional and an aesthetic purpose and provide some character of the street. Greening the road infrastructure in the City of Skopje will address several positive aspects:

- a) physically separate traffic moving in opposing directions;
- b) prevent uncontrolled, unpredictable, and unsafe traffic movements;
- c) create a safe landing for pedestrians one-half of the way across a major street;
- d) provide a planting area for landscaping and streetlights;
- e) provide an excellent opportunity for the integration of stormwater treatment;

Greening strategies of the City of Skopje

Green Infrastructure of roads – central and side green medians as sources for greening the boulevard infrastructure in Skopje



Preserving historic landscape green spaces in the City of Skopje are important aspect in creating authentic urban character of the city by defining the urban structure, providing the identity of urban green areas, contributing to the aesthetic, historical and cultural identity of the city and defining the green infrastructure of the city.



Figure 7. Historic green spaces in the Skopje Fortress, Macedonia

5 SUSTAINABLE URBAN GREEN DEVELOPMENT IN THE CITIES

The expected outcome results in this scientific paper is creating urban climate mitigation and adaptation planning that will focus on the complexity of the cities with special emphasis of the City of Skopje. Targets for urban mitigation of carbon dioxide emissions are now urgent and imply reconfiguration of urban energy systems, transport, built environment and protecting and safeguarding biodiversity. Urban adaptation of cities requires integrated thinking that encompasses a whole range of urban functions. Sustainable city can be defined as a city that is significantly decoupled from resource exploitation and ecological impacts and is economically and ecologically sustainable in the long term.

The methodology approach in this scientific paper focuses on defining the measures for risk management and vulnerability of the urban climate, overcoming urban adaptive capacity aspects and creating urban climate adaptation planning and greening strategies that will be factor for sustainable development in the City of Skopje. The expected outcome results in this scientific paper is creating urban climate mitigation and adaptation planning that will focus on the complexity of the cities.

Urban green spaces are the crucial elements of every city. They affect the appearance of the city, provide diversity and shape the structural and the functional elements that cities. The concept for sustainable urban development and creating a city with high quality of life, City of Skopje should emphasize the concepts of keeping the existing public green



This Scientific paper will contribute to the wealth of information already available on climate change by going beyond context specific urban case studies that can help urban centers become better prepared and more resilient to respond changes in climate. It provides an overview of the current state of knowledge and practice, but also at existing gaps in our knowledge and new directions for work in this area.

The strategic approach to sustainable development according to the Macedonian scenarios include strategies that reduce the urban heat island effect, improve air quality, increase resource efficiency in the built environment and energy systems, as well as land use, urban forestry and biodiversity that to contribute to greenhouse gas emissions reduction while improving a city's resilience. The selection of specific adaptation and mitigation measures should be made in the context of other sustainable development goals by taking current resources and technical means and social needs of the citizens of the city of Skopje.

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