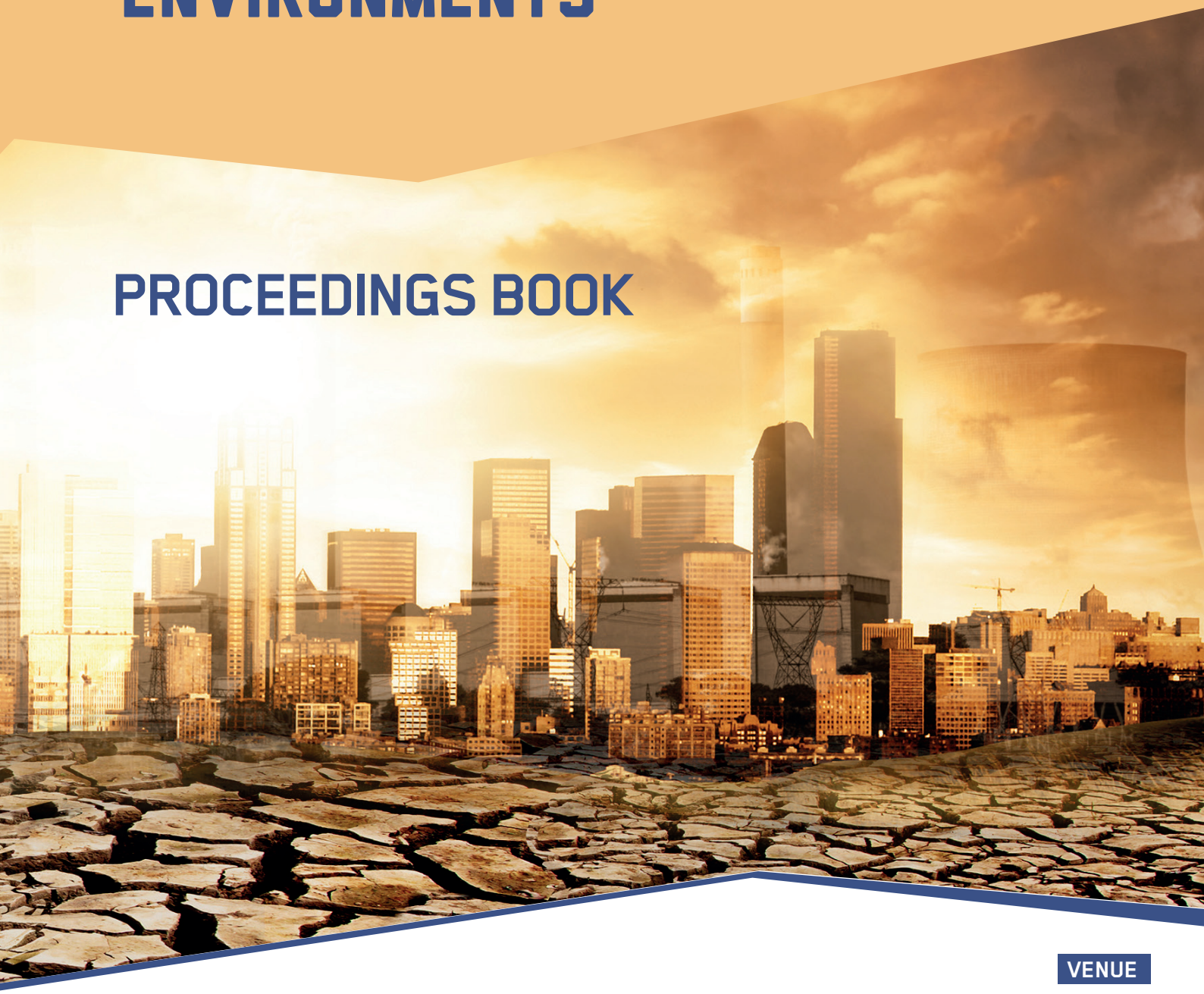
INTERNATIONAL CONFERENCE

PRODUCTION OF CLIMATE RESPONSIVE URBAN BUILT ENVIRONMENTS

PROCEEDINGS BOOK



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PREFACE

The international conference on the "Production of Climate Responsive Urban Built Environments" was held at Istanbul Policy Center, Istanbul, Turkey, from May 22–24, 2019. The conference aimed at constructing a discussion platform for the ways in which political, technical, and social dimensions of space production can harmoniously work to create truly climate responsive urban built environments. The ultimate aim of the conference was to bring international academics working on climate change together in a shared platform as well as bridge academia with urban planning practice. The call for papers attracted a wide range of contributions from social sciences, particularly from the fields of urban design, urban planning, and architecture. Thirty contributions from international scholars were selected after a rigorous review process by the scientific committee.

The conference hosted two keynote speakers. Professor Gerald Mills, from the University College Dublin, traced the development of urban climatology and its integration with global science by drawing on examples from different cities. He emphasized the urgency of transforming global climate change policies into forms appropriate to the distinct character of individual cities. Professor Simin Davoudi, from Newcastle University, drew attention to the concept of resilience in the face of climate change. She elaborated on "evolutionary" and "relational" meanings of resilience by discussing different approaches to spatial planning.

The contributions from the conference participants address themes related to different scales of space production such as thermal comfort, urban micro-climate, urban heat island, nature-based solutions, and governance of climate responsive urbanism. This volume includes select proceedings presented under different themes. The contributions by Dursun & Yavaş, Mutlu et al., and Toparlar et al. focus on the ways in which urban design and landscape attributes influence micro-climatic conditions, as well as the energy demand in different climatic contexts. The contributions by Bakovic, Ödül & Kuşçu-Şimşek, Işık & Kuşçu-Şimşek, and Diren-Üstün cluster around the digital simulation tools useful for modelling current climatic conditions or future climate change scenarios. Topaloğlu & Kayasü's contribution focuses on energy efficiency in existing housing stock through the use of clues from vernacular architecture. The contributions by Burat and Salmon & Yepez elaborate on the capacity of urban planning and urban design projects in terms of adaptation to climate change. Lastly, Maria Federica Palestino et al.'s contribution focuses on how the attitudes of the government and the media effect climate responsive space production.

I would like to take this opportunity to thank all the members of the scientific committee of the conference, keynote speakers, session moderators, and attendees for their continuous support, contributions, and cooperation in making the conference successful and memorable. I hope that future conferences on climate responsive cities will be as stimulating as this recent one was, as the contributions presented in this proceedings volume indicate.

Dr Ender Peker

KEYNOTE SPEAKER: PROFESSOR GERALD MILLS



URBAN AND GLOBAL SCALE CLIMATE SCIENCE

Abstract

Historically, the impact of cities on climates (and vice versa) has been studied from two perspectives. At the scale of individual cities, the scientific study of the urban climate is nearly 200 years old. However, significant progress has only taken place in the last about 40 years as the principles of atmospheric science have been applied, knowledge has been built through careful experimental design and descriptions of the urbanized landscape have improved. We now have a far better understanding of how cities effect climate at micro- to urban scales, and there are many models available that can simulate aspects of this urban climate effect. More recently, at the global scale, cities have been identified as major drivers of climate change and as places that are especially at risk from the projected changes, such as sea-level rise and warming temperatures. This recognition has made cities a key scale for both climate change mitigation and adaptation policies. In this talk, I will discuss the development of urban climatology and its integration with global climate science; I will draw on examples from different places to demonstrate that global climate change policies must be appropriate to the distinct character of individual cities to be effective.

Biography

Gerald Mills is a physical geographer with an interest in urban environments, especially the effects of cities on climate and vice versa. He studied Geography at UCD, Dublin (Ireland) and graduated in 1984. He completed a PhD at The Ohio State University, where he studied GIS and Climatology; his dissertation topic was on the climates of streets. He worked for 7 years in the United States, mostly in Geography at UCLA, California. He returned to Ireland and UCD in 1997 where he has remained. He teaches in the areas of quantitative methods, climatology, GIS and environmental issues. His research work since the mid-1980s has focused on urban climates using observations and modelling and on the application of urban climate knowledge to urban planning and design. Most recently, he is working with others on the WUDAPT project, which has the objective of gathering information on cities globally that can be used to support climate studies. He is a co-author of Urban Climates, which attempts to provide a modern synthesis of urban climate science. He has been a member of the International Association for Urban Climate since its formation in 2000 and has acted as editor of its newsletter and as President.

KEYNOTE SPEAKER: PROFESSOR SIMIN DAVOUDI



EVOLUTIONARY RESILIENCE, RELATIONAL SPACE AND ADAPTIVE PLANNING

Abstract

We live in a complex and uncertain world which, among other things, is faced with climate breakdown with unknown and potentially catastrophic consequences. Governing uncertainties is particularly challenging for spatial planning which is primarily a future-oriented activity. In response to this challenge, the concept of resilience has attracted a growing attention and become a keyword of our time. But, what does resilience actually mean, and how is it interpreted in policies and practices? In this talk, I unpack two fundamentally different meanings of resilience (engineering and evolutionary) and discuss how they are aligned with two different understandings of space and place (absolute and relational) and two different approaches to spatial planning (blueprint and adaptive). I would argue that the engineering interpretation of resilience is underpinned by principles that are similar to those underlying the absolute understanding of space and blueprint approaches to planning, while the evolutionary interpretation of resilience is aligned with the relational understanding of space, and the adaptive approaches to planning.

Biography

Simin Davoudi is Professor of Environment and Planning and Director of the Global Urban Research Unit (GURU) at the School of Architecture, Planning and Landscape, Newcastle University, UK. She is past President of the Association of the European Schools of Planning (AESOP) and Fellow of the Royal Town Planning Institute, the Academy of Social Sciences, and the Royal Society of Arts. She has served as expert advisor for several UK government departments, EU directorate generals, UK and European research councils and national research assessment exercises. Simin has held visiting professorships at the universities of: Amsterdam and Nijmegen (Netherlands), BTH (Sweden), Tampere (Finland), Virginia Tech (USA) and RMIT (Australia) and served on several advisory councils (such as Hong Kong University, Finland Urban Academy). She is co-Editor of the Journal of Environmental Planning and Management. Her research and publications cover various aspects of urban planning, environmental governance, climate change and resilience. Selected books include: The Resilience Machine (2018 Routledge), Routledge Companion to Environmental Planning (in press), Justice and Fairness in the City (2016 Policy Press), Reconsidering Localism (2015 Routledge), Town and Country Planning in the UK (2015 Routledge), Climate Change and Sustainable Cities (Routledge 2014), Conceptions of Space and Place in Strategic Spatial Planning (Routledge 2009), Planning for Climate Change (Earthscan 2009), and Planning, Governance and Spatial Strategy in Britain (Macmillan, 2000).

THERMAL COMFORT EFFECTS OF NEW URBAN DEVELOPMENT PROJECTS:THE CASE OF ERZURUM

Doğan Dursun, Ataturk University, Department of City and Regional Planning
Merve Yavaş, Ataturk University, Department of City and Regional Planning

ABSTRACT

The main objective of this study is to explore the consistencies between the urban patterns of new high-rise urban development projects Şehristan and Yeşil Yakutiye residence and the cold climate conditions in Erzurum, Turkey. This study aims to produce a thermal comfort model of these two new high-rise housing projects and determine the level of sensitivity of their urban design projects to climate conditions. It questions whether the urban patterns in and around the housing areas eliminate the winter disturbances and the capability of these new urban developments to transform outdoor space into a center of attraction. In this context, the case study was conducted in the winter period. ENVI-met, a software designed to simulate the surface, plant, and air interactions of an urban environment, was used. The findings show that while Şehristan is not compatible with cold climate conditions and creating cold stress for the environment, the Yeşil Yakutiye project has a slightly better score in terms of thermal comfort due to its larger open spaces. Both of the projects do not take advantage of the existing climate conditions and instead create uncomfortable outdoor environments discouraging residents from spending time outdoors.

Keywords: thermal comfort, urban design, Şehristan, Yeşil Yakutiye, Erzurum

1. INTRODUCTION

Human activity and built environment, in addition to the geographical location and local climate of cities, determine the characteristics of urban climate. It is a well-known fact that urban design parameters and practices influence urban microclimates. There are many studies in the literature focused on the effects of different urban design parameters on microclimate for specific urban spaces. Most of them are focused on individual design parameters such as street orientation, street width, aspect ratios, building and pavement materials, and vegetation. In general, those issues are separately taken into consideration in each study, but a different method based on comparative assessment is needed for climate-related studies due to the complexity of determinants on urban climate. Many different kinds of design parameters such as sealed surfaces, green areas, height of the buildings, street orientations, materials on building surfaces, and width of streets affect relevant meteorological indicators such as temperature, direction and speed of wind, evaporation, humidity, and sunshine duration. These parameters may have both negative and positive effects on the local climate. They can create heat or cold stress in urban environments and make it feel climatically uncomfortable. The effects of multiple urban design parameters on microclimate for one specific open space are tested in the context of this study. The analysis is made with the help of the simulation program ENVI-met, which works with digital versions of built environments and climatic data. As it is stated in the literature, software may not fully simulate an urban environment due to its complex structure. However, these programs may provide comparable results of the existing and simulated microclimatic conditions associated with the design parameters. These programs provide a chance to evaluate the expected effects of different design solutions for one specific area in terms of pedestrian comfort.

This case study tests the negative and/or positive effects of new high-rise housing projects in the center of Erzurum (Şehristan and Yeşil Yakutiye) on thermal comfort and demonstrates the climatically sensitive or insensitive urban policies of decision makers in new development areas. With this aim, temperature, predicted mean vote, sky view factor, and mean radiant temperature were tested for these areas in terms of climatic comfort. In this context, the study concentrated on different urban design strategies in order to show the thermal comfort level of new high-rise urban development projects in Erzurum in the winter period. The height of the buildings, plantation, grass surfaces, and difference in spatial

proportions of different materials were the design strategies considered and tested in this study. The ENVI-met model is utilized to characterize and show the microclimate conditions under the influence of different spatial organizations of residential areas.

2. METHODOLoGY

The method is based on the microclimate simulation for a specific urban environment with the help of the software. It includes land use and local climate data containing both surface materials (grass, soil, asphalt, concrete), height of the buildings in the surrounding area, vegetation, air temperature, air humidity, mean radiant temperature, surface temperatures, and speed and direction of wind in both Şehristan and Yeşil Yakutiye project areas, which are in the most densely populated districts of Erzurum. As there are no microclimate stations in that part of the city, the meteorological input data were obtained from the surrounding Erzurum Meteorological station. The climate data obtained in urban areas from 2018 were used. Erzurum is located in the eastern part of Turkey with an elevation of 1,850 meters. According to the Köppen Climate Classification system, Erzurum has harsh continental climatic conditions, in which residents experience long, cold winters and hot, short summers. In order to simulate the climatological situation of the selected area of Erzurum, the program ENVI-met was used. ENVI-met is a microclimate simulation software giving information about the effects of vegetation, green area, and structure of the city on the microclimate (www.envi-met.com; Bruse, 2004). For the microclimatic simulation of new high-rise residential areas, the current structure of the place was defined in the software and tested. In the context of this study, the existing situation of the project areas were tested with the aim of demonstrating the effect of new residential districts' design on thermal comfort. New urban design scenarios were not suggested in this study.

3. THE SITE and SIMULATION TOOLS

3.1. The Site

Residential districts are important parts of urban physical environments as their functions determine both the quality of life and identity of a city for inhabitants. Their designs and geometric proportions affect microclimates and functionalities and thus lead to differences in social, economic, and environmental outcomes. In this context, new urban development areas (Figure 1 and 2) containing high-rise residential buildings located in the center of the city of Erzurum were selected as the focus of this study.



Figure 1. Satellite Image of the Erzurum City Center and Study Areas

Şehristan and Yeşil Yakutiye Dwelling Projects are large residential projects in the area of the city with the highest population and built density. Both of the project areas are located in the center of the city and identified as urban transformation projects aiming to change ruined urban regions into high-quality living spaces. These areas cover approximately 32,000 m² and 43,000 m² and contain open spaces, green areas, streets, and high-rise buildings. They are located in the area of the city with the highest population and built density.





Figure 2. Satellite Image of the Şehristan and Yeşil Yakutiye Dwellings

Şehristan is a transformation project changing from public property to private property (the land formerly belonged to the general directorate of rural services). Yeşil Yakutiye is located in the historical settlement area. Both projects have building typologies not found in most parts of the city center. The majority of the open spaces in residential clusters consist of hard pavement and vegetation. Heights of the surrounding buildings vary, with mid- and low-rise buildings mixed together. The effects of the shade from the north-facing high-rise buildings in combination with the hard pavement in public spaces induce pedestrian discomfort, especially in the winter period.

3.2. Modelling in ENVI-met v4.1

ENVI-met is a software developed for simulating the climatic conditions in specific urban environments by considering surface materials, vegetation, built environment, and climate data. In this program, users enter the data to build a three-dimensional model of their case study area by adding buildings, vegetation, and surface materials to a 3-D grid to make a simulation of microclimate conditions in a specific environment. As stated by Bruse, when the 3-D model of the case area and climatic data were entered, the ENVI-met calculates main wind flow, temperature, humidity, and turbulence by using a full 3-D predictive meteorological model (2013). This model is employed in many studies related to urban climate in recent years. They are mainly concentrated on modelling urban microclimate conditions (Bruse and Fleer, 1998); measuring the effect of green areas on urban climate; evaluating thermal comfort in outdoor spaces; and simulating air pollution (Lin et al., 2016). In order to test the accuracy of the simulation results, most of these studies made evaluations based on the comparison of measured and simulated values. This method also helps to see the suitability of input parameters. As indicated in the previous studies, rational predictions can be produced with the help of this model for different complex urban environments (Lin et al., 2016). In addition to this, ENVI-met software supports researchers in making a simulation of various design possibilities and providing an opportunity to assess their positive and negative effects on urban climate.

The model has been preferred for simulations due to its ease of use, availability, and reliability (Bruse, 1999). Moreover, researchers can evaluate urban microclimatic changes along with thermal comfort and mean radiant temperature (MRT) by means of this model. The results of ENVI-met demonstrate how the micro climate changes with different influences such as buildings and vegetation. In order to investigate and assess outdoor thermal comfort, the model can be evaluated as a useful instrument. After setting the climate data (temperature, wind speed, wind direction, humidity, relative humidity) on the program, ENVI-met has three stages for the simulation. At first, modelling of the case study area is completed. Secondly, the configuration is set. And finally, the performance of the model is assessed.

In the context of this study, all the ENVI-met tests are applied in the case of the Şehristan and Yeşil Yakutiye projects. Each cell has been set with a dimension of 2(x) x 2(y) x 2(z) meters. The core area was measured approximately 3 ha for Şehristan and 4 ha for Yeşil Yakutiye. The whole simulation area was almost 7 ha with an area input file of 60×60×30 grids. In order to model this environment with references, development and topographic maps and aerial photos of the city were utilized. With the help of these maps and our fieldwork, the land use of each grid cell was determined. If the grid cell has mixed land-use characteristics, the materials with the largest area were set in the software.

In order to reach stable results, a 38-hour simulation was run on ENVI-met. The simulation began at 00:00 (15.01.2018) with continuous time intervals every hour. In order to get a more accurate result in the ENVI-met simulation, the results from the first eight hours were discarded. Climate data were obtained from the weather station located in the Erzurum city center, which is approximately 1 km and 2.5 km, respectively, west of the case study areas. For an assessment of the current conditions of the residential areas, two simulations have been examined for cold winter conditions.

4. RESULTS

Air temperature (°C), relative humidity (%), wind direction, and wind speed (m/s) were collected from the area of study on January 15, 2018. The air temperature on the measurement day in both Şehristan and Yeşil Yakutiye Project areas was very low. This is due to the cold winter season in Erzurum and the structure of the built environment in the case study areas (Figure 3 and 4). When the simulation is analyzed, it is observed that building structures in the projects are creating shadow and decreasing air temperature. The dark areas in the simulations show the high levels of thermal stress. The whole area has lower comfort levels, but the dark areas have extreme cold stress. Comparing the new building structure in the project areas, Yeşil Yakutiye is more comfortable than Şehristan and has

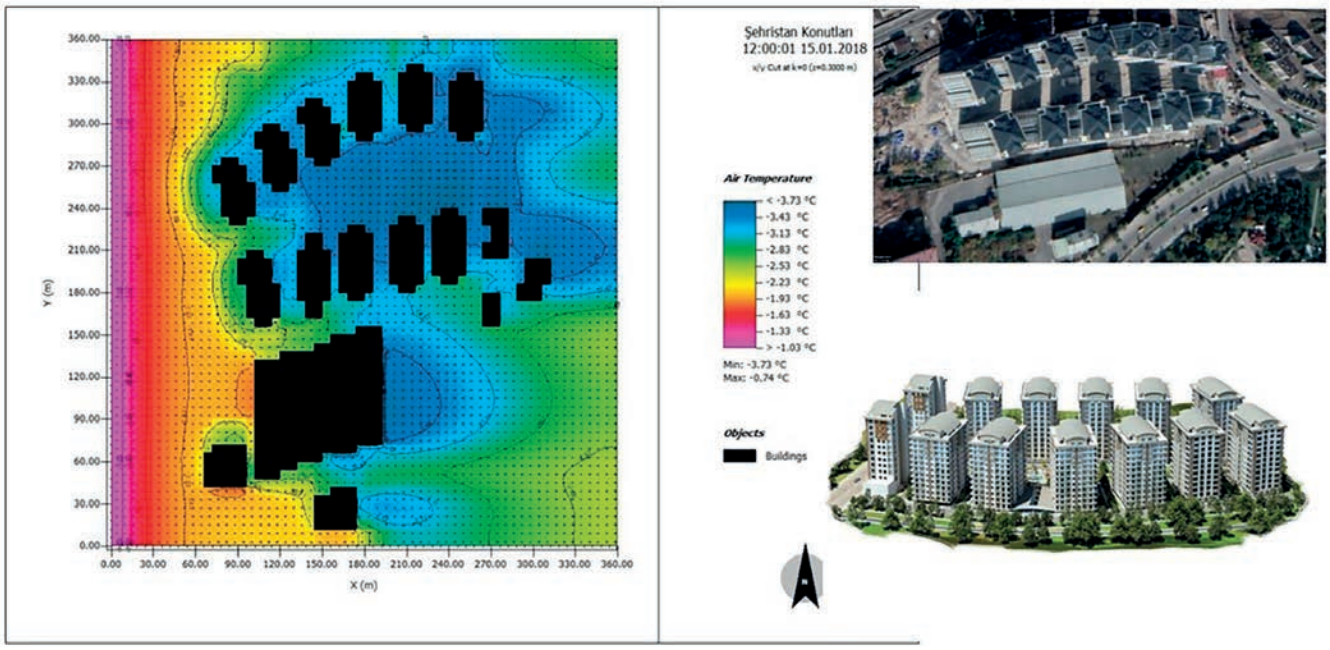


Figure 3. ENVI-met Simulation for Şehristan Project

less thermal stress. The heights of the buildings in the clusters, especially on the south side, are not conducive to the climate conditions and geographical position. These samples show that the urban design solutions for new high-rise housing projects produced negative results in terms of thermal stress. The simulations show the increase of problem areas and also show that both designers and the responsible authorities should consider a cold climate sensitive perspective when renewing the urban design of the area. Interestingly, municipalities have been constructing these urban transformation projects in the city center for five years and producing new high-rise residential clusters. Although transformation projects are opportunities to create livable, sustainable, and climate-sensitive urban areas, these cases display that such projects often create climatically insensitive urban spaces.

In addition to microclimatic analysis, ENVI-met evaluates outdoor thermal comfort. This is why it observes the Predicted Mean Vote (PMV) among its output data (Fanger, 1970). The PMV index was developed to analyze indoor environments and is generally used in the field of biometeorology (Johansson et al., 2014; Thorsson, Lindqvist, & Lindqvist, 2004), but later it was adapted to the outdoor environment. It is based on the methods predicting the mean response of a larger group of people according the ASHRAE thermal sense scale based on a seven-step scale ranging from –3 (cold) to +3 (hot). In this range, 0 represents neutrality. When the PMV index is calculated, air temperature, relative humidity, mean radiant temperature, wind speed, metabolic rate, and thermal clothing insulation are essential parameters. In order to test the accuracy of the index, a field

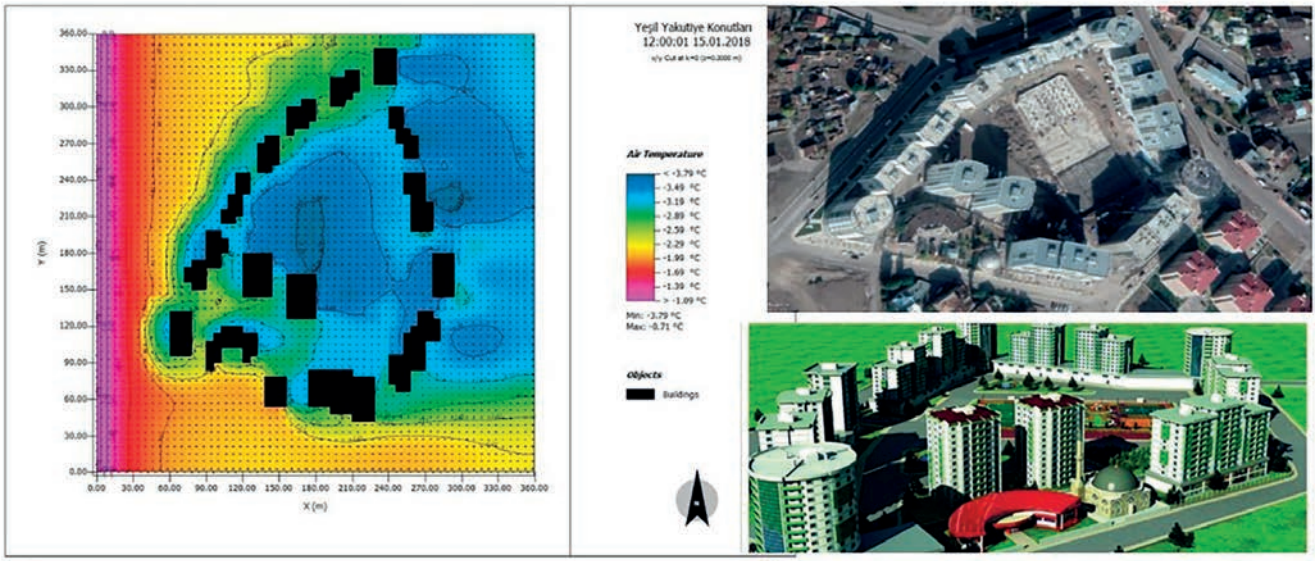


Figure 4. ENVI-met Simulation for Yeşil Yakutiye Project

survey and a questionnaire study were conducted. The software's predictions on microclimate were tested according to participants' thermal perception. In the survey process, people were asked to state their thermal perception as it is defined through ASHRAE seven-point scale (ASHRAE 55, 2010) as cold (–3), cool (–2), slightly cool (–1), neutral (0), slightly warm (+1), warm (+2), and hot (+3). Those categories are the same in the PMV index thermal stress level (Table 1). Participants included personal information on their gender, age, weight, height, time of exposure, clothing, and activity while they participated in the survey. This study was conducted in the same location where the meteorological measurements were made. Participants' distance of less than 3 m to the measurement point was the criteria for selecting participants (Spagnolo & de Dear, 2003; Xi, Li, Mochida, & Meng, 2012), and height of 1.1 m was the micrometeorological measurement level (ISO, 1998). The PMV results were tested according to the answers given by the interviewees by considering their metabolic rate and clothing. These two parameters were used in the thermal comfort simulation. As Olesen and Parsons (2002) stated, participants were standing (with metabolic rate of 70 W/m^2) and had a thermal clothing insulation of 0.57 clo (clothes thermal insulation) for summer and 1.14 clo for winter.

In the context of this study, PMV simulations were made for both areas in order to evaluate outdoor thermal comfort. According to the PMV results, both areas experience thermal stress, but Yeşil Yakutiye experiences less thermal stress than the Şehristan Project (Figure 5. and 6.).

Table 1. PMV Index Thermal Stress Levels (Matzarakis et al. 1999, p.77)

PMV (CO)	Thermal Sensation	Thermal Stress Level
→-3.5	Very Cold	Extreme cold stress
(-3.4) - (-2.5)	Cold	Strong cold stress
(-2.4) - (-1.5)	Cool	Moderate cold stress
(-1.4) - (-0.5)	Slightly Cool	Slight cold stress
(-0.4) - 0.5	Comfort	No thermal stress
0.6 – 1.5	Slightly warm	Slight heat stress
1.6 - 2.5	Warm	Moderate heat stress
2.6 - 3.5	Hot	Strong heat stress
3.5 +	Very hot	Extreme heat stress

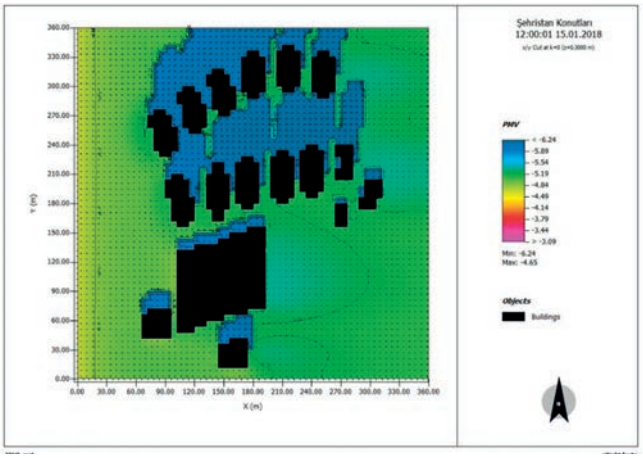


Figure 5. Predicted Mean Vote Simulation for Şehristan Project

As seen from the PMV simulation, both the Şehristan Project and the Yeşil Yakutiye Project areas experienced extreme cold stress on this selected day in January.

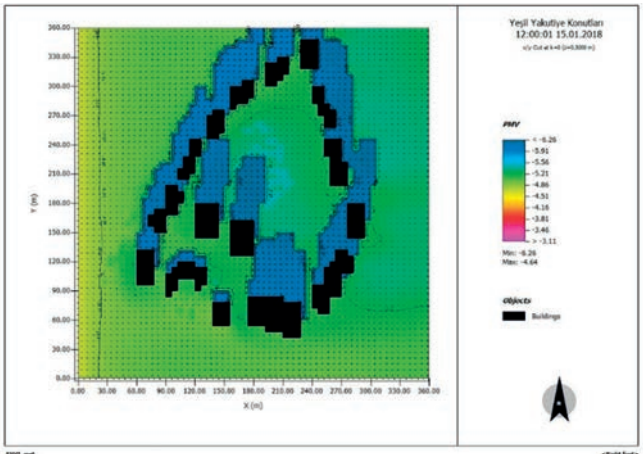


Figure 6. Predicted Mean Vote Simulation for Yeşil Yakutiye Project

Sky view factor (SVF) is the geometry-related indicator showing the impact of insolation on urban climate. Urban geometry is one of the most important factors determining the urban climate and outdoor comfort. Sky view factor shows the ratio of sky visible in the middle of the street (Milosovicova, 2010). SVF is a measure between 0 and 1. When the ratio is equal to "0," there is no building and no sunlight, and insolation is absorbed and later released toward the sky. The higher the ratio of SVF, the lower the heating of the urban environment. A higher ratio SVF restricts the release of heat into the atmosphere at night and slows down the night cooling of the urban environment. SVF values can be calculated by the ENVI-met software. Mapping of the SVF for the two case studies are illustrated in Figure 7, with the lighter green corresponding to higher SVF values.

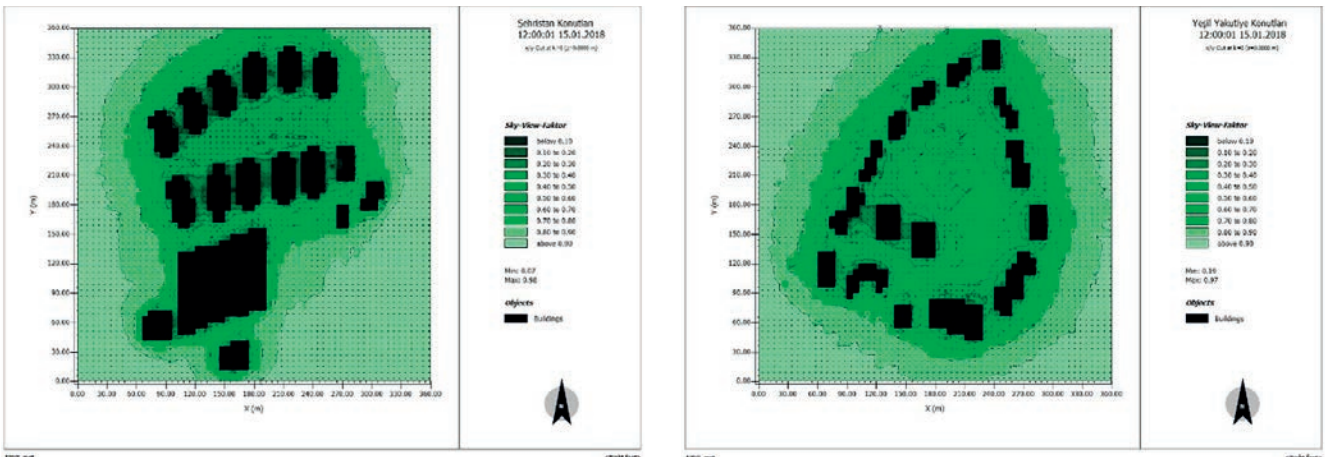


Figure 7. ENVI-met Simulation of Şehristan and Yeşil Yakutiye-SVF

In Şehristan, the SVF values inside the courtyards are low and range between 0.3-0.4. They are a bit lower between buildings, ranging from 0.1 to 0.2. Yeşil Yakutiye has better SVF results than Şehristan due to the cluster design. The SVF values at the courtyard are as high as 0.6. It is 0.4 between buildings. The SVF analysis showed that these two places have similar urban design parameters, i.e., cluster designs, but different SVF values due to distances between buildings. H/W ratio is also a geometry-related indicator impacting urban climate. In the H/W ratio, while H shows the height of the buildings, W displays the spacing (width) between them. The value of this ratio demonstrates how much sunlight and radiation reaches the street and heats the air near the ground. The ratio of the height of the buildings and distances between them is different in the case study areas. While narrow shared spaces and high-rise buildings (12 floors) characterize Şehristan, wide common spaces and buildings of various heights (9-10-11-12 floors) are seen in Yeşil Yakutiye.

In climate-based studies, solar insolation is an important factor in determining human thermal perception. It has critical effects on microclimate conditions. In human bio-meteorological research, solar insolation is often quantified in terms of the mean radiant temperature (MRT). It integrates all short- and long-wave radiation fluxes. ENVI-met software calculates MRT results. In this study, MRT is calculated for two case study areas to see and evaluate the solar radiation in the winter period (Figure 8.).

According to the results, while the average Mean Radiant Temperature in Şehristan is 27°C, it decreases to 10°C in shadowed areas. Although the Yeşil Yakutiye case has produced similar MRT results, the Şehristan Project is worse than the Yeşil Yakutiye due its abundance of shadowed spaces.

The findings show that while Sehristan project is not compatible with cold climate conditions and creates cold stress for the environment, the Yeşil Yakutiye project has a slightly better score in terms of thermal comfort due to its larger open spaces. Both of the projects are not taking advantage of the existing climate conditions and create uncomfortable outdoor environments discouraging residents.

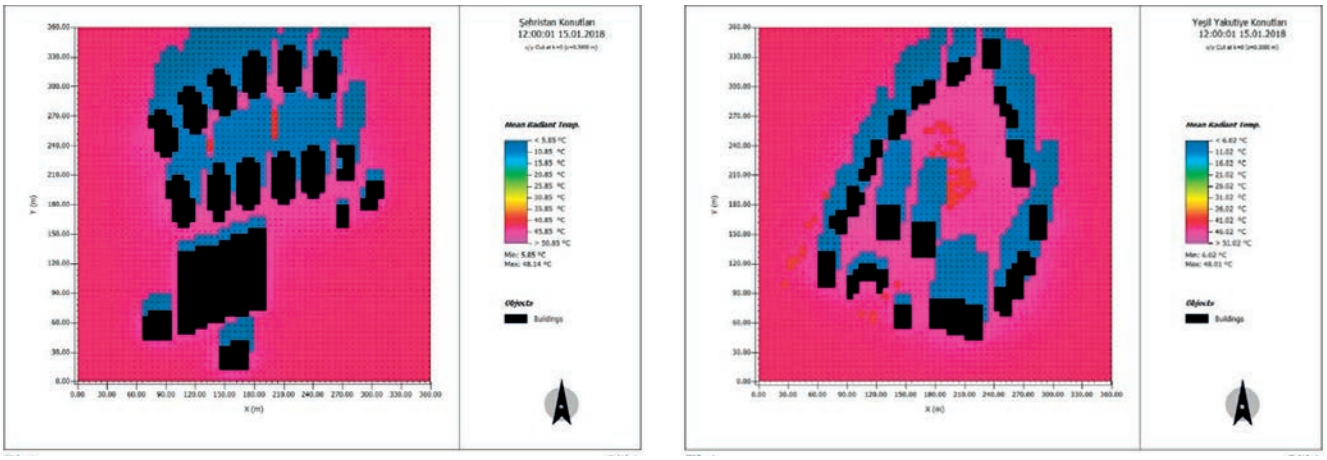


Figure 8. ENVI-met Simulation of Şehristan and Yeşil Yakutiye-TMRT

5. CONCLUSION

In the context of this study, micro-climatic simulations of new high-rise residential clusters in the historic center of Erzurum were made and evaluated. The findings showed deteriorating thermal comfort in this area. Urban design parameters can have specific environmental effects that are both measurable and predictable; knowledge of these can help improve decision-making on the design of open spaces in urban environments. This analysis showed that the heights of the buildings in the projects, especially in the case of Şehristan, are not consistent with their climate conditions and geographical position. Şehristan and Yeşil Yakutiye are both new urban transformation projects, and their climate conditions should have been carefully considered. New development projects should have to consider these conditions. New urban transformation projects are big chances for a more sustainable and comfortable future and should offer new insights for cities. The urban design of the case study area should be revised according to the winter city perspective. Otherwise, we are adding new problems to the problems of the past.

In light of the results from the simulation of these high-rise residential complexes, some urban design suggestions can be proposed with the aim of reaching better thermal comfort levels in these areas. Three types of small interventions can be proposed to improve the microclimatic of the urban environment in the area of study. The first intervention is the complete replacement of the concrete pavement with similar cool materials such as grass and granite stone. The second one is the increase of the amount of trees (approximately 15 meters tall) in order to block winter winds and create shading canopies. Generally, the effect of shading and blocking canopies is most effective in the summer at noon and in winter days. Therefore, trees are used to block winter winds and to create shades in summer. The third intervention is the addition of social spaces in the public spaces of the complexes. These implementations can create attractive places and positive social effects in the cold winter days, but they can also add visual quality, light, and air circulation in the open spaces. These interventions can potentially improve the air temperature and comfort indices. By using climatic simulation software such ENVI-met, these effects become both measurable and predictable. This study and the information provided will help decision-makers to create climatically comfortable urban environments and will improve the design of residential districts in urban environments. Further studies should be made with more design proposals, and their simulations should be reproduced to test the conditions creating better thermal comfort in urban environments.

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ENVI-MET ANALYSIS OF THE EFFECTS OF BUILDING AND PLANT DESIGN ON THERMAL COMFORT IN COLD CLIMATE ZONES

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ABSTRACT

Architectural structures and exterior cladding are often carried out without considering the climatic characteristics of cities. The architectural structure of the city often deviates from the cultural texture, as do roof and material preferences, thereby consuming more energy. With this study, the thermal comfort relationship between the building and the plant design in Erzurum, which is located in the cold climate region in Turkey, was analyzed using ENVI-met. For this purpose, the building of the Faculty of Architecture and Design at Atatürk University, which is a new building, was used. The measurements for the study were taken on November 2017. Predicted Mean Vote (PMV) maps were created to show the current status of the building and five different scenarios.

According to the results of the analysis, the most comfortable result for winter months, with 0.2 °C air temperature difference, was due to the presence of broad-leaved and coniferous trees. Plants increase thermal comfort, especially in places in which they cut wind speed in winter months. In order to create a thermally comfortable area in urban spaces, the number of plants should increase, and the right plant design should be made.

Keywords: Outdoor thermal comfort, building, plant design, ENVI-met and PMV, Erzurum

1. INTRODUCTION

Global warming is a major concern for the entire world, especially since it has shown severe effects earlier than expected (Brysse et al., 2013). Especially in the tropics, the increase of air temperature, natural disasters, solar radiation, and humidity have caused thermal disturbances (Niu et al., 2015). Considering that urban heat island effects are felt more in urban areas than in rural areas, designs for outdoor thermal comfort are of great importance (O'Malley et al., 2015; Salata et al., 2016; Sharmin et al., 2017; Middel et al., 2019). Today, studies are mostly about reducing urban heat (Gartland, 2012; Aflaki et al., 2017; Fabbri et al., 2017; Lobaccaro and Acero, 2015; Martins et al., 2016; Piselli et al., 2018; Acero et al., 2018). Some of these studies are on the positive effects of city parks (Lu et al., 2017); some of them on the cooling effects of green roofs (Al-Obaidi et al., 2014; Santamouris, 2014; Berardi, 2016). However, there are few studies on how to reduce the climatic effects of winter on cities (Chen et al., 2015; Li et al., 2016; Xu et al., 2018).

When looking at winter cities, it is important to create outdoor thermal comfort areas for people to use outdoor spaces more effectively (Jin et al., 2017; Ma et al., 2019; Xu et al., 2019). Especially in winter cities, studies on campus areas are important for increasing the comfort of outdoor spaces.

Erzurum is the coldest city in Turkey and was selected for this study for this purpose. In the Faculty of Architecture and Design at Atatürk University, which is a newly constructed building, different landscape designs were simulated for the November 2017. The analysis determined the best type or outdoor area for thermal comfort, as the landscape design affects the thermal comfort of the environment.

2. MATERIAL AND METHOD

Erzurum is the largest province in the Eastern Anatolia region, with a population of 767,848 (Anon., 2019). Looking at the temperature for the last 90 years in the city of Erzurum, the highest air temperature was recorded at 36.5 °C, and the lowest air temperature was recorded at -37.2 °C (MGM, 2019).

2.1. Material

The Faculty of Architecture and Design is located at 39°53'35.72"N and 41°13'51.31"E (Figure 1). The construction of the building was completed in 2017. The Faculty of Architecture and Design is located in the West campus of Atatürk University.



Figure 1. Study area location map (Google Earth, 2019)

2.2. Method

The coldest day in the area of study in November 2017 was selected, and measurements were taken with the WS300 measurement device within a 24-hour period. In November 2017, the building's temperature and wind speed in the immediate vicinity were measured (Figure 2).



Figure 2. Temperature measuring device (WS300) and wind measuring device (TROTEC BA16)

According to the measurements taken for the study area, the situation was analyzed in ENVI-met 4.4 winter program (Bruse, 2004). In order to determine which outdoor landscape design is more comfortable for the area, different landscape designs were created and analyzed in the same program (Figure 3).

Five different scenarios were developed for the area. The following simulations were created for the field:

- The scenario where the faculty is completely asphalt (1)
- The scenario where the faculty is completely grass (2)
- The scenario where there are only deciduous plants (140 pieces) around the faculty (3)

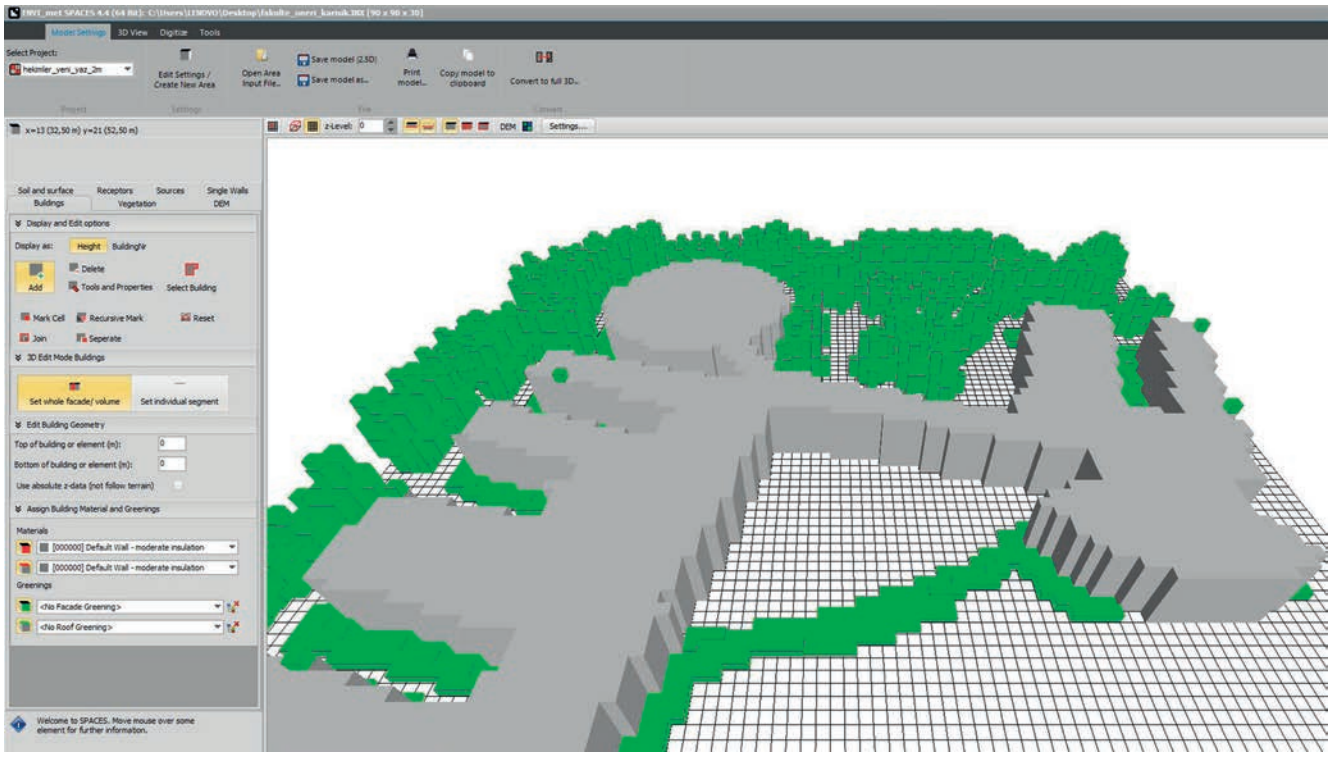


Figure 3. ENVI-met interface

- The scenario where there are only coniferous plants (140 pieces) around the faculty [4]
- The scenario where the plants around the faculty are completely mixed (coniferous, deciduous, bush and grass, 140 pieces) [5]

In the calculation of outdoor thermal comfort, ENVI-met 4.4 winter program and Predicted Mean Vote (PMV) index in the software were used as it is the last version. The second most commonly used index in outdoor thermal comfort is PMV (Potcher et al. 2018). Since PMV analysis can be done in the demo of the ENVI-met program; PMV analyzes were applied in this study. To make PMV analysis, air temperature, relative humidity, wind speed and the mean radiant temperature values should be known. In addition, average information of the people in the region where thermal comfort will be evaluated is required. With this information, ENVI-met program performs thermal comfort calculations with the method of Fanger (1972). The outdoor thermal comfort was determined according to the range of values given by Matzarakis et al. (1999) when the PMV results were evaluated. PMV thermal index ranges are shown in Table 1.

Table 1. PMV Thermal Index ranges (Matzarakis et al., 1999)

PMV Range	Thermal perception	Grade of physiological stress
← -3.5	Very cold	Extreme cold stress
-3.5 / -2.5	Cold	Strong cold stress
-2.5 / -1.5	Cool	Moderate cold stress
-1.5 / -0.5	Slightly cool	Slight cold stress
-0.5 / 0.5	Comfortable	No thermal stress
0.5 / 1.5	Slightly warm	Slight heat stress
1.5 / 2.5	Warm	Moderate heat stress
2.5 / 3.5	Hot	Strong heat stress
3.5 ←	Very hot	Extreme heat stress

3. ENVI-MET ANALYSIS

3.1. Current Situation Analysis

When the current status at 2017 November of the Faculty of Architecture and Design was analyzed in the ENVI-met program, the outdoor air temperature range was -6.1 °C at the minimum value and -1.3 °C at the maximum value. The values were evaluated at 08:00, 10:00, 12:00, 14:00, 16:00, and 18:00 and are given in Figure 4 and Figure 5.

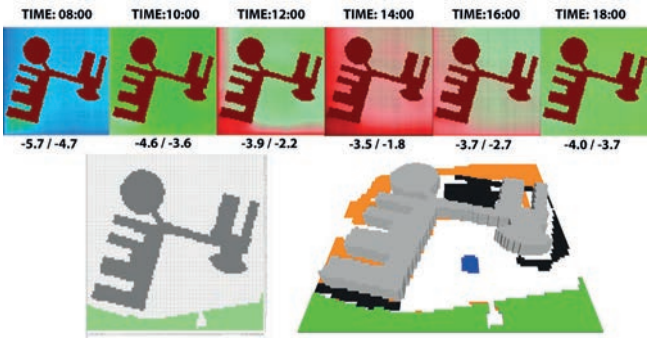


Figure 4. Current situation: hourly air temperature values and analysis interface

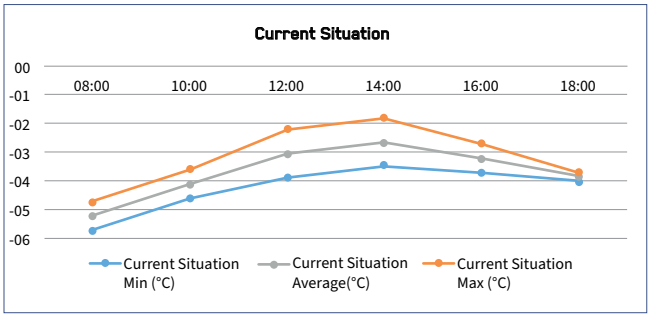


Figure 5. Current situation: hourly air temperature values

In the current situation analysis, the wind direction and relative humidity did not change much from 08:00 to 18:00, while the average air temperature was the highest (-2.7 °C) at 14:00 (Figure 6).

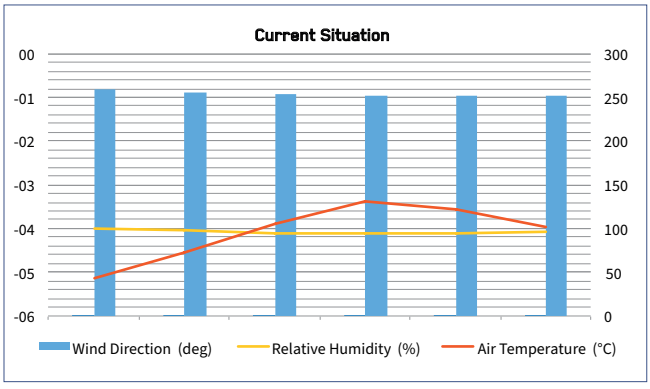


Figure 6. Current situation: wind direction, relative humidity and air temperature analysis

3.2. Asphalt Scenario Analysis

In this scenario in which the area around the faculty is completely asphalt, the average was 5.1 °C at the minimum value and -2.3 °C at the maximum value. The values evaluated from 08:00 to 18:00 are shown in Figure 7 and Figure 8.

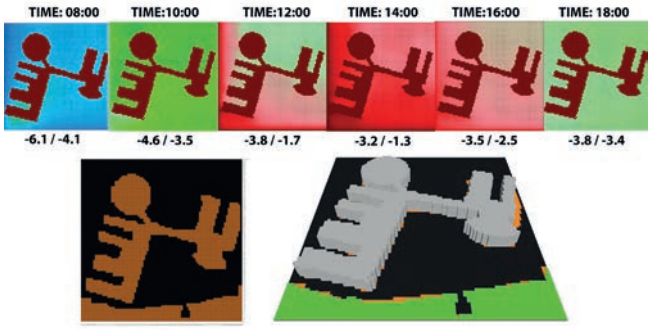


Figure 7. Asphalt scenario hourly air temperature values and analysis interface

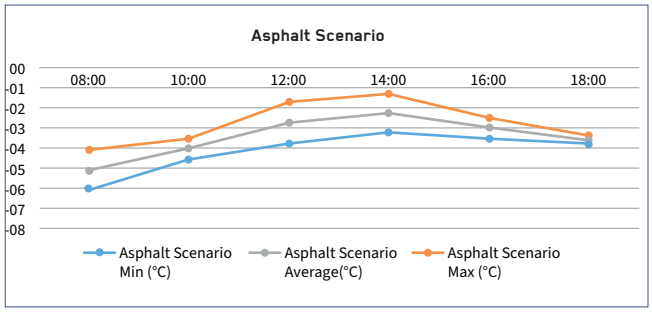


Figure 8. Hourly air temperature values in the asphalt scenario

When examining the hourly wind direction, relative humidity, and temperature graph of the analysis, the highest recorded average temperature (-2.3 °C) is at 14:00, and the other values did not change much (Figure 9).

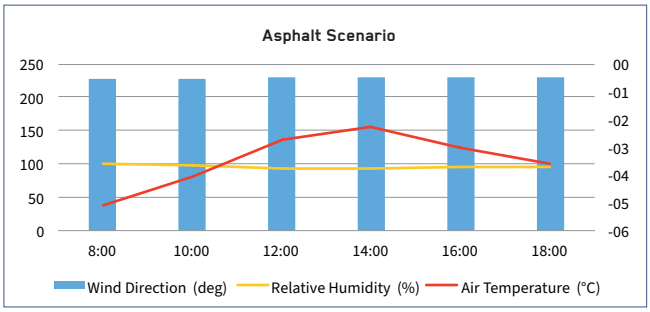


Figure 9. Asphalt scenario, wind direction, relative humidity and air temperature analysis

3.3. Grass Scenario Analysis

Looking at the scenario in which the landscape area around the faculty was completely covered with grass surfaces, the air temperature was minimum -3.5 °C and maximum -2.2 °C. Hourly temperature values are given in Figure 10 and Figure 11.

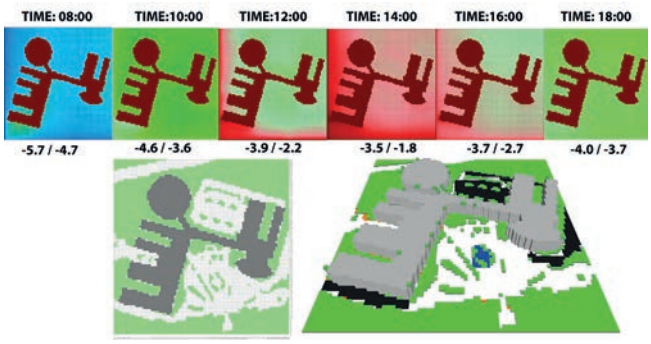


Figure 10. Grass scenario hourly air temperature values and analysis interface

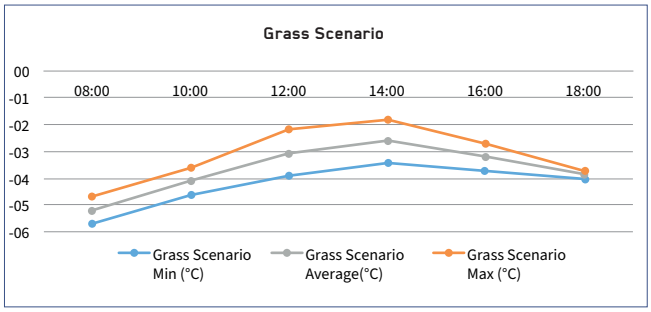


Figure 11. Hourly air temperature values in grass scenario

When the hourly wind direction, relative humidity, and temperature graph of the generated grass scenario are examined, only the temperature graph changes. The highest average temperature (-2.6 °C) was recorded at 14:00 (Figure 12).

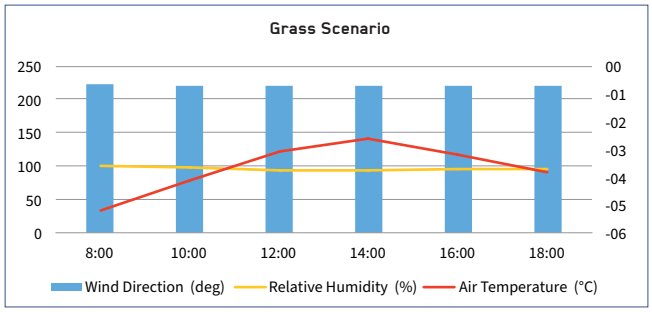


Figure 12. Grass scenario, wind direction, relative humidity and air temperature analysis

3.4. Deciduous Scenario Analysis

Among the scenarios proposed for the study area, the temperature values were minimum -3.3 °C and maximum -2.0 °C in the scenario where the faculty was deciduous. The temperature values according to the hours are given in Figure 13 and Figure 14.

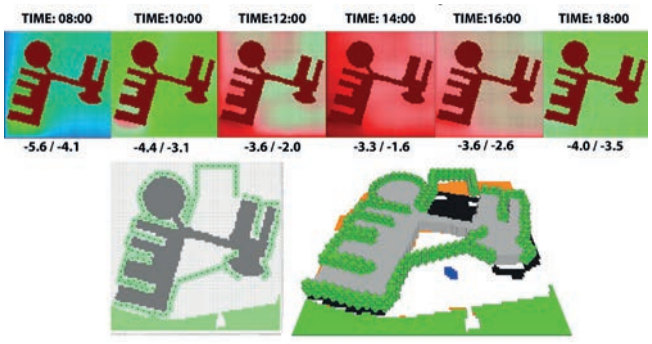


Figure 13. Decidious scenario hourly air temperature values and analysis interface

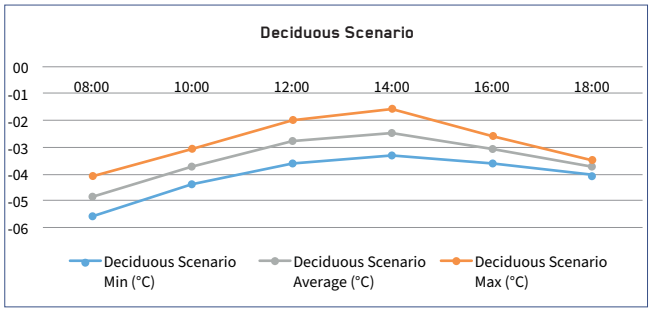


Figure 14. Deciduous scenario hourly air temperature values

When looking at the hourly wind direction, relative humidity, and temperature graph of the deciduous scenario, the temperature graph changed hourly, and there was not much change in wind direction or relative humidity. The highest average temperature (-2.5 °C) was recorded at 14:00 (Figure 15).

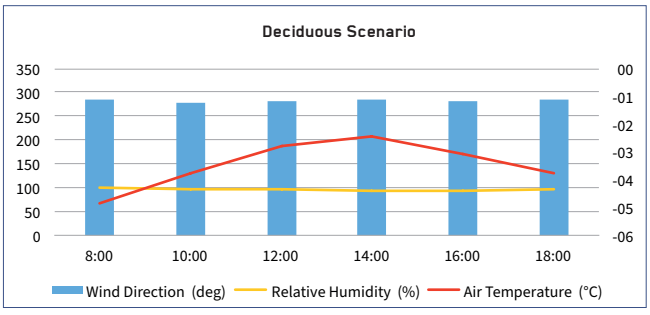


Figure 15. Deciduous scenario, wind direction, relative humidity and air temperature analysis

3.5. Coniferous Scenario Analysis

In the coniferous scenario, the temperature is minimum -3.3 °C and the maximum -2.0 °C. The graph of the hourly temperature change is given in Figure 16 and Figure 17.

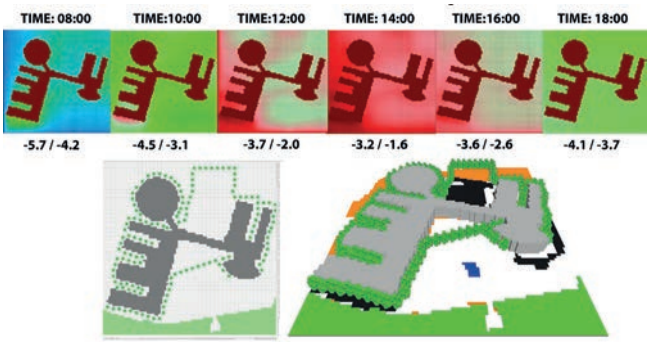


Figure 16. Coniferous scenario hourly air temperature values and analysis interface

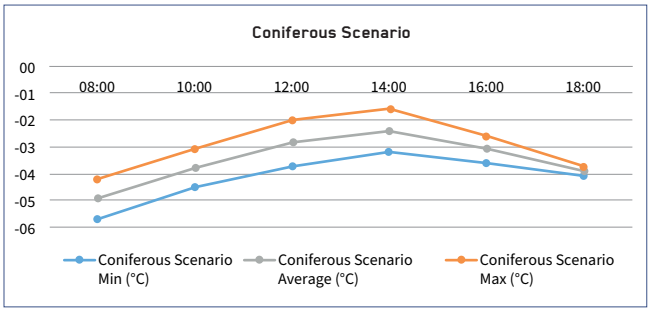


Figure 17. Coniferous scenario hourly air temperature values

When examining the hourly wind direction, relative humidity, and temperature graph of the coniferous scenario, it is seen that the temperature graph changes hourly, and there is not much change in wind direction or relative humidity. The highest average temperature (-2.4 °C) was recorded at 14:00 (Figure 18).

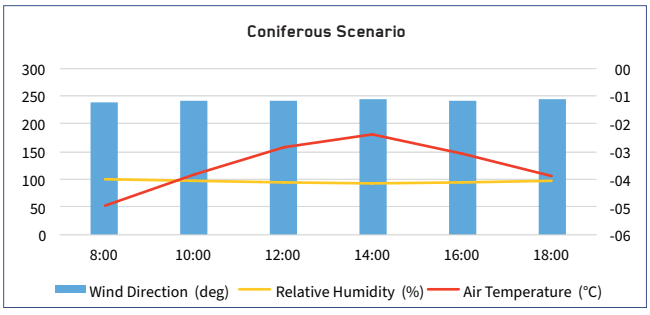


Figure 18. Coniferous scenario, wind direction, relative humidity and air temperature analysis

3.6. Mixed Type Scenario Analysis

In the case of a mixed type scenario, the temperature is minimum -3.4 °C and maximum -2.3 °C. The graph of the hourly temperature change is given in Figure 19 and Figure 20.

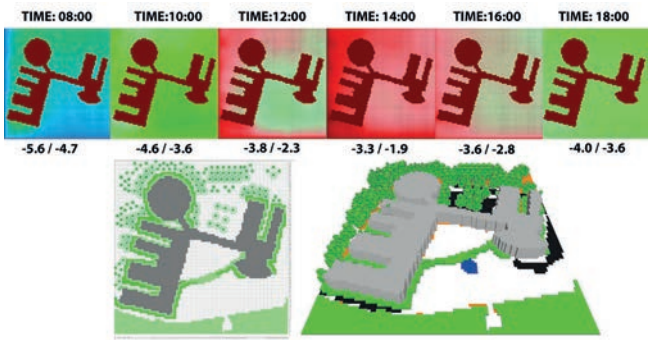


Figure 19. Mixed scenario hourly air temperature values and analysis interface

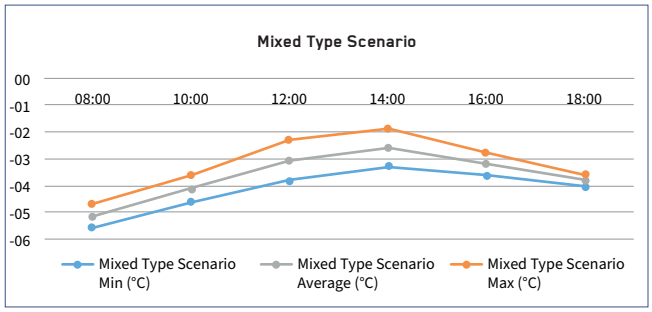


Figure 20. Mixed type scenario hourly air temperature values

When examining the hourly wind direction, relative humidity, and temperature graph of the mixed type scenario, it is seen that the temperature graph changes hourly, and there is not much change in the wind direction or relative humidity. The highest average temperature value was recorded (-2.6 °C) at 14:00 (Figure 21).

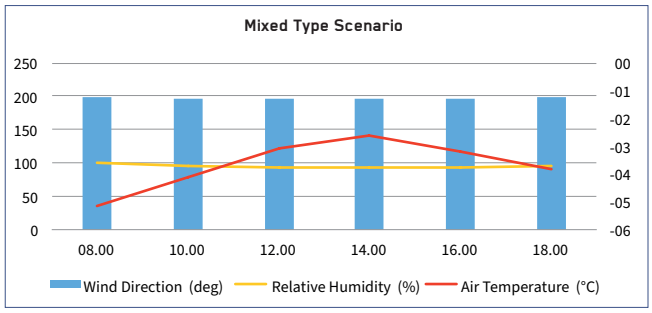


Figure 21. Mixed type scenario, wind direction, relative humidity and air temperature analysis

The results of all scenarios and the air temperature analysis of the current situation are given in Figure 22. The environment of the faculty is heated by the air temperature between 12:00 and 16:00. The warmest air temperature in the faculty is at 14:00. When looking around the building, the highest temperature is recorded in the areas of the building facades and glass surfaces on the west side.

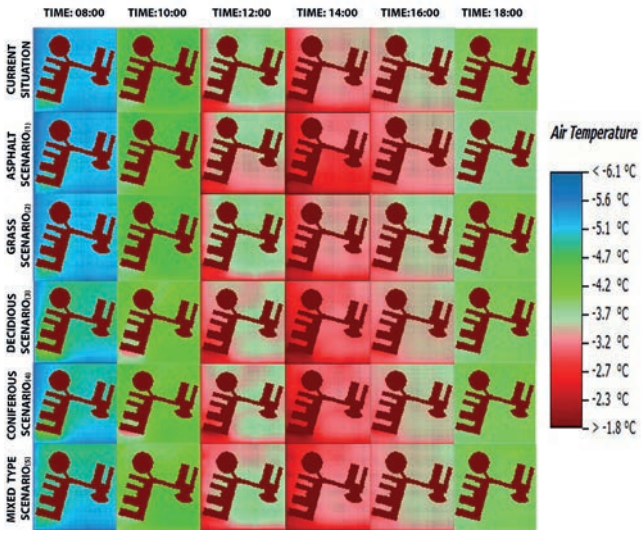


Figure 22. Hourly analysis of all ENVI-met scenarios

4. PREDICTED MEAN VOTE (PMV) ANALYSIS

Looking at the scenarios and the current situation, the wind speed and direction did not change significantly; only the air temperature changed. Therefore, in order to better understand the effects of the faculty's thermal comfort on humans, PMV analysis was performed in the area of study. PMV analysis includes all criteria for thermal comfort. This seems to be more appropriate for the reliability of the study. The PMV analysis range is based on the lowest and highest value of the results.

When the PMV analysis was examined, the most suitable time interval for thermal comfort was between 12:00 and 14:00. According to the results of the analysis of the current situation and scenarios, when looking at the minimum range values (Figure 23), the mixed type and the coniferous scenarios had the highest values (-6.2 and -6.2) at 12:00. Other scenarios were found to be 0.1 colder at the same time compared to these scenarios (-6.3).

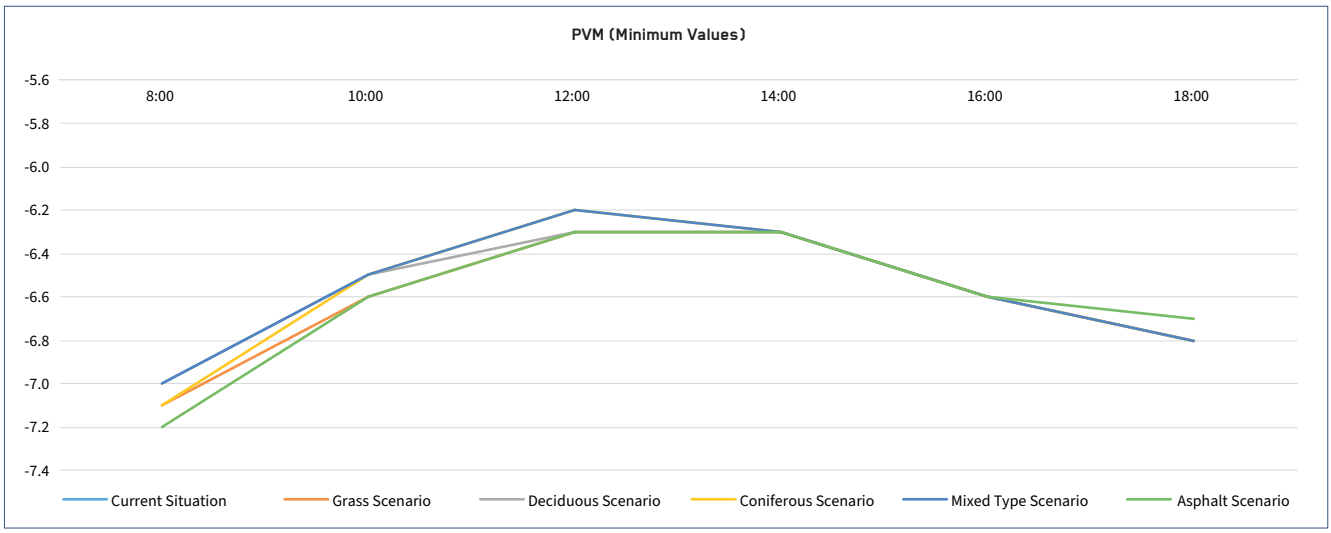


Figure 23. PMV minimum values

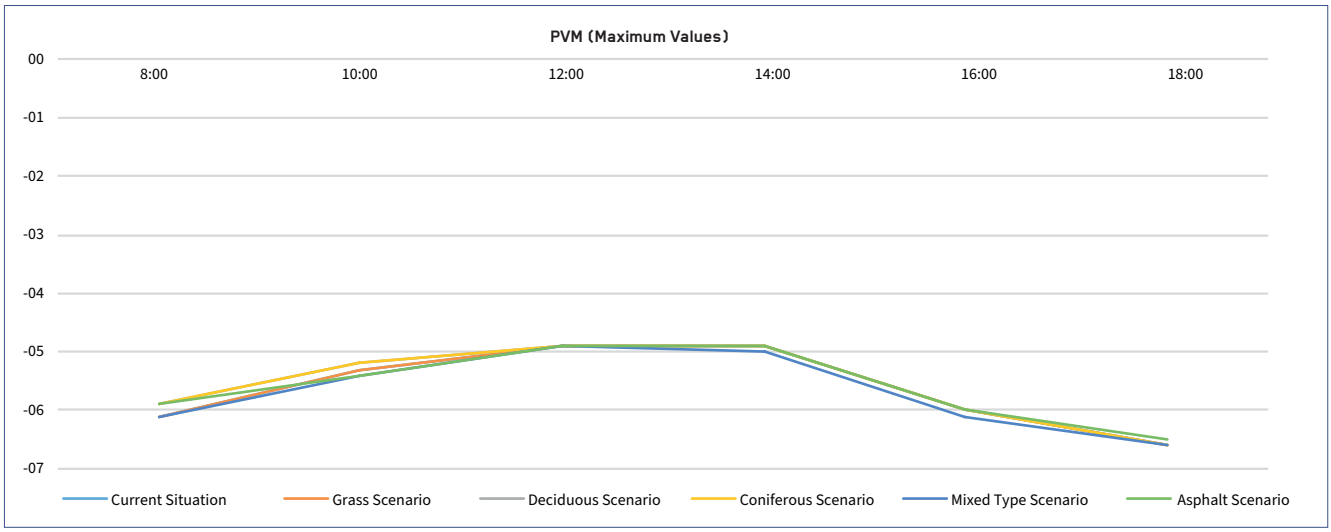


Figure 24. PMV maximum values

PMV analysis results showed that maximum values (Figure 24) were recorded between 12:00 and 14:00. All scenarios reached -4.9 at 12:00. The hottest value between 08:00 and 10:00 was recorded in the deciduous scenario and coniferous scenario.

Looking at the average PMV range (Figure 25), the highest thermal comfort area between the hours of 08:00 and 10:00 was 0.1 more in the deciduous scenario and the coniferous scenario than in the others. Between 12:00 and 14:00, all scenarios were recorded at the same temperature (-5.6). The coolest scenario for 16:00 is the mixed type scenario, while at 18:00, the best temperature is the asphalt scenario, with a difference of 0.1.

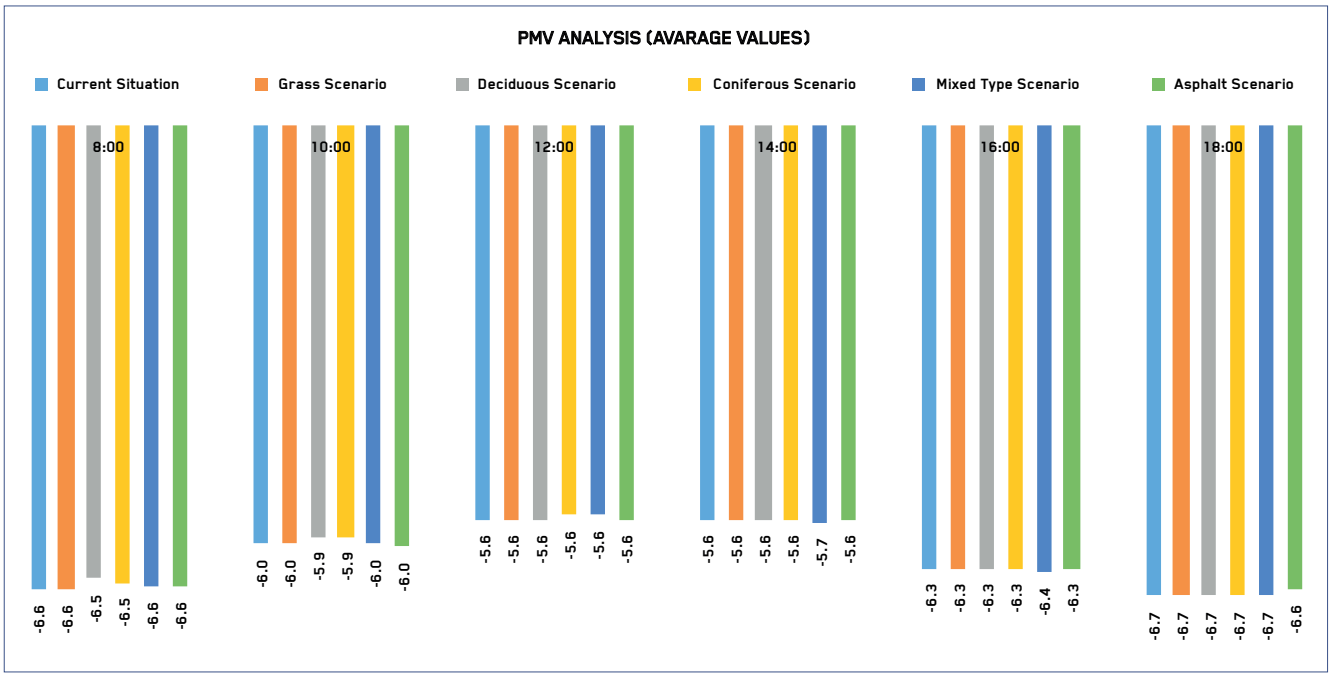


Figure 25. Average PMV values

5. CONCLUSION

According to the results of the analysis, the most comfortable hours at the faculty were between 12:00 and 14:00. The most comfortable scenarios were the deciduous scenario and coniferous scenario. In addition, the mixed type scenario is among the scenarios that are comfortable.

According to the results, vegetative design is important in terms of thermal comfort in cold winter cities. The right designs will make a more comfortable environment for people. The use of coniferous and deciduous plants is important in this respect.

The analysis shows that the environment is cooler in terms of thermal comfort during the entrance hours in which the faculty is used most intensively. In these scenarios, the use of deciduous and coniferous plants make the environment more comfortable (Figure 26). This can be explained by the fact that plants provide a more sheltered environment around the building.

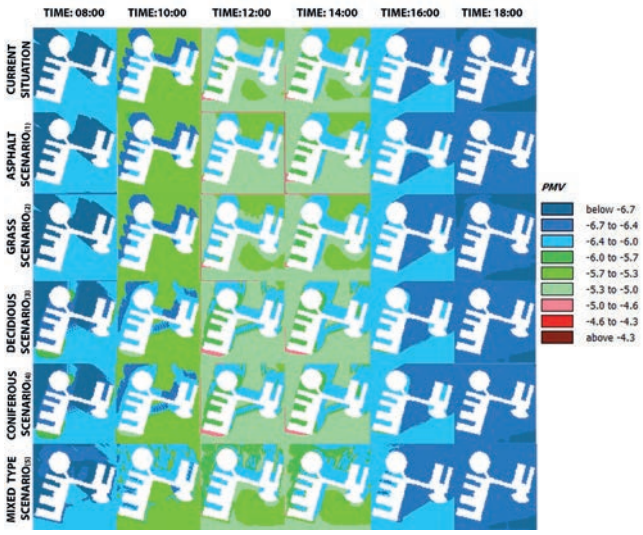


Figure 26. Hourly PMV Analysis Maps

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MORE THAN A GREEN SPACE: HOW MUCH ENERGY CAN AN URBAN PARK SAVE?

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ABSTRACT

Today, buildings are responsible for approximately 40% of the global energy demand. Among this demand, the share of space heating is larger than the share of space cooling. However, considering global climate change and rapid urbanization, the share of space cooling will possibly surpass the share of space heating within the 21st century. To counter this, engineers and designers focus on more efficient cooling systems and better building designs. An alternative way to reduce the cooling demand can be to optimize urban microclimates under which buildings operate. This can be achieved with climate responsive urban environments, such as by incorporating urban parks into urban designs. Through shading and evapotranspiration, a park can decrease air temperatures in its close vicinity; but how much energy saving can this lead to? This study focuses on the Stadspark in Antwerp, Belgium, and its surroundings up to a distance of 850 m away from the park. Computer simulations and on-site measurements were utilized for this research, focusing on July 2013. According to the simulations, the maximum park cooling effect was calculated as 3.4°C, and the effect was found to be noticeable 498 m away from the park. The result of the park cooling effect on building energy demand was determined numerically for a representative building. For this purpose, two microclimatic conditions were specified at a location (1) 80 m and (2) 400 m away from the park. Overall, the location close to the park had a cooler microclimate, which led to a maximum reduction in daily cooling demand by 43% for the representative building. Since the calculated park cooling not only affects the building investigated but also extends to an area of 200,000 m2, such energy savings can lead to considerable decreases in carbon emissions and energy consumption.

Keywords: Urban climatology, Park cooling effect, Climate adaptation, Energy demand

1. INTRODUCTION

According to the data from the International Energy Agency (2019), 40% of the total energy demand in the world is from buildings. Globally, the majority of this demand is from space heating. However, considering the effect of global climate change and the rapid urbanization of the world population, the demand for space cooling is expected to rise (European Commission, 2016; International Energy Agency, 2019). This rise might be so substantial, the study by Isaac & van Vuuren (2009) predicts, that the share of space cooling might surpass the share of space heating within the 21st century.

Energy use in buildings can be affected by many factors, such as occupant behavior (Gaetani, Hoes, & Hensen, 2016), building installations (Hensen, 1993), building envelopes (De Boeck, Verbeke, Audenaert, & De Mesmaeker, 2015), and urban microclimate (South & Grimmond, 2006). Prior research on building energy demand demonstrated that buildings can become more energy efficient with building scale measures, such as facade insulation or energy-efficient machinery. Even though research on building energy efficiency enhancement through building scale measures is well researched, the link between building energy demand and urban microclimate has not received the same attention in the past.

Urban microclimates can be altered through urban scale measures, such as by using vegetation (e.g., urban parks) (Ca, Asaeda, & Abu, 1998), implementing water bodies (e.g., water fountains) (Tominaga, Sato, & Sadohara, 2015), altering urban form (e.g., street orientation) (Golany, 1996), using alternative materials (e.g., high albedo materials) (Taha, 1997), and decreasing anthropogenic heat release (e.g., lowering the number of cars in traffic)

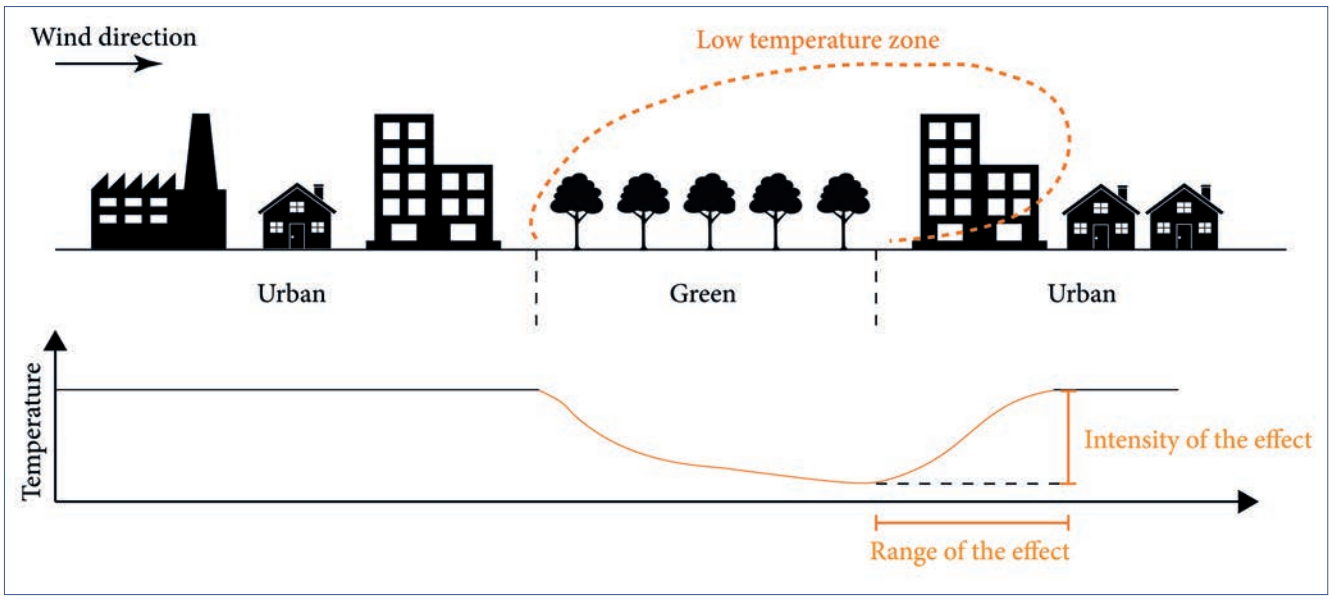


Figure 1. Schematic representation of the PCE, demonstrating two parameters: range of the PCE and the intensity of the PCE (modified from Honjo and Takakura (1990)). The figure is taken from Toparlar et al. (2017).

(Ichinose, Shimodozono, & Hanaki, 1999). Among these measures, the influence of urban parks on urban microclimate can be quite significant (e.g., up to 3.7°C (Vidrih & Medved, 2013)) depending on the park size (Toparlar, Blocken, Maiheu, & van Heijst, 2017b). This cooling effect caused by the parks, which is commonly termed as the Park Cooling Effect (PCE), is widely researched within urban climatology. The PCE can be conceptualized by focusing on two parameters (Honjo & Takakura, 1990): (1) intensity of the PCE, referring to the maximum decrease in air temperature and (2) range of the PCE, referring to the horizontal distance where the cooling effect is present (Figure 1).

Even though the effect of urban parks on urban microclimate is well documented in prior studies, an entirely computational study linking the PCE to building energy demand is lacking. In the current literature, only the measurement study by Ca et al. (1998) has linked the effect of an urban park to building energy demand. In this conference paper, a newly developed computational approach for studying the effect of urban microclimate on building energy demand is presented, and the effect of an urban park in Antwerp, Belgium, is used as a case study. In this regard, the paper is a synthesis of three prior publications by the authors of the present paper (Toparlar, Blocken, Maiheu, & van Heijst 2017a, 2017b and 2018)human morbidity and mortality and thermal comfort. Historically, urban microclimate studies were conducted with observational methods such as field measurements. In the last decades, with the advances in computational resources, numerical simulation approaches have become increasingly popular. Nowadays, especially simulations with Computational Fluid Dynamics (CFD.

2. STUDY DESCRIPTION

The study focuses on Antwerp, Belgium, and on an urban park called 'Stadspark' in the city center (Figure 2). To study the Urban Heat Island (UHI) effect

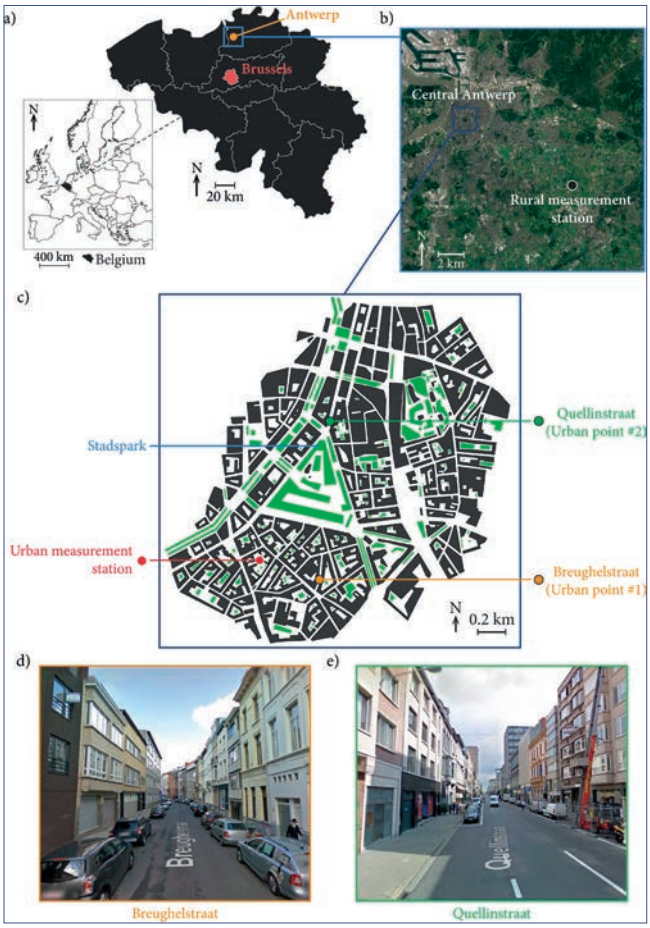


Figure 2. a) Location of Belgium and Brussels (capital region); b) Location of the central Antwerp area and the rural measurement station; c) View of the Antwerp city center with the Stadspark, the urban measurement station, and the two urban locations under study; d) View from the Breughelstraat, where urban point #1 is located; e) View from the Quellinstraat, where urban point #2 is located. The figure is taken from Toparlar et al. (2018).

in Antwerp, the Flemish Institute of Technological Research (VITO) uses two measurement stations, one in the city center of Antwerp and the other approximately 8 km away from the city, inside a bio-farm (Figure 2b). From these stations, VITO has collected 15-minute averaged data for air temperature, relative humidity, solar radiation, wind speed, and wind direction from June 2012 until September 2013.

Two computational methods are utilized in this study: 1) Computational Fluid Dynamics (CFD) for urban microclimate simulations; 2) Building Energy Simulations (BES) for the analysis of building energy demand. CFD simulations are performed to evaluate the PCE and to produce the necessary microclimatic information for the BES. To perform the CFD simulations, the Stadspark and its surroundings up to a distance of 850 m are modeled in a computer environment. For this purpose, drawings and geographic information system (GIS) data are obtained from the Antwerp Municipality. The drawings obtained documented all the buildings in the city center and the location of all the trees taller than 2 m. Inside the study area (Figure 2c), building height ranges from 3m to 60 m, and the average building height is 13.4 m.

3. SIMULATION SETTINGS AND PARAMETERS

In this section, settings and parameters employed in the CFD simulations and building energy simulations are summarized. For more detailed descriptions, the readers are advised to refer to the two referenced studies (Toparlar et al., 2017b, 2018).

3.1. CFD simulations

Within the area of interest, all the buildings and trees taller than 2 m are explicitly modeled (Figure 3a and b). Regions outside this area are modeled implicitly, and geometrical obstacles are represented with an aerodynamic roughness length (z_o) (m), based on the Updated Davenport Roughness Classification (Wieringa, 1992).

The computational domain and its extents are specified based on the height of the highest building (H = 60 m) and in line with various CFD best practice guidelines to ensure that an appropriate domain is generated (Blocken, 2015; Franke, Hellsten, Schlünzen, & Carissimo, 2007). The domain size is determined as 6500x6500x420 m^3 ($LxWxH_d$), and this dimensioning leads to a maximum blockage ratio of 0.85%, which is considerably less than the 3% recommended. Inside the domain, a computational grid is generated following the above-mentioned guidelines. The resulting grid is composed of 9,078,916 hexahedral cells (Figure 3d).

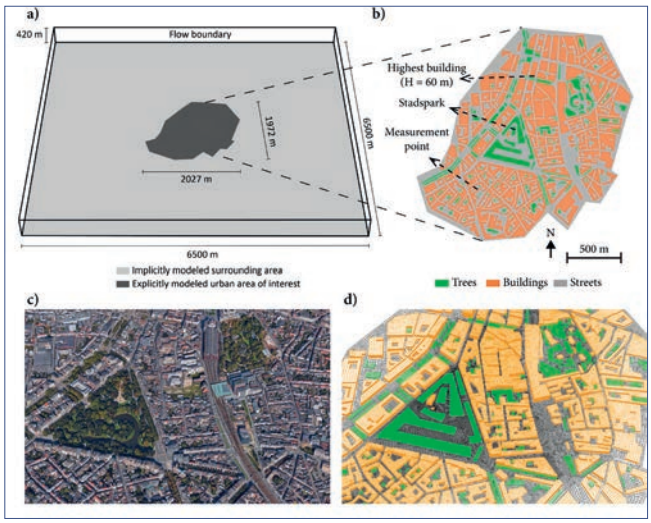


Figure 3. Computational domain: a) View of the complete domain; b) View of the explicitly modeled part of the domain with buildings, trees, and streets; c) Aerial view of the area of interest from the south; d) Corresponding computational grid on buildings, street, and tree surfaces (total cell count: 9,078,916 cells). The figure is taken from Toparlar et al. (2017b)

Four vertical boundaries shown in Figure 3a are specified as flow boundaries, which can either be inlet or outlet depending on the hourly wind direction measured at the rural measurement station. The top boundary is a free-slip wall with zero normal gradients for all the variables. Street surfaces, building roofs and facades, and the ground boundary surrounding the area of interest are all modeled as a wall type boundary. At the inlets, the following profiles are implemented for mean wind speed U(z) (m/s), turbulent kinetic energy k(z) (m^2/s^2), and turbulence dissipation rate ε(z) (m^2/s^3) (Richards & Hoxey, 1993):

$$U(y) = \frac{u^*}{\kappa}\ln\left(\frac{y+y_0}{y_0}\right) \quad \text{(Eq. 1)}$$

$$k(y) = \frac{u^{*2}}{\sqrt{C_\mu}} \quad \text{(Eq. 2)}$$

$$\varepsilon(y) = \frac{u^{*3}}{\kappa(y+y_0)} \quad \text{(Eq. 3)}$$

where u* (m/s) is the atmospheric boundary layer friction velocity, κ (-)(=0.41) is the von Karman constant, z (m) is the height coordinate, z_o (m) is the aerodynamic roughness length, and Cμ (-)(=0.09) is a model constant. Air temperature is modeled with a uniform profile. Based on the data acquired from the rural measurement station, wind speed, wind direction, and air temperature imposed at the inlets are specified. At the outlets, zero static gauge pressure is imposed. At the walls, Standard Wall Functions (SWF) (Launder & Spalding, 1974) are employed with the sand-grain based roughness modification (Cebeci & Bradshaw, 1977). The roughness relationship specified by Blocken, Stathopoulos, & Carmeliet (2007) is satisfied to ensure a homogeneous flow field.

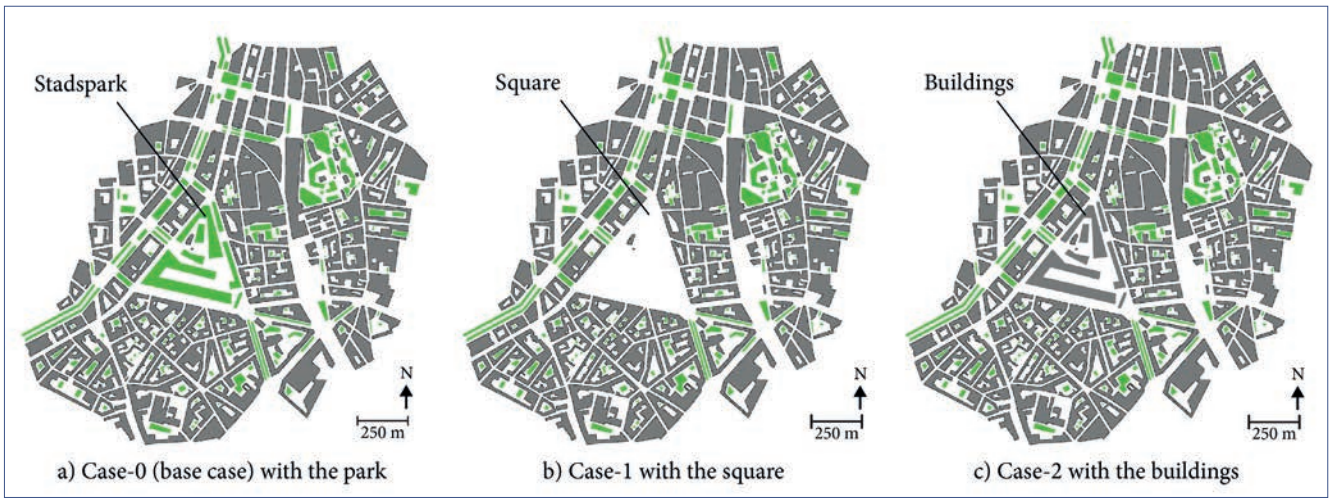


Figure 4. Representation of the comparison cases: a) Base case with the park; b) case-1 with the square instead of the park; and c) case-2 with the buildings instead of the park. The figure is taken from Toparlar et al. (2017b).

3D Unsteady Reynolds-Averaged Navier-Stokes (URANS) equations are solved in combination with the realizable k-ε turbulence model for closure (Shih, Liou, Shabbir, Yang, & Zhu., 1995). Radiation is handled with the P-1 radiation model (ANSYS Inc., 2013), and natural convection is modeled with the Boussinesq approximation. The cooling effect of the trees is modeled based on the model described by Toparlar et al. (2017b). The SIMPLEC algorithm (Doormaal & Raithby, 1984) is used for the pressure-velocity coupling and second-order discretization schemes are used for all terms. Simulations are performed with hourly (3,600 seconds) time steps. Using the same computational settings, which consider rural meteorological measurements as the basis for the boundary conditions, two sets of CFD urban microclimate simulations are performed. For the first set, simulations are performed for June 29-30, 2013. In these simulations, the focus had been to determine the maximum PCE by evaluating different urban design scenarios. Three different cases with changing urban geometries are considered: 1) Case-0 (base case) with the original Stadspark present; 2) Case-1 with open space instead of the park, similar to a public square; 3) Case-2 with representative buildings instead of the Stadspark (Figure 4).

The second set of simulations is performed for the entire month of July 2013. This includes 768 time steps, solved with 460,800 iterations. The aim of these simulations is to create location-specific microclimatic conditions for two urban points: (1) in the street named Breughelstraat (urban point #1), located 400 m south of the Stadspark, and (2) in the street named Quellinstraat (urban point #2), located 80 m northeast of the Stadspark (Figure 2c). In these simulations, the recorded air temperature data at the urban measurement station (Figure 2c) is used for comparing the simulation results with the measurements. In addition, the hourly simulation results for air temperature (°C), wind speed (m/s), and wind direction (°) are recorded to generate location-specific Microclimatic Conditions (MCs), which are used as inputs for the building energy simulations. All CFD simulations are performed with the commercial CFD solver ANSYS Fluent (ANSYS Inc., 2013).

3.2. Building energy simulations

BES are performed with the EnergyPlus 8.6 software (US Department of Energy, 2010). In total, there are three BES cases based on three different location-specific MCs, two gathered from the urban points of interest (from CFD simulations) and one from the rural measurement point (from the measurement data).

The simulation cases consider the same building form and orientation. The building modeled is a terraced house, which is quite common in Antwerp (Figure 5). The construction characteristics are specified as a typical building from Belgium constructed during the period from 1946 until 1970. In the study by Toparlar et al. (2017b), a wider range of construction characteristics are considered, but the present paper focuses only on one type of construction characteristic for the conciseness of the paper. The building evaluated is modeled as an office building with respect to its occupancy schedules and internal heat gains. In Table 1 and Table 2, the construction characteristics and occupancy operation schedules with internal heat gains are summarized, respectively.

In line with the recommendations of the EnergyPlus reference book (US Department of Energy, 2016), simulations are performed with 10 time steps per hour. The measured rural microclimatic data and the two simulated urban microclimate data are used as inputs in the format of EnergyPlus weather files (.epw).

Similar to the CFD simulations, only the BES results for the month of July 2013 are evaluated. From each BES case, the resulting monthly and daily cooling demand (kWh) data are extracted. Results are reported in terms of cooling demand per unit area (kWh/m²) and in terms of percentage differences in cooling demand among different cases.

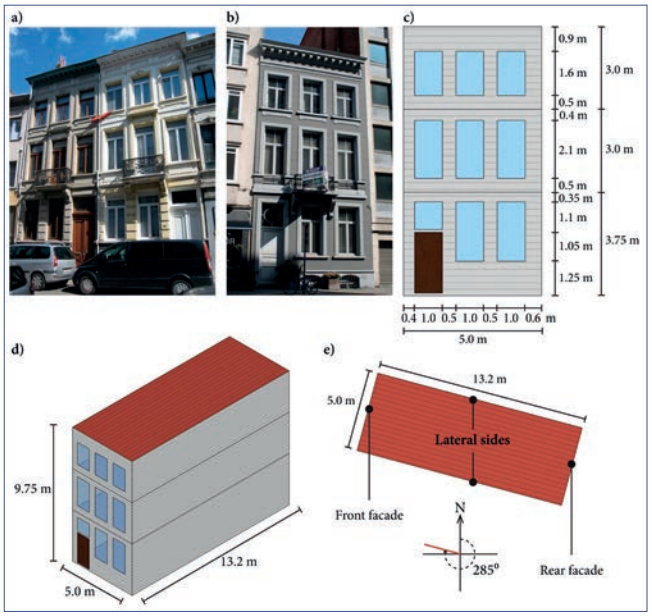


Figure 5. Terraced buildings (a) in the Breughelstraat, where urban point #1 is located; (b) in the Quellinstraat, where urban point #2 is located; (c) the front façade of the modeled building and its dimensions; (d) an isometric view of the modeled building; (e) top view of the modeled building with the orientation indicator. The figure is from Toparlar et al. (2018).

RESULTS

3.3. Comparison of the simulated and the measured air temperatures

The measured air temperatures at the urban station are compared with the resulting air temperatures occurring at the same point inside the computational domain. The comparison is visualized in Figure 6. The figure shows that CFD simulations are capable of reproducing the diurnal variation in the air temperature with fairly good accuracy as the average absolute temperature difference between the measurements and CFD is 0.88°C. The maximum underprediction of air temperature by CFD occurs on July 10, 12:00 hours with -3.2°C, and the maximum overprediction by CFD is on July 7, 22:00 hours with +2.4°C. The maximum simulated UHI effect (urban/rural air temperature difference) is recorded as 6.0°C on July 22.

Table 1. Component specifications of the modeled building based on the construction characteristics of buildings from the 1946–1970 period in Belgium. The data is from Cyx, Renders, Van Holm, & Verbeke (2011), and the table is modified from Toparlar et al. (2018).

Building component (1946 – 1970 building.)	Details (exterior to interior)	U-value ($W/m^2.K$)	Thermal time constant (τ) (hour)
Building walls	Brick / air cavity / brick	1.7	83.0
Building roof	Brick / air cavity / insulation (2cm) / brick	1.9	10.0
Building floor	Wood / finishing	0.85	459.1
Building windows	Concrete	5.0	-
Building doors	Single glazing	4.0	2.6
Ex/infiltration rates	14.9 $m^3/h.m^2$		

Table 2. Occupancy/operation schedules and internal gains modeled in BES. Values are obtained from CIBSE (2004) and US Department of Energy (2010).

Occupancy/operation schedules							
Cooling system		People		Lighting equipment		Equipment	
Time interval (hour)	Setpoint	Time interval (hour)	Presence of people	Time interval (hour)	Lights (on/off)	Time interval (hour)	Equipment (ON/standby)
00:00 – 08:00	27°C	00:00 – 08:00	Not present	00:00 – 08:00	OFF	00:00 – 08:00	Standby
08:00 – 18:00	24°C	08:00 – 18:00	Present	08:00 – 18:00	ON	08:00 – 18:00	ON
18:00 – 24:00	27°C	18:00 – 24:00	Not present	18:00 – 24:00	OFF	18:00 – 24:00	Standby
Heat gains							
Number of people A	Heat gain per person (W)			Lighting (W/m^2)		Equipment (W/m^2)	
18	120			12	12	16 (ON) / 6.4 (Standby)	

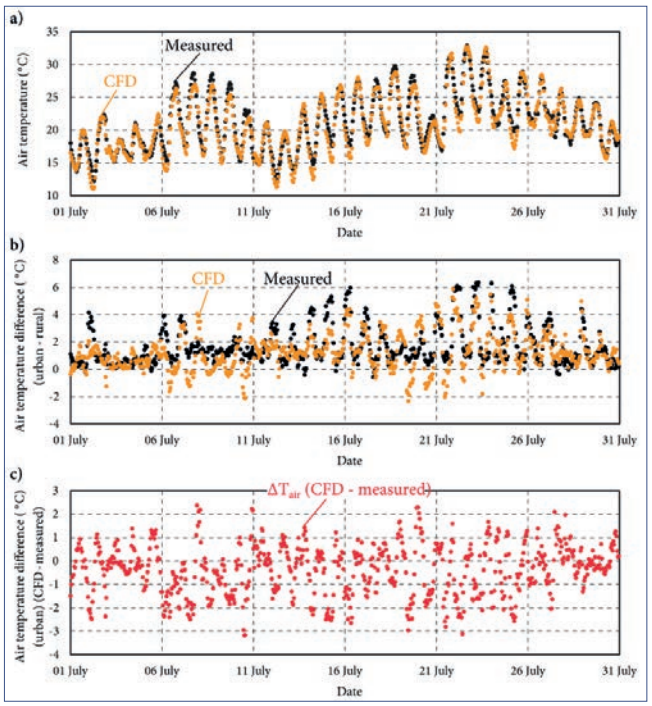


Figure 6. a) Measured vs simulated (CFD) air temperatures obtained at the urban measurement station in July 2013; b) hourly urban-rural air temperature differences based on the measurements and CFD results; c) differences in hourly air temperatures between the measurements and CFD simulations obtained at the urban measurement station.

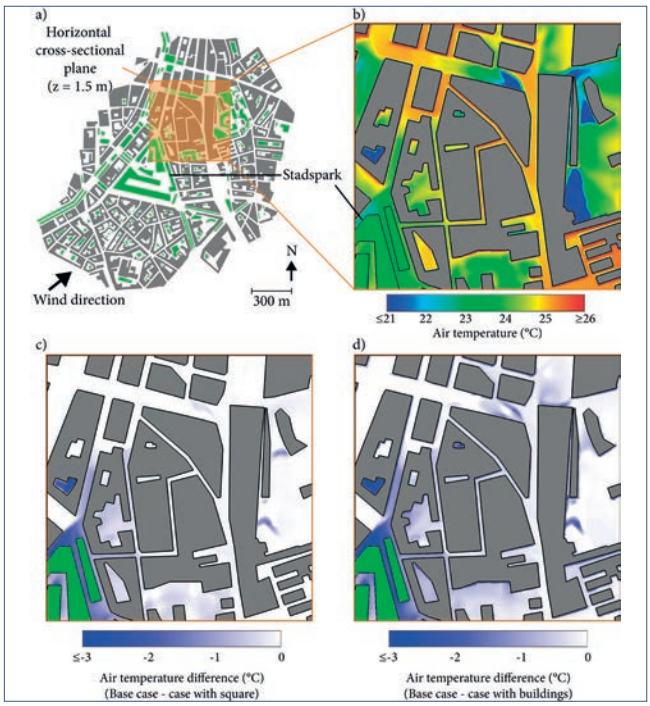


Figure 7. The PCE for June 30, 2013 at 15:00: a) Horizontal cross-sectional plane with the wind direction at 15:00; b) Contours of air temperature for the base case with the urban park; Contours of the air temperature difference between c) the base case and the case with the square; d) the base case and the case with buildings. The figure is taken from Toparlar et al. (2017b).

3.4. Evaluation of the park cooling effect (PCE)

The PCE is reported for June 30, 2013, 15:00 hours, as this was the time where the maximum effect is observed. The cooling effect is analyzed at the horizontal plane (at z=1.5 m, pedestrian height). In Figure 7b, the contours of air temperature are plotted for the base case with the urban park. In Figure 7c, resulting air temperature contours for the case with the square (case-1) is subtracted from the resulting contours for the base case. Similarly, in Figure 7d, contours for the case with representative buildings (case-2) is subtracted from the contours for the base case. In these figures, darker blue colors indicate a higher cooling intensity. As expected, the intensity is maximum in regions close to the urban park. According to the results, the PCE can be expressed as (urban park replacing the square/replacing the buildings):

- Intensity of the cooling: 2.7°C / 3.4°C
- Range of the cooling: 407 m / 498 m

3.5. Location-specific microclimatic conditions

Location-specific MCs are specified for: (1) the rural area, (2) the urban point of interest (PoI) #1 (Breughelstraat) (urban #1), and (3) the urban PoI #2 (Quellinstraat) (urban #2). The first MC is determined based on the measurements, whereas the other two are determined based on the CFD simulations performed. The air temperature data demonstrates that the warmest MC corresponds to urban #1, and the coolest is rural MC. On average, urban #1 is 3.3°C warmer than the rural PoI, whereas urban #2 is 2.4°C warmer. This difference is caused by the proximity of urban #2 to the Stadspark. On some specific days when the prevailing wind direction is from the southwest (when urban #2 is in the wake of the park), the air temperature difference between urban #2 and urban #1 can reach a maximum of 5.3°C.

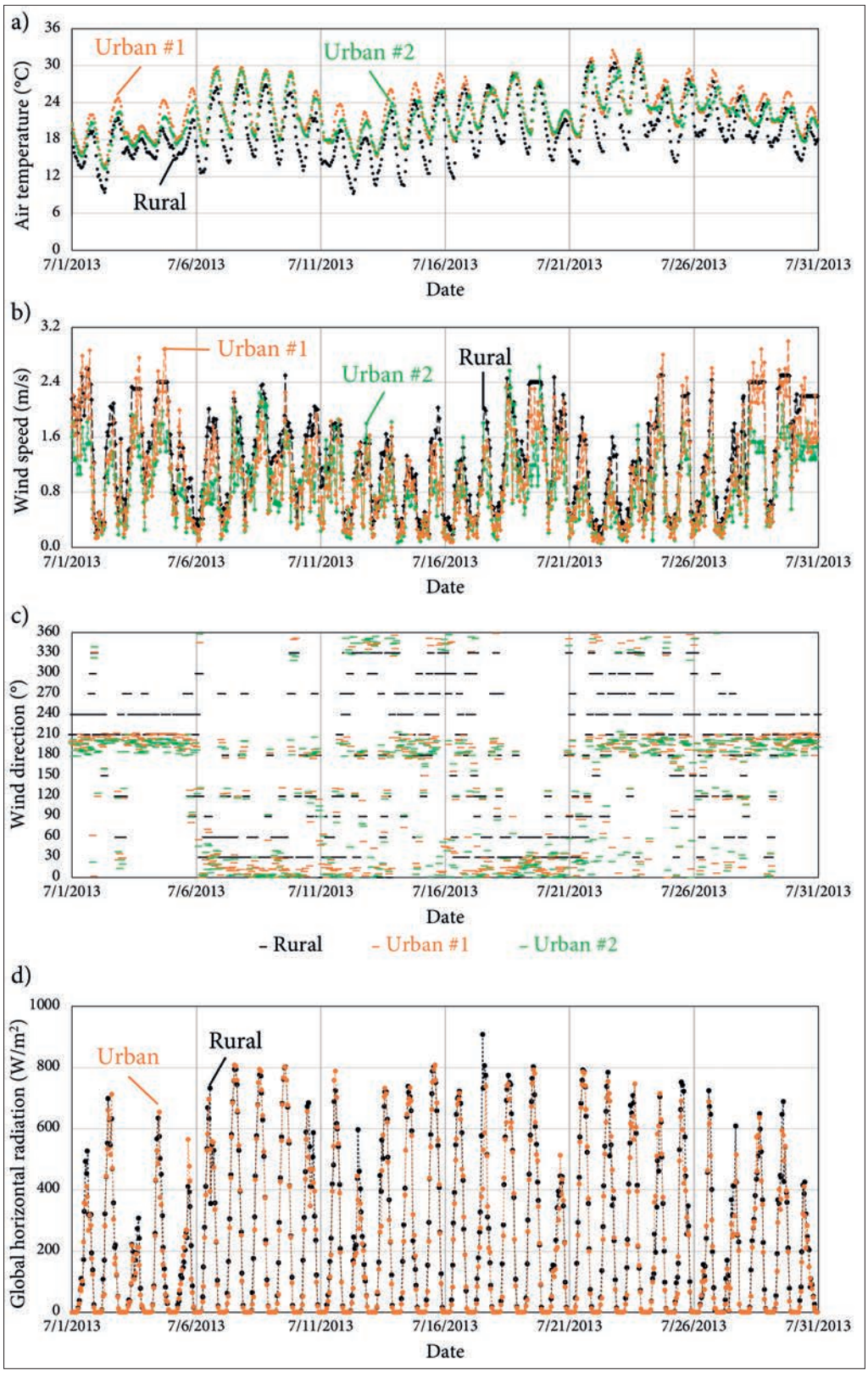


Figure 8. Location-specific MC obtained at the rural point (black), urban #1 (orange), and urban #2 (green) for a) air temperature; b) wind speed; c) wind direction (0 indicates north wind); d) global horizontal solar radiation. The figure is taken from Toparlar et al. (2018).

3.6. Impact of Stadspark on building cooling demand

The impact of Antwerp's UHI effect and the Stadspark's PCE on building energy demand is investigated based on the three cases specified. Based on the BES, the representative office building under the rural MC is found to have a monthly cooling demand of 8.55 kWh/m^2. The highest cooling demand is for the building under the MC of urban #1, with 11.71 kWh/m^2. The monthly cooling demand of the same building is found to be 9.84 kWh/m^2 under the MC of urban #2, which indicates a considerable drop from the case of urban #1. Compared to the rural conditions, being in the city center and away from the park has led to a 42.8% increase in the cooling demand. However, being in the

vicinity of the park led to a 22.4% drop (compared to being in the city center and away from the park) in the monthly cooling demand.

It should be noted that these results are calculated for the monthly cooling demand, and daily variations in the cooling demand of the buildings under different MCs can be very different. Even though on average the monthly cooling demand for the case of urban #2 is found to be 22.4% less than the case of urban #1, daily variations differ to a large extent and are quite dependent on the daily prevailing wind direction. To document this, the daily prevailing wind direction is summarized based on one of the four possible wind directions in an X-Y coordinate system where +X denotes east and +Y denotes north. The ratios of daily cooling demand of the representative building under urban #1 and urban #2 microclimatic conditions are presented in Figure 10.

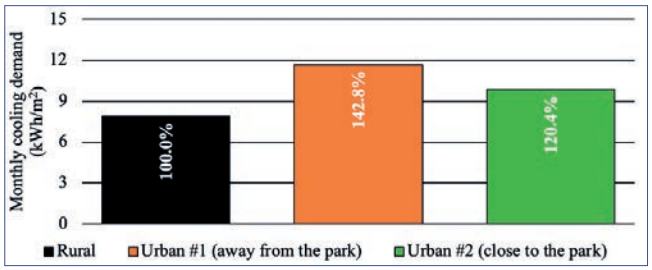


Figure 9. BES results for the cooling of the representative office buildings under different microclimatic conditions. Urban #1 is away (400 m away) from the urban park of interest, whereas urban #2 is closer (80 m away) to the urban park of interest

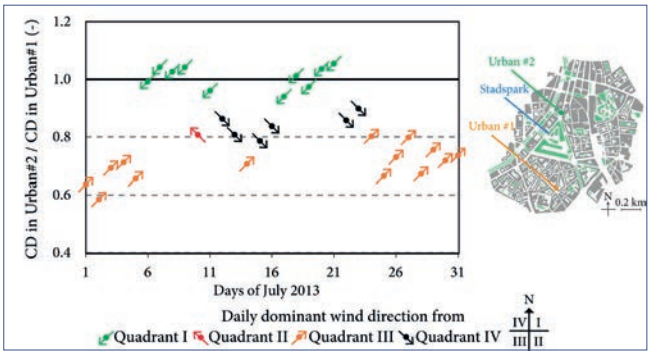


Figure 10. The ratio of daily CD during July 2013 for a representative building in urban #2 (close to the park) and urban #1 (away from the same park) and its relationship with the daily wind direction measured in the rural measurement station.

In Figure 10, daily cooling demand (CD) ratio as recorded for urban #2 and urban #1 is reported, where lower ratios indicate a higher CD saving for urban #2. The figure shows that higher differences in the daily CD occur especially in the days when the prevailing wind is from the southwest (quadrant III in Figure 10). This result stems from the relative positioning of urban #2 with respect to the Stadspark. In the days when the wind is from the southwest, the approaching wind first encounters the Stadspark and the PCE is convected downstream toward the point where urban #2 is positioned. In the days when the prevailing wind direction is northeast, the CD reduction is negligible (i.e., <2%), and in some days the reduction is non-existent. According to the daily CD differences, the maximum cooling demand reduction is calculated as 43%, corresponding to July 2. This finding demonstrates the importance of meteorological wind direction on building energy demand, especially when a local, urban cooling source is present.

4. DISCUSSION

Various studies have investigated the effect of urban parks on urban microclimates, such as the one by Toparlar et al. (2017b). However, to the best of our knowledge, only the study by Ca, Asaeda, & Abu, (1998) investigated the impact of an urban park on the building cooling demand. Ca, Asaeda, & Abu, (1998) used measured air temperature differences in the wake of an urban park and in nearby locations and calculated that, for the buildings in the wake of the park, 15% energy savings can be achieved during noon time. No specific building typology or construction characteristics are mentioned in the study by Ca, Asaeda, & Abu, (1998). In the present paper, the focus had been to evaluate only one building type (office) and one construction characteristic (a 1946–1970 building from Belgium). To understand how buildings with different use types (i.e., residential) and construction characteristics (i.e., based on low-energy guidelines) can be affected by the same park cooling effect, the readers are encouraged to refer to the earlier journal publication of the authors (Toparlar et al., 2018).

The PCE reported in this study is noticeable in various streets in the wake of the park studied (Figure 7). According to the calculations based on the contour plots, a minimum 0.1°C cooling effect is noticeable in an area of approximately 200,000 m² in the wake of the park, when the wind is from the southwest and with a velocity of 6 m/s at 10-m high. This cooling effect can help buildings located in the wake of the park to operate with decreased summer-time cooling demands, the extent of which would be dependent on the intensity of the cooling effect around the particular buildings.

With the rapid increase in air-conditioning devices in the world (Cox, 2012), the cooling demands of buildings in urban areas should be more carefully evaluated. One critical aspect here is that some cooling devices in cities (i.e., air-conditioning devices) can release heat to the urban environment, and this heats up the cities even more, creating a vicious cycle. Therefore,

it is critical to create urban microclimates that can offer better conditions for buildings to operate. Based on the findings of this study, urban microclimate interventions can be conducted by carefully positioning urban parks and aligning the surrounding streets in a way to carry the PCE further away from the park itself.

5. SUMMARY AND CONCLUSIONS

This study focuses on evaluating the impact of an urban park on the microclimate in its vicinity and, consequently, on the energy demands of buildings surrounding the park. This evaluation is conducted through a case study where a real park in Antwerp, Belgium, named Stadspark is considered.

CFD simulations are performed to investigate the urban microclimate in the central Antwerp area, first to calculate the park cooling effect convected from the Stadspark and then to generate location-specific microclimatic conditions (MCs) for different buildings. These MCs are later used in building energy simulations as inputs. In addition to the simulations, meteorological measurements are conducted at a rural point and an urban point. The rural measurements are used as inputs to the CFD simulations, and the data from the urban measurement points is used as the basis for comparison with the measurement results. CFD urban microclimate simulations are performed for the entire month of July 2013, and the resulting air temperatures are found to be able to predict measured air temperatures with an average absolute difference of 0.88°C. In-depth analysis of the park cooling effect showed that the park investigated was able to cool down its surroundings with a maximum cooling intensity of 3.4°C, and a minimal 0.1°C cooling effect is calculated 498 m away from the park, denoting a relatively high range of park cooling.

Based on the rural measurements and the CFD simulation results at two urban points, three MCs are used as the climatic conditions in the building energy simulations of a representative building from Belgium. The building modeled is a typical 1946–1970 period office building. One of the urban points is chosen 80 m northeast of the Stadspark (in its wake, with respect to the prevailing wind direction), and the other urban point is chosen away from the park (approximately 400 m south of the park). According to the building energy simulations, the representative building has a monthly cooling demand of 8.55 kWh/m^2 if it is subjected to the rural MC. On the other hand, the same building is found to have 42.8% more cooling demand if subjected to the MC of urban #1 (away from the park) and 20.4% more if subjected to the MC of urban #2 (close to the park). The results demonstrate that the park investigated can reduce the cooling demand of a building by 22.4% on a monthly basis. This reduction can be as high as 43% on a daily basis. This study demonstrates that the impact of urban microclimate on building energy demand can be quite significant, and in the presence of a localized urban cooling source, such as an urban park, the cooling demands can be considerably reduced. Engineers, urban designers, and policy makers are recommended to consider urban parks and similar urban-scale adaptation measures while utilizing an energy plan for their cities.

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THE SIGNIFICANCE OF SIMULATION TOOLS IN ACHIEVING SUSTAINABLE URBAN ENVIRONMENTS

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ABSTRACT

Urban environments have faced significant problems over recent decades as they try to accommodate exploding populations. One of these issues is creating a comfortable and pleasant environment for urban dwellers. Prior to the industrial revolution, our ancestors listened to the environment and benefited from its climatic and geographical conditions. The industrial revolution paved the way for mass production, new technology, and rapid urban growth. Unfortunately, the environmental and social aspects of urbanization were, to a large extent, disregarded for the sake of economic development. Nevertheless, in the case of urbanization in developing countries, proper planning and design strategies need to be implemented in order to create pleasant, comfortable, and sustainable environments. At this point, simulation tools, especially those that are used to model urban microclimates, have proven indispensable given that they enable urban planners to better understand urban environments in terms of both present and future microclimate dynamics. Although numerous tools and indices have developed to assess this, their use is often disregarded during pre- and post-design phases due to how complex their parameters tend to be. Even so, the value of simulation tools should not be underestimated, and the output they provide should be used to evaluate meteorological and physical parameters.

This paper evaluates the simulation tools currently available on the market (i.e., ENVI_met, RayMan, UrbaWind, TownScope), looks at their parameters (i.e., meteorological, physical, user-related) as well as their indices (i.e., PMV, PET, UTCI, SET), and examines their level of output within a brief review of the literature and various case studies.

Keywords: microclimate, simulation tools, sustainability, urban built environment

1. INTRODUCTION

In recent years, urban development has attracted great attention. Studies on creating sustainable cities can be recognized at scientific meetings and conferences, for example, the World Urban Forum 5 (UN Habitat, 2010) and Sustainable Development and Planning (Wessex Institute of Technology, 2011). These and other meetings focus on economic, social, and environmental perspectives of urban development. In addition, much of the relevant literature and research has focused on urban and sustainable development issues (Harris, 2000). The rapid urbanization phenomenon has become an important issue in urban planning and sustainable development. This is because rapid urbanization often leads to adverse environmental impacts, including changes in the urban microclimate.

With global warming, extreme temperatures, heat wave frequencies, intense rainfall events and the intensity of tropical cyclones are increasing (Sweeney, 2009). Due to climate change, global weather temperatures are expected to rise by 0.2°C in the next century (IPCC, 2007).

For example, heat waves will be stronger and last longer. This is a worldwide problem mainly observed in regions with hot climates, resulting in an increase in hot weather events and other diseases related to temperature. For humans, both mental and physical performance decrease at disturbingly high temperatures, and deaths and diseases caused by air pollution tend to increase in extremely hot weather (Harlan et al. 2006). In addition to global warming, cities are vulnerable to exposure to urban heat. In urban areas, the urban poor and those who live in sub-standard houses are particularly vulnerable to heat waves due to high population density and lack of green areas (Harlan et al. 2006).

Emerging before the climate change issue, sustainability and, more specifically, urban sustainability have held various definitions and objectives since the 1960s. The fact that these

concepts are linked is because of the common problems associated with both movements. The goals of sustainability and urban sustainability, and the possibility to implement them, actually contribute to the reduction of climate change. One of the main causes of climate change is the increase in human-source greenhouse gas emissions, which is clearly stated in the first four reports of the Intergovernmental Panel on Climate Change (Sweeney, 2009). As the largest part of greenhouse gas emissions is caused by metropolitan cities, urbanization and construction should be sustainable. However, questions and assumptions have begun to emerge as to how sustainable urbanization should look, what is the definition of "sustainable," and how can sustainability be achieved while benefiting from the global economy (Marsden, 2009).

1.1. Urban Sustainability and Simulation Tools

Urban sustainability concept focus on cities being ecologically sustainable, that the use of environmental resources and production of environmental pollution should not exceed the capacity of nature to reproduce resources and absorb the pollution (Whitehead, 2009).

In Habitat II (1996), particular attention was given to the interaction of social, environmental, and economic processes within urban spaces. Recently, urban sustainability has become synonymous with an integrated urban policy and planning/design in which the social, economic, and environmental conditions and needs of cities are addressed together.

Although the practice of intervening in the built environment to shape and direct the appearance and function of settlements has taken place over thousands of years, the term "urban design" has recently emerged (Street, 2009). While Hippocrates states that nature has positive effects on human health, Vitruvius (2001) suggests that the order of streets and buildings should be shaped according to sun and wind. Today, climate change issues have led to a review of planning and design principles. It is now emphasized that microclimate conditions should be part of the planning and design process (Nikolopoulou and Steemers, 2003; Nikolopoulou and Lykoudis, 2007).

Various factors and formulations influence urban design and its use of sustainable principles. Although the principles of sustainable design have been established, it is a long process to monitoring their success. However, with the development of technology, computer modeling has begun to gain great importance. Simulation by computer modeling has become and remains an important approach to understanding a wide range of human and natural systems (Manson, 2009). The simulation helps to explain how the system will or should look in the future, providing various scenarios and the ability to model possible consequences for potentially dangerous or expensive designs.

For this reason, simulation is being used as a complementary tool, replacing some types of non-practical experiments (Manson, 2009). Climate simulations, for example, give an idea of the future that cannot be achieved in any other way. It is important that design projects can be assessed via simulation and the possible problems can be determined from the beginning. This gives simulations an important role in sustainable urban design. Before the implementation of the project, identifying, improving, and re-analyzing the design process avoids wasting time and damage to environmental factors.

This paper argues that sustainability can be achieved through implementing appropriate design strategies and using simulation tools in order to predict and therefore minimize potential problems. In doing so, it evaluates the current simulation tools available on the market (i.e., ENVI_met, RayMan, UrbaWind, TownScope), evaluates their parameters (i.e., meteorological, physical, user-related) as well as their indices (i.e., PMV, PET, UTCI, SET), and examines their level of output within a brief review of the literature and various case studies.

2. SIMULATION TOOLS AND MICROCLIMATE

Due to the mutual interaction of urban built environments and microclimates, simulation tools can be used as a key indicator for assessing whether or not planning/designing projects is sustainable. Although the measurements and survey studies can provide significant details about current situations within an environment, simulation tools can reach a step further and assess not only existing conditions but also the creation of various scenarios and examine projects before implementation. TownScope, UrbaWind, RayMan, and ENVI_met simulation tools are evaluated for their assessment of microclimate conditions for further determining the components of a sustainable urban environment that can be achieved.

2.1. Townscope

TownScope is based on solar access decision-making for a sustainable urban design perspective (Teller and Azar, 2001). It contains solar evaluation tools with a three-dimensional urban information

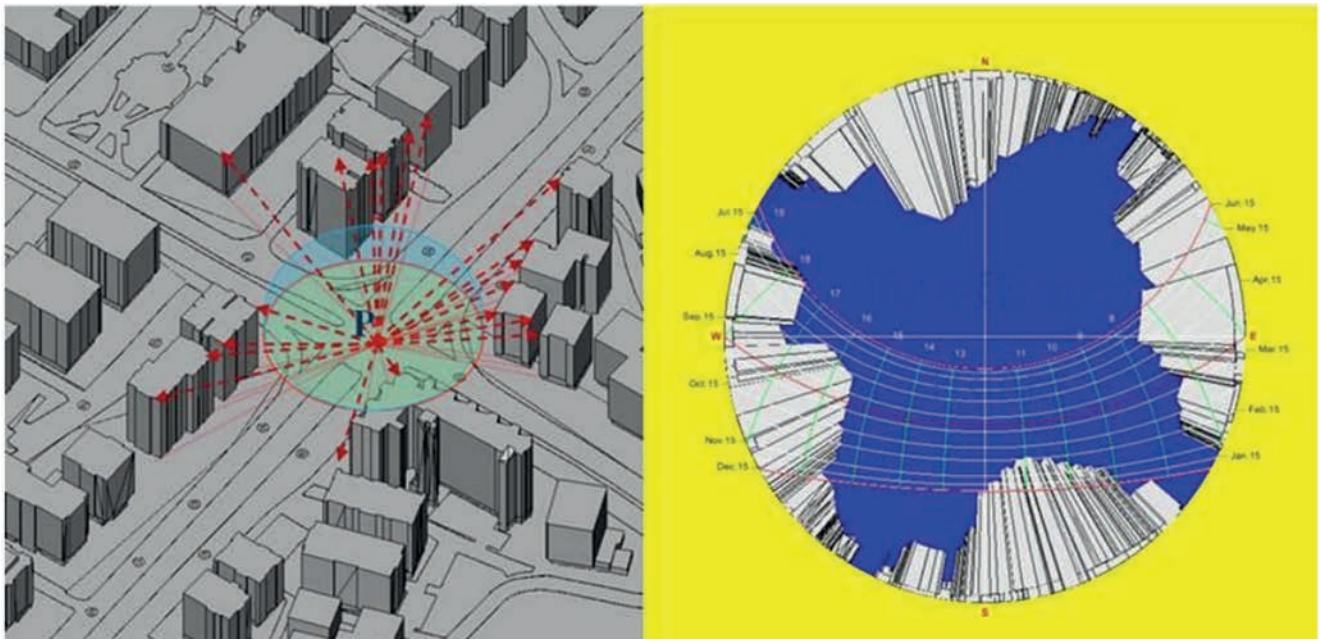


Figure 1. View and output from Townscope III software (adopted from Canan, 2017)

system. The scale of the simulations is determined according to the principles of urban design, examining interactions between urban open spaces and the surrounding environment (buildings, roadways, pavement, vegetation, etc.). Via Townscope, solar access (solar radiation), thermal comfort (comfortable/uncomfortable), sky opening (Sky View Factor), and visibility analyses can be conducted (Figure 1). However, the software does not provide the data for other weather parameters (air temperature, wind, and humidity) similar to PMV, PET, or any other index assessing human thermal comfort and does not allow simulations for any other day except June 15. There are only a few studies conducted via Townscope (Teller and Azar, 2001; Marique et al, 2017; Canan, 2017), which minimizes its ability for further assessment.

2.2. UrbaWind

UrbaWind is a modeling software for pedestrian wind comfort, specially developed for urban areas. It determines discomfort areas and is important for the mitigation of uncomfortable urban environments (Meteodyn, 2018). It calculates the wind characteristics and effects of buildings on wind flow. As a result, the coefficient of the mean and gust velocity as well as the turbulence and pressure coefficient can be obtained (Figure 2). An evaluation of wind comfort (Gedik et al, 2017; Sanquer et al., 2017), energy production (Caniot et al., 2016), and natural ventilation (Costanzo, 2017) can be conducted using these results (Fahssis et al., 2010a; Fahssis et al., 2010 b). Although it is a tool specially developed for urban areas, the exclusion

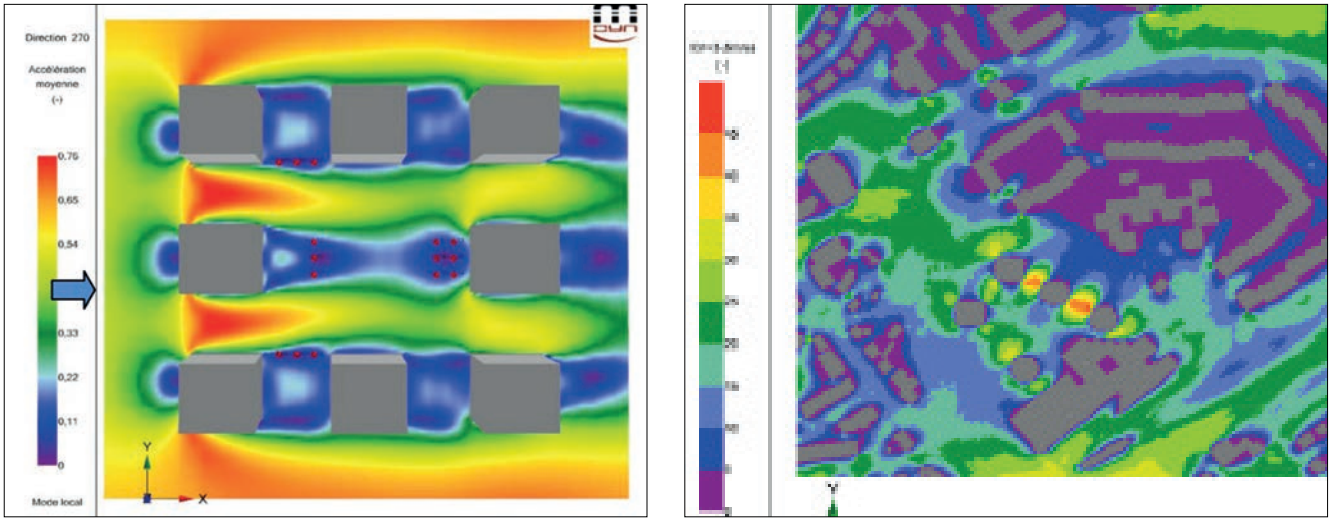


Figure 2. Outputs of UrbaWind- wind flow (left) and wind comfort (right) (adopted from Caniot et al, 2016)

of other microclimate parameters (air temperature, solar radiation, humidity, etc.) and the outdoor thermal comfort evaluation index limits its use for a comprehensive assessment of microclimate conditions.

2.3. RayMan

Rayman is a simulation tool used for calculating the radiation fluxes within an urban environment through model approaches including air temperature, humidity, cloud cover, air transparency, and time and date when the simulation is done. To estimate the radiation flux density, the model divides the environment into two layers, the upper and lower hemispheres, where the lower one has a sky view factor covered by solid surfaces and its adjustment can be done easier than the upper one. Rayman can model the urban environment in two ways. The first one is by using fish-eye photography, while the second is a detailed design of built environments (Figure 3) such as buildings, trees, and other obstacles (Matzarakis et al. 2007). The outputs of Rayman are graphs and tables of hourly, daily, and monthly averages. The extension such as SkyHelios model (Matzarakis and Matuschek, 2011; Fröhlich and Matzarakis, 2018) can be used in order to visualize or interpret the RayMan results, as it includes the spatial dimension of microclimate. Studies conducted with RayMan vary in scale and focus area, such as the shading or cooling effects of trees and vegetation (Konarska et al., 2014; de Abreu-Harbich et al., 2015), university campuses (Lin et al., 2010 ; El-Ashry et al., 2017), schools (Kwon et al., 2017), urban heat island effect (Ketterer and Matzarakis, 2015), and urban canyons (Herrmann and Matzarakis, 2012). However, there are some drawbacks of the software due to the need to manually enter some points of data and the inability to include the low solar angles and reflected short-wave radiation.

2.4. ENVI_met

ENVI_met software has been used as a tool for assessing microclimate conditions and outdoor thermal comfort. It is a complex tool based on thermodynamics and fluid dynamics distributing the air flow, humidity, radiation, and temperature, taking into consideration the interaction between air, plants, and buildings (Bruse, 2009).

The increase in interest in climate change and the urban heat island effect has led to the widening of studies assessed by ENVI_met. There are a number of studies implemented on the urban scale (Tan et al., 2017; Kyriakodis et al., 2017) as well as those implemented for certain open spaces such as squares, parks, courtyards, urban canyons (Sun et al., 2017; Salata et al., 2016; López-Cabeza et al., 2018), or university campuses (Taleghani et al, 2017; Göçer et al., 2018; Bakovic and Göçer, 2018b). Moreover, there are studies assessing the effects of surface finishing materials (Tsitoura et al., 2017; Bakovic and Göçer, 2018a) as well as facade materials (Jänicke et al, 2015), the effects of trees and green areas (Sun et al., 2017; Chatzinikolaou et al., 2018) on outdoor thermal comfort and the urban heat island (Kolokotroni, 2017; Zhao et al, 2017), as well as the energy saving potential of green spaces (Kong et al., 2016). ENVI_met provides the outputs of microclimate data (Figure 4) in maps, tables, and graphs and allows for the further evaluation of outdoor thermal comfort (Figure 5) via the extension BIO_met, including human-related parameters (age, height to weight ratio, clothing, etc.). On the other hand, the constant distribution of wind during the day is considered to be the main drawback of the tool.

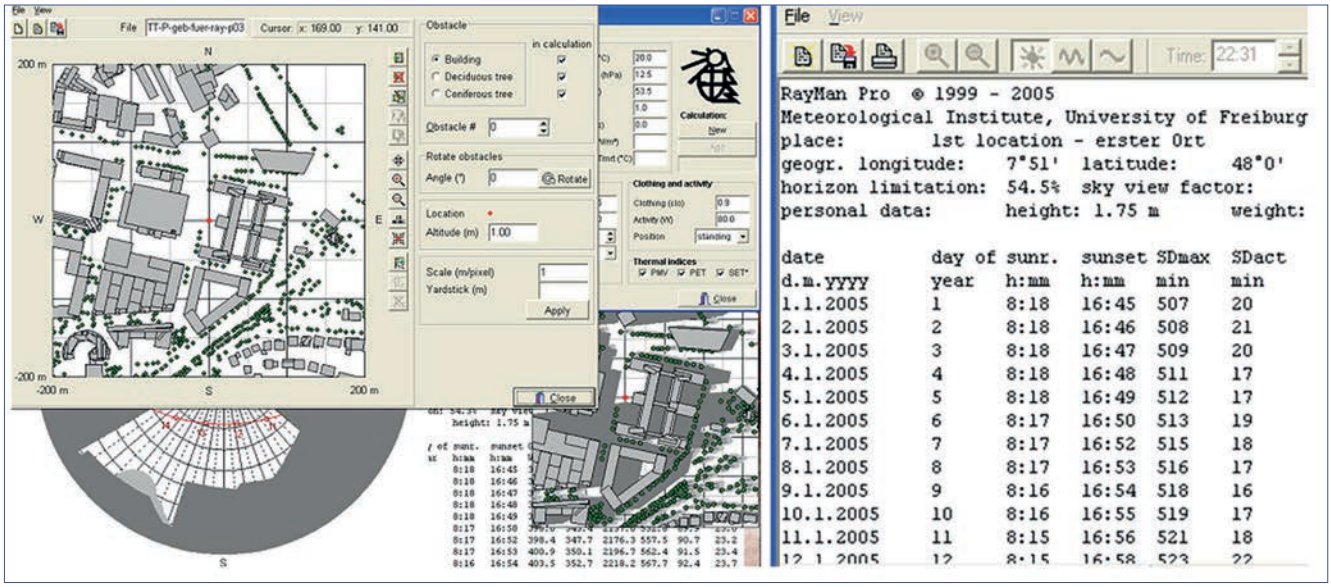


Figure 3. Rayman preview for buildings and vegetation input (left) and data output for SVF and sunshine duration (right) (adopted from Matzarakis et al., 2012)

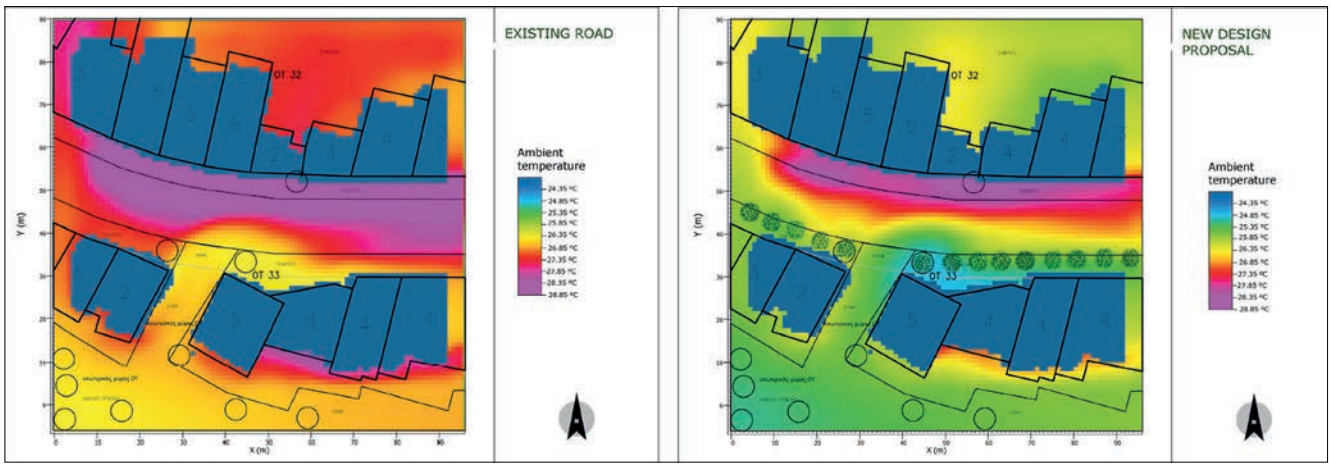


Figure 4. Output of ENVI_met simulation for existing (left) and proposed (right) road surface material temperatures (adopted from Tsitoura et al., 2017)

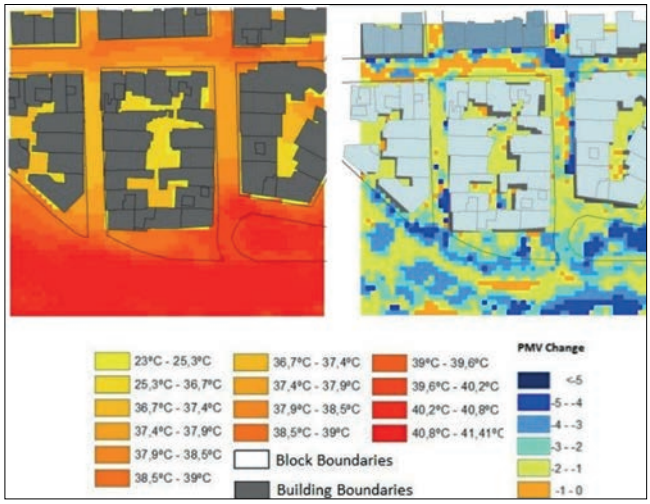


Figure 5. Air temperature (left) and PMV index (right) outputs of ENVI_met simulation (adopted from Chatzinikolaou et al., 2018)

3. DISCUSSION AND RECOMMENDATIONS

According to the abilities of simulation tools, studies on the following components and their impact on sustainability can be conducted:

1. Building orientation, height/width ratio, building form/geometry, building surface material, building construction material
2. Street orientation, street h/w ratio, surface material
3. Presence of vegetation, vegetation type, canopy, vegetation location
4. Water elements and location
5. Air quality and pollution
6. Urban Heat Island effect
7. Wind corridors/natural ventilation and wind speed assessment, wind comfort and stress, wind energy potentials
8. Air temperature assessment
9. Solar radiation assessment, Sky View Factor
10. Humidity assessment
11. Outdoor thermal comfort assessment (PMV, PET, UTCI, SET)

Simulation tools for assessing microclimatic conditions should assess the air temperature, solar radiation, humidity, and wind data, because these parameters are the key factors influencing microclimate. If the simulation tool lacks one of these, then the complexity of microclimate issues will not be understood. As microclimate conditions affect the user, the tool should include the user related data and track the changes according to the outputs. Among the evaluated simulation tools, ENVI_met software can be considered the most suitable tool for assessing outdoor thermal comfort in urban built environments since it assesses a complex set of variables.

Yet, there is a need for studies of existing built environments to determine the accuracy of simulation tools in certain climate zones and physical conditions. Similarly, user-related validation should be conducted. Moreover, the social aspect of sustainability should not be disregarded during the early phases of the design process, as it cannot be simulated but rather directly experienced in a present-day situation.

The involvement of simulation tools during the planning and design process should become compulsory for government representatives as well as private organizations in order to effectively form and define guidelines for urban planning and design. The progress in this sphere will assist in building sustainable cities and environments.

4. CONCLUSION

Urban sustainability shows that it is necessary to think more carefully about the complex relations that make up the urban area. Urban sustainability and climate change policies should be more involved in planning and design processes and should be modeled and controlled with simulation tools to more wisely use resources. A sustainable design approach involves a variety of components, and it is important to be able to implement them in a controlled manner. Consideration of these components can provide alternative methods for improving the existing built environments, as well as providing new audits to determine standards, implementing regulations in the design process, creating different scenarios, and possibly reducing or mitigating negative effects.

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MONITORING TEMPORAL MICROCLIMATIC CHANGE IN AN URBAN AREA: THE CASE STUDY OF UMRANIYE DISTRICT

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ABSTRACT

Istanbul has undergone significant constructional changes, especially in the last 16 years, due to increasing urbanization in parallel with the increase in the population and urban transformation studies. Ümraniye is one district in which significant physical changes, such as construction and the transformation from low-rise to high-rise buildings, have most visibly occurred. It was decided that the Ümraniye district would be chosen as the area for this study as the authors predicted that these constructional changes would cause significant microclimatic changes.

The main aim of the study is to monitor and show climatic change by using satellite images with a retrospective GIS-based change detection method. The comparisons were made through Landsat thermal images during the summer term between the years 2002 and 2018. The results were compared with the constructional changes that took place in the region, and then they were statistically tested. The results showed that there was a strong correlation when significant constructional changes occurred in the area. Furthermore, the results revealed that while extreme heat has arisen from the expansion of the building bases, extreme cooling has arisen due to the height of buildings.

Keywords: Urban climate, Climatic change detection, Remote sensing, Modeling.

1. INTRODUCTION

The world is experiencing storms, heavy rains, heat waves, droughts, and many other risks as a result of rapidly increasing urbanization and an ever-growing population (WMO, 2018). Today, 55% of the world's population lives in urban areas, and this ratio is expected to increase to 68% by 2050 (UN, 2015). The growth of mega cities is especially remarkable (United Nations, 2007).

The population increase in cities leads to anthropogenic effects triggering climate change and thus increases the risks arising from it (Echevarría and Hoeven, 2017; Kahraman and Şenol, 2018). Rapid physical changes in cities change the urban climate on the macro, meso, and micro scale (Soo-Gon et al., 2007; Grimmond et al., 2010; Xiaofeng et al., 2010; Tomlinson et al., 2011; Oke et al., 2017). This rapid urbanization disrupts the meso/microclimate of cities and leads to the formation of areas that are uncomfortable such as heat islands and cold islands. This situation indirectly leads to health problems such as asthma, heart attack, and high blood pressure and increases the mortality rates related to them. Due to sudden heat waves during the summer months, 30,000 people died in Europe in 2003 and 55,000 people died in Europe and Russia in 2010 (Barriopedro, 2011). This problem, which has caused a massive number of deaths, is now handled as a disaster in many countries, and action plans are prepared against it. Urban planning and design play an important role in fighting these problems.

In this respect, urban climate, which is a very complex and extensive subject, is an important research subject for urban planning. The strategies to be developed against this situation vary according to the climatic characteristics and regional effects. Therefore, urban and climatic characteristics should be adequately interpreted. This also depends on properly discussing the present situation, changes, and previous problems.

Strategies to be developed for sustainable cities should be addressed as a whole, not only with future estimates according to today's data but also taking into account changes from past to present (Kuşçu Şimşek and Ödül, 2019). The main aim of this study is to monitor and show climatic change by using satellite images with a retrospective GIS-based change detection method. Through the method used in this study, which is sufficient for the temporal monitoring of the district, problem points can be marked and target points can be determined for more precise investigations. The results obtained from this study will hopefully provide important inputs for urban climate strategies to be developed for Istanbul.

2. MATERIAL AND METHODS

2.1 Study Area

The Ümraniye district is located on the Anatolian side of Istanbul and is a prime example of urbanization in the city, with a rapid increase in the district's population and population density after 1950. In terms of population, the third district of Istanbul has a surface area of 45 km². Both Black Sea and Mediterranean climate characteristics are seen in the district (Ümraniye District Governorate, 2016).

After becoming an organized industrial zone in the 1960s, the number of slums in the district has gradually increased. After the 2000s, the district municipality started urban transformation projects in the region with the motto "Ümraniye is rising." With the adoption of the Urban Transformation Law, the number of skyscrapers and high-rise houses in the district rapidly increased. In addition, in 2017, 2B lands in the district were opened for urbanization following the decision of the Istanbul Metropolitan Municipality. Following this decision, the number of new, large construction projects started to rise in neighborhoods such as Kazım Karabekir, Topağacı, Tepeüstü, Dumlupınar, Hekimbaşı, Elmalıkent, and İnkılâp, where the 2B lands in the district are located (Milliyet, 2018). In recent years, with the increase of urban transformation projects, Ümraniye rapidly became a district of luxury skyscrapers and high-rise residences. In the last 20 years, the district has undergone many

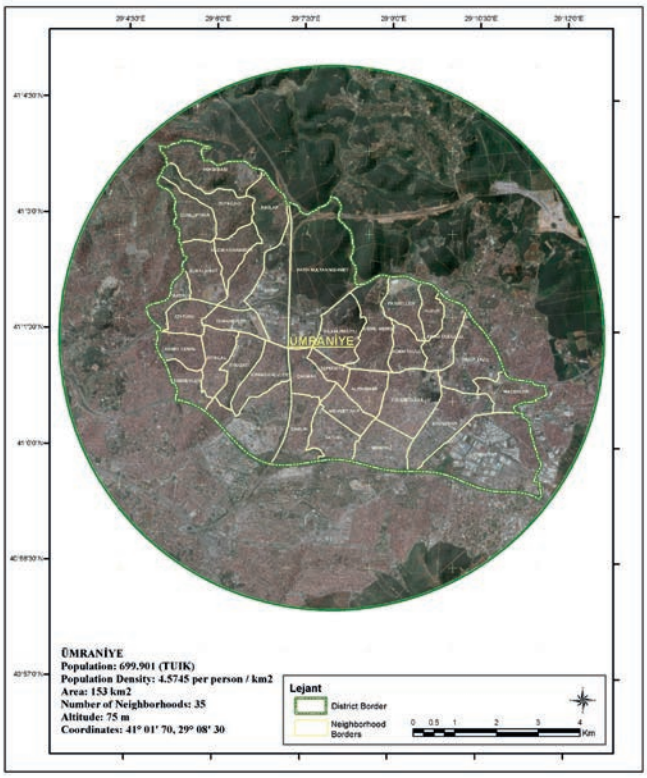


Figure 1.1 Study Area

structural changes, including the construction of high-rise buildings. Therefore, the district was chosen as the study area for this research in order to determine whether these changes resulted in significant meso/microclimatic changes in the region.

2.2 Data Sets

The data and their contents, which were used in the study, were presented in Table 2.1. Surface temperatures, obtained from Landsat satellite images by making atmospheric corrections, were used in thermal change detection analysis. As a result of this analysis, extreme warming regions and cooling regions were detected in the microclimate. In order to examine the relation of these changing regions with the physical changes in the city, the building data were prepared in the GIS environment for the year 2002. The physical changes, which occurred between 2002 and 2018 in the district, were determined by using the preexisting building data and the Google Earth satellite images.

Table 2. 1 Contents of the data used

Supplied institution	Content of the data		Area of use	
İBB	2018 year Umraniye district building data		Correlation Tests	
USGS	Landsat satellite images names		Landsat satellite images Resolution (m2)	Change Detection Analysis
	14.06.2002	LT05 L1TP	60 x 60	
	03.07.2003	LT05L1TP	60 x 60	
	05.07.2004	LT05 L1TP	60 x 60	
	08.07.2005	LT05 L1TP	60 x 60	
	27.07.2006	LT05 L1TP	60 x 60	
	12.06.2007	LT05 L1TP	60 x 60	
	30.06.2008	LT05 L1TP	60 x 60	
	19.07.2009	LT05 L1TP	60 x 60	
	04.06.2010	LT05 L1TP	60 x 60	
	09.07.2011	LT05 L1TP	60 x 60	
	17.06.2012	LT07 L1TP	60 x 60	
	30.07.2013	LT08 L1TP	100 x 100	
	15.06.2014	LT08 L1TP	100 x 100	
	20.07.2015	LT08 L1TP	100 x 100	
	22.07.2016	LT08 L1TP	100 x 100	
	09.07.2017	LT08 L1TP	100 x 100	
	10.06.2018	LT08 L1TP	100 x 100	
Google Earth images	2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018 years high resolution satellite images		Interpretation of the results with the help of high resolution satellite images after temporal change analysis	
NİK İnşaat Ticaret Ltd. Şti	2002 Year Quickbird Orthoready satellite image with panchromatic band, 8 bit, 60 cm spatial resolution			

2.3 Methodology

The main aim of the study is to monitor urban climate change by using satellite images. The thermal change detection analysis proposed by Kuşçu Şimşek and Ödül (2019) was applied. This method is based on the comparison of surface temperature information obtained from satellite images for different periods, with the help of a mathematical model created in the GIS environment. Subsequently, these obtained thermal exchange data were tested by correlating them with the data on the physical changes in the region experienced from year to year. The steps taken in this study are presented in Figure 2.1.

In the selection of satellite images, taking into consideration the purpose of the study, images of the summer period, when warming was higher, were preferred. From 2002 to 2018, 17 Landsat images were selected, provided that there was one image from each year.

Spectral radiance values were gathered by using sensor calibration parameters in order to obtain surface temperatures through thermal imagery when evaluating the satellite images. Thermal data were corrected, according to the Landsat 7 ETM and

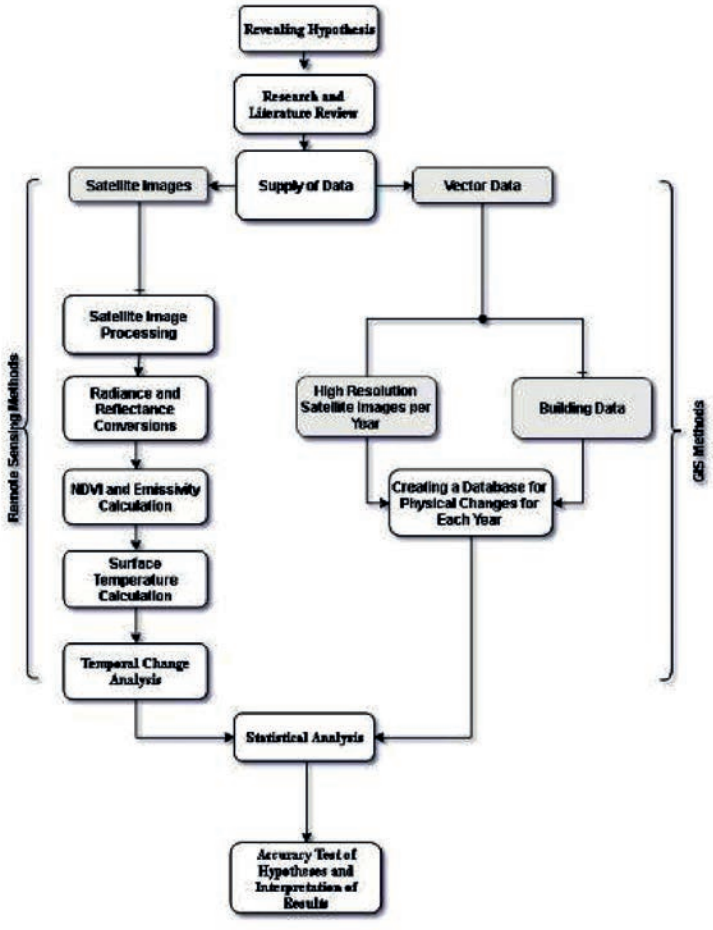


Figure 2.1 Process steps

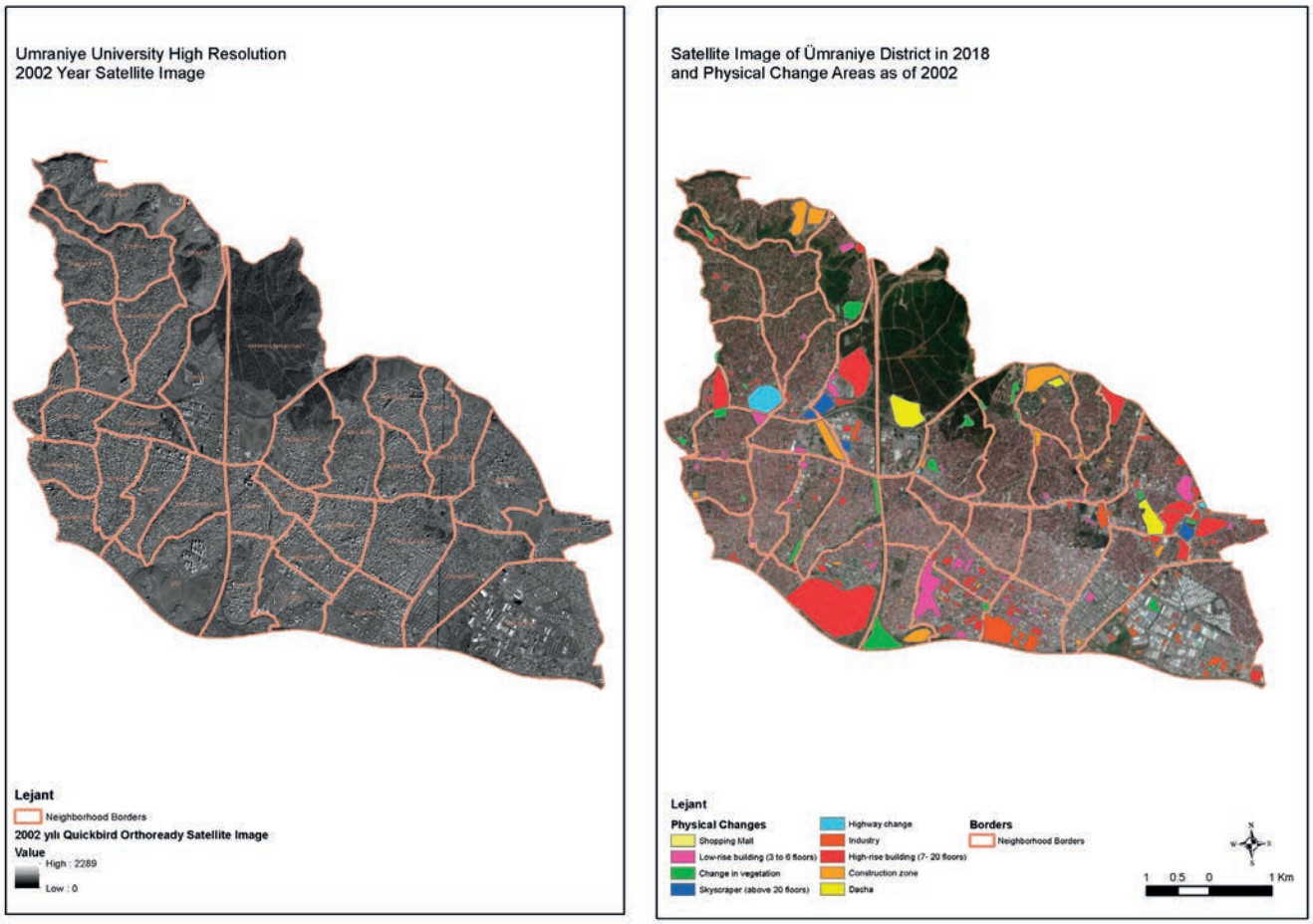


Figure 3.1. Physical changes

Landsat 8 radiometric calibration parameters, before starting the image processing studies. Then, the NDVI (normalized difference vegetation index) and ε (emissivity) values, which make the reflection qualities of surface elements clear, were calculated by the formulae provided by Van de Griend and Owe (1993). Then, according to the radioactive transfer equation that was used by Jiménez-Muñoz et al. (2009), the radiation brightness values were calculated. Lastly, surface temperatures were calculated separately for all thermal images (Kuşçu Şimşek and Ödül, 2018).

Later, the thermal change detection method was applied to these thermal images. The image of the year 2002 was selected as the reference data, and the images of the other years were used as the comparison data. Then, the obtained thermal changing maps were compared with the physical changes created in the GIS environment.

3. RESULTS

The constructional and environmental changes occurring in the district of Ümraniye are given in Figure 3.1, and the microclimatic changes in the regions where these changes are located are given in Figure 3.2.

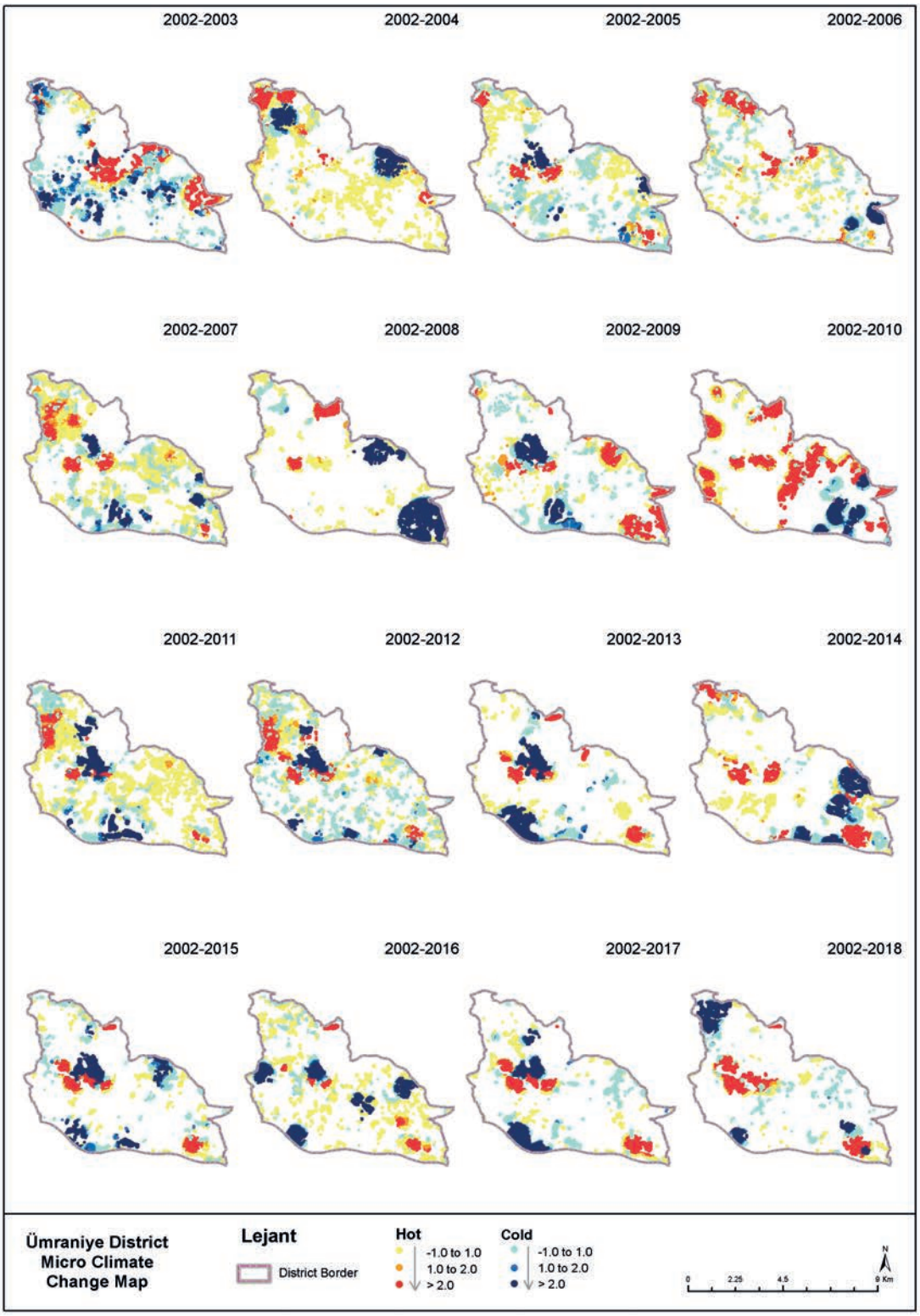


Figure 3.2. Ümraniye district microclimatic change map

Then, the relationship between the areas that got warmer/colder and the construction areas were checked through statistical testing by the bivariate correlation method at a significance level of 0.01. According to the results, significant relationships were observed both at hot and cold points, and the relationship level reached 0.405 and 0.677, respectively.

In this study, in order to determine the effects of physical changes in the region on urban climate, the micro-climatic changes were compared with these physical changes for each year. As a result of these comparisons, it was determined which physical changes caused overheating or overcooling. Then, by evaluating data from all years, the factors causing the heating or cooling of the regions were determined as a percentage (Figure 3.4 and Figure 3.5).

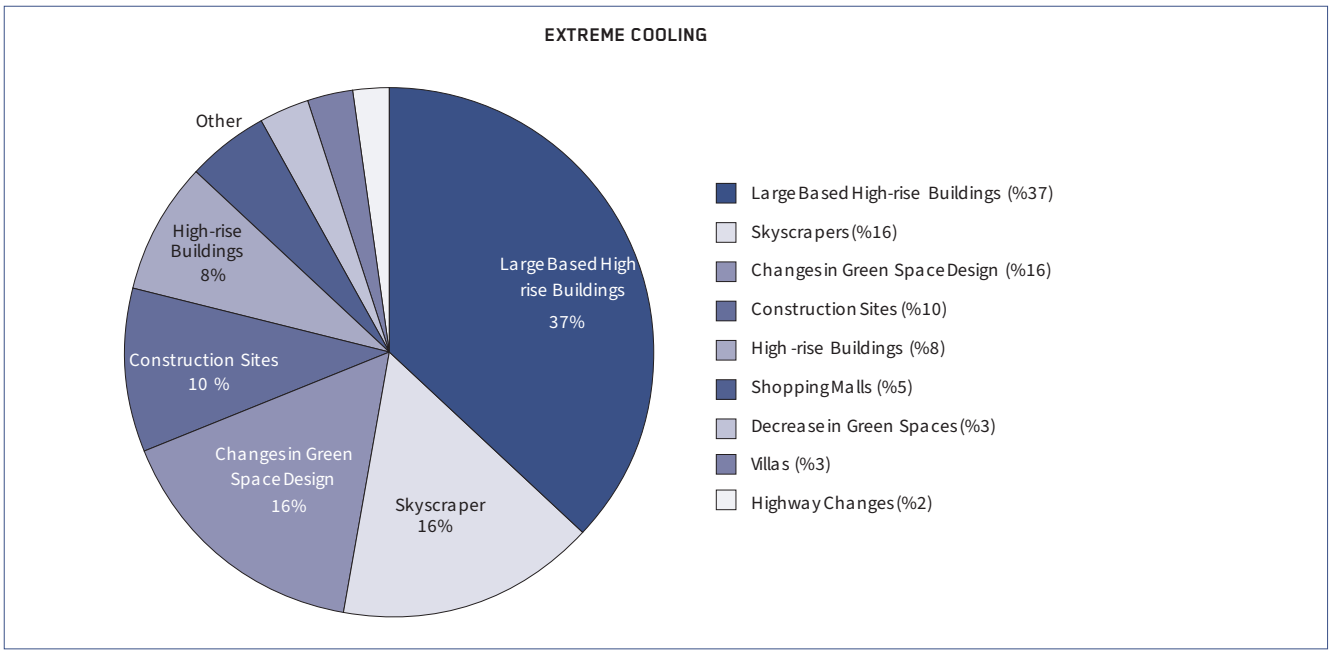


Figure 3.4. Physical change percentages that cause extreme cooling

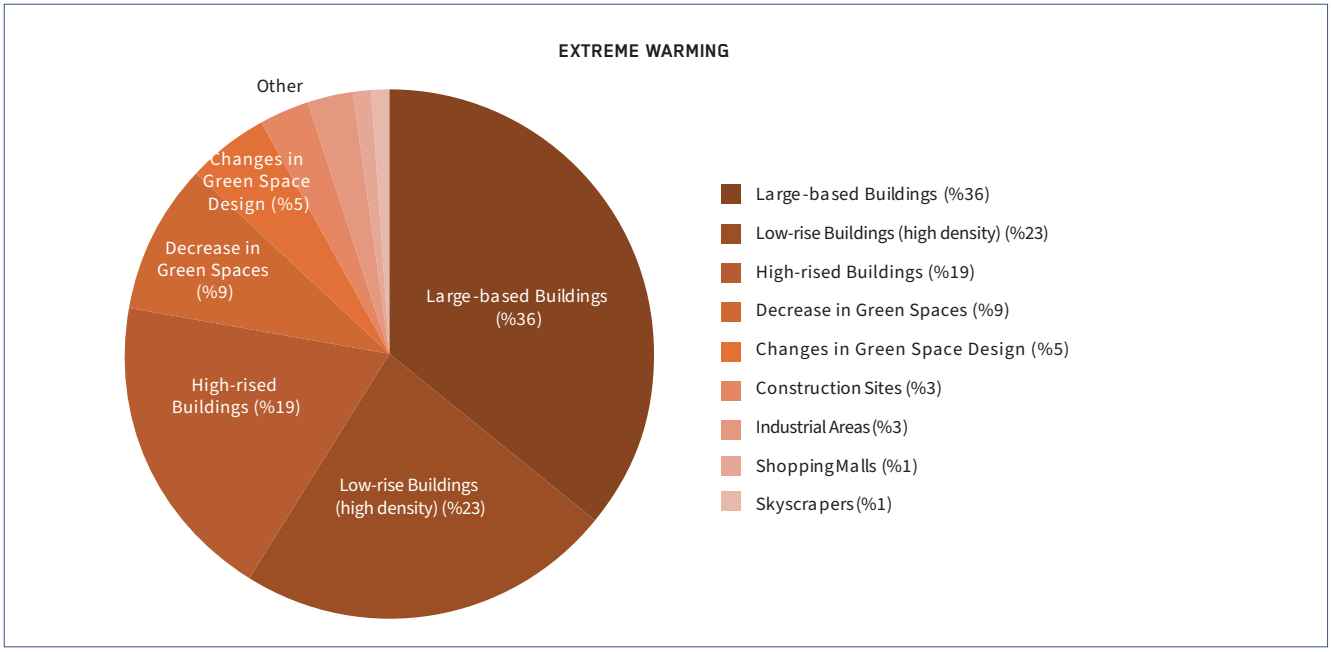


Figure 3.5. Physical change percentages that cause extreme heating

According to the results of the study, overcooling is due to the increase of large-based high-rise buildings, the increase of skyscrapers, and the increase in green areas. On the other hand, the reasons for extreme warming are the increase of large-based buildings, the rise in the density of low-rise buildings, the increase of high-rise buildings, and the decrease of green areas. The rise in the density of buildings (up to 20 stories) demonstrated extreme warming effects due to the increase of impermeable surfaces, decrease of vegetation cover, and the prevention of the airflow between buildings. In addition, changes in vegetation, construction sites, highways, and industrial areas, as well as in large-based constructions such as shopping malls, have changed the urban microclimate.

4. CONCLUSION AND DISCUSSION

The unplanned transformation of cities negatively affects their structure and human health in a climatic manner. For example, due to sudden heat waves, 55,000 people died in Europe and Russia in 2010, and similar problems were experienced in many countries. In Turkey, there is no inventory of deaths occurring in the face of sudden heat waves. However, a mid-latitude belt in Turkey is exposed to frequent heat waves. Therefore, it is possible to predict that many deaths may occur in our country due to extreme temperatures. For all these reasons, it is of the utmost importance to raise this issue.

Ümraniye, which was selected as the study area, was subjected to urbanization in parallel with the rapid population growth after 2000. Construction has a significant impact on urban climate change (Voogt and Oke, 1997; Levermore et al., 2017). For example, while large-based constructions cause rising temperatures (Kuşçu Şimşek, 2013; Gridharan et al., 2004), the high and low floor mix buildings increase the ventilation (Skinner, 2006). Skyscrapers have a cooling effect depending on the shade effect and the turbulence area they create (Oke et al., 2017).

As a matter of fact, the results of this study, supporting the literature, reveal that the structural changes in the region significantly affect the climate of the region. The physical changes and the measures to be taken in the urban climate are given below.

- Skyscrapers create extreme cold zones due to the shadow effect and turbulence effect. Before constructing such buildings, their climatic relationship with the environment should be analyzed.
- Filling the empty parcels with similar building types between buildings causes warming due to increased concrete surfaces and obstruction of air ducts. Therefore, the geometric relationship between buildings should be designed to provide airflow.
- High-rise buildings that have dense concrete surface areas (dense and frequent construction) in their surroundings cause extreme heating. Geometric relations between buildings should be taken into consideration in order to be able to prevent this situation, which increases warming due to the effect of the concrete surface.
- Industrial zones cause extreme heat. This effect can be reduced by methods such as the selection of facade materials and the afforestation of building spaces.
- Destruction of the forest areas leads to extreme warming. Forest areas should be protected.

According to the results of this study, it was determined that physical changes affected the urban climate. Monitoring and analyzing the climatic changes of cities and creating action plans to combat urban climate change and promote sustainable cities are needed.

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URBAN CLIMATE CHANGE PREDICTIONS THROUGH USING ARTIFICIAL NEURAL NETWORKS: A CASE STUDY OF 3RD BOSPHORUS BRIDGE

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ABSTRACT

Urban climate change is one of the most important factors affecting human comfort. In this study, the mesoscale climatic changes that resulted from the construction of the Yavuz Sultan Selim (YSS, Third Bosphorus Bridge), which plays an important role in the northward expansion of Istanbul, were investigated. The artificial neural networks (ANN) were used as the prediction method.

The surface temperature obtained from Landsat 7 and Landsat 8 satellite images, normalized vegetation index (NDVI), emissivity and digital elevation model, and distance to road, forest, and coast data were used as GIS bases. The simulation was applied in two stages. In the first simulation, the surface temperature in the year 2017 was estimated by using data from the years before the construction of the bridge. In the second simulation, the surface temperature of the city as a result of the urban expansion through the northern forests and the effects of the Yavuz Sultan Selim Bridge was estimated.

This study investigates whether urban climate changes have been created and/or will be created via major projects planned in the city by using ANN.

Keywords: Urban Climate, Urban Climate Change, ANN Model, Remote Sensing, GIS

1. INTRODUCTION

Due to the changes in global economic relations, the importance of cities is gradually increasing as the growing world population exhibits a tendency to accumulate in cities. While 3% of the world's population lived in cities in the 1800s (ECOSOC, 2011), currently 55% of the world's population lives in cities, and this ratio is expected to reach 68% in 2050 (UN, 2014). Urbanization increasing in parallel to the population brings about many environmental problems and, indirectly, health problems. The primary examples of these problems include greenhouse gas emissions, urban waste, air pollution, water pollution, noise pollution, light pollution, etc. In addition to these, urban climate change, which has recently come to the agenda in Turkey, stands out as an important urban problem.

Global warming, which has been monitored since the end of the 19th century, is one of the most important problems in today's world and in cities. The population growth and increasing anthropogenic effects of climate change are among the most important causes of these problems (Chen et al., 2006; Owen et al., 1998). The expansion of urban areas causes natural land cover to be displaced by impervious surfaces, resulting in the deterioration of surface energy balance and an increase in surface temperature (Stull, 1988).

This problem, which should be taken into consideration in terms of the quality of human life, needs to be handled from a broad perspective due to its complex structure. Each city has its own unique climate character, which varies according to its geographical location, topography, morphological structure, density, ecological characteristics, and its inhabitants' lifestyle and consumption patterns.

Istanbul is one of the major metropolitan cities in the world, with over 15 million inhabitants. In recent years, with the increasing population and urbanization, natural land surfaces have been rapidly covered with concrete, and accordingly, the climatic conditions of the city have changed (Kuşçu Şimşek and Şengezer; 2012). When climatic studies conducted on Istanbul are examined, they are generally based on meteorological details or on architectural details, but there is still not a sufficient number of studies carried out on a suitable scale and scope to benefit planning studies.

If Istanbul is evaluated with its general characteristics in terms of climatic conditions, compared to other metropolises, it has significant geographical advantages and shows a unique climate structure dependent on them. The sea that surrounds the city from three sides, forest areas and water basins in its surrounding, the Bosphorus Strait, and topography with variable heights are important factors contributing to this uniqueness and the city's topographical advantages.

Considering the relationship between land use, the natural environment, and transportation, the development of Istanbul has continuously shifted northward since the opening of the Bosphorus Bridge in 1973 and then the Fatih Sultan Mehmet (FSM) Bridge opening in 1988 (Oktem, 2005). More recently, the construction of Istanbul Airport and the 3rd Bridge have fragmented forest areas on the northern periphery of Istanbul, and the shifting of urban sprawl to the north has threatened Istanbul's forest areas and wetlands. The aim of this study is to estimate the climatic changes that were created/will be created in the region as a result of the construction of the YSS Bridge and the use of artificial neural networks.

2. MATERIAL AND METHODS

2.1. Study Area

The region surrounding the YSS Bridge, which was selected as the study area, is located around the northern part of the Bosphorus, which is densely covered with forests. The study area was selected within the framework of the bridge line in order to eliminate the effects of Istanbul Airport, located in the north of Istanbul (Figure 1).

Istanbul has different climatic characteristics due to the effects of the Marmara Sea and the Bosphorus. In winter months, it is under the influence of the cold-dry air masses coming from the Black Sea and the cold-rainy air mass coming from the Balkans as well as the mild and rainy southern air masses coming from the Mediterranean. In the whole province, the

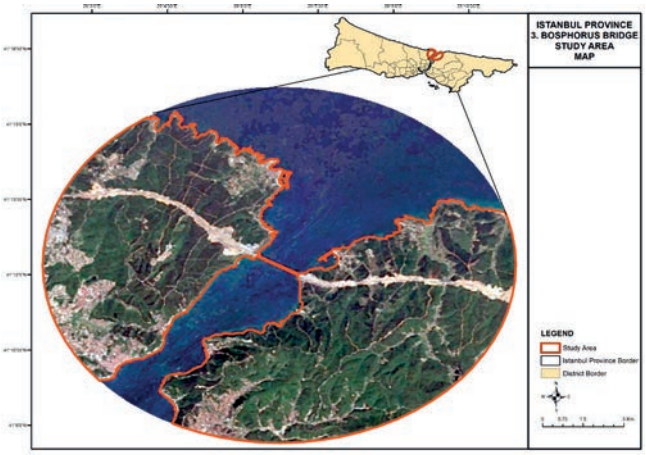


Figure 1. Study Area

cold rainy weather (northeaster) of the Black Sea and the mild weather (southwester) of the Mediterranean follow each other. In the province, no high-temperature differences are observed between summer and winter and between day and night (IPDCT, 2019).

2.2. Data Sets

In the simulation, parameters that are related to the surface temperature, such as normalized difference vegetation index (NDVI), emissivity, altitude, distance to forests, distance to the coast, and distances to roads, were used to obtain data.

NDVI, emissivity images were formed by the calculations made according to satellite images. The dates of the used satellite images are June 12, 2010, July 17, 2011, and July 9, 2017. Landsat-7 ETM+ were used in 2010 and 2011, and Landsat-8 OLI / TIRS satellite images (since the Landsat-7 ETM+ satellite image was not available) were used in 2017. The resolutions of the satellite images are spatially and thermally 30 m and 60 m in Landsat-7 ETM+ and 30 m and 100 m in Landsat-8 OLI and TIRS, respectively.

The data on the distances to forests, coast, and roads were obtained through digitization in the GIS environment and through performing distance analysis.

2.3. Methodology

It is necessary to utilize the opportunities provided by the technologies of our age in order to be able to monitor and model the urban area, which is quite complex and dependent on many parameters. Therefore, the active use of GIS, remote sensing, and simulation techniques have become necessary for planning.

The remote sensing of the Earth's surface via satellites is one of the safest and most consistent ways of

monitoring the change in the land cover associated with urbanization on the regional scale, despite atmospheric influences (Henry et al., 1989). Thermal data, which can be obtained on a regular basis with remote sensing technology, enables climatic simulation studies, together with the detection of heat islands (Bozorgi et al., 2018). The currentness of the data and the methods used in the conducted studies affect the success of the results (Bugs et al., 2010; Özşahin and Kaymaz; 2015).

In this study, GIS and remote sensing methods were used for preparing the base maps. NDVI, emissivity images were obtained from Landsat images for each year, and elevation data were obtained through DEM. The data of the distances from forest, coast, and the road were calculated from their boundary data, which are in vector format. Then, the main databases were formed. The artificial neural network (ANN) algorithm was used in this study in order to investigate the nonlinear relationship between the obtained parameters and the surface temperature.

2.3.1. Atmospheric Correction of Satellite Images

In order to prepare the data to be obtained from the satellite images, firstly, the satellite images taken in raw form are subjected to preprocessing, and image corrections are made. In this stage, the spectral radiance values are gathered by using sensor calibration parameters in order to obtain surface temperatures through thermal imagery when evaluating the satellite images. Thermal data were corrected according to the Landsat 7 ETM (Chander et al., 2009; USGS, 2016) and Landsat 8 radiometric calibration parameters (USGS, 2018) before starting the image processing studies.

Then, the NDVI and ε (emissivity) values, which make the reflection qualities of surface elements clear, were calculated. The emissivity values change due to the surface roughness, vegetation cover, etc. In this study, to estimate the emissivity values of different land surfaces, the NDVI threshold method (NTM) formulated by Sobrino et al. (2008) was used. Then, according to the radiative transfer equation, which was used by Jiménez-Muñoz et al. (2009), the radiation brightness values are calculated. Lastly, surface temperatures are calculated separately for all thermal images.

2.3.2. Climate Simulation by Artificial Neural Networks

Artificial neural networks (ANNs) are a simplified model of the human nervous system. It has features such as a massive parallel, distributed storage and processing, self-organizing, adaptive, self-learning, and fault tolerance (Shao et al., 2011). The method is used, especially in the solution of problems in which multi-factor, multi-parameter criteria should be considered or in which the relationship between factors is uncertain (Mi et al., 2005). Hence, it is suitable to simulate the problems that have a complex structure as urban systems, climate, ecology, environment, etc.

In the study, the surface temperature changes that will emerge due to the urban expansion which is an expected result of the construction of the YSS in the north of Istanbul are strived to be estimated using ANN. After the starting of construction, the northern forests, which provide natural land cover, were exposed to anthropogenic effects. So, the data of years 2010 and 2011, which are the years before the start of the construction of the YSS Bridge, were selected as the training data of ANN, and 2017 the year after when the construction was completed was selected as the year to be estimated.

The study was completed at two stages.

At the first stage, the existing surface temperature information was tried to be predicted using the data from the previous years before the bridge was built. The most accurate result was obtained by examining the correlations of the images obtained at this stage with the current surface temperature data. The coefficients of the obtained most accurate prediction were note downed for use in the other stages of the study.

At the second stage, the urban expansion, which was expected to occur due to the lure created by the link roads and the YSS Bridge, was defined with scenarios (Figure 4). The scenarios created were determined by considering the actual pattern of the settlement area due to the lack of a development plan for the region. New data expressing these scenarios were created by the texture transfer method and visualized by making surface temperature simulations on these data (Figure 2).

Seven parameters were used as inputs in the simulation. These are NDVI, emissivity, altitude, distance to forests, distance to the coast, and distances to roads in 2010 and 2011. Surface temperature data for the years 2010 and 2011 were used as output data. The artificial neural network model is shown in Figure 3.

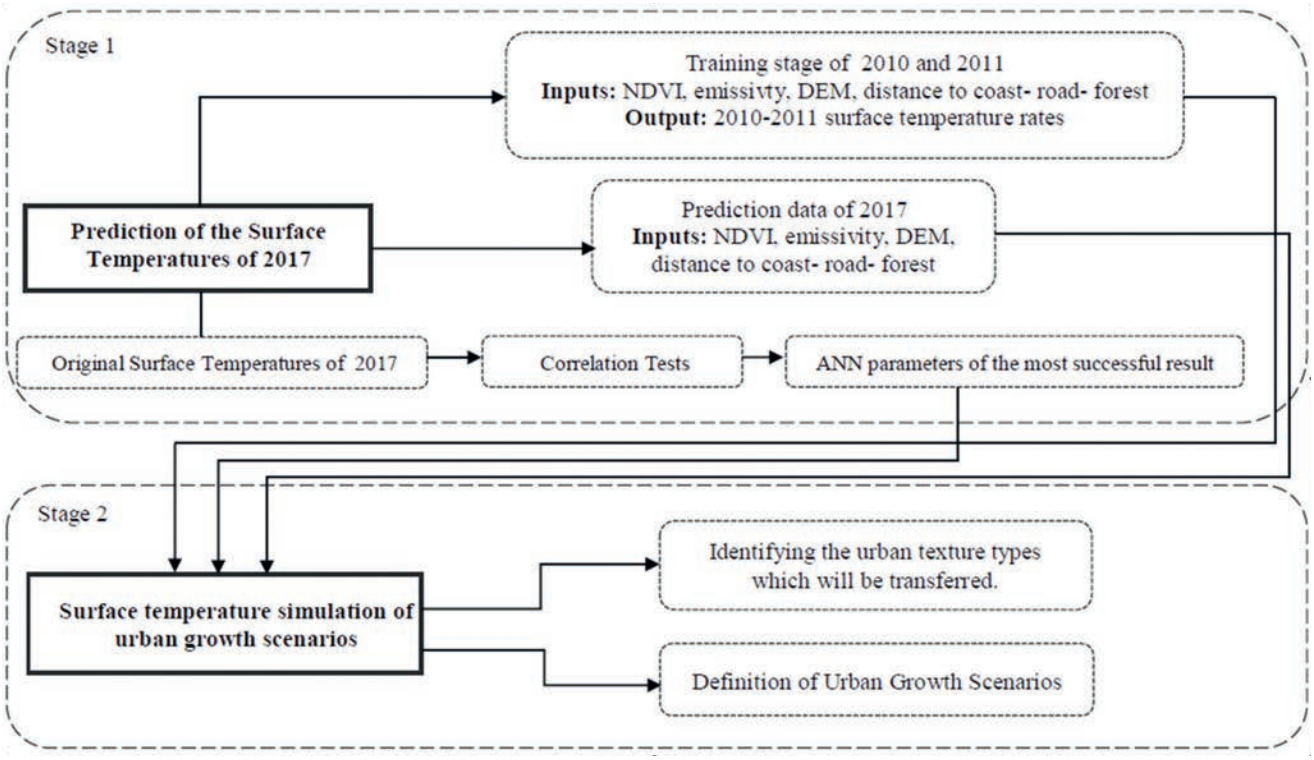


Figure 2. Workflow

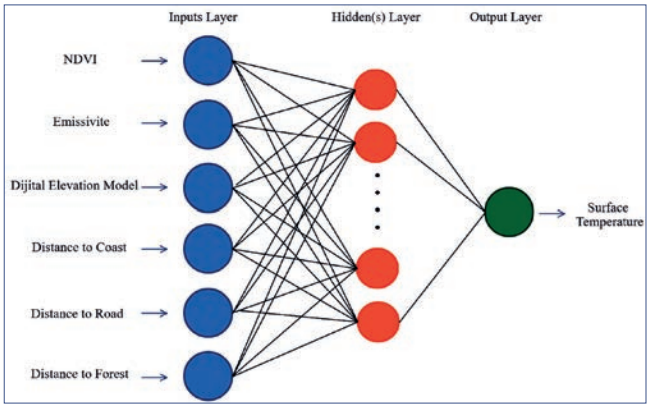


Figure 3. ANN Network

During the training stage of the simulation, the forward-feed backpropagation algorithm was selected as the network type and the logsig, which is a logarithmic function, was selected as the transfer function.

After selecting the number of neurons in artificial neural networks in the training stage, many trials were performed using the study by Panchal and Panchal (2014) as a basis. According to Panchal and Panchal (2014), the basic rules for selecting the correct number of neurons are as follows:

- The number of hidden neurons should between the number of input layers and the number of output layers.
- The number of hidden neurons should be the sum of 2/3 of the number of input layers and the number of output layers.
- The number of hidden neurons should less than two times the number of input layers.

Many neurons were tried according to these rules. The effect of the used parameters on the output as a result of the training is observed as the weight matrix. By using this weight matrix, the simulation was made for the input data for the year 2017.

Making use of the obtained correlation results, it was decided which parameters could be used in order to estimate the surface temperature, and the city's expansion scenarios were applied. The urban texture types applied in these scenarios were chosen conveniently according to the texture types in the study area. The selected urban texture types given in Figure 4 were used in all scenarios in a mixed manner.

2.4. Findings

The neurons tried in the simulation and the correlation results that change depending on these neurons were presented in Table 1. According to the tried coefficients, the highest correlation coefficient between the original and the estimated surface temperature for the year 2017 was 0.687. This value was obtained using three hidden layers and seven neurons. Then, the simulation output of the year 2017 was visualized by being printed, and the surface temperature of the original and of the year 2017 was compared (Figure 5).

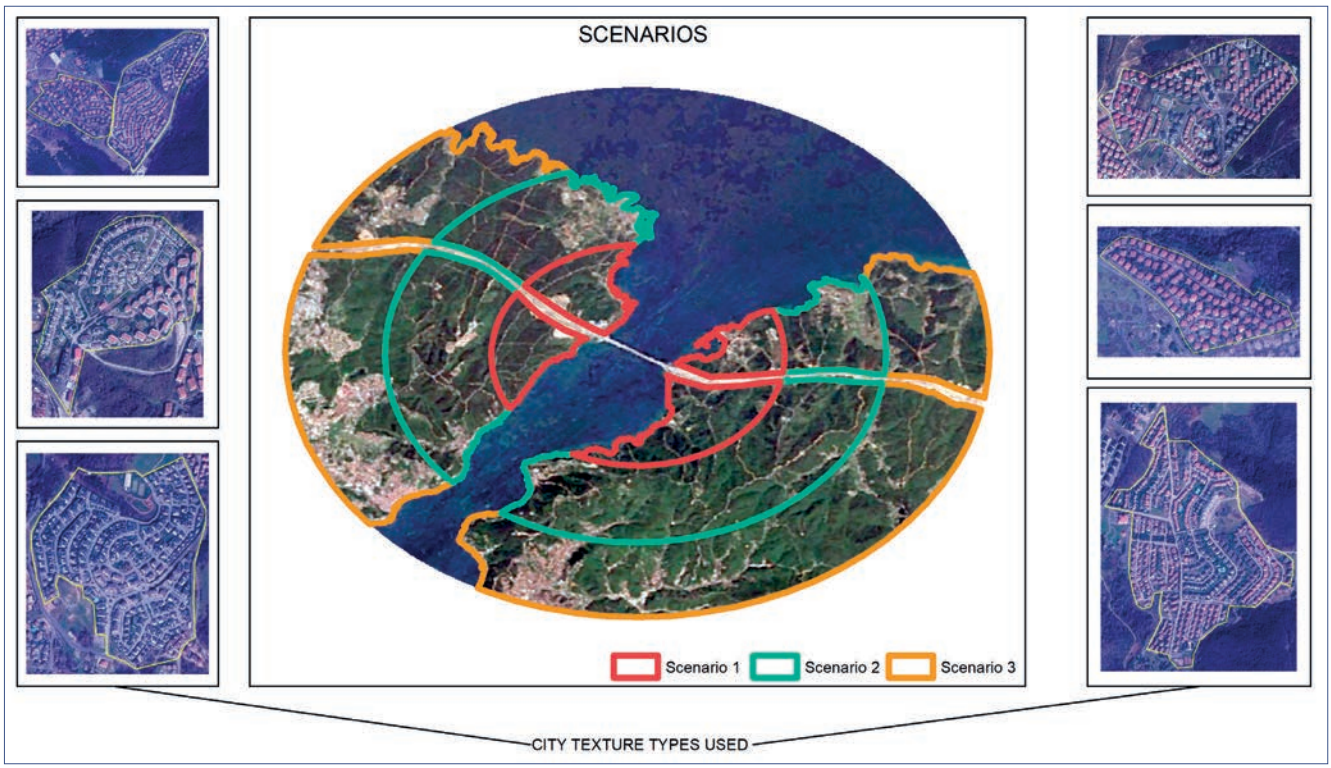


Figure 4. The Used Urban Texture Types

Table 1. Correlation Results

Trials	Number of Layers	Number of Neurons	Epochs	Correlation Between Original and Estimation
T1	2	5	10000	0.583
T2	2	5	20000	0.477
T3	2	10	50000	0.649
T4	3	6	50000	0.647
T5	2	6	100000	0.667
T6	2	6	200000	0.686
T7	3	6	100000	0.664
T8	2	5	100000	0.683
T9	3	6	200000	0.572
T10	2	4	100000	0.534
T11	2	6	500000	0.190
T12	2	10	200000	0.657
T13	2	8	200000	0.537
T14	2	5	300000	0.448
T15	2	5	200000	0,070
T16	2	7	200000	0.680
T17	2	11	200000	0.210
T18	2	12	200000	0.461
T19	3	7	200000	0.687
T20	3	5	200000	0.518
T21	3	4	200000	0.683
T22	3	8	200000	0.576

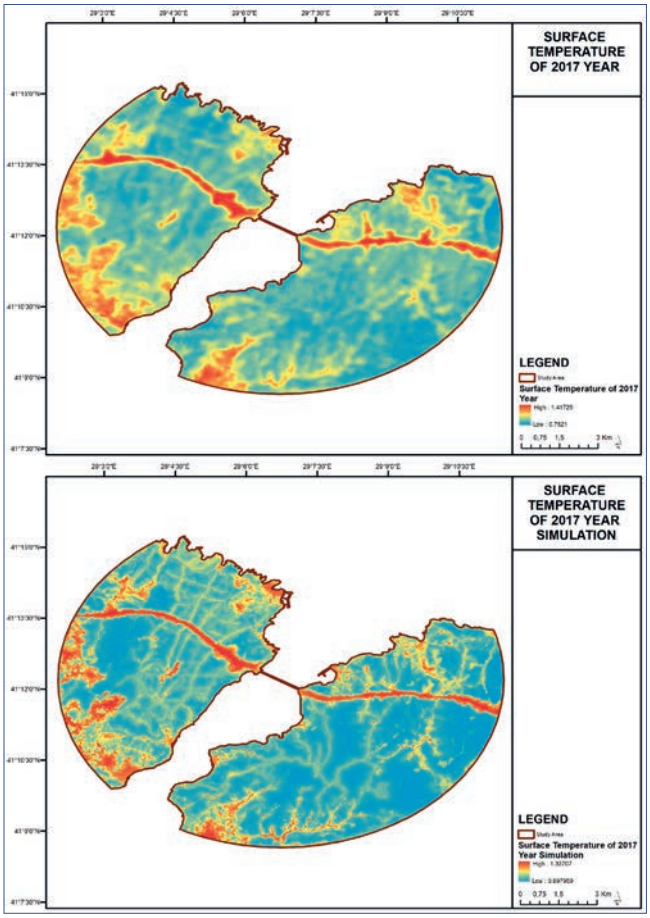


Figure 5. Surface Temperature, 2017 original (Up), 2017 simulation (Bottom)

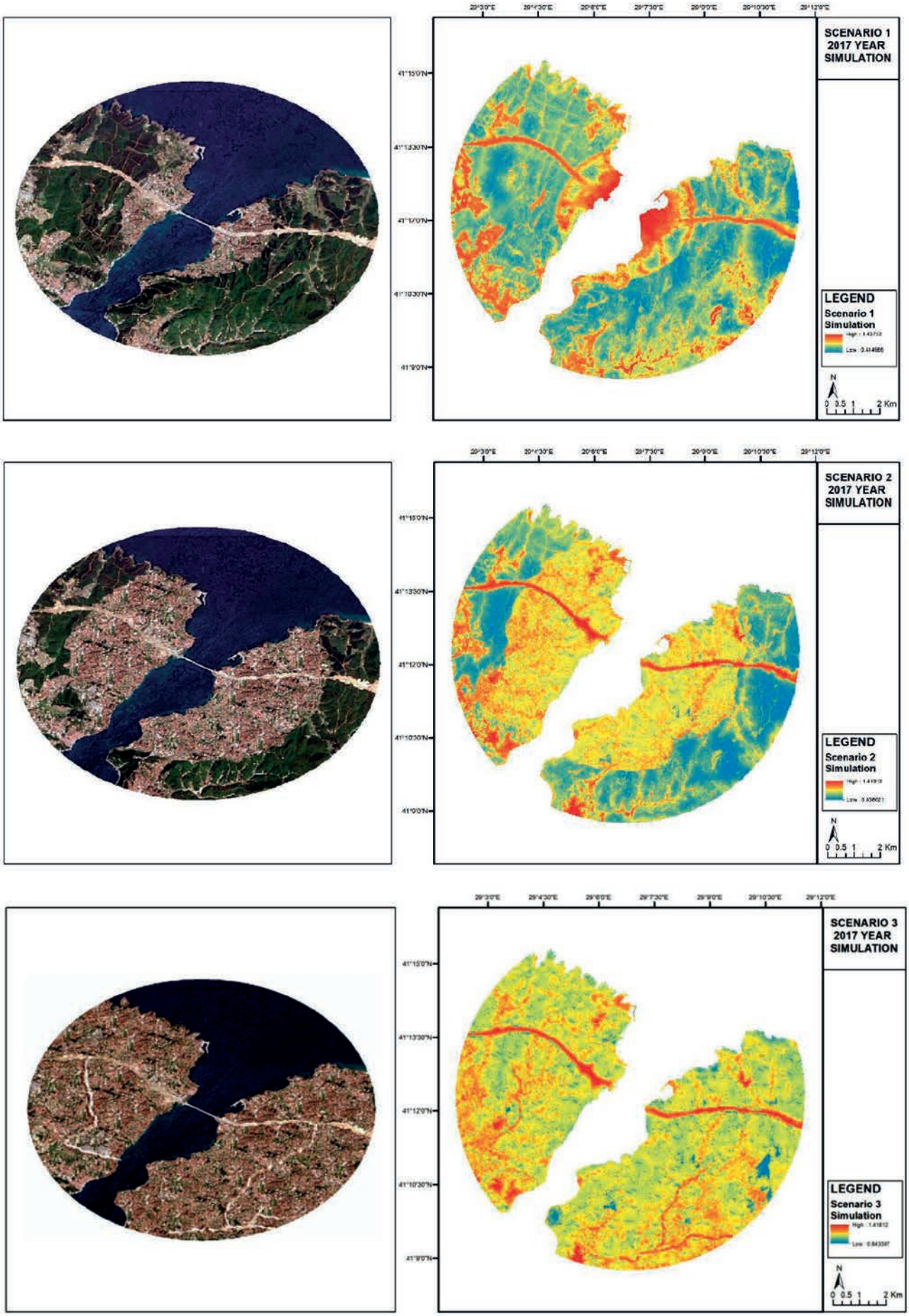


Figure 6. Simulation Results for Scenarios

According to the obtained correlation and visual results, it was concluded that the parameters used in the simulation could be used to estimate the surface temperature. Then, urban expansion scenarios were applied. The simulation results of the scenarios were presented in Figure 6.

3. CONCLUSION

In Istanbul, which is among the largest metropolises in the world, urban sprawl is expanding to the north following the construction of several megaprojects, and green areas are rapidly being destroyed. The creation of impervious surfaces and the displacement of green cover change the urban climate substantially. Since urban climate strategies have not been developed against these factors, Istanbul is becoming vulnerable to climate change. Applying urban climate simulations before urban planning plays an important role in developing early measures against climate change.

In recent years, the ANN model has been widely used in climate estimation. For instance, in the study of Bozorgi et al. (2018), NDVI, percentage of green cover pixels, and NDBI (Normalized Difference Built Index) were used as parameters for estimating surface temperature. This method attempted to predict the change in surface temperature as a result of covering the urban surface with green vegetation or concrete surface. According to the results, it was seen that the covering of urban lands with green vegetation is more effective than concrete surfaces (like buildings) in reducing the surface temperature of the urban environment. In another study, Kumar et al. (2015), used land use types, latitude-longitude, and elevation information of the study area in simulating the surface temperature as an input parameter in the ANN model.

In this study, NDVI, emissivity, elevation, distance to forests, distance to the coast, and distance to roads were used as input parameters for the estimation of surface temperature in the ANN model. According to the results, the highest correlation coefficient was found as 0.687. It should be pointed out here that, in this simulation, a complex problem which was affected by many factors (topography, impervious surfaces, greenness, urban geometry, land use, land cover, urban texture, building hight, building base area, sky view factor, population density, etc.) was tried to be solved and only six of them were used as a parameter. So, the correlation result can be accepted as a high correlation for this simulation. If the number of input parameters can be increased, the obtained results will be more accurate.

The results obtained in the study were presented below as follows:

- It has been demonstrated that the effect of urban surface changes on the local climate can be estimated with ANN.
- ANN simulations could be done according to the urban development plans.
- With this kind of study, estimations about the possible effects of megaprojects that are planned in cities can be made, and measures can be taken against possible problems.
- Urban texture transplantation, which was used in the study, is a suitable method that can be used with ANN to estimate the changes that will occur in urban areas.
- According to the simulation results, the destruction of forests and the increase in concrete surfaces affect the urban climate and increase surface temperatures.

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IMPACT OF VERTICAL AND HORIZONTAL URBANIZATION ON URBAN HEAT ISLANDS IN ISTANBUL

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ABSTRACT

Urban heat island (UHI) intensity in Istanbul is estimated to be approximately 3°C during summer seasons over the last 50 years. This temperature has been continuously increasing as a result of the replacement of green areas in the urban fabric of the city. This situation is consequence of horizontal and vertical expansion of urban geometry. Horizontal expansion increases impervious surfaces and roughness, while vertical expansion blocks wind corridors and prevents urban ventilation. Both expansion variations cause the urban heat island effect. The urban heat island issue is one of the most serious problems in megacities, especially in summer time since it intensifies the impact of heat waves by exacerbating thermal risks for urban residents. It is important to identify the effects of urban expansion on hot spots in order to develop efficient mitigation strategies to reduce the urban heat island. In this study, the thermodynamic micro-scale urban climate model MUKLIMO_3 is used to simulate the urban heat island effect for different urban expansion scenarios in Istanbul. Three different scenarios were created for urbanization: two vertical and one horizontal. The model's sensitivity and the effects of the scenarios on UHI all over the city were presented. Our findings indicate that the horizontal expansion results increase the temperature up to 3°C. The effects on the urban climate are not limited by the expansion regions, and different degrees of changes are expected over the whole city. On the other hand, in vertical scenarios the temperature increase is approximately 1°C or less, and it affects only the built-up areas. However, the position of the high-rise buildings changes the wind field distribution, which might elevate the air pollution problem in the city. Horizontal and vertical urban expansions are not substitutions for each other, but this case study is helpful to understand how these expansion scenarios contribute to the urban heat island effect.

Keywords: Urban climate, Urban Heat Island Effect, Istanbul

1. INTRODUCTION

The urban climate is defined by WMO (1983) as the local climate that changes with the interactions between the built areas and the regional climate. In cities, the surface is generally rough and dry because the natural vegetation cover is replaced by buildings and streets. Human impact on nature significantly affects the urban areas and creates environmental problems. The examples of these impacts are elevated air pollution levels, decreased urban ventilation resulting from the increased surface roughness of buildings, and changes in the frequency and intensity of extreme meteorological events due to intensification of urban heat islands.

In urban areas the temperatures tend to be higher than in neighboring rural areas as a result of heat island formation over cities. This is verified for different levels and scales of urban development patterns, ranging from villages to mega cities. There are significance differences in solar energy absorption and heat storage properties between urban and rural areas. Urban materials readily absorb and store more solar heat than do vegetated areas outside of the city during daytime and emit more long wave radiation during the night. In addition, increased roughness elevates the temperature differences between the urban and rural surfaces. The urban rural temperature difference is called an urban heat island (Oke, 1987). Luke Howard first used this definition to describe the conditions in London in 1833 (Steward, 2011). The urban heat island emerges in urban areas due to the diminishing vegetation cover in cities, the presence of dense buildings, roads, and the increased thermal heat capacity of the surrounding areas of the cities with more heat spread from surfaces with vegetation cover. Urban heat islands (UHI) can appear in the

daytime or nighttime during the year. In particular, the temperature difference between the city and the surrounding countryside reaches its highest value during clear quiet nights. Windier conditions support heat advection and lower the temperatures at local heat accumulation points. Therefore, trough strength of UHI is measured in dry, calm, and clear sky conditions. The increase in residential areas and asphalt roads and the decrease in green areas increase the strength of UHI. In terms of urbanization, both horizontal and vertical expansions have impacts on urban climate. The rate of impervious surface in the city is increasing in the case of horizontal urbanization. In the case of vertical urbanization, vertical geometry is affected, and problems with daylight utilization, wind canyons, and other issues arise.

Istanbul is the fasting growing city of Turkey and the 15th largest megacity in the world, with a population larger than 15 million. Urban heat island intensity is approximately 3°C around Kartal province (Unal et al 2019). Compared to the other cities with a similar population and urban development, urban heat island intensity is relatively small because of the Bosporus Strait, Black Sea, and Marmara Sea. In this study, we model the urban climate of Istanbul by using urban climate model MUKLIMO_3 for today's land use distribution. Then, we investigate the urban climate under two different urbanization expansion scenarios over Istanbul and their effect on urban heat island intensity.

2. DATA AND METHOD

For this study, micro-scale climate model MUKLIMO_3 is used to simulate the urban climate of Istanbul. MUKLIMO_3 is developed by the DWD (German Meteorological Service – Deutscher Wetterdienst) and based on the meso-scale weather forecast model with the addition of the heat, momentum, and moisture exchanges between the urban fabric and the atmosphere. The non-hydrostatic thermodynamic version of MUKLIMO_3 simulates the atmospheric temperature, humidity, and wind field on a three-dimensional model grid (Bilgen and Unal, 2016).

The model simulations for today's conditions are validated by using hourly meteorological observations collected by AKOM's (Disaster Coordination Center) meteorological stations over selected locations. Our comparisons reveal that the local climate conditions predicted by MUKLIMO_3 are similar to the observations. The model produces slightly cooler temperatures over the city, and the model biases are at most 5 K. This bias range is similar to the range estimated by the studies of Holec et al., 2017; Gál and Skarbit, 2017; Straka, 2017 for different cities in the world.

2.1. Land Use over Istanbul

MUKLIMO_3 model requires initial conditions for three different categories. These are land use classification, terrain height, and land use table, which contains special parameters defined for the city of interest. Three different data sets were used to generate land use information over Istanbul. The Istanbul Metropolitan Municipality Geographical Data Set and Başar Soft Geographic Information Systems (GIS) Data Set were used for the classification of built-up areas. The CORINE Land Cover Raster Data was used to define land use classes other than buildings such as forest, agricultural lands, water, etc. The percentage of building density in each grid box with a horizontal resolution of 200 meters was calculated in order to be able to create the classes for the settlement areas. All land use classes can be seen in Table 1 and Table 2. Istanbul land use map contains 25 land use classes, 200m x 200m resolution over 551x361 grid boxes. Sixteen out of 25 classes define the built-up areas with different density and average building heights. Istanbul land use map and study area can be seen in Figure 1.

The most critical part of urban climate modeling is to determine appropriate land use classes as realistic as possible. The physical parameters defining land use classes have standard values and are defined based on the literature by model developers (DWD-Deutscher Wetterdienst Department Climate and Environment Consultancy). However, not all of the parameters are suitable for the megacity Istanbul. For example, leaf area index (LAI) and building height parameters are redefined for the newly introduced classes. Also, albedos of each class type are calculated by using satellite data with a special toolbox that was created by Free University Berlin (Unal et al., 2018).

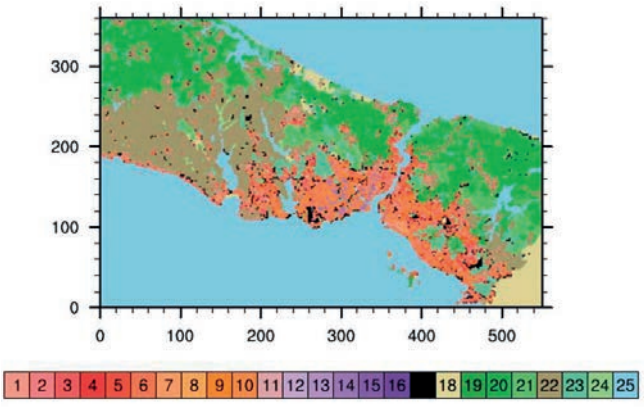


Figure 1. Istanbul land use map and model domain

Table 1. Building classes of land use map

Class Number	Building Density	Building Height
1	5%-15% low density	←10m
2		10m-20m
3		20m-30m
4		→30m
5	15%-30% mid density	←10m
6		10m-20m
7		20m-30m
8		→30m
9	30%-50% dense	←10m
10		10m-20m
11		20m-30m
12		→30m
13	→50% high density	←10m
14		10m-20m
15		20m-30m
16		→30m

Table 2. Land use classes of Istanbul

Class Number	Class Definition
17	Traffic and park
18	Bare soil
19	Coniferous forest
20	Broad leaf forest
21	Mixed forest
22	Agriculture
23	Wasteland with grassland and shrubbery
24	Wasteland with grassland
25	Water

2.2. Urban Expansion Scenarios

Horizontal and vertical urban expansions are tested to present their effects on the urban heat island phenomenon. For the horizontal case, the land use class 23, wasteland with grassland and shrubbery, is converted to the land use class 7, in which 15–30% of the grid boxes contain mid-density buildings, 20–30 meters tall. On the other hand, in vertical cases, two different approaches are tested. Low-level buildings (land use classes 1, 5, 9, and 13) are raised six meters (approximately two extra floors) for the first vertical scenario (vertical 1). In the second vertical scenario (vertical 2), low and mid-level buildings (land use classes 1, 2, 5, 6, 9, 10, 13 and 14) are raised six meters. To apply the scenarios, the parameters in MUKLIMO_3 land use table are modified. The area on the domain, which is affected by the horizontal and vertical urban expansion scenarios, can be seen in Figure 2.

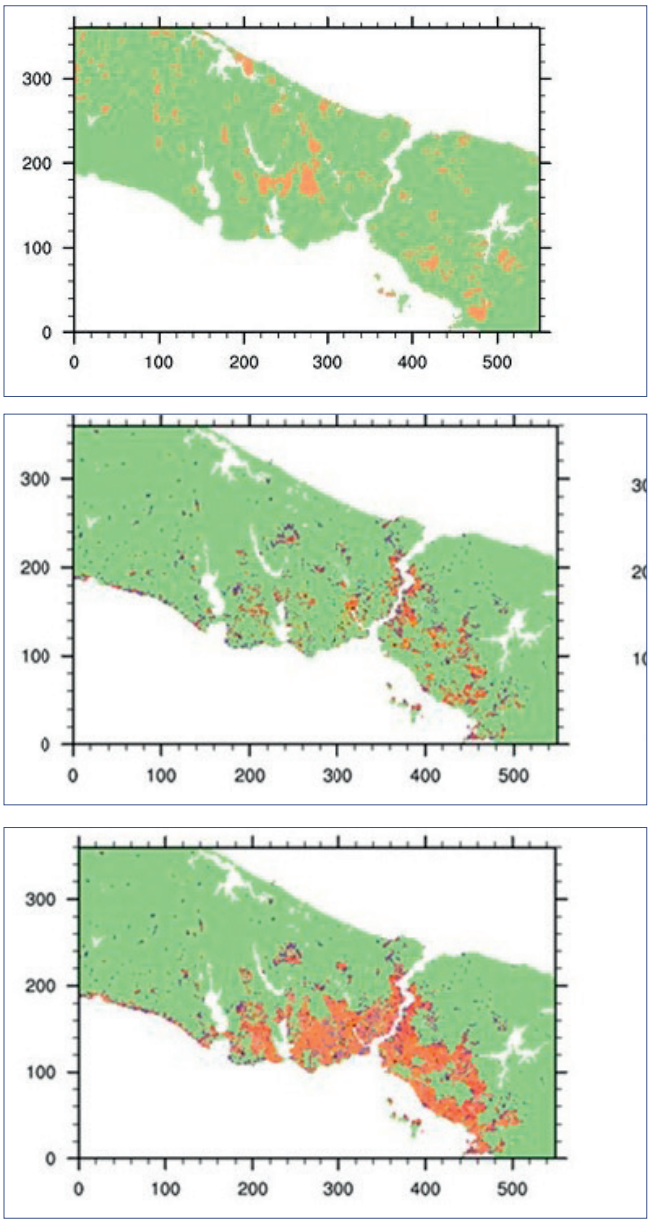


Figure 2. Horizontal urban expansion scenario (up), vertical 1-low-level buildings (left), vertical 2-low- and middle-level buildings (right)

3. RESULTS

MUKLIMO_3 model was run to assess the UHI effect of built-up areas over Istanbul. One horizontal and two different vertical urban expansion scenarios were tested to see the impact of each scenario on the strength of the UHI. Urban development scenarios are very important in terms of urban transformation, urban planning, and urban climate. The implementation of the hypothetical scenarios through the model is valuable since it reveals the impact of the scenario on urban climate and helps us to develop mitigation scenarios on the city scale.

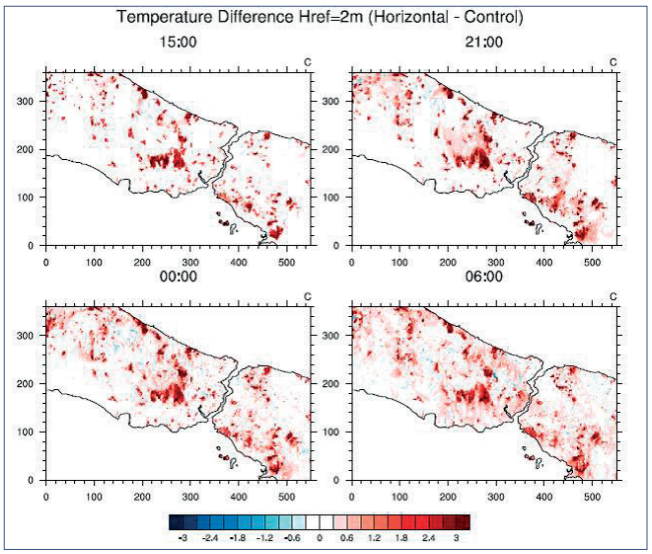


Figure 3. Temperature difference of horizontal urban expansion scenario and control run

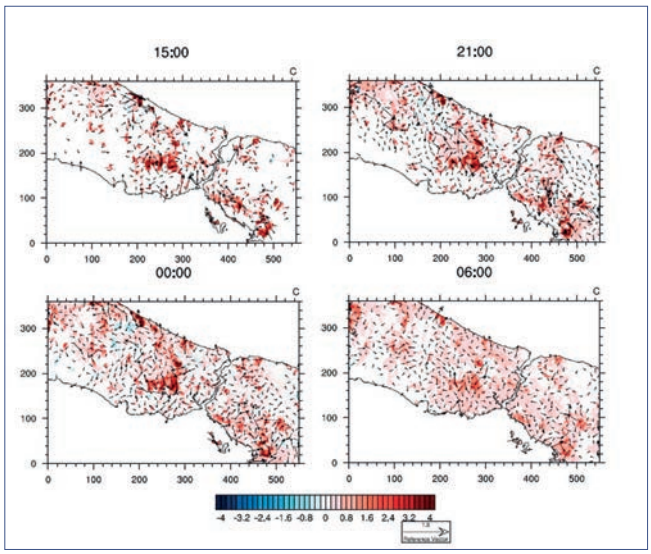


Figure 4. Wind direction differences of horizontal urban scenario and control run

It is clear that in the case of horizontal development, the intensification of the urban heat island effect is more pronounced (Figure 3). There is an increase in air temperatures up to 3°C mainly over the areas that are covered by buildings. However, the absorption of solar radiation and emitted long wave radiation over the newly built-up areas change the local circulation by exchanging heat with the environment. As a result, the temperatures of the surrounding areas around the new developments increase. Our results indicate that the horizontal scenario causes a serious impact on UHI over Istanbul. Besides the urban heat island effect, the population growth caused by the applied horizontal urban development scenario is calculated approximately. All building class grids in the MUKLIMO_3 domain were determined, and the building area per person was calculated according to Istanbul's population of 15 million. Considering that there are also offices, schools, hospitals, etc. in the building classes, the usage area of the building per person is calculated as 60 square meters. With this calculation, the existing building area of the MUKLIMO_3 domain has increased 7% by transforming the class 23 open spaces to class 7 buildings with a height of 20–30m and 15–30% density. This scenario corresponds to a population growth of approximately 9 million.

The true measure of urban heat island intensity is estimated by considering the temperature difference between urban and rural areas for days with dry, calm, and clear atmospheric conditions. Therefore, urban climate model MUKLIMO_3 are forced by winds at 100 m around 1 m/sec. So that, the wind structure around the city is basically created by the thermal differences of the urban and natural surfaces. Hence, the wind field of the control simulation does not reveal any prevailing wind direction over the city. The difference between wind fields of horizontal expansion and control simulations are presented in Figure 4 at four different times of day. Because of the created wind corridor between the buildings, in a certain part of the city, wind speed increases 0.5 m/s. The change in the thermal differences between the sea and urban areas increases the strength of the sea breezes along the shore lines of the Black Sea and Marmara Sea.

For vertical scenarios, it can be seen that urban hot spots occur only in the main built-up area of the city. Figure 5 illustrates the temperature difference between vertical scenario 1 and the control simulations. In this scenario, the heights of the low-level buildings increased six meters. The temperature difference between vertical 1 scenario and the control simulation is about 0.5°C and at certain locations, reaching to at most 1°C.

The results are similar for the vertical 2 scenario. On the other hand, temperature rise is more intense than

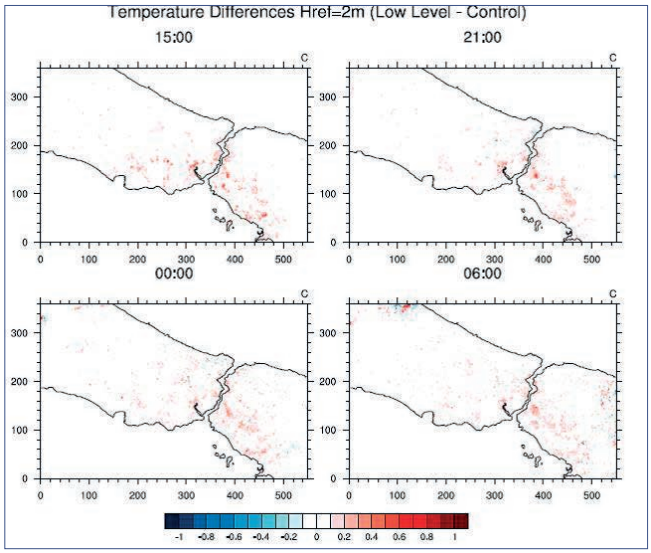


Figure 5. Temperature difference of vertical 1 urban expansion scenario and control run

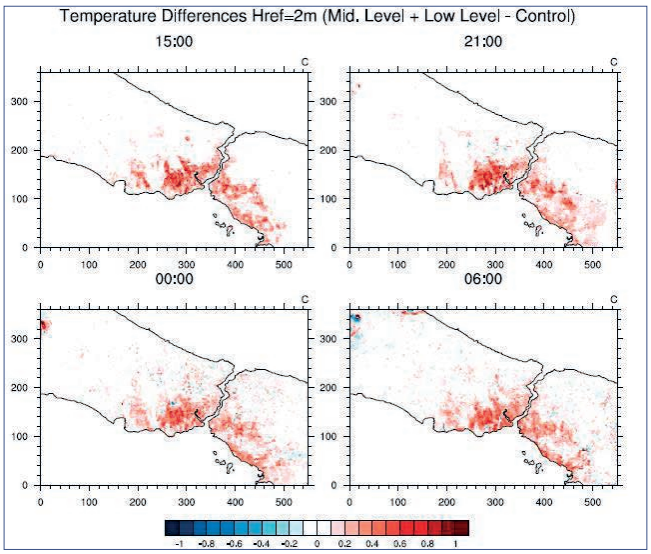


Figure 6. Temperature difference of vertical 2 urban expansion scenario and control run

the vertical 1 scenario as seen in Figure 6. In vertical 2, two extra floors are added to low- and mid-level buildings so the impact area is larger.

The temperature difference between vertical 2 and control simulation is 1°C for the whole impact area. The contribution of vertical urban expansion scenarios to the population is also calculated by using the same method in the horizontal case. The population growth is approximately 2 million and 6 million, respectively, for the vertical 1 and vertical 2 scenarios.

4. CONCLUSION

Urban climate model MUKLIMO_3 is used to estimate the UHI effect of built-up areas over Istanbul. The model is first tested for a summer day in July, which is called the control run. Then, the simulated temperature field is validated point-wise at the selected locations with AKOM observations. Our comparisons of hourly simulations with the observations reveal that MUKLIMO_3 successfully simulates the daily temperature fluctuations over Istanbul. The model climate in urban areas is slightly cooler than the observations; however, still the degree of the biases is consistent with the simulations done for other cities. The discrepancy between simulations and observations might arose because of the fact that the land use table or the 200 m resolution might be inadequate to represent the diversity of the land use categories over Istanbul. However, micro-scale climate model MUKLIMO_3 is still a useful tool to simulate 24 hours of daily temperature change in rural and urban areas. It is also used for creating different urban expansion approaches to test the impact of the mitigation efforts.

The results of these expansion scenarios show that population growth and increase in the build-up areas increases the occurrence of hot spots. The results indicate that the horizontal urban expansion causes a temperature increase up to 3°C. The effects on urban climate are not limited by the expansion regions, and different degrees of changes are expected to be seen over the whole city. In vertical scenarios the temperature increase is nearly 1°C and less, and it affects only the built-up areas.

Horizontal and vertical urban expansion scenarios are tested to quantify the impact on UHI intensity. These expansion methods should not be considered as a substitute for one or another. However, these kind of case studies are important for decision makers to understand how urban expansion and population growth contribute to urban climate change.

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TAMIREVI: A MODEL RESTORATION PRACTICE FOR HISTORIC HOUSES IN MARDIN

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ABSTRACT

In today's world, environmental awareness is as critical for the existing building stock as it is for new structures. Any intervention in the urban fabric must comprise energy-efficient technology for our long-term survival. Since historical urban landscapes constitute a significant part of the building stock, it is imperative to integrate climate-responsive systems into their conservation.

Tamirevi, a historical house in Old Mardin, is the site of a pioneer, energy-efficient conservation project. The overall mechanical system is a balance of historic and contemporary technologies. It aims to act as a model for future conservation projects in the region, since part of Tamirevi was repurposed as a permanent exhibition dedicated to environmentally-conscious methods.

The process of designing a case study in order to improve the sustainability of Tamirevi began with stakeholder meetings. A survey was conducted to understand the occupants' energy consumption habits. The evaluations of these questionnaires shaped the methods used in the restoration project. This allowed Tamirevi to fulfill its goal of becoming a model restoration practice for historic homeowners and residents in Mardin.

The restoration of Tamirevi is one of the major outcomes of the KORU project, which is carried out by the Association for the Protection of Cultural Heritage (KMKD), to build capacity in cultural heritage protection in Turkey. This article will focus on the methodology and innovation implemented in the Tamirevi project.

Keywords: energy efficiency, historic buildings, sustainable heritage, environmental conservation

1. INTRODUCTION

The Capacity Building in Cultural Heritage Protection (KORU) Project is conducted in the cities of Antakya and Mardin. It is managed by the Association for the Protection of Cultural Heritage (KMKD) in partnership with Edinburgh World Heritage and funded by the British Council's Cultural Protection Fund. KORU has four pillars: documentation and renovation, community engagement and training, sustainability of historic cities, and safety. Within these pillars, the project has organized trainings for individuals in professions that influence the protection of cultural heritage, created an online QGIS database of historic buildings in the two cities, and renovated a historic building in Mardin, among many other outputs.[1]

KORU's "Sustainability of Historic Cities" pillar required the energy-efficient restoration of a historic Mardin house. As this was the first project of its kind in Turkey, the work package came to be called "Rest-Lab," short for "Restoration Laboratory." The name was a nod to the experimental nature of the application. It was translated into Turkish as "Tamirevi."

Through Tamirevi, KORU Project aims to create a model that initiates discussion of energy-efficient architectural conservation. Its emphasis on being a "model" is based on the realization that it is no longer enough to make stand-alone climate-responsive interventions in the urban fabric; a project must spark further action. Community engagement became a paramount component because of Tamirevi's goal to influence its surroundings. The project engaged the people of historic Mardin from day one by involving them in the design process. A survey was carried out to determine the needs of the traditional houses in the old city, and the restoration project was designed according to its results. Tamirevi is expected to inspire other, similar projects in the area, as well as spark further research into energy consumption patterns and energy-efficient technologies applicable in Southeast Turkey.

The first section of this paper describes the common

ground between environmental sustainability and architectural conservation, where conservation's benefits to ecological longevity are laid out. The second section outlines the design of the Tamirevi project, the origin of KMKD and EWH's vision for it, and its application through a participatory process. The third section details what interventions made Tamirevi energy efficient. The fourth and final section describes how this project was designed as a model for the historic city of Mardin.

2. ARCHITECTURAL CONSERVATION AND SUSTAINABILITY

The United Nations Educational, Scientific and Cultural Organization (UNESCO) set the Sustainable Development Goals in 2015. Goal 11 (SDG 11) is to "make cities and human settlements inclusive, safe, resilient and sustainable" (UNESCO, 2015). It unifies two aims: Target 4, to "strengthen efforts to protect and safeguard the world's cultural and natural heritage," and target 6, to "reduce the adverse per capita environmental impact of cities" by 2030 (UNESCO, 2015). In this sense, architectural conservation and environmental sustainability serve the same purpose.

SDG 11 recognizes the eminence that architectural conservation has been gaining in ecological literature. There has been a persistent perception that historic buildings are inefficient, which has been used as an excuse to demolish them and design new, energy-efficient structures. However, considering that energy efficiency means using less energy to perform the same functions, it is perfectly achievable in an old building as well as a new one. Many historic buildings predate powered heating, cooling, and electrical lighting, so they contain numerous passive technologies that more modern buildings often lack. As a result, it is much more sustainable to renovate historic buildings to be energy-efficient than to build new structures in their stead, however environmentally conscious the latter may be.

2.1. Conservation and Sustainability in Urban Planning Strategies

Numerous contemporary urban planning movements favor designing for density and optimizing existing resources. One example is smart growth, which emphasizes the need to "strengthen and direct development towards existing communities" (About Smart Growth, 2019). This principle encourages a participatory process. Another example is reurbanism, which focuses on walkability and mixed-use planning. Both have plenty of common ground in the conservation of historic fabric, and both are focused on creating cities that decrease energy consumption. Richard Moe, former director of the National Trust for Historic Preservation in the United States, outlined the common ground between environmental and historic conservation in six points:

1. Promote a culture of reuse
2. Reinvest at a Community Scale
3. Value the Lessons of Heritage Buildings and Communities
4. Make Use of the Economic Advantages of Reuse, Reinvestment and Retrofits
5. Re-imagine Historic Preservation Policies and Practices as They Relate to Sustainability
6. Take Immediate and Decisive Action (Sustainable Stewardship, 2009)

KORU Project's "Sustainability of Historic Cities" pillar is aligned with the sustainable conservation movement, i.e., the idea that architectural conservation has environmental benefits. This movement developed largely as a reaction to the green building trend, which focused almost exclusively on new construction. This preference for new construction is particularly legible from the scarcity of points awarded for adaptive reuse, restoration, and renovations in famous accreditation programs such as LEED or BREEAM. While the reaction has been successful in the inclusion of some criteria added to LEED's Neighborhood Development Program, the change has been far from noticeable for many in the sustainable architecture sector. International award programs must adopt historic conservation more radically to promote effective environmental change, since, in an often-quoted phrase attributed to architect Carl Elefante, "the greenest building is the one already built." The main reason behind this statement is the sheer amount of energy that goes into the demolition and construction of buildings.

2.2. Embodied Energy

There are two types of energy in a structure: embodied and operational (Suhr and Hunt, 2013, p.18). Embodied energy is all that goes into the erection of the building, including the mining, manufacturing, attainment, and transport of construction materials, as well as the transportation of labor. Operational energy is used in the operation of finished building, such as electricity.

Constructing a new, energy-efficient building wastes the embodied energy of the one it replaced. In addition, it will spend even more energy and resources for demolition, transportation of the rubble off-site, and the construction process: "demolishing... a [standard,

two-storey] home creates 200 tons of waste" (Lubeck, 2010, p.10). It will have to lower operational costs much more drastically to compensate for the demolition and will probably fail to do so. In this sense, reusing a historic building is the ultimate form of recycling (Lubeck, 2010, p.18).

The successful renovation of an energy-efficient historic building can decrease its operational costs just as much, without consuming additional resources. National Trust for Historic Preservation's Preservation Green Lab found that "selecting options that retain and retrofit existing windows are the most cost-effective way to achieve energy savings and to lower a home's carbon footprint" (Saving Windows, 2016). Using one or two of the retrofit methods such as weather stripping, installing an exterior window, or using double-glazed windowpanes can provide the same energy performance as a new, high-performance replacement window (Saving Windows, 2016).

2.3. Benefits for the Homeowner

A homeowner must know how to ask the right questions, to themselves and their architect or contractor. For this, they must think not only of their bottom line (their profit) but also of the triple-bottom line (3BL): people, planet, and profit (Lubeck, 2010, p.15). The elements of 3BL are parallel to the three E's of sustainability: equity, environment, and economy.

Renovating buildings has a positive effect on homeowners' budgets as well as the environment's wellbeing. While an energy-efficient restoration project may seem to have prohibitive upfront costs, most owners do not realize that a poorly designed or maintained home will generate "higher quality expenses, higher maintenance expenses and additional deferred maintenance down the road" (Lubeck, 2010, p.15). Therefore, it is important to consider all aspects and do extensive research before making the decision to demolish or renovate a building.

3. ENERGY EFFICIENCY: THE STORY OF TAMIREVI

The historic city in Mardin was designated as an urban site on September 21, 1979. The site for KORU's restoration project was recommended by KMKD's local partner, Mardin Museum. The museum rented the structure from its owner for ten years in exchange for its restoration. It was agreed that the museum would take over the building's management once the restoration project was completed.

The first step toward the restoration of Tamirevi was the completion of a preliminary survey of the structure in order to identify any emergency risks to it. The second was community engagement: a questionnaire-based survey of neighborhood issues and stakeholder meetings were conducted in Mardin to obtain a clear idea of general expectations. A total of two stakeholder meetings clarified how this building could become a model for other residents of the historic city and informed the subsequent design process. Decisions taken in these meetings were concretized in the restoration project during the selection of mechanical and electrical systems. Since the project has no precedent in Turkey, KMKD worked with consultants from an Edinburgh-based sustainable architecture firm to realize KORU's vision of the building.



Figure 1. Tamirevi, South Facade

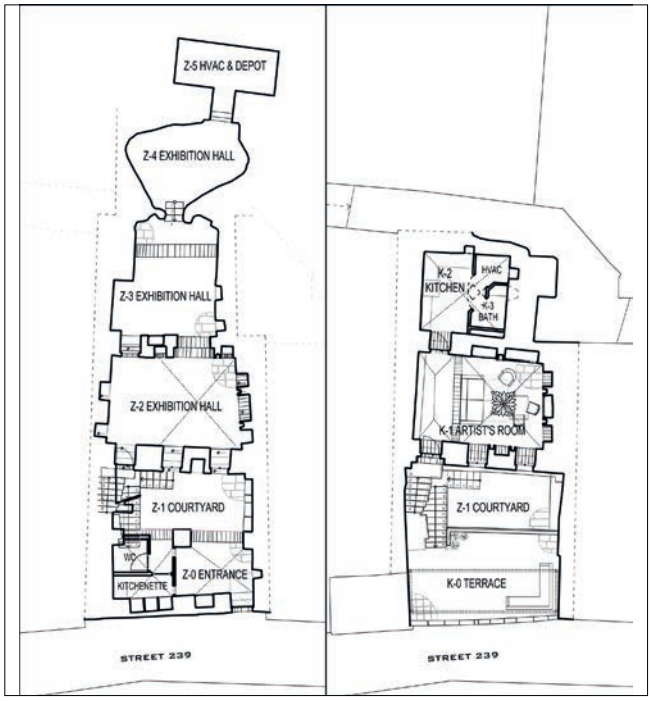


Figure 2. Tamirevi, ground and first floor plans

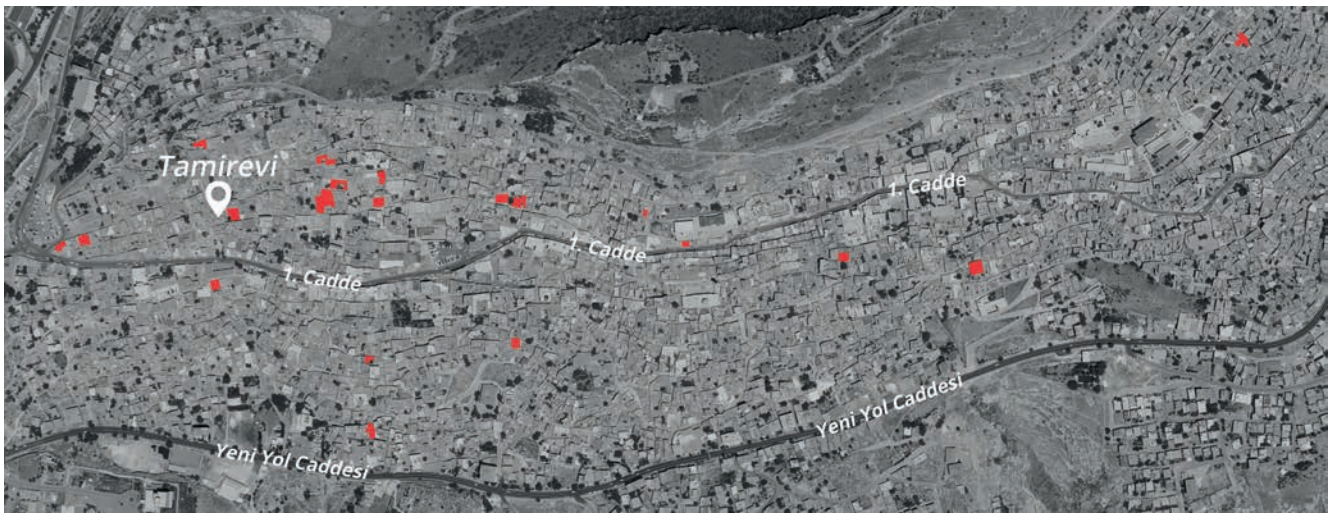


Figure 3. Houses where the questionnaires were conducted in Old Mardin in 2018, mapping by Mesut Dinler.

3.1. Understanding Daily Habits on Energy Consumption: Questionnaires

The residents of twenty historic houses in Old Mardin completed questionnaires concerning daily habits and primary problems concerning energy consumption (Figure 3). All the selected buildings are typical Mardin houses with stone masonry structures. The size of the houses (and households) varied between two rooms to nineteen rooms.

The questions in the survey sheet were divided into three categories. The first category is focused on energy efficiency and involves questions about the architectural elements of the house and specific problems associated with them. The second category relates to the building's energy performance with a focus on heating, cooling systems, and average utility bills. The third category comprised a multiple-choice list of issues related to the house such as inadequate heating, excessive fuel expenses, inaccessibility of fuel, leakage, dampness, lack of insulation, and vegetation (Figure 4).

The survey results revealed that the roofs were the biggest cause of energy issues, either due to leakage or lack of proper insulation. In half of the houses, the original vaulted ceilings are covered by cement coating to prevent leakage. The use of cement in historic structures is extremely problematic: cement behaves differently around water than stone does, so it can cause serious deterioration in the original material. Another issue was that doors and windows were not sealed properly, especially since stone blocks framing the openings are prone to deterioration.

Regarding the heating system, the survey indicated that all houses in Old Mardin are heated with traditional stoves. Seventy-five percent of households used electrical space heaters in addition to stove heaters, which greatly raise utility bills in the winter. Old Mardin does not have a natural gas grid because of its dense historical urban fabric and its bedrock foundation.

Hot water was another issue. The questionnaire showed that daily life is drastically affected by water shortages once every two days. Each dwelling has a

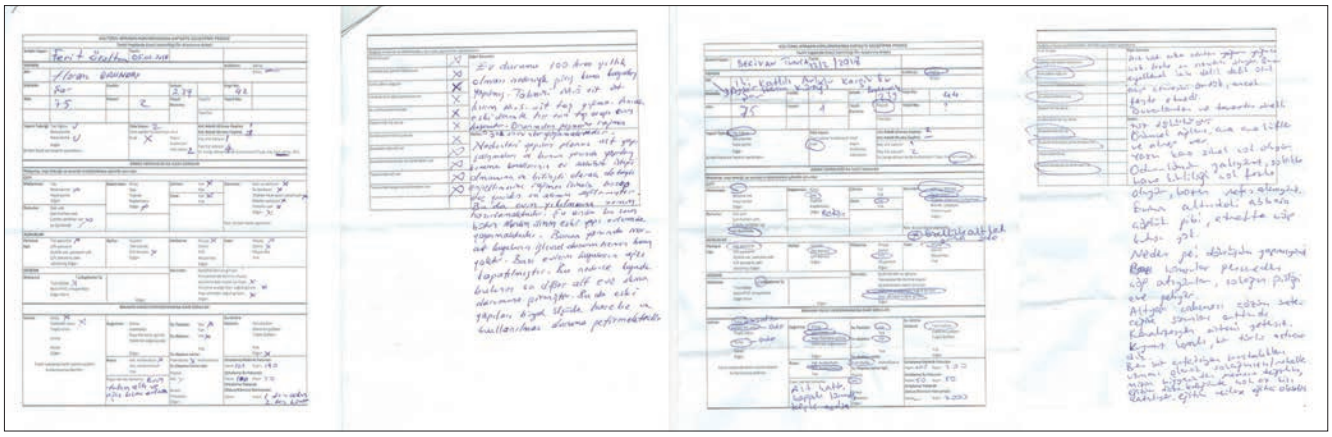


Figure 4. Two of questionnaires filled out by the households.

traditional well and a more modern rooftop water tank as an attempt to solve this issue. Nevertheless, 50% of the wells were not actively used in the surveyed buildings, and 80% of the households reported that water tanks and water pipes froze on harsh winter days. It was evident that Tamirevi had to develop a more consistent solution for hot water usage.

Questionnaire results confirmed that the conservation project must address common problems in a realistic way and find methods to reduce energy consumption per dwelling. Since the project approach united many parameters, professionals from various disciplines met for two stakeholder meetings in Mardin.

3.2. Adaptation of a Restoration Project Depending on Energy Consumption Habits

Two stakeholder meetings were held with the participation of KMKD, Mardin Museum, KUDEB (Directorate for the Conservation, Implementation and Supervision of Cultural Assets), academics from Artuklu University (local university in Mardin), and independent energy performance experts. The meeting agenda included the function, architectural needs, energy-efficiency improvements, overall process, workflow, and maintenance of Tamirevi. It was essential to clearly define the stakeholders' collaboration scheme and respective responsibilities throughout the schedule.

In a traditional Mardin house like Tamirevi, the building already employed several passive energy systems prior to intervention. For instance, cooling and ventilation were provided via natural airflow through the openings. As Aaron Lubeck succinctly described, "Old homes are green. Old home operations are not," and we must renovate historic structures to optimize the use of their passive methods (Lubeck, 2010, p. 249). There was no sanitary system in Tamirevi, since domestic water was carried from the well, and the outhouse in the courtyard served as the toilet. In 2018, the building still used a stove as the main heating system, which required all residents to share the same space throughout the winter.

The stakeholders agreed that Tamirevi must be fitted with contemporary heating, cooling, ventilation, and sanitary systems. The construction technique of a stone masonry building does not encourage new layers of mechanical and electrical installments for the integration of modern plumbing and ductwork. Therefore, it was necessary to come up with smart solutions while maintaining "minimum intervention & maximum efficiency."

It was fundamental to quantify the existing energy performance of Tamirevi. An energy consultancy firm was commissioned to obtain the building's "Energy Identity Certificate." The purpose of these certificates is framed by Act No: 5627, "Act Concerning Energy Efficiency" and its extension, "The Energy Performance of Buildings Directive." Tamirevi's performance class is B, and its emission class is C, which proved the dire need to utilize renewable sources in the mechanical and electric systems installed during the renovation to increase its energy performance.

Mardin is one of the most suitable cities in Turkey for solar energy systems with regard to average solar radiation and sunshine duration data throughout the year (Eskin, 76, 2006). However, less than ten photovoltaic panel systems are active in the Mardin Province, according to DEDAŞ (the local electricity distribution corporation). All of these are on industrial properties, and there is no example of residential use yet. Domestic usage of solar energy must be expanded, since small buildings constitute a significant portion of energy consumption.

Following the initial discoveries, the potential and alternatives for renewable energy sources were investigated in-depth for the pre-project mechanical and electrical reports. A group of consultants were chosen in the stakeholder meetings to evaluate suggestions presented in the pre-project reports and to integrate them into the architectural design process.

4. WHAT MAKES TAMIREVI ENERGY EFFICIENT?

Tamirevi is different from any other conservation project in Turkey due to its emphasis on energy efficiency. The first step in any "energy efficient" project is to find the optimal renewable energy sources and methods. In Tamirevi's case, the electrical and heating demand was met by installing photovoltaic panels on the roof, and the heating demand is fulfilled by an air-sourced heat pump. Since flat roofs define Mardin's unique silhouette, photovoltaic panels were placed along the east-west direction with a 10-degree angle. These twelve panels on the roof are expected to meet the energy demands of the building.

4.1. Insulation in Tamirevi

Keeping heat inside the structure is just as important as providing renewable energy sources. Therefore, the second step was to improve u-values in order to minimize heat loss. Existing u-values registered in Tamirevi's Energy Identity Certificate were worryingly high; therefore, the thickness and qualification of

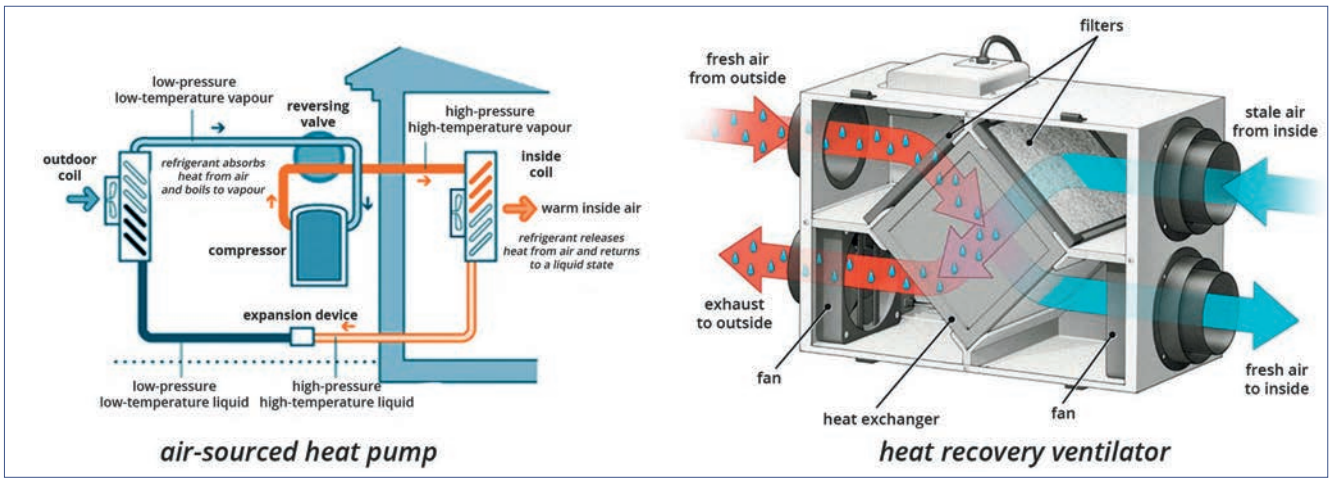


Figure 5. The working principle diagrams of air-sourced heat pump (Air Source, 2012) and heat recovery ventilator (Ponschok, 2017)

insulation layers came into question. The u-value of the exterior walls was 0,74 w/m²K. This value could not be decreased through structural changes or insulation since stone masonry may not be coated or cladded. It will be possible to utilize tapestries on the walls following completion, but this will not yield the same improvement in the u-value.

Only the roof and soil-contact flooring could be insulated, so the structure was not wrapped in the recommended building envelope. The roof was found to cause the greatest heat loss among all the structural elements due to a lack of appropriate insulation, since heat rises. Simulations with thermal insulation in the roof and soil-contact flooring of ten centimeters showed the u-value of the roof decreased from 0.72 w/m²K to 0.28 w/m²K.

Another important cause of heat loss is openings. U-values of doors and windows are very difficult to decrease in historical buildings. To achieve this, the windows of Tamirevi are to be reconstructed using an authentic design but with double-glazed windowpanes instead of single-glazed. Additionally, all windows and doors will be made airtight with draught seal tapes and sealants. Non-structural elements such as curtains and shutters could also help to minimize heat loss.

4.2. Energy Solutions in Tamirevi

Tamirevi uses a heat pump as the central heating/cooling system. The working principle of a heat pump is to take the low-temperature energy medium (air or water) from outside and increase its temperature using alternative means. There are three types of heat pumps: air-sourced, water-sourced, and ground-sourced. Of these, an air-sourced heat pump consisting of an external and internal unit was selected for the project. The internal unit has an integrated boiler that provides hot water for domestic use and underfloor

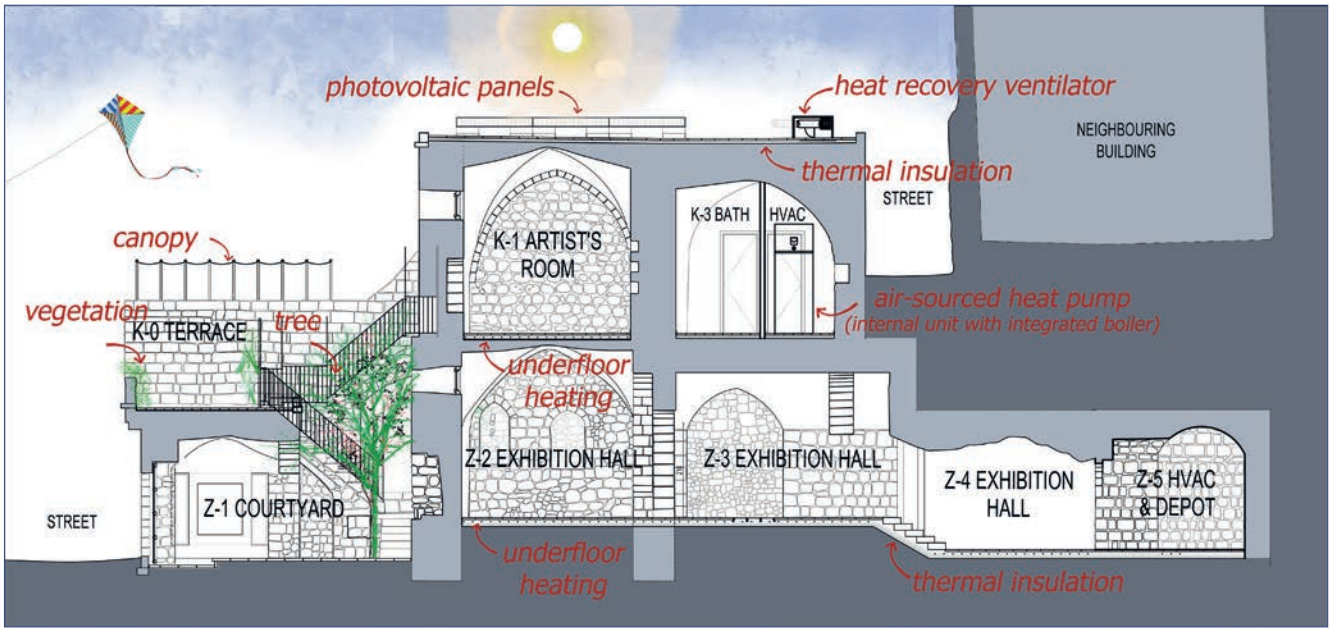


Figure 6. Longitudinal Section of Tamirevi Displaying Energy Efficiency Solutions

pipes. An air-sourced pump uses less energy than a regular boiler because it uses pressure to compress the air during heating. The warmed/cooled water will be distributed via collectors and underfloor pipes.

Tamirevi utilizes a heat recovery ventilator (HRV), compatible with its heat pump, for ventilation. While circulating the air, the HRV uses excess heat from stale air being extracted from the building via suction ducts and uses this energy to heat up incoming, fresh air. Hence, it makes the most of the heat.

Several passive measures were taken at Tamirevi, especially against overheating. The main façade of the house faces south, where thick stone walls absorb heat and keep the house cool to a certain extent. Local surveys revealed that toward the middle of the summer the walls no longer act as thermal mass and start radiating the heat to the building's interior. Therefore, a canopy was designed over the terrace that can partially shade the façade and prevent overheating. The canopy was designed to be dismantled in the winter months. It is also typical to plant trees in Mardin courtyards, especially acacia or pomegranate, because trees provide shading and prevent overheating. In an earlier phase of the construction, an acacia tree was to be planted in the northeastern corner of the courtyard after the restoration process. However, it eventually became clear that the roots of the tree would damage the infrastructure and masonry elements. Smaller vegetation will be utilized in the open spaces of the building, but the canopy will be the only solution against overheating for the front façade.

5. WHAT MAKES TAMIREVI A MODEL?

This paper posits that Tamirevi is a model for historic houses in Mardin, and even small buildings in Turkey. The fact that Tamirevi is a historic building where energy-efficient technologies are employed makes it a pioneer in Turkey. Furthermore, the renovation of the house was designed according to the results of comprehensive surveys and community meetings to ensure that it meets the needs of the area. The restoration process was specifically designed to maximize exposure and community engagement with the structure both during and after the construction.

5.1. During Construction

One of the other outputs of the KORU Projects is trainings. A set of adult trainings were organized in both Mardin and Antakya to train professionals in fields that could have great influence over cultural heritage conservation, such as carpenters, stonemasons, teachers, journalists, tour guides, local governments, and historic homeowners. Another training, KORU Kamp (Conservation Camp), was organized in both cities to engage university students from all over Turkey. Of these, the carpenter and stonemason trainings in Mardin, as well as KORU Kamp Mardin, all took place at Tamirevi. The trainee carpenters and stonemasons also worked on the construction of Tamirevi to complete the project.

Tamirevi's involvement in KORU trainings began its integration into the neighborhood and to the city at large as a model and a laboratory where conservation and energy efficiency were being practiced. Another factor that contributed to this was that the construction site was open to public visitation throughout the process. Guided tours (security equipment provided) were offered to any who wished to see how the project was being implemented.

5.2. Following Completion

At the time of writing, the renovation of Tamirevi will be completed in a few months. The building will then serve as a permanent exhibition and artist's residence. The building's calendar and finances will be managed by Mardin Museum, KORU's local project partner, until the end of the renting lease.

The permanent exhibition in the ground floor will feature a descriptive model of Tamirevi, information about energy efficiency and the deterioration of stone masonry structures. Part of the radiant heating pipes will be exposed through glass flooring in the energy efficiency room. Samples of deterioration found in the building prior to the renovation will be encased to show, along with information about remedies and prevention methods.

The upper floor of Tamirevi comprises a short-term residence. Artists will be able to apply to reside here through the Mardin Museum while attending the increasing number of biennials and festivals that happen in the city. It is hoped that this will catalyze further engagement between Mardin's cultural institutions and the community.

The energy generated by the photovoltaic panels will meet the electrical and heating/cooling requirements of the exhibition and artist's residence. Any excess energy generated will be sold back to the city grid. Once this becomes known, and systems such as subsidies and loans for energy-efficient technologies are initiated, it is hoped that the water tanks on historic Mardin's rooftops will be replaced with low-rise photovoltaic panels that will not be a burden on the city's treasured silhouette.

6. CONCLUSION

Climate-responsive design is not only applicable to new structures but also historic ones. The unity between environmental sustainability and architectural conservation is critical to the ecological health of our cities. Utilizing the existing building stock is imperative to minimize waste, and renovating houses with on-site, renewable energy sources is important in decreasing air pollution.

Historic cities and neighborhoods, such as Old Mardin, should be considered as a whole. Existing institutional structures, such as KUDEB, may implement and supervise energy-efficiency standards on a larger scale. When doing this, it is important to initially prioritize passive solutions and the buildings' envelope, since technological interventions may be quite expensive and beyond the homeowners' means. Although some historical structures, including Tamirevi, are already equipped with authentic, eco-friendly responses, most are not. In either case, it is essential to update historical buildings to prolong their life as well as that of their environment. It is also crucial to remember historic conservation's "minimum intervention-maximum efficiency" tenet, in order not to destroy the cultural value of the city in the name of energy efficiency. After all, "sustainability is the pursuit of longevity," and longevity is ensured through cultural worth (Lubeck, 2010, p.7).

KORU Project's Tamirevi is a model for energy-efficient restoration projects in Turkey. Its location in Mardin, one of the most suitable areas for solar energy systems in the country, foreshadows a great profit margin for the homeowner, thus it is the most likely to spread this technology on a neighborhood scale. The technological interventions in this building may be difficult to apply in many homes because of high upfront costs, but it is the authors' hope that systems will be implemented to standardize, subsidize, and incentivize energy-efficiency in cities at large.

Tamirevi's energy-efficiency calculations revealed a need for further quantified research into the amount of energy that various building types use per season. This is especially true for Southeastern Turkey, which shows great potential for solar power generation. There must also be a reiteration of local construction methods and materials to best utilize traditional, passive solutions in historic buildings.

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PROPOSING AN INTEGRATIVE SOLUTION OR STORMWATER MANAGEMENT: BLUE-GREEN TOSBAGA CREEK

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ABSTRACT

The precipitation regime throughout the world is fluctuating due to the climate crisis, with unforeseen results beyond forecasts. Flooding, watershed overflow, and drought are some of the problems cities are facing. To alleviate the problems caused by extreme precipitation, NBS such as sustainable drainage systems and blue-green networks, to perform along with gray infrastructure, are being introduced and implemented. Retrofitting cities with this infrastructure may be a slow, costly, and disruptive process. The responsible public institutions are slow to act and hesitant to adapt to new ways of operating and to develop cooperation with other responsible parties, which is required for the development of blue-green networks. Urban design projects for planned but undeveloped extensions of settlements can provide opportunities to showcase blue-green networks in such an institutional and social environment. This paper discusses the possibility and the benefits of providing sustainable drainage solutions for planned but unconstructed urban extensions. The discussion is modeled on an urban design project prepared for the Tosbağa Creek Recreation Area Idea Competition. The competition team proposed a blue-green network that would not only provide connections with the built city fabric and establish links with recreational public spaces but also serve to improve climate responsiveness at the urban district scale.

Keywords: blue green infrastructure, nature based solutions, stormwater management, urban design, Tosbağa Creek

1. INTRODUCTION

The world is going through a climate crisis, and settlements are under the threat of that disaster. The climate crisis affects us through climatologic events like unprecedented precipitation, drought, and changes in high and low temperatures. Heat waves increase the intensity of the urban heat island effect, which is already a problem for cities. Water management-related problems, on the other hand, lead to loss of life, loss of property, sanitary problems, and disruption of infrastructures. Stormwater management has become one of the most important topics for climate crisis mitigation because of the unprecedented number of downpours.

After a flood, surface flooding, or watershed overflow, there are two paths the local administrations and the governments can take to make sure that this problem will not be repeated. One path is to improve and expand the already existing stormwater drainage infrastructure as a tested and tried engineering solution. This engineering solution, also known as gray infrastructure, is easily chosen by most administrations, since the methods of and the organizational framework for analysis, calculation, planning, and implementation is well established. The other path is blue-green infrastructure. Blue-green infrastructure involves using streams, creeks and green spaces, natural or artificial, readily available or designed, built or retrofitted, for the specific purposes of rainwater harvesting, filtering, detention, and retention during times of downpours. This infrastructure can function along gray infrastructure or by itself. Blue-green infrastructure is more flexible and easier and cheaper to implement compared to the conventional rainwater drainage infrastructures. Blue-green infrastructure solutions, by employing ecosystem services, provide many benefits and opportunities on the social, economic, and ecological fronts, unlike its gray counterpart (Woods Ballard, *et al.*, 2015).

The development of blue-green infrastructure relies on a different approach than gray infrastructure. During the process of planning, designing, and developing of blue-green infrastructure, professionals from many different fields, like ecologists, biologists, hydrological engineers, meteorologists, landscape architects, architects, and city planners, must get involved in the

process, and this process also necessitates cooperation among several public institutions.

Greater municipalities, district municipalities, and other public bodies, such as the local bureau of the General Directorate of State Hydraulic Works responsible for flood prevention, are slow in grasping the importance of meteorological events triggered by climate crisis and the importance, advantages, and benefits of blue-green infrastructures. Whenever they are faced with the task of making a choice between gray infrastructure and blue-green infrastructure, they opt for gray infrastructure to solve their watershed overflow and flood problems.

This paper discusses the possibility of providing sustainable drainage solutions for planned but unconstructed urban extensions by making use of urban design projects. Planned but unconstructed extensions of cities can be replanned and redesigned to include nature-based solutions (NBS) in order to make use of the ecosystem services to the best of their abilities, while retrofitting built-up areas with NBS will definitely take more time and will be a harder task. Cooperation among institutions is weak at best, and cooperation has to be practiced and developed. To learn to cooperate and work together with professionals of diverse fields, urban design projects provide a smaller operational scale compared to developing and implementing a blue-green infrastructure project for an entire river basin. Urban design as a midscale and interdisciplinary planning and design field can provide applicable solutions to specific spatial problems at the micro basin scale. Micro basins, streams and dry creeks are components of larger river basins, not necessarily having running water throughout the year, but draining the rainwater in its basin. Those micro basins and dry creeks are generally overlooked in urban development plans, during preparation of which feasibility of development, property and development rights are more effective, and urban development can easily extend over them. This approach exists because of our conceptualization of nature.

2. SHIFT IN THE NATURE-CULTURE RIFT: WE ARE NATURE!

The prevalent conception of nature relies on an idealized separation of man and nature, city and nature, culture and nature, urban and rural, and the like. There are not only dual opposites in this approach, but idealization of *nature* is an important chapter of this approach as well. Nature is idealized as a machine, such as a mechanical clock, with which man can operate, replace its components with manmade ones, even if they are not broken, and even redesign and rebuild it with all new man-made elements.

Even though the history of this duality goes way back before the modern industrial city emerged (Williams, 2005, Oelschlaeger, 1991), this conceptualization and separation provided the basis of modern urban planning. Our institutions, their modus operandi, and their responsibilities as well have been modeled in accordance with this thinking: where one institution's field of responsibility ends, it is bordered by another one's. In this sense, the modern city was built over a terrain tailored according to engineering solutions based on scientific calculations, property relations, the development process, artistic concerns, and institutional structure, as well. Nature in this process stood as the mute fabric over and under which infrastructures and buildings were mounted atop and underneath. The processes and flows of nature in this scenario were not conceived. The relation of physiography of the site to water drainage was overlooked, and this function of the site was replaced by engineered drainage systems that are inflexible and invisible. This way of planning, engineering, designing, and developing created discontinuities in the ecosystem.

3. CITY, TOPOGRAPHY AND STREAMS

In general, the problem with settlements regarding the introduction of blue-green infrastructure systems is that cities generally spread over land regardless of the natural drainage pattern. The natural drainage pattern is composed of dry creeks and streams, which are legible through the contour lines on topographical maps. During the construction of structures, dry creeks are filled and built upon, and the beds of the streams and creeks can be changed, narrowed, and even filled. This attitude toward the water bodies surrounding the cities is a reflection of nature vs. culture duality. In order to overcome the risk of flooding from the engineering side, the response has been to let streams run in concrete canals or pipes and build other infrastructure upon them.

Mersin constitutes a good example to this type of development. The streams in Mersin display dendritic structures, and the main traffic arteries run perpendicular to the streams disturbing their continuity. Most of these streams are flowing in closed canals, and it is not easy to trace them in the urban fabric. During the urbanization process of the city, streambeds have been narrowed by filling and modifying their sections, just because of the property and development rights. Where culverts or boxes

have been used to let the stream flow under a street, the opening provided by the culverts and boxes were insufficient. Some dry streams were destroyed by development.[1]

Mersin is one city in which watershed overflow and surface flooding caused loss of life and property. During the precipitation that took place on December 27–31, 2016, 268.1 mm per sqm rain was received, 107.4 of which was received on December 29. This event caused surface flooding and watershed overflow in Mersin, killing five people, damaging 1,141 houses (with a monetary equivalent of 4,526,300 TLY), and damaging 9,390,930 TLY of workplace property. In total, 136,604 da of agricultural land was damaged, and 4,000 chickens and 335 ovine perished. The cost of the damage to agricultural areas is estimated to be 116,073,573 TLY. The cost of the damage to infrastructure was around 5,000,000 TLY, along with 3,150,000 TLY of damage to roads and bridges and 940,000 TLY of damage to railroads. The cost of damaged and scrapped vehicles is not included in these numbers.

After the events, MESKİ, as the responsible institution, announced that a stormwater master plan was completed.[2] According to the master plan, 2,488 km of new drainage pipes are going to be laid in three phases from 2017 until 2050, with a total cost of 2,165,349,327 TLY. In 2017 and 2018, the first 10.5 km- of the pipes were urgently installed. Along with MESKİ, the Greater Municipality of Mersin responded by opening gaps on the refuges along boulevards that acted as barriers to surface water.

In Turkey, institutions are generally slow to grasp the importance and the breadth of climate crisis adaptation and react in return. The Ministry of Environment and Urban Planning sent a circular to the governorships and the municipalities in Turkey on January 23, 2019. The circular was titled "Climate Change and Disaster Measures." The first two articles of the circular aim at clearing debris and obstacles in the streambeds and giving priority to remediation and improvement of streams and creeks. Along with these, article 11 asks for devising recreational areas that would function as retention basins during downpours. Only one article out of fourteen mentions that public institutions could possibly use recreation areas as a part of the rainwater drainage system.

Not only the ministries but also the municipalities disregard the problem and try to achieve these goals in bureaucratic and technical fields but not spatial. The spatial decisions for mitigation and adaptation are related with urban land use, transportation planning, settlement density, and urban form. These decisions may include future landuse scenarios to curb carbon emissions, incentives to control spreading of urban development on barren land through infill and redevelopment strategies on already developed land, measures to regulate urban climatic variables like rain and heat and strategies for carbon sequestration. The necessary decisions effective in generating the daily movement of the urban population and also determining the mode of travel are missing. At present, climate crisis action plans of greater municipalities do not include such decision. Their responses include actions more from the technical side, like reduction of carbon footprint through installing smart traffic lights systems and reduction of waste. How the new development will spread over the underlying topography is another critical decision for cities. The "natural" drainage pattern legible on topographical maps must be considered in setting up blue-green infrastructures or as parts of such structures.

In this regard, the Greater Municipality of İzmir stands out. The municipality has issued a green infrastructure strategy document, called İzmirDoğa, as one of the three runner cities of the Urban GreenUp project, funded under the EU's Horizon 2020 program. The objective of the Urban GreenUp is "the development, application and replication of Renaturing Urban Plans in a number of European and non-European partner cities with the aim to mitigate the effects of climate change, improve air quality and water management, as well as to increase the sustainability of our cities through innovative nature-based solutions." (https://www.urbangreenup.eu/solutions/) The Greater Municipality of İzmir is planning, designing and developing nature based solutions for climate crisis mitigation and adaptation, and the outcomes of the project will hopefully provide guidance for other cities as well, but local governments need to spring into action sooner than that.

Today, we are being forced to understand that our urban environment, which we have developed according to the city versus nature duality, has to be fixed. The spatial and infrastructural solutions like Green Infrastructures, Low Impact Development, Sustainable Drainage Systems, Water Sensitive Urban Design, and NBS are a reflection of the new understanding of integrating the ecosystem

1 These findings are from a survey conducted by the author and a colleague, Fikret Zorlu, from the Department of City and Regional Planning, Mersin University, and from encounters with hidrologists from the local branch of General Directorate of State Hydolic Works.

2 The institution apparently had information about the faulty and insufficient grey infrastructure and the preparations for the plan were initiated much earlier. The plan was completed in November 2016.

services into the urban fabric employing them for a more resilient and urban structure that allows us to reconnect with the ecosystem. Those systems allow cycles and ecological flows to continue and/or recreate them both for the benefit of humans and the ecosystem.

As the transformation of our settlements necessitates changes in social, ecological, and technological systems as well, urban design projects may be helpful in this process. They can be used as showcases of nature based solutions to climate change mitigation and how this transformation can be handled. Undeveloped extensions of settlements can be used for such practices with much ease compared to already developed districts of settlements.

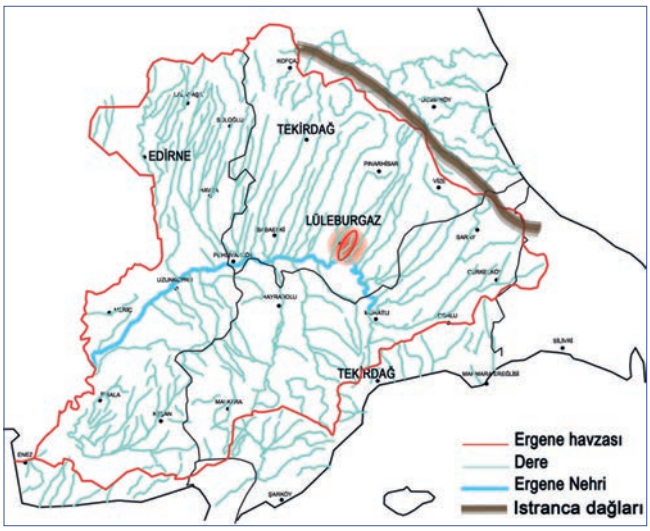


Figure 1. Tosbağa Creek is located in catchment area of Ergene River.

4. BLUE-GREEN TOSBAĞA CREEK: CYCLE-PARK-SCHOOL

The Municipality of Lüleburgaz, a town located in the middle of the Trachea peninsula with a population of 109,000, opened the Tosbağa Creek Idea Project Competition on 27 October 2017. The aim of the competition was to develop design ideas and to establish the relations of the recreation area located along a section of the Tosbağa Creek. The competition aims to contribute to the identity of the settlement, to improve quality of life in the area, and to improve relations between humans and nature. Tosbağa Creek

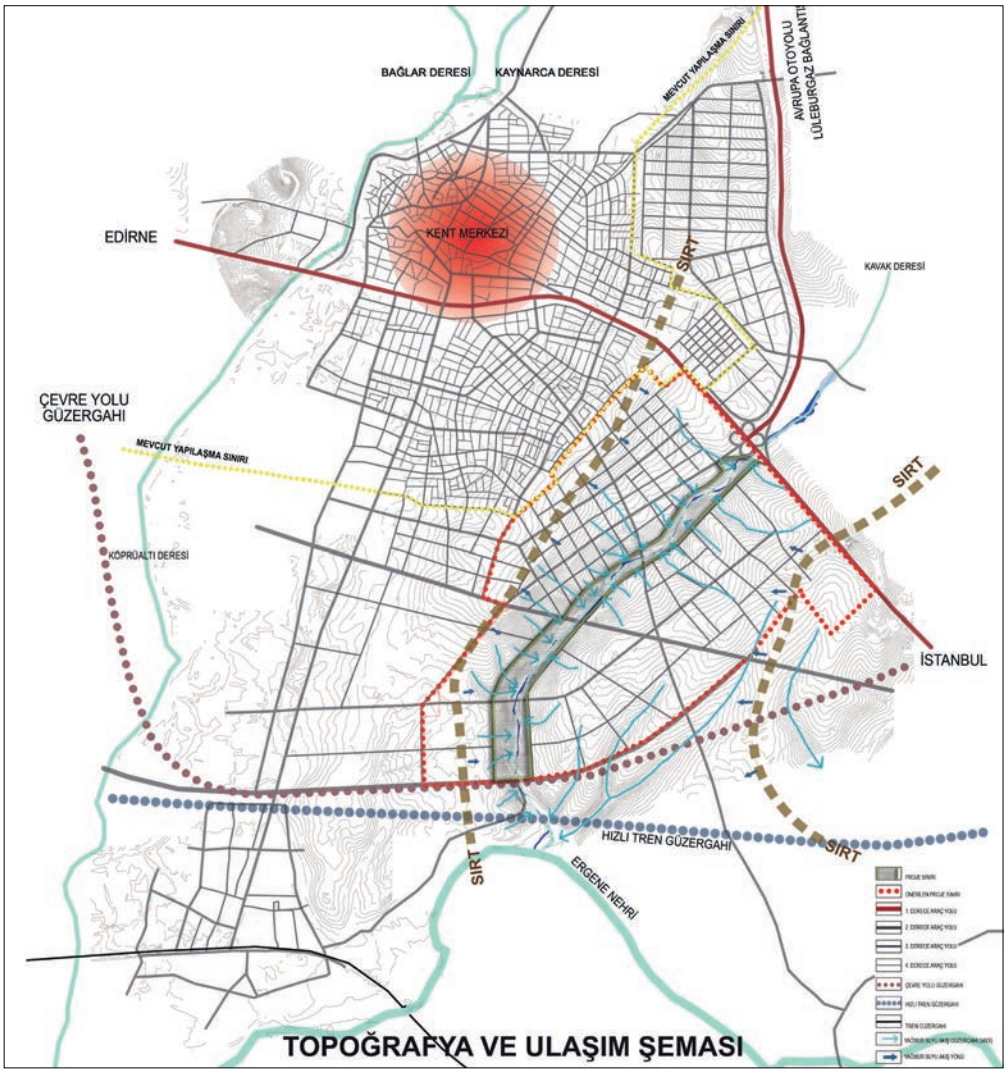


Figure 2. The official competition area (the narrow strip around Tosbağa Creek in the middle) and the extended project area (marked with a red dashed line). The dry creeks are marked with blue arrows.

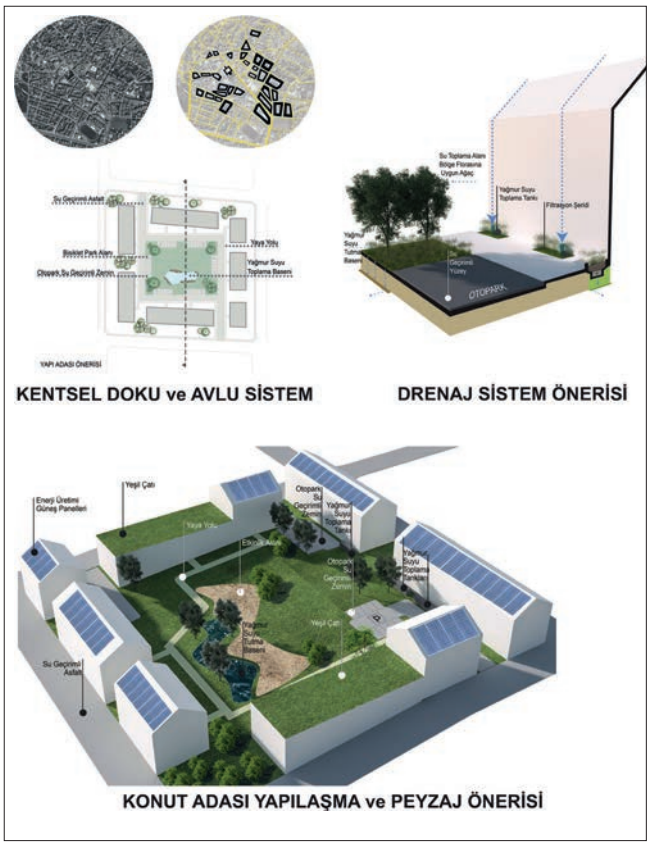


Figure 3. Building block solutions.

is located to the south of Lüleburgaz. The official competition area consisted of a section of a micro basin, draining into the Ergene River. The competition area was bounded on two sides by the extension area of Lüleburgaz city, which is still undeveloped.

We conceived the park not as a separating or limiting strip of green space but as a uniting blue-green magnet, both for people and wildlife. In order to make sure that that park would function as a blue-green infrastructure and a lively daily and weekly social and recreation area for every age group, linkages with the city center and the undeveloped extension area were important. The undeveloped urban extension was conceived as an advantage to design the components of the blue-green system.

From the contours on the base map provided by the municipality, the catchment area of Tosbağa Creek and the dry creeks feeding the creek were specified. To realize our vision, the project area was extended to the micro basin of Tosbağa Creek (Figure 1). The implementation development plan was superimposed with the catchment area and dry creeks map, and the development plans were modified to establish the aforementioned linkages with the park (Figure 2).

The buildings were to be developed with green roofs and green walls. The backyard gardens of the building blocks were designed to function as retention basins and rain gardens. Streets replacing the dry creeks in the development plan were designed with new profiles as components of water train. The green spaces in the implementation development plan were used as retention basins as well (Figure 3).

These were the steps taken to establish blue and green linkages with the city and the urban extension area, to achieve the continuity of green spaces, and to widen the water drainage network (Table 1). Therefore, the new project area we defined would function as a biotope.

Table 1. Components of Blue-Green Tosbağa Creek

Scale	Component
Lot and building	Green wall
	Green roof
	Green wall
	Rain barrels
	Permeable pavements
Building block scale	Rain gardens
	Permeable pavements
Open and green spaces	Retention basins
	Permeable pavements
	Rain gardens
	Cisterns
	Street trees
	Renewed street sections
Creek - Tosbağa Creek	Artificial wetlands
	Filtration strips
	Bioswales

To maintain the accessibility of the park for residents in the city center and the undeveloped urban extension on both banks of the creek, bicycle routes, pedestrian paths and bridges, ramps, and bicycle and car parks were designed.

The program for the park was based on the approach outlined above. The park was modeled as the last and most important piece of a sustainable drainage system with extensions to the micro basin of Tosbağa Creek, contributing to the water cycle by cleansing and filtering rainwater by means of artificial wetlands and filtering strips. The Tosbağa Creek recreation area would be a showcase of sustainable drainage systems. The performance of the park would be monitored by the scientific and technical personnel who would be stationed at the proposed ecology academy, and the needed adjustments and modifications would be made by them as well. The ecology academy would serve as

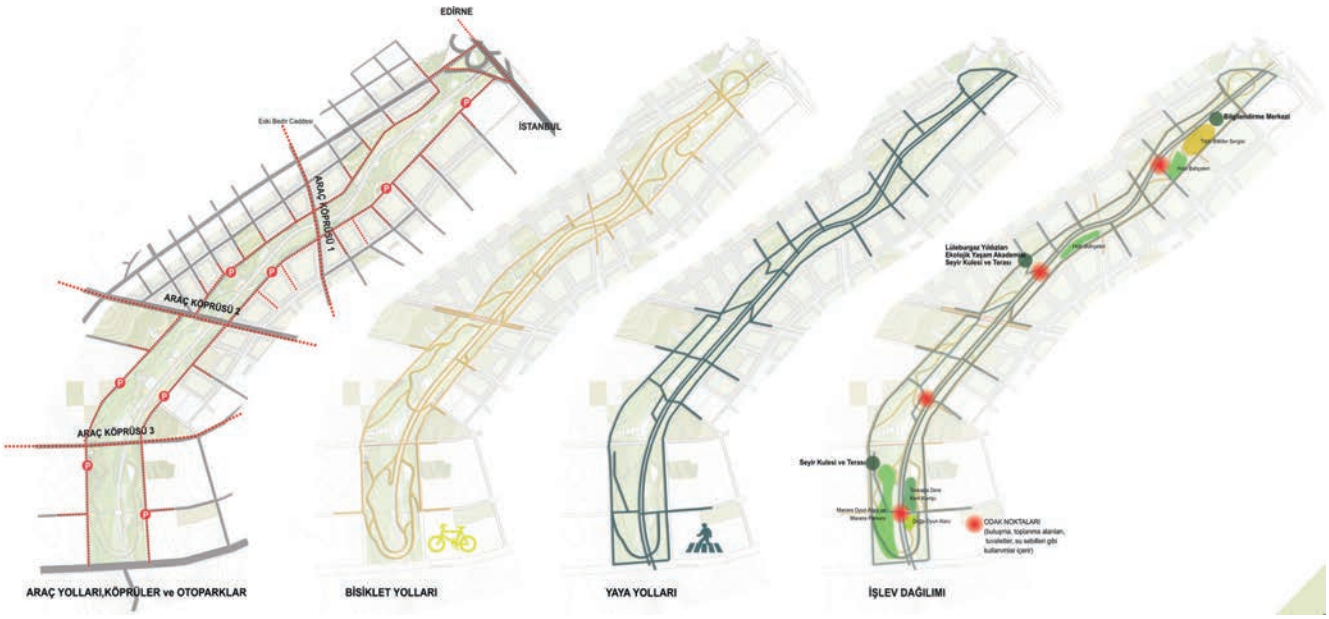


Figure 3. The access routes by car, by bicycle, and on foot.

an ecology school, not only for the school children, but also for the residents of Lüleburgaz.

The planting design of the project relied on plant succession. According to the approach, the planting design was proposed to improve the location's functionality and comfort, of which rested on the planting design. For that purpose, only plants from local flora were proposed. It was intended that the local flora would manifest itself through the processes and stages of ecological succession. Monitoring of this process and making the needed interventions, like removal of exotic and invasive species, would be made by the expert personnel from the ecology academy.

The keywords of our project were Cycle-Park-School. The park, acting as blue-green infrastructure with its extensions protruding into the city, would contribute to the water *cycle* that is broken by the drainage infrastructure of the city and would house an ecology academy as a *school* for monitoring the infrastructural performance of the park and for raising visitors' awareness. The *park* would display the importance of the relationship between humans and nature.

5. CONCLUSIONS

Urban design projects that include NBS have the potential to break the inertia of institutions and the public toward developing and implementing climate crisis adaptation and mitigation. By developing solutions for a part of a settlement rather than the whole of it, models for cooperation among institutions can be tested and developed. Also, solutions and implementation models better suited to local conditions would be developed, tested, and tried. The public, on the other hand, will be informed about climate crisis, climate adaptation, and mitigation through experience. As there are not any established standards and details regarding the SuDS, this would be a step toward developing standards and details suitable to the local context.

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EVALUATING THE IMPACT OF URBAN PLANNING PROJECTS ON CLIMATE CHANGE: TOWARD A COMPOSITE INDICATOR FOR LATIN AMERICA

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ABSTRACT

Life Cycle Analysis (LCA) is a consolidated technique to evaluate the impact of industrial products against environmental criteria. Among the set of indicators usually proposed by LCA datasets and methodologies, climate change occupies a permanent place with the Global Warming Potential (GWP) indicator as defined by the Intergovernmental Panel on Climate Change (IPCC). It reflects the relative effect of the main greenhouse gases on climate change considering a fixed period (100 years, for example, for GWP100). The LCA technique and this particular indicator were adapted to urban planning practices in 2011 through the development of the NEST tool dedicated to the evaluation of urban planning projects. Originally developed for the European context, LCA is currently being adapted to the context of Latin America considering specific local challenges and the locally tailored database. Key variables related to climate change for urban planning projects not only include the capacity of a project to generate or prevent Green House Gases (GHG) emissions but also the adaptation potential for the city against risks generated by climate change.

Keywords: Neighborhood, indicator, climate change, Latin America

1. INTRODUCTION

In a complex climate context, with a growing problem of resources and eminent population growth, the need arose to create sustainable and resilient cities for the 21st century. At a global level, proposals are being generated in this regard. In Latin America, some ideas have been developed, particularly at the city level. At a neighborhood level, prototypes and models such as eco-neighborhoods or improvement plans have been proposed in several countries, but little or nothing has been done to develop tools for evaluating the sustainability of urban proposals that specifically addresses climate change-related issues and urban resilience.

In general, most of the tools created worldwide and in Latin America are at the city and sector level. In some eco-neighborhoods in Europe, tools have been proposed based on environmental efficiency monitoring indicators. The results are remarkable because they are easy to use and understand by the chain of participating actors (authorities, urban planners, and inhabitants). Also, in Europe, tools of all kinds (Lotteau, 2017) have been developed to certify sustainable neighborhoods, as in the case of France's eco-neighborhood certification.

There is a large variety of tools to plan, manage, or design eco-neighborhoods and eco-cities. In spite of this, in many countries, there is still a need for tools to assess the sustainability impact of urban proposals at a neighborhood scale, which helps decision-makers and allows them to follow-up with the necessary actions to ensure that the principles of sustainability do not get lost in the long design-construction process of sustainable neighborhoods (Yépez, 2011). The effects of climate change, among other challenges, require that the urban planning of existing and new cities responds with sustainable strategies, which means not only theoretical strategies but also specific, evidence-based proposals.

Based on this need, NEST was proposed in France in 2011. NEST is a tool that assesses urban proposals in terms of sustainability through indicators (biodiversity, water, energy, CO_2, waste, air quality, social and economic indicators) at the neighborhood scale. A distinctive feature of this tool is the interesting and innovative proposal to evaluate urban components considering their environmental impact based on the adaptation of the life cycle analysis (LCA) technique. (Lotteau, Yepez, Salmon, 2015)

LCA is a commonly used technique in many sectors, but most of its applications lead to highly technical and scientific results, in general very complex, which positions this technique far from the reach of most of the typical stakeholders involved in the design of cities. NEST sought to adapt this technique as a tool for urban planners and decision makers. The tool is based on professional practices onsite, considering the characteristics and technical capabilities of professional architects and town planners as well as the technical teams of the municipalities to establish an interface adapted to this practice to ensure interest in its use. NEST is a plugin integrated in Sketchup that allows for modeling a neighborhood project and assessing its environmental efficiency through comparing scenarios to help decision-making. Changes and modifications in the scenarios can be evaluated in real time and thus ensure the best option to propose (Pousse, 2018).

The LCA tool, long used in industrial and product manufacturing to determine its environmental impact through indicators, is the only validated quantitative impact evaluation tool considering all phases of a product's life. The technique is well accepted on a global level, and its process is controlled by a set of standards that strictly guide its application (ISO 14040 series). Numerous tools were developed to facilitate its application: software, national or international environmental databases, general or by economic sectors, and impact indicators database. The indicators represent a key aspect of the process, since they are the visible result of the analysis process. With its highly scientific content, its pedagogical capacity is also an essential quality when transmitting the results to third parties. The supply of indicators is large, and their choice depends on the sector of application and the objective of the study. In the construction sector, a group of indicators has been agreed upon and integrated into the regulations regarding LCA. The indicator of climate change, Global Warming Potential (GWP), is probably the most consensual and used in all sectors nowadays, considering the importance of the phenomenon of climate change. It is calculated taking into account a specific time horizon (20, 100, or 500 years) and is based mainly on IPCC research regarding greenhouse gas emissions. But, it does not consider aspects related to adaptation to climate change.

The idea of applying the LCA technique on the urban scale, considering the city as a sum of "urban products" proposed in neighborhoods, was a long process of adapting it to a typical urban planning process that almost never considers the environmental impacts and sustainability of urban production. This technique measures the environmental impact of a "final urban product" at the neighborhood scale through retrieving data on the surfaces of buildings, public spaces, green spaces, roads, equipment and services, mobility schemes, organization of production, and management of waste, etc. The impact is measured according to the number of inhabitants and/or users. Three scenarios are proposed: a basic one that represents the current trend of urban development in the study site, a second one that integrates improvements, and a third scenario under the premise of sustainability in an eco-neighborhood model. This dynamic allows designers as well as all stakeholders involved in the decision-making chain (authorities, inhabitants, technicians, specialists, financiers, etc.) to see the impact of urban design from an understandable environmental perspective. The tool was applied in neighborhood projects in France to validate its structure and relevance. NEST was also a basic tool used for urban research projects with European funds, such as URBILCA, about LCA in cities. Other projects like ESSAI URBAIN, where the tool was applied at the scale of an existing historical sector in the city of San Sebastián (Spain), were also proposed to evaluate improvement in terms of sustainability and environmental efficiency in that sector. NEST is the basis of several developments that have shown their usefulness and evolution to respond to new local needs in urban terms.

2. LATIN AMERICA AND CLIMATE CHANGE

In its web portal in 2019, the WWF stated that the climate of Latin America is changing due to the increasing concentrations of atmospheric carbon dioxide. Rainfall patterns are changing, temperatures are rising, and some areas are experiencing changes in the frequency and severity of extreme weather events. The impacts range from the melting of Andean glaciers to devastating floods and prolonged droughts (cf. Figure 1). In the upcoming years, experts foresee an increase in the number of hurricanes, storms, droughts, heat waves, and tornadoes that affect the region. The weather will become more extreme: the areas that suffer from droughts will become more arid, and humid areas will have a greater volume of rain. The two oceans that surround the continent, the Pacific and the Atlantic, are warming and acidifying as sea level rises, destroying marine ecosystems. The food and water supply will be affected in several places, and all types of human settlements in the region will be affected by climate change. Towns and cities, as well as infrastructure, will be increasingly at risk. The health and well-being of the population will be adversely

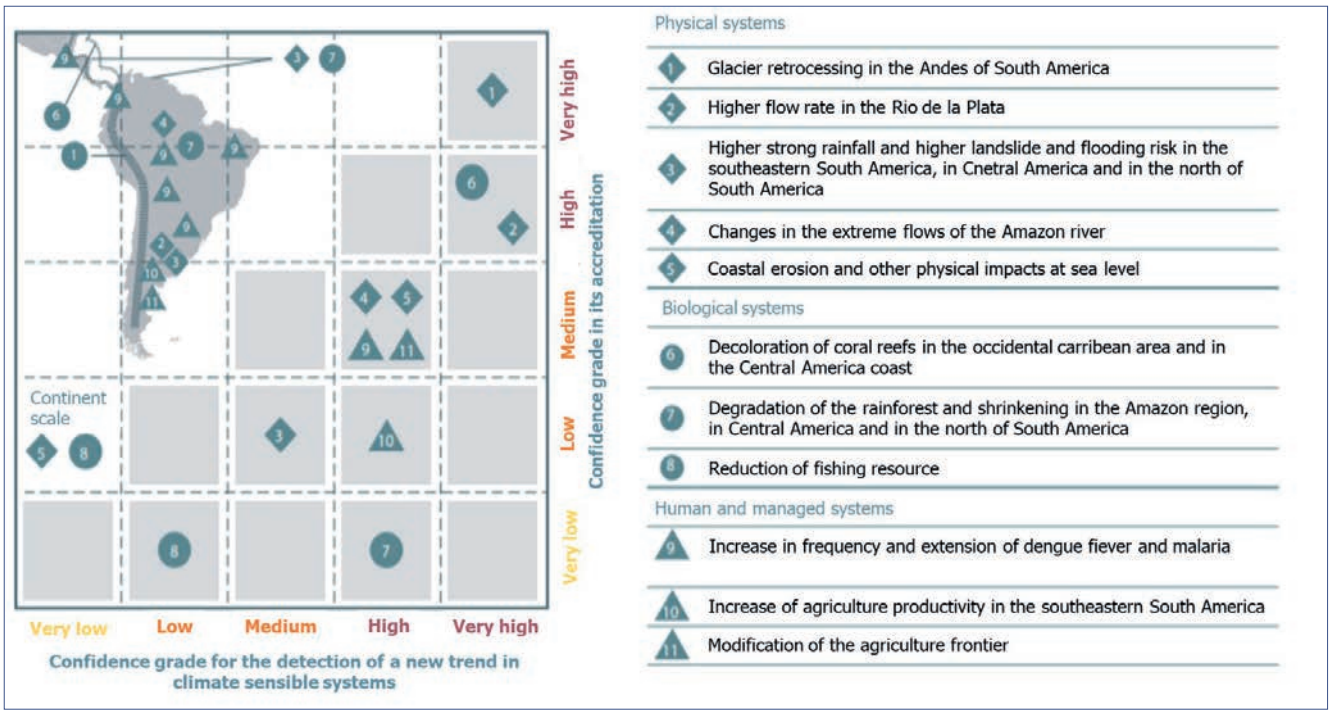


Figure 1. The role of climate change in natural and human systems configuration, 5th evaluation report of the IPCC, 2014

affected, and natural ecosystems will be weakened or destroyed due to economic needs. Latin America and the Caribbean has the highest population growth in the world, and it is estimated that the population will grow by 26.3% by 2050, up to 784 million inhabitants. Ecuador currently has approximately 16 million inhabitants, and in 2050, it will slightly exceed 23 million inhabitants. (UNO, 2015)

The region is rich and fragile. The largest arable land reserves in the world are concentrated in Latin America and the Caribbean, 576 million hectares, equivalent to approximately 30% of its territory. Approximately 47% of the regional surface is covered by forests, and 92% of the regional forest is found in South America, mainly in Brazil and Peru. These two countries together with Colombia, Ecuador, Mexico, and Venezuela host between 60 and 70% of all forms of life on the planet (IPBES 2019). The third part of the world's renewable water resources is located in the Latin America region. However, three of its main hydrographic zones, the Gulf of Mexico basins, Brazil's South Atlantic, and Paraná and La Plata (Uruguay), account for 40% of the regional population in 25% of the territory, with only 10% of total water resources. Many areas in Mesoamerica, the Andes, the Brazilian Northeast, and the Caribbean, suffer from recurrent or chronic water shortages. The atmospheric circulation and the oceanic currents have created deserts in the north of Mexico, Peru, Bolivia, and Argentina.

The 27 countries of Latin America have ratified the Kyoto Protocol, but the economic and political crises in several countries in the region have prevented the implementation of effective actions to combat global warming. Poverty, accelerated urbanization, insufficient basic infrastructure for access to drinking water and sanitation, economic instability, and excessive public debt stand out among the factors that impose these limitations. However, many countries have proposed interesting policies on renewable energies and energy efficiency, innovative instruments in transport policies, and economic instruments for the reduction of carbon emissions or for the protection and sustainable use of biodiversity and renewable natural resources (UNEP, 2018).

At the urban level, several initiatives in the region have been launched such as Climate Resilient Cities in Latin America (CRC), with 13 cities in seven countries participating (Mexico, El Salvador, Colombia, Peru, Brazil, Paraguay, and Argentina) (Flacso, 2018). In Quito, in January 2019, ten Latin American cities presented their positions and action plans to develop cities for climate change: Buenos Aires, Curitiba, Guadalajara, Mexico City, Lima, Medellin, Rio de Janeiro, Salvador, and São Paulo. These cities reaffirmed their commitment to the launch of the Climate Action Planning Program for Latin America of C40 (https://resourcecentre.c40.org/). Another initiative is the 100 Resilient Cities program by the Rockefeller Foundation in which 13 Latin American cities participate through implementing their own resilience plan; however, only one, the Metropolitan Region of Santiago, includes climate change as one of its main challenges.

In the case of Ecuador, it is important to understand that the country emits 0.15% of greenhouse gases worldwide. According to a study by the Ministerio del Ambiente, the energy sector expels the highest levels of carbon dioxide (CO_2), followed by the sectors of land use and forestry, agriculture, industries, and solid waste. In March 2019, the country approved an international agreement that commits Ecuador to work toward the implementation of measures to reduce carbon emissions and increase its level of resistance to extreme climate changes. This commitment is called the Determined National Contribution (DNC). The objective of the DNC is to achieve a 20.9% reduction in CO_2 emissions by 2025 (Republic, 2019).

In the city of Quito, a strategic diagnosis was made in 2014 under six axes: environmental, economic, social, territorial, historical areas, and mobility. Quito was evaluated through urban sustainability indicators developed by Salvador Rueda, in which the current state of the city was diagnosed and improvements were proposed for each indicator. In 2016, the Environmental Atlas "Quito Sostenible" was launched, where the city was analyzed according to several indicators. This Atlas was presented in the framework of Habitat III, held in the same city, where the New Urban Agenda was signed. In 2018, a resilience plan was presented as part of the city's participation in the 100 Resilient Cities program. In 2019, a prospective plan called "Quito Vision 2040" was proposed to the community to deliver guidelines to the city and organize initiatives for developing solutions for resilience, climate change adaptation, sustainability, and quality of life.

3. INDICATORS FOCUSED ON URBAN PROJECTS AT THE NEIGHBORHOOD SCALE

In Ecuador, as well as in Latin America as a whole, the demand for environmentally friendly buildings and urban terms is still in the embryonic stage. Some ambitious proposals have taken the path toward sustainability and pushed this issue in recent years, and several countries are moving forward.

In Ecuador, respect for nature is enshrined in the constitution; however, the guidelines are lowered and the considerations are less specific or diluted. Ecuador has a constitutional and normative context that supports the planning, management, and territorial ordering for sustainable construction and energy efficiency in a building and at the city level but not at the neighborhood level. The Ministerio del Ambiente and the Instituto de la Ciudad de Quito have partially implemented the diagnosis of sectors of the city through indicators, prioritizing consolidated areas such as some neighborhoods in the city's historic center. At the building level, Resolution No. 172 about eco-efficienct buildings became an ordinance as recently as 2019, showing progress in the city's legislation on these issues. At the neighborhood level, nothing specific has been proposed by the authorities at the normative level. However, in 2018, the municipality called for a public urban competition "Mi Barrio ejemplar y sostenible" with the participation of technical teams and neighborhood organizations, where it was proposed to seek sustainable planning at the neighborhood scale with an agenda for actions until 2040. Sixty-two teams were registered (composed of a neighborhood organization and a technical team), and 27 projects were finally evaluated to select four winning proposals, one for each sector of the city: South, Center, North, and the Valleys. The issue of sustainability in these four winning projects was addressed differently, without the possibility of evaluating the proposed sustainability or the viability of their execution and the environmental, social, economic, and cultural impacts.

This progression, in the interest of applied sustainability, shows the need for adequate tools for the planning of the territory at all scales, seeking in some way to ensure the sustainable development of the city.

4. PREVIOUS EXPERIENCE OF LCA AT THE DISTRICT SCALE IN LATIN AMERICA USING THE NEST TOOL

With the idea of evaluating the sustainability of urban projects in Ecuadorian contexts, NEST was used in urban projects in the Gulf of Guayaquil in Puerto Roma. This evaluation was realized within the context of the Habitat III competition for universities. The proposal from the Universidad De Las Americas won the competition. In this version of NEST, the buildings do not respond to locally constructed systems and products. Therefore, the standards used for environmental efficiency are not comparable with the Ecuadorian requirements. The main difficulty was that the database of this tool was developed based on urban products with European construction standards and specific territories found in the cities of Europe. This first evaluation forced us to rethink how to evaluate the characteristics of local urban production and to ask ourselves about the construction, architectural, and urban processes in Latin America that will help us define an adapted tool.

The NEST tool, in its philosophy and configuration of indicators, can be used, but in its database, it must be

reconsidered. Transforming a square meter of Andean upland is different than transforming a square meter of pines in the Landes in France, as is transforming a square meter of residential housing in France different than transforming a square meter of a gated communities in Latin America. At the building level, a Passivhaus building, where the maximum energy demand in cooling and heating must not exceed 15 kWh/m² per year and the primary energy consumption for all energy services must not exceed 120 kWh/ m² per year, is not comparable with Ecuadorians' housing, for example, which in urban areas consume 155.4 kWh/ m² year as an average (INEC, 2012) without any environmental or eco-efficiency consideration as understood in Europe or other countries. It is also necessary to consider that many of these values can vary depending on the use of cooling or heating systems due to the demands in the territories where these buildings are constructed. In countries like Ecuador, much remains to be done in regard to implementing sustainability standards.

NEST gave us a clue and a methodological basis that we have considered for this proposal; in addition, it showed us the interest of using indicators that can be easily explained for all stakeholders involved. On this basis, we developed a proposal for indicators adapted to local contexts.

5. PROPOSAL

Although there is a variety of tools in the urban planning sector, as mentioned before, the indicators are easy to measure and interpret and allow us to compare different city models as they provide multiple pieces of information about the patterns of life generated by each urban pattern. From many different fields of science, indicators are used as measuring instruments for the observation and analysis of processes, the visualization of data, or as an aid for decision making (María-Salas Mendoza-Muro, 2010).

Indicators are proposed on a neighborhood scale, because it is the smallest scale of urban analysis where the inhabitant has influence. The neighborhood is the space of the domestic grouped around a symbolic element (Lefebvre). The neighborhood is defined by the pedestrian scale, it must be provided with accessible collective equipment and should not exceed a perimeter of three kilometers (Ledrut). In the neighborhood everything makes sense: the criteria of size and structure of the urban components respond to the physical, social, and economic conditions of the people who inhabit it. The neighborhood can be defined at the administrative level, but the use of this space can actually generate a different dimension for its inhabitants when defined by belonging.

The creation and use of urban indicators are not new, but in recent years the emergence of urban and environmental issues has made its use possible not only for diagnosis but also for the evaluation of the application of public policies. Its use and utility have been approved by ECLAC, the European Union, the Organization for Economic Co-operation and Development, Eurostat, the World Health Organization, as well as within the framework of the Sustainable Development Goals (SDGs) of the United Nations (UN).

SDG as well as the New Urban Agenda of Quito signed in Habitat III in 2016 mark the global commitment to sustainable urban development. The fact that these global road maps have indicators can help us adapt the SDGs to the city scale.

If we use them as they are, these objectives are still somehow generic, and there is little understanding of how to apply them concretely on projects, especially at the neighborhood level. The existing indicators are diagnostic-oriented and more adapted to larger scales. The indicators proposed in some tools are either very complex or simple and are usually evaluated by experts with almost non-existent information at the neighborhood scale, as shown by the example in Figure 2.

Urban indicators quantify the data of main urban forms and their systems. They qualify their formal or functional aspects according to the major system but not their impact. The objective is then to territorialize these objectives at the neighborhood scale and to create or consolidate indicators based on global objectives to be reached from the local neighborhood scale (cf. Figure 3).

6. TOWARD A NEW TYPE OF CLIMATE CHANGE INDICATOR FOR EVALUATING URBAN PROJECTS

The climate change indicator, being a quantitative indicator, integrates this same problem of definition, but also suffers from an oversimplification if we consider the current situation of the climate change phenomenon. Although it is important to take into account the greenhouse gas emissions of a project, an urban project must also now position itself against the risk of the effects of climate change and then anticipate its necessary adaptation. We propose then to evolve the climate change indicator to consider both mitigation and adaptation aspects.

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate 11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	11.5.1 Number of deaths, missing persons and persons affected by disaster per 100,000 people[a] 11.5.2 Direct disaster economic loss in relation to global GDP, including disaster damage to critical infrastructure and disruption of basic services[a]

Figure 2. Example of indicators used in the SDG's definition



Figure 3. Territorialization process of indicators toward the neighborhood scale

Table 1. Influencing factors and corresponding data sources for defining a new type of composite indicator for the climate change impact of urban projects

IMPACT	INFLUENCING FACTOR	DATA SOURCE	MEASURE
MITIGATION of climate change / GHG Emissions	Land transformation and use	Land capacity for mitigating CO2 (forest, natural areas, agricultural areas, green spaces)	Area ratio between territory and green typology
	Urban and building projects	GHG emitted by materials and energy consumption	Construction area + infrastructure area
	Urban mobility	Direct GHG emissions from local mobility facilities	Number of km/mobility mean (scenario to be defined by the practitioner)
	Local economic activity	Direct GHG emissions from local industry	Economic activity/ industry typology
ADAPTATION to climate change / Risk management	Flooding	Ground permeability, sustainable urban drainage	Permeable surface
	Fires	Rainfall rate + local temperatures	Protection areas, prevention equipment (water disposal), access to emergency materials
	Local food provision	Drought, pests, biodiversity	Local production areas (garden, roof, facade) and local potential
	Water provision	Drought, average temperature	Use of local water (rain harvesting and storage – dedicated surface) + water management
	Preservation of biodiversity (and its eco-systemic services)	Temperature, green corridors	Green corridors (surface), use of endemic species, protected islands, connections between green areas
	Public spaces	Shade, temperature	Shade (public space coverage index)

We have defined, for each of the two fundamental aspects of climate change, the influencing factors of an urban project, how these factors are modified in different planning scenarios, and what type of data accessible in the project stage can be collected and analyzed to measure the impact. Although the definition of these elements is simple in the case of mitigation, the influencing factors and their corresponding data in the case of adaptation represent a much greater challenge since they refer to highly heterogeneous phenomena and a logic of risk and not of impact as is traditionally the case in LCA. Table 1 presents this initial re-definition.

7. CONCLUSION

Evaluation allows us to make great progress in the process of constructing an urban planning scenario, since it gives figures to complex phenomena and then guides the understanding of the proposal toward its supposed effects. The use of LCA allows us in this evaluation process to introduce objective criteria based on hypotheses and data, not only on perceptions and intuition as it is often used in urban planning. The difficulty, however, is to measure in a fair and balanced way, with timely and representative data that, although limitations must always be admitted, may provide a meaningful interpretation of the impacts generated.

The revision of the climate change indicator is necessary in the current context where climate change is no longer a hypothesis but a prospective vision. Urban projects, established for the long term, must consider and integrate climate change indicators, not only based on mitigation. Therefore, it is proposed to continue this work in order to define the indicator and its application to an experimental process in peri-urban neighborhoods of Latin American cities in order to arrive at an efficient and pertinent tool.

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CLIMATE CHANGE AS A LEVER FOR PLACE-BASED REGENERATION POLICIES: THE CASE OF NAPLES, ITALY

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ABSTRACT

Despite national governments and cities are urged to put strategies for mitigation and adaptation on their agenda, in Italy climate change struggles to get into the priorities of urban policies, and is even less present in collective imaginations and claims. This is due to a mix of political, social and ecological factors, including the willingness to deny strategic value to environmental policies and to invest in compensation rather than prevention of the related risks. Fragmented plans and policies for climate change management correspond to an equally mild demand for actions by the general public. This paper argues that the scarce public perception of climate impacts on urban environments is largely due to the global rhetoric by institutions and media that has ended to de-politicize the issue, pushing it away from the public discourse. Bringing the climate back to the centre means, on the contrary, sharing descriptions and actions that allow exploring climate effects in relation to local contexts. Starting from the results of previous researches, the paper explains how climate change could work as a lever for overcoming the global rhetoric. The current transition in Naples emphasizes how deconstructing the technocratic discourse on climate helps enhancing sustainable development and community resilience. Situating climate change policies in the directions of both the new urban and the strategic metropolitan plan is a way of promoting shared processes of spatial regeneration.

Keywords: multilevel governance, perception, public discourse, place-based regeneration, climate change

1. INTRODUCTION

Despite national governments and cities are urged to put strategies for mitigation and adaptation to climate change on their agenda, in Italy the issue of climate change struggles to get into the priorities of urban policies, and is even less present in collective imaginations and community claims. This is due to a mix of political, social and ecological factors, including the willingness to deny strategic value to environmental policies and to invest in compensation rather than prevention of the related risks. Fragmented plans and policies for climate change management correspond to an equally mild demand for actions by ordinary citizens and the general public. On the other hand, current environmental movements do not seem to be considerably interested in struggling for climate.

Starting from the knowledge acquired so far through the research of *Occupy Climate Change*, this contribution clings climate change to the specificities of the context of Naples.

The paper argues that the scarce perception of climate impacts on urban environment is largely due to mistakes in institutional and media communication that have begun to de-politicize the issue, pushing it away from public discourse.

After exploring the issue of climate change in the Italian context, and reporting learnings from previous researches carried out in the urban region of Naples, its impact on local media is investigated, as well as how climate change is treated in urban policies by the City and the Metropolitan City of Naples. The perception of climate change by environmental movements and associations is also analyzed, with a particular focus on Greta Thunberg's generation, closer to the claims of the "Fridays for Future" global movement.

2. THE GOVERNANCE OF CLIMATE CHANGE IN ITALY

The issue of climate change is not among the priorities of the Italian government in spite of European claims for reducing CO_2 emissions. There is a national strategy for mitigation and adaptation to climate change, but the appropriate plans and measures to implement the strategy are still ongoing (EEA, 2019). However, already

in 2012 Italy was the European nation with the higher number of cities adhering to the *Covenant of Mayors,* launched by the European Union in order to spur local administrations to undertake the reduction of emissions. This first position underlines the interest in climate change by Italian Mayors. Italian cities adhering to the Covenant, in fact, are 4,682, the second nation is Spain with 2,270 cities, and the third France with 185 cities (Covenant of Mayors, 2019).

Today, while green economy entrepreneurs, penalized by the difficult launch of energy policies and by the broad ignorance of sectoral incentives, press to accelerate environmental transition, policy makers and local administrators, engulfed by strict administrative and management routines, are not prepared to carry out an effective environmental governance. This is also due to difficulties in overcoming the sectoral responsibilities of local authorities, that prevent to carry out an intelligent management of resources.

The national priorities seem to be the following: hydrogeological instability and earthquakes that cyclically affect Italy Apennine ridge, health damages owing to industrial pollution and bad waste management, struggles against oil drillings and big transport infrastructure.

Only sporadic local or regional administrations are taking seriously climate change into consideration, investing in plans and measures, but they are not ascribable to an overall strategy. Since March 2019 something is changing, at least from a symbolic point of view. Last fall the President of the Italian Republic, while visiting the mountain region of Belluno where hectares of forests were caught in a storm, declared that Italians are currently paying the price personally for the consequences of the global climate crisis.

3. METHODOLOGY

The governance of climate change (from now on CC) has been investigated applying to the urban region of Naples some of the most widespread theories within the scientific literature regarding CC (Galderisi & Colucci, 2018). In particular, the concept of ***evolutionary resilience*** (Davoudi, 2012) has been adopted to read the urban context as an assemblage of complex systems and the concept of ***human smartness*** (Concilio, Marsh, Molinari, & Rizzo, 2016) in order to enhance local communities' environmental knowledge. These concepts have been explored in the Ponticelli Neighborhood in eastern Naples, where a social vegetable garden and its management is evolving in a new model of governance.

To understand how the public perceives CC - from institutions to citizens - a careful examination of the most influential national and local newspapers from 2010 to 2019 has been carried out. In addition, from November 2018 to April 2019, ten in-depth interviews were conducted and two focus groups with public officials, practitioners, politicians and representatives of associations and movements were applied[1].

Finally, a mixed methods approach has been carried out through a questionnaire with open-ended and closed questions. The questionnaire was distributed to 150 students who were 15 to 20 years old in order to reconstruct the point of view of the "Fridays for future" generation.

4. THEORIES IN USE

The scientific literature on CC embraces different branches. This paper adopts an ***Urban Political Ecology*** approach, aiming to understand the social impacts of CC on contemporary space and society. This framework encompasses territorial conflicts, public policies and decision-making processes carried out by public actors as well as struggles and actions related to the environmentalism of poor urban communities (Martinez-Alier, 2002).

We employ a critical approach that, starting from a global overview of practices and events, aims to combine the issue of CC with the principles of ***Environmental Justice***, in order to analyze these concepts in relation with the specificities of local contexts (Dawson, 2017).

This research approach distrusts the mainstream dimension of CC, spread by policy-makers and technocrats, that considers the environmental risk the object of a new functionalism leading neoliberal European agendas.

According to this point of view, the insistent attention to CC strengthens mainly those government tactics that, boosted by media, leave in public imaginations feeding on apocalyptic institutional and media narratives. These narratives produce the often-desired effect of de-politicizing the public sphere (Swyngedouwn, 2011).

The fears behind these imaginations end up keeping the general public at a distance. At the same time, they hide the interests of those taking advantages

1 This work, developed in the framework of the *Occupy Climate Change* research, which explores climate change perception in Naples, Rio de Janeiro, New York, Istanbul and Malmo, is based on a cooperation between researchers from the Department of Architecture of Federico II University of Naples and researchers from the Environmental Humanities Lab of KTH of Stockholm.

of populism in order to draw huge CC funding to the technical and bureaucratic èlites.

Accordingly, the *Urban Political Ecology* approach shows that the current hegemonic CC policies are intended to enhance the social and political *status quo* rather than support the achievement of egalitarian changes. In this perspective, enhancing environmental and contextual knowledge becomes a promising driver for climate-sensitive regeneration processes.

5. INITIAL FINDINGS WITHIN THE CONTEXT OF NAPLES

The initial research carried out by the Department of Architecture at Federico II University of Naples in 2011 dealt with analytical methodologies to tackle the impacts of stormwater on the urban region of East Naples[2]. At that time, only few Mediterranean cities were interested in adopting environmental regeneration and adaptive projects as the bulk of their public administrations[3] and the social dimension of CC was nearly overlooked.

A second research study was necessary for showing the importance of the social dimension, through the launch of a *Smart Lab* – designed to be a place for exchanges between researchers and inhabitants - in which impacts of CC on local imaginations were investigated[4] (Palestino, 2016), thus stimulating aware, sustainable and situated regenerations of places[5] (Palestino, 2017).

Working in the field, it gradually became clear that, besides the good practices experimented on a worldwide scale, bringing the issue of climate change to the attention of ordinary citizens, as well as environmental movements and local associations, constitute a provocative, not simple, challenge.

To do this it is necessary to deconstruct the technical competences of designers and planners, listening to local knowledge and looking at the effects that climate produces in local contexts and the consequent needs of inhabitants and users.

In the ongoing *Occupy Climate Change* research, instead, the difficulty of bridging some interpretative ambiguities intimately connected to the theme is emerging. The ambiguities concern the following: the design of public policies too focused on mitigation and adaptation and not addressed to the management of the environmental transition; the urgency of educational formulas aimed at the transformation of ordinary citizens' behaviors and to the innovation of decision-makers' routines, as well as the enhancement of public images able to formulate new urban claims also in the field of innovative ecosystem services.

On the other hand, what remains totally unexplored is the set of risks associated with the media manipulation and the pressures of social media to which the CC, as evidenced by the sudden surge of "Fridays for Future", is subject both on a global and local scale.

6. MEDIA

In recent years the media has ignored CC and the related impacts on the city and instead described Naples through the lens of waste management and the environmental disaster known as the Land of Fires (Dines, 2016). Far from the public discourse, the issue has lost the push that elsewhere makes for an engine of political oppositions and conflicts of any kind (Latour, 2017).

Research on the reports on CC in the most important Italian newspapers from 2010 to the present shows that news about Naples and its metropolitan surroundings are full of stories of deaths and accidents, as well as damages due to landslides, floods, heatwaves and dryness, fires, lightning, fallen trees and so on. In particular, news of the snowfall in February 2018 has to be reviewed as a break among different narratives. As a matter of fact, due to the weather alerts, which are usually spread by the Civil Protection Department, the press began to broadcast and comment on the bulletin of city ordinances which are promulgated in order to ensure the safety of citizens by closing schools, historical areas and urban parks.

Due to the increase of extreme weather events, newspapers have reported on the lack of ordinary and extraordinary urban maintenance, linking the effects of CC to the irreversible deterioration of the urban landscape that puts the urban image of Naples at risk because of the gradual loss of distinctive trees such as cluster pines.

A media debate on CC started in the second half of the February 2019, in conjunction with two events involving different social classes of Neapolitan society.

2 The research "Stormwater resilient urban open spaces under changing climate conditions" was supported by Federico II University of Naples Division of Science and Technologies under Faro funding for the launch of original researches. See Moccia and Palestino (2013), Palestino (2014).

3 In the first stage of the research, addressed to the collection of best practices, it was difficult to find relevant examples in Italy south of Bolzano.

4 The Department of Architecture, Federico II University of Naples, was among the partners of the research "Metropolis. Integrated Methodologies and Technologies for adaptation and security of urban systems", in the framework of the National Operative Program Research and Competitiveness 2017-2013.

5 On the outcomes of the Smart Lab see the "Resilient Ponticelli" video at: https://vimeo.com/246951600.

During the first Neapolitan event regarding the Fridays for Future, a group of associations and movements concerned with the environmental struggles of the last twenty years organized the Friday urban routine, which asks students to consider the struggles against CC as a way to plan their future. At the same time, there was also the meeting among urban elites interested in promoting a forestation plan for the metropolitan area of Naples and the Italian coordinator of the environmental association *The Climate Reality Project,* which is headed by the Nobel Peace Prize winner Al Gore.

7. PUBLIC INSTITUTIONS

As for the involvement of public actors, the issue of CC has moved up in the Neapolitan policy agenda since 2009 and has remained there since 2015. More recently, after a stalemate that broke off in March 2019, the metropolitan mayor enacted a resolution called OCG, "Oxygen Common Good". The resolution calls for the enforcement and mitigating of environmental pollution including the following measures: a general plan for charging electric vehicles; increasing controlled traffic zones and pedestrian areas; civic involvement in implementing, supporting and regulating urban green areas; energy efficiency measures on municipal buildings; restoration and reopening of closed parks due to management problems by the municipalities; allocation of 10.000 new trees to be devoted to urban reforestation in municipalities belonging to the Metropolitan City of Naples. In addition, measures to contrast harmful emissions in the port and to relocate oil depots from eastern Naples were added.

Environmental consciousness began in 2009, when the City of Naples joined the Covenant of Mayors launched by the European Union in order to give local governments a strategic role in defining voluntary policies against the effects of CC. In this direction, the City of Naples took the responsibility to manage the Sustainable Energy Action Plan (SEAP) aimed at mitigating the impact of greenhouse gas emissions. The economic crisis and the financial difficulties occurring in the meantime, together with the incoming of a new mayor who was supported for a while by a strong environmentalist Municipal Council, has gradually strengthened this position thanks to the opening of a municipal office devoted to "Environmental monitoring and SEAP implementation."

Today, after a period, between 2016 and 2018, in which environmental challenges were disregarded, the issue of CC is finally at the core of a promising relationship between urban regeneration and adaptation to CC. This is evident from the guidelines for the new Municipal Urban Plan, recently issued by the City of Naples.

We are therefore in a period of transition where both the Urban Plan of Naples and the Strategic Plan of the Metropolitan City aspire to a sustainable development model that is grounded in community practices from below. Allocating mitigation and adaptation policies to CC both in the urban and in the strategic plan could be the right move to re-politicize public policies.

8. PUBLIC OPINION, ACTIVE CITIZENS AND CLIMATE CHANGE

Neapolitan public opinion is starting to become aware of the effects of CC with time and some difficulties. In the summer of 2018, some environmental organizations of national relevance, such as WWF and Legambiente, were interviewed in the framework of the *Occupy Climate Change* research and complained about the difficulty of influencing ordinary citizens through awareness campaigns on CC. On the contrary, the network of schools, associations, parishes and individual families, founders of an "Urban Social Garden" within a public park neglected by the municipality of Naples highlighted how those who take care of the land are naturally sensitive to the impacts of CC, which they seize daily in the reverberations of the effects of climate on the products of the land. However, observing the evolution of the experience of the Urban Social Garden was not only a way to measure this widespread sensitivity but above all an opportunity to monitor if and how much the city administration is ready to overcome the traditional management model.

Re-appropriating the park is the work of the Local Health Authority (ASL) based in the public housing district of Ponticelli, one of the poorest in the city, which is located in the extreme eastern periphery. A few years ago, in search of an area in which to experiment on outdoor therapy for drug addicts to be integrated into the social fabric of their neighborhood, the ASL expressed interest in reusing the public park *Fratelli De Filippo*, one of the largest in Naples, closed to the public in 2008 for management and public order problems. A first Memorandum of Understanding signed in 2014 between the municipality, owner of the area, and the ASL did not prevent the latter, despite difficulties of a different nature, in giving back a part of the park that had remained long forbidden to public use.

Today, five years later, the park management formula, revised and implemented in synergy with the municipal offices, has led to a new inter-institutional collaboration agreement signed by the contracting



Figure 1. Vegetable gardening in the Ponticelli district (photograph by Gianni Fiorito)

parties to give rise to a more advanced management, born from the cooperation among the Green Service of the City under the Department of Urban Green and Sport, the Combat Poverty Service, and the Social Emergency Network under the Department of Social Policies, and the Dependencies Department of the ASL Naples 1. This new agreement therefore proves that, in addition to the awareness of the ongoing environmental transition and its complex needs, institutions have finally achieved a multilevel governance approach.

As for the environmental movements in the urban region of Naples, when questioned about the interest in mobilizing in the name of CC, some representatives coming from past experiences in the fight against the ruinous management of waste (Armiero, 2014) and the environmental disaster of the Land of Fires (De Rosa, 2017), declared that they had no interest in getting involved in future movement. However, they reversed their decision in front of the media wave triggered by the *Fridays for Future* movement which, under the leadership of the fifteen years old Greta Thunberg, culminated in the global strike of March 15, 2019. In Naples over 20,000 people took part in the event, including many young people, as was to be expected given the age of the organizer who launched the event through social media.

This turnout constituted another reason to test the city through a questionnaire on CC perceptions, through a sample of 150 students from Greta's generation: more precisely 25 boys between 15 and 16 years, coming from a high school in the center of Naples, and 125 university students between 19 and 20 years, coming mainly from the Metropolitan City of Naples.[6]

From the questionnaire, which was administered just before the global strike, it emerged that the knowledge of the topic is still very embryonic, similar to the observations recorded among mature citizens and movements.

Young people, in particular, attribute the frequency of unexpected meteorological events gradually increasing such as hail, drought, snowfall, water bombs, and heat waves to CC; at least 30% of those surveyed have noticed the intensification of the night heat and 25% of the sample look at the tropicalization of the Mediterranean sea with suspicion. The extreme variability of the climate has transformed the way of living for almost one-third of the sample, undermining their health with respiratory problems and colds caused by continuous changes in temperature or sleep disturbances due to the summer night heat and

6 The Metropolitan City of Naples includes 92 municipalities which are located on a surface of 1.171 km^2 and inhabited by more than three million inhabitants.

pushing families toward increasing the use of air conditioning systems. Only one-quarter of the sample is aware of the fact that their daily life has to adapt to climate variability.

Adaptation was interpreted as ways of dressing more responsive to changes in temperature, as well as the growing of a general feeling of climate alert, and the difficulty of enjoying the city during increasingly frequent meteorological emergencies. For 75% of the sample, the representative places of CC refer to the melting of the glaciers in the poles, 15% refer to North America, Asia and Australia, and only 5% mention their city as exhibiting the effects of CC.

Sixty-two percent of the sample stated that they did not experience CC in Naples or its surroundings; while the 38% identified urbanized areas, urban parks and peri-urban and rural areas the places exemplifying the effects of CC. Twelve percent of respondents also added that holiday places show the signs of CC.

Among the measures to combat CC, the need to encourage alternative forms of energy was reported, followed by the option of planting trees, creating green roofs, and designing new parks. Half of the respondents think that mayors should promote the use of bicycles, one-third insists on enhancing public transport, about 20% would be willing to eliminate the personal use of their car, while a little less than 10% of participants think that using special construction materials and colors can help absorb and reflect less heat. To the question "What would you be prepared to do personally to fight against CC?" all responded positively, indicating, in order of preference: recycling waste, lower consumption of non-renewable energy, the preferential use of train compared to airplanes and cars, the consumption of food at zero km and consuming less in general. Only 28% of the sample claimed to have personally experienced the effects of CC and reported sudden climatic changes often accompanied by a pungent feeling of impotence or fear, or complained about the deterioration of resources and the destruction of their living environments. Many of the participants signaled the desire to learn more about CC and its effects.

9. CONCLUSIONS

Until 2019, the issue of CC was not well understood among the public and was relegated to the institutional duties of a small office responsible for environmental monitoring and *Sustainable Energy Action Plan* implementation in the City of Naples. Recent global mobilizations and the subsequent media pressure seem to have triggered greater awareness among the public and led to greater commitments from local authorities. Just think of how, for example, in the guidelines for the City Urban Plan, CC is in the heart of the announced regenerative model, or how the Strategic Plan for the Metropolitan City has been communicated through the promotion of widespread urban forestation, which is useful to combat CO_2 emissions at regional scale.

As the survey showed, the lack of scientific knowledge on the related issue –which will surely have to be separated from dogmatism and ideologies– corresponds to a widespread perception of behaviors and lifestyles evolving as a result of CC.

This perceptive sensitivity, especially because it is supported by an interest in learning more, is already beginning to contrast the media narratives of an exotic elsewhere that is frightening, as well as the repetitive bulletins of damages spread through local chronicles.

The young protesters of the "Fridays for Future", with their curiosity to know, represent new narratives and imagine urban intervention re-appropriating spaces of everyday life which can work as a tactic to re-politicize the environment.

As the experience of Ponticelli Urban Social Garden demonstrates, the beginning of a participatory inter-institutional management practice has not only slowed the process of de-politicization of the public sphere through the growth of a community that has made the right to the environment a principle of environmental justice, but it also contains all the potential to reverse this process. It does so by involving the municipal institution in the revision and improvement of the current management formula, inaugurating an innovative model of multilevel governance.

The awareness of the effects of CC by the Ponticelli gardeners suggests to the *Occupy Climate Change* researchers that the groups and movements concerned with the Land of Fires region are switching from resistance struggles against illegal waste dumping and the phenomenon of toxic fires to more mature experiences of direct land recovery.

Co-managing environmental transitions enhances the sustainable regeneration of portions of degraded territory, facilitating the reorganization of vulnerable settlements thanks to the awareness and participation of local communities.

AKNOWLEDGEMENTS

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OTHER ABSTRACTS PRESENTED IN THE CONFERENCE

OUTDOOR THERMAL COMFORT AND USAGE CHARACTERISTICS IN HISTORICAL AND MODERN URBAN SQUARES OF ISTANBUL, TURKEY

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ABSTRACT

The use of public space has changed due to gradually increasing populations, change of user trends and presence of approaches that fail to observe thermal comfort and locality when making decisions related to open space planning and design. In this context, providing thermal comfort in open spaces appears to be a field of study that needs to be discussed. This study proposes a new approach to examine the thermal values and usage characteristic of the two city squares' outdoor thermal comforts, located in historical and new urban patterns, in Istanbul which is located in the temperate humid climate zone of Turkey. The selection of case areas are based on the social media popularity rate, so Sultanahmet Meydanı was selected in the historical area, and Şirinevler Meydanı was selected in the modern area of Istanbul. The research method consists of microclimate and morphology analysis to define the thermal comfort values of squares, user experience analysis with social media data, and evaluation of results. The results show that the urban form, wind characteristics, the presence of vegetation, water bodies, and morphological properties of squares are effective on thermal comfort distribution in urban areas. When compared to the simulated values of historical square and modern square in summer, it is seen that historical square has lower temperatures and better thermal comfort values. The findings may contribute to a better understanding of the impacts of urban morphology, architecture and landscape characteristics on urban microclimate and user preferences. Once natural, spatial and social parameters are successfully examined and designed, open spaces will benefit from natural resources optimally, hence spatial quality will have been improved. It is therefore crucial for thermal comfort and environmental quality, consequently for users' health and convenience that urban squares are in harmony with spatial, social and climatic characteristics of the city.

Keywords: Urban morphology; urban microclimate; data analysis; outdoor thermal comfort.

EFFECTS OF URBAN BLOCK TYPOLOGIES ON WIND FLOW CHARACTERISTICS: THE CASE OF IZMIR, TURKEY

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ABSTRACT

Climate responsive urban design is neglected due to intensive urbanization, and therefore the dense urban structure reduces the continuity of wind flow and makes the urban environments unventilated. Wind is the natural phenomenon to ventilate the urban environments; however, high-speed wind flow due to the large building bodies causes pedestrian wind discomfort. This study aims to investigate the outdoor wind performance of typical urban blocks such as point, linear, V-shaped and low and high-rise. As different from the previous studies focusing on the typical urban blocks in related literature it aims to take into account both pedestrian wind comfort and urban ventilation. The Alsancak Neighborhood was chosen as the study area since it is the most enjoyable public place for urban inhabitants in the city of Izmir, Turkey. Wind observation in the area shows that high-speed wind flow especially formed around large and high-rise buildings causes pedestrian wind discomfort. Along with the pedestrian discomfort, the linear and continuous building blocks located on the seaside of the settlement obstruct the penetration of cool sea breezes into the city. Therefore, the city becomes thermally uncomfortable in summer. As a method, CFD (computational fluid dynamics) techniques were used. The results show that the point block provides the best outdoor wind performance compared to the other studied urban blocks. It was found that appropriate urban block arrangements can allow the penetration of wind flow into the urban fabric while providing pedestrian wind comfort. The findings could be generalized to enhance wind conditions in different urban settlements regardless of location and climate since the typical urban blocks were investigated in this study. Along with the theoretical contribution to the international literature, the findings can contribute to the creation of new local urban planning policies taking into account the wind phenomenon in the city of Izmir.

Keywords: Urban block, urban ventilation, pedestrian wind comfort, computational fluid dynamics (CFD).

UNDERSTANDING CLIMATE CHANGE AND URBAN HEAT ISLAND IMPACTS ON THE BUILT ENVIRONMENT

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ABSTRACT

The residential building sector is a high-priority area in climate change and urban heat island research due to its large share of CO_2 emissions, the substantial energy saving opportunities it represents, and the increasing occupant comfort expectations. In the future, a shift in building energy use from space-heating towards space-cooling is expected due to global warming. Corresponding environmental impacts will also change accordingly. Moreover, the lengthy periods of overheating will become a major challenge for the occupants of the residential buildings. Especially, the day-time occupants (those that are most exposed to overheating and those that cannot effectively take the necessary adaptive measures such as children and the elderly) will be at the highest risk.

This paper presents the simulation-based results of the climate change and urban heat island impact assessment for a typical multi-story residential building in Istanbul. First, a climate change projection based on RCP 8.5 (business as usual, representing high CO_2 emissions) determined by the Intergovernmental Panel on Climate Change (IPCC) was created for 2060 by morphing the baseline weather data. Obtained 2060 data was further morphed to include the urban heat island effects for an urban context. For building simulations, two cooling scenarios were developed representing different building usage profiles (naturally ventilated and fully air-conditioned). As building performance metrics, building heating/cooling energy demands, CO_2 emissions and occupant thermal comfort were evaluated. The results show that the cooling energy demand and/or occupant comfort level will be strongly influenced by the predicted temperature increases. The results not only underline the necessity of taking adaptive measures, but also emphasize the importance of decarbonization of the electricity production in reducing the future negative impacts of climate change on the buildings. The presented results will also provide a basis for future studies on retrofit for climate change.

Keywords: climate change, urban heat island, residential buildings, building energy performance and occupant comfort

NOT TWO WORLDS BUT ONE: THE NATURE OF URBAN ARCHITECTURE

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ABSTRACT

"Cosmos is the first city" wrote the Stoic philosopher Chrysippus. He claimed that all cities that are governed by law should be modeled after the cosmos. Modern cities, however, have been conceptualized and built not as a manifestation but as the antithesis of nature. To our minds, city and nature belong to two ontologically distinct categories. The former, which is an artifice, is built upon the latter, which is non-human and primeval. Assuming that city is an encroachment, issues that pertain to collective human activity are considered utterly disruptive. While the advance of recent critical scholarship in anthropology and sociology that question the culture-nature division is important, it is of little help to the environment-conscious designer. Even if designers agree that such false divisions do not hold, how this awareness translates into design is not clear. We have no resources or guides beyond the prevalent assumptions and norms, which are largely based on the split worldview. We need new or recovered perspectives to make sense of the existing order and to re-define it. Along these lines, the two basic premises of this paper are: 1) It is impossible to assume a realistic environmental stance without eliminating the dualistic understanding, and 2) Some architects, landscape architects, and urban designers have put forth creative alternatives to overcome the dichotomy. Based on these propositions, the main objective of the paper is to highlight such exemplary design attitudes and to present urban situations that acknowledge, embody, reflect, and re-animate the rhythms and elements of the natural world. It is hoped that the proposed inquiry into situations that are designed or discovered to harness the water, the sun, the earth, and the air within the social and the physical fabric of the city will offer alternative ways of positioning the human prospect in the environment.

Keywords: nature-culture split, design alternatives to city-versus-nature dichotomy, re-situating the human prospect in the environment.

CO-DESIGN OF A NATURE-BASED SOLUTIONS ECOSYSTEM FOR REACTIVATING A PERI-URBAN DISTRICT IN QUITO, ECUADOR

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ABSTRACT

Climate change is hitting Quito with a shift in average temperatures, an increase in flooding during the rainy season and stronger fires during the dry season. It also affects food production systems, water provision from the surrounding mountains, local biodiversity and generates new types of risks within the city. With 5,9 Mton of CO_2 equivalent emitted in 2017, the city of Quito still has a low emission average compared to similar cities in the world. It aims, however, at reducing its emissions at a 5% annual rate until 2025. For this purpose, Quito has developed specific plans like the "Vision 2040" and the "Resilience Strategy". It proposed in 2018 and 2019 a set of urban competitions for embodying such visions into territorial, urban and architectural realities. The present paper results from an award winning proposal to the "Mi Barrio ejemplar y sostenible" urban competition launched in 2018 and based on developing the "Vision 2040" for San Enrique de Velasco, a typical peri-urban district of Quito. This proposal was developed considering a co-design process using both traditional methodologies, like interviews and workshops with inhabitants, and innovative tools, like Unlimited Cities based on collaborative urbanism. Against a deprived and segregated district, the proposal considers using the under-development science of nature-based solutions (NBS) as a main driver for rehabilitating cohesive spirit among neighbours, developing local economy, recovering the important natural assets of the area, solving issues like storm water management and lack of comfort in public areas with ecological means and developing new landscapes. Beyond public spaces it also proposes a regulation framework for orientating private property densification towards including NBS. This proposal for San Enrique de Velasco aims at shaping new perspectives for the whole city of Quito under a resilience perspective, where NBS plays a novel major role against climate change.

Keywords: nature-based solutions, city planning, co-design, Quito

NBS AS A POLICY AND PLANNING MEASURE TO MITIGATE CLIMATE CHANGE IMPACTS

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ABSTRACT

Climate change is a major global challenge with impacts at multiple scales and interconnections with numerous environmental processes and factors, such as flooding, heatwaves and the security of food/water. International organizations such as the World Bank or the United Nations agree on the increasing adverse impacts of climate change on urban areas and conduct programs on mitigating effects of climate change and associated disaster risks and providing sustainable innovation actions. Conventional 'top-down' engineering solutions or spatial planning alone cannot ensure cities' capacity to mitigate the impacts of climate change. Physical measures such as flood barriers or embankments, may be highly effective and efficient within their lifespan. However, they are inflexible, difficult to integrate into dense urban fabrics due to conflicting interests in property ownership, they require high maintenance and they make limited contributions to other societal challenges. Hence, alternative approaches are needed that integrate the physical, social, economic, and environmental dimensions to govern the impacts of climate change and associated societal challenges. Through a systematic literature study and policy analysis, this paper evaluates and integrates findings from selected European cases to find answers to the following questions: 1) "How can NBS, as a policy and planning measure, help to mitigate climate change impacts in urban areas?" 2) "Whether can NBS contribute to more equity and justice in cities?", and 3) "Can NBS help to integrate the different dimensions, such as social, economic, environmental as well as the physical?" The results can inform future urban development strategies and policies with the ultimate goal of being climate resilient.

Keywords: climate change, nature-based solutions, disaster risk reduction, equity and justice in cities

THE EFFECTS OF URBAN MORPHOLOGY AND TOPOLOGY ON URBAN HEAT ISLANDS: A SPATIAL REGRESSION APPROACH

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ABSTRACT

Urban heat island (UHI) has recently been a hot research topic since the vast majority of the cities are hosting UHIs across the globe resulting in lower quality of life and even loss of human lives in urban areas. In a most general sense, the increasing concentration of people in urban areas creates denser urban land uses which cause pollution and congestion leading to more UHIs. In addition to the land use causal determinants of the UHIs, addressing the spatial and urban morphological determinants is also needed. Analyses based on spatial information may help in developing UHI sensitive development the strategies for the mitigation of the UHIs in urban areas. Besides, UHIs sensitive policies may also provide more resilient, and climate-friendly urban development plans with a notion of more liveable urban spaces. With this regard, this study aims at estimating the effects of spatial and morphological determinants of UHIs in a large-scale city, Izmir, Turkey by using remote-sensing based temperature data. Ordinary Least Squares (OLS) and Spatial Durbin Model (Spatial Lag) are used to estimate Land Surface Temperature (LST) by introducing (1) Graph Theory-based accessibility indices (sinuosity, total depth, and angular segment length) and centrality measures (degree centrality, betweenness centrality, closeness centrality, and clustering coefficient) as morphological explanatory variables, (2) level land use data, and (3) road characteristics (area, length, width) as the explanatory variables. Regarding the results, this study reports quite significant findings. First, UHIs are not randomly distributed across the city, whereas, their concentrations depict place and urban morphology dependent distribution patterns. Second, the Graph Theory based urban morphology indices reveals that the higher centrality of the topology and accessibility in cities lead to more UHIs. Policy implications are discussed.

Keywords: Urban heat island, Urbanization, City-road network, City morphology, Network analysis

INFORMAL GREEN INFRASTRUCTURE (IGI) AND THE PURSUIT OF CLIMATIC-RESPONSIVE ENVIRONMENTS IN QUITO CITY

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ABSTRACT

Loss of green landscape to informal housing development is a classic problem in fast growing cities of developing countries, which may contribute to the pace of climate change. This situation calls for mechanisms that integrate informal settlements in efforts of mitigation and adaptation. This research develops an empirical description of the concept of informal green infrastructure (IGI), proposed as a tool to anticipate the making and unmaking of green infrastructures in informal settlements when planning for climate-responsive urban environments. Using a case study design in informal settlements of Quito, I explore how the socio-spatial constraints blend with the pursuit of human agency and the surrounding green landscapes to shape IGIs as infrastructures of everyday life. Learning from everyday practices that sustain IGIs in place may yield some implications for adaptive capacities in wider scales. Data collection involves a mix of qualitative methods. These include archives analyses, transect walks, different formats of interviews, and observations. The study identified community allotments, footpaths over neighbouring slopes and ravines, and pitches for football and volleyball as the most prevalent infrastructures that fit into the criteria of IGI. The principal findings were: (1) Community allotments constitute platforms for engendering interactional multiscale social networks of reciprocal exchange and help for women. (2) Footpaths provide connectivity to mobility infrastructures that allow dwellers reach their daily destinations. (3) Pitches enable leisure choices, income generation, and enhance collective agency in pursuing governmental interventions toward improved informal settlements. Additionally, IGIs constitute green spaces developed and maintained by users. IGIs secure their ongoing functionalities by transforming incrementally in harmony with the networks in which their users embed. Hence, for the three types in this study, IGIs' stakeholders are actors involved in policies relevant to food retailing, urban transportation and sports practicing, which are often overlooked in the green space debates.

Keywords: Green infrastructure, informality, climate-responsive, Urban sustainability

APPLICATION OF GEODESIGN TO UNDERSTAND CONCERTED PROTECTION MANAGEMENT AND RESILIENCE OF THE MANDJI ISLAND

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ABSTRACT

The overall objective of this study is to make a contribution to the resilience of Mandji Island, Ogooué maritime province in Gabon, through the implementation of a landscape project using the Geodesign method of harvesting decision, from geographic planning focused on landscape design through three-dimensional modelling, "Geodesign changes geography by design" said Carl Steinitz. A 3D visual cartographic support with CityEngine will allow for a better landscape integration of the existing or future coastal protection schemes of the different actors projects. The present contribution makes the inventory of the vulnerability and protection of the island Mandji, object of our study, located in Gabon in Central Africa, we will work on two main sites; the Cap Lopez oil terminal area; and the Pointe Clairette urban area at Akosso Point on Port Gentil Bay. This territory whose geomorphology through its low altitude, four meters from sea level makes it subject to coastal risks such as erosion, flooding and marine submersion. We will use the concepts of coastal resilience, landscape approach, and consultation in our diagnosis of the process of protection planning the 3D mapping of infrastructures and different actors will illustrate the actions and scenarios of the future vision of this site.

The application of Geodesign to understand resilience is based on the fact that any resilient project is built on an integrated planning. Geodesign improves this approach with concertation tools which it offers so much on the spatial visualization as on the mediation between the stakeholders.

Keywords: Geodesign, coastal resilience, CityEngine, Gabon.

TRANSITION TOWARDS URBAN-NATURE DICHOTOMY TO NATURE-BASED LIVING: LESSONS FROM IZMIR

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ABSTRACT

Izmir has a population of 4.2 million inhabitants in the western part of Turkey. Increased number of inhabitants creates pressure on environmental resources and complicates city services. Therefore, resilience thinking is needed in the future development of the Izmir city-region.

Greening urban plans and following blue & green growth strategy is Izmir's main target in coming years. To this end, the city signed Covenant of Mayors (CoM) in 2015. As a member of CoM, Izmir completed a Sustainable Energy Action Plan (SEAP), declared a target of cutting 20 percent CO2 emission by 2020. To align with CoM's targets, the city has developed some actions mainly for urban transportation and environment. However, to obtain basis for climate change adaptation plan, the next target of CoM till 2030, Izmir has applied to some EU projects. The first effort was H2020 UrbanGreenUP project, started in 2017, aiming to support re-naturing urban plans through innovative nature-based solutions (NBS). As a frontrunner city, Izmir has decided to adopt this strategy into local agenda and completed Turkey's first "Green Infrastructure Strategy" to adjust all the NBSs in a larger urban context.

The main assumption in this study is that bottom-up processes solving environmental problems at the local level have a strong transition effect in changing the local situation. Therefore, the site selection for UrbanGreenUP project has been carefully considered to cover urban-nature dichotomy. The aim was to perform 'Proof of Concept' (PoC) approach testing urban nature dichotomy to urban-nature continuum and eventually towards nature-based living. The paper critically reviews NBS literature and discusses PoC realisation and the role of new bottom-up practices (i.e. community-supported urban farming/bio boulevard, tactical design elements, citizen science experimentations etc.) to reach this end.

TRANSITION TOWARDS A POST-CARBON CITY: CRITICAL IMPACT ASSESSMENT FOR ISTANBUL

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ABSTRACT

'Post-Carbon' cities are one of the new approaches which aims to increase cities' and regions' resilience to today's or future's environmental, social and economic stresses. 'Post-Carbon' approach suggests solutions to climate change, environmental degradation, social inequality and economic shocks. Moreover, this approach is an opportunity to decrease the vulnerability and to increase the adaptive capacity of cities. This paper is based on a EU FP7 Project "POCACITO – Post-Carbon Cities of Tomorrow". The objective of POCACITO is to facilitate the transition of EU cities (including the case study cities of Barcelona, Copenhagen, Malmö, Istanbul, Lisbon, Litoměřice, Milan, Turin, Rostock and Zagreb) to a forecasted sustainable or 'post-carbon' economic model eventually leading to an evidence-based EU 2050 post-carbon city roadmap. This paper aims to evaluate Istanbul's transition towards a post-carbon city by critical impact assessment and to highlight a sensitivity model for the city. The sensitivity analysis has revealed the most important and critical factors/variables for the city and the degree of sensitivity of components to any stresses or changes in Istanbul. The sensitivity model highlights: i) natural disasters, education level and connectivity are the most 'active' factors; ii) transportation, energy efficiency, water management and carbon emission are the most 'passive' factors; iii) quality of life is the 'highly critical' factor; and iv) population, real estate market, climate change impacts, attractiveness, resilient economy, urban facilities, building density, quality of housing stock, urban sprawl/growth and citizen awareness are 'critical factors'.

Keywords: climate change, post-carbon cities, critical impact assessment, Istanbul

CHALLENGES OF URBAN LIVING LABS AS PLACES FOR LOCAL INNOVATION FOR CLIMATE RESPONSIVE CITIES

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ABSTRACT

Finding new approaches to overcome complex urban problems such as climate change has always been of interest to policy-makers and academics. The changing dynamics of urban development result in the diversification of new practices during which experimentation is used to inform urban practices. Some examples include living labs, demonstrators and prototyping. Amongst these approaches, urban living labs have become a popular form of urban experimental innovation in many countries in the last decade. These urban living labs respond to the increased complexity of urban climate challenges calling for local solutions that acknowledge local conditions, politically, technically and socially. In many urban living labs, local innovations to climate problems are being developed, tried and tested and improved, leading to urban innovations ready for repetition and upscaling. The involvement and participation of local stakeholders and citizens is generally considered key to deliver solutions that are accepted and work. Even though there has been wide attention for this form of urban innovation, there has been little attention on the innovation process itself within urban living labs. In our presentation, we explore this innovation process, including the role of stakeholder and citizen participation. Based on a comparative case study of nine innovations in urban living labs in the city of Amsterdam, we analyse and discuss the claims of urban living labs with regards to innovation and citizen participation. Our cases show that there is an inherent tension between the development of innovations to be adopted elsewhere, by others, and the development of innovations that work in the particular context in which they have been developed. We argue that the process of experimentation allows different orders of learning in urban living labs. In such processes, combining mechanisms of learning and embedding is key to promoting the development of particular local climate solutions.

Keywords: Urban living labs, climate change urbanism, learning, local innovation

DENSITY OF THE HABITAT ON THE CONTEMPORARY MEGACITIES. PEOPLE, SPACE AND URBAN FUTURE

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ABSTRACT

Since 2008 the urban population has exceeded the rural population, this has been the first time on the history of our urbanized planet, the explosion has occurred in short time after 1950 and this phenomenon is still growing. The contemporary urbanization interested the large urban areas, where is possible to analyze the high density of habitat, are located mostly on south of Asia, where the urban population will become more than 1000 millions of people, like in China and we will see more than 400 megacities on the world, this is the dimension of our next future the explosion of the urbanization and immigration.

The vision for 2050 for the megacities will consider these are major global risk areas. Due to the highest concentration of people, high density and extreme dynamics, they are particularly prone to supply crises, social disorganization, political conflicts and natural disasters. Their vulnerability can be high. This is the setting of our future development if the urbanization will continue in this way. The high density of population in large cities and megacities affects our environmental, social and economic changes, especially the urban life, which create a new form and model of living and new attitudes of co-habitation, and which force people to adopt these new conditions of habitat.

This research focuses on the consequences and effect of the urbanization in Environmental, Social and Economic aspects. The case studies to work on the comparison between Asian Cities and African Cities. The aims are elaborate a state of the urban habitat in the high urban density areas. Is a reflexion to consider a new vision to develop a better urban future.

Keywords: Urbanization, Megacities, Population growth, Urban Habitat

RECOGNIZING THE SPATIAL PATTERN OF ENERGY-SAVING BEHAVIOR

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ABSTRACT

Smart Cities are urban areas that use Information and Communication Technologies (ICT) in order to reduce resource consumption and increase the quality of life of citizens towards sustainable urbanism. Therefore, the vision of 'Smart City' plays an important role in urban sustainability, the solution of social, economic and environmental problems in cities. However, the 'smart' part of the city does not only involve the smart technological solutions such as smart grids, smart meters or IoT devices but also includes the power of the citizens who solve their problems in the cities via smart innovation tools. In this context, this study explores the multidimensional structure of energy-saving behaviour which starts from the individual actions through interventions and feedbacks, and grows at the community level, within the two dimensions of energy efficient urban lifestyles: dwelling and urban mobility. Therefore, a web-based platform (CODALoop) has been designed to produce a 'Decision Support System' to increase citizen's energy awareness which is a precursor condition of energy conservation via feedback mechanisms. The impacts of historical and comparative feedbacks on energy consumption behavior of individuals will be examined on the example of the neighborhoods of Kadikoy District. Kadikoy has been selected as a case district among 39 districts in Istanbul Metropolitan Area because of the diversified socio-economic structure, and the significant local authority attempts such as building regulations, participatory policy-making, and recycling policies to reduce the district's carbon footprint and energy use. Finally, the study will contribute to the spatial analysis of energy consumption and energy saving data in Kadikoy, and show how individuals can change their energy consumption behaviour via smart innovation tools.

Keywords: energy consumption, energy awareness, Geographic Information Systems (GIS), spatial analysis.

SURVEY OF OCCUPANT BEHAVIOR ON THE ENERGY USE IN TURKISH DWELLINGS: MERSIN EXAMPLE

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ABSTRACT

Occupant behaviour is one of the major factors influencing building energy consumption and contributing to uncertainty in building energy use prediction. There is a lack of knowledge of the effect of various energy saving measures, especially because the influence of user behaviour and lifestyle has not been studies to the same extent as the technical aspects. To meet the high expectations for energy savings in the future, it is therefore important to obtain much more knowledge on the user related part of the energy consumption in order to include and affect this part of the consumption

On the other hand during the design stage, architects and engineers need to consider how the building occupants will impact final energy use. Accordingly, building designers need data, models, tools and case studies able to provide an evidence-based understanding of the human dimensions of energy use.

This paper will focus on developing a new interdisciplinary approach to the analysis and assessment of user influence on the building energy consumption. The method will be based on surveys of energy use and user behavior which will provide an opportunity to establish a knowledge and experience base for the assessment of real obtained energy savings and hence better opportunity to direct future energy policy.

In this conceptual framework, main focus of this research is to evaluate the occupant behaviour and household characteristics based on concepts such as comfort, health and energy efficiency. Scope of this research includes occupants' quality demands of dwellings. For this reason an experimental study was conducted to analyse the effectiveness of various architectural plan types which belongs to different income groups live in Mersin. Quantitative analysis of a survey of 3 different income groups (high, medium and low income groups) and built forms of residents living in Mersin Metropolitan region was conducted to evaluate the relationship between energy consumption, occupant behaviour and architectural design. Findings showed that there is a significant relationship between residential quality, energy consumption and occupant behaviour.

Keywords: Occupant behaviour, Housing Quality, Energy Efficient Design

UTOPIAN AND DYSTOPIAN RESPONSES TO URBAN CLIMATE CHANGE ADAPTATION: THE IMPACT OF THE FILM INDUSTRY IN AWAKENING FUTURE PROFESSIONALS

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ABSTRACT

Urban dystopias which reflect human concerns on deterioration of natural and built environmental conditions have been produced throughout the film industry. Some of these products present a story on an unknown future in which the human life is salved and constructed on equitable systems or faces extinction following a catastrophic event that occurred on earth. The climate change is an inspiration to movies which reflects the human concerns on the future of life on earth, especially in urban areas. It is assumed that dystopias have a great potential on people's awareness for the future hazards and risks of natural and built environmental conditions. This study discusses the role of dystopian views especially reflected in the film industry in creating awareness and consciousness among people for the vanishing human race and urban environments. It investigates the role of dystopian movies with scenarios focused on climate change on the future professionals of urban environment and their related projects. A questionnaire has been developed and carried out among the students of Çanakkale Onsekiz Mart University. The focus group has been the students in the departments related to design and construction of built environment. The essential aim of the questionnaire is to understand and evaluate the fluctuation of the awareness level of the students particularly after watching the movies related to the climate change. Among the other questions, the questionnaire also asks the students if their personal and professional perspective and understanding of climate change have changed or not following their experience on climate change related fiction movies and documentaries. Finally, the research argues how the dystopian movies could be used as an effective tool to evoke professionals who work in design and construction industry to develop more sustainable and climate adaptive environmental conditions.

Keywords: dystopian movies, climate change, awareness of future professionals, built environment



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